Department of Informatics and Mathematical Modelling (IMM)

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Master Thesis

Creativity, Learning & Flow

The Role of Engineering Competitions

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Jesper Laen Sørensen

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Contents

0.1 Abstract

This project is an attempt to grasp the involvement generated by engineering competitions, and see to what extends this kind of activity with advantage could be incorporated in the university curriculum.

The empirical study to support this project is the performance of two engineering competitions, carried out by students of technology in an international environment. Observations and informal interviews with the students participating in these events were analyzed, and several flow elements were substantiated, for instance the paradox of management, clear goals and feedback, and concentration on the current activity.

Ørsted Andersen's observation form has been applied to operationalize the subjective nature of the experience of flow, since concentration is a good marker of the experience of flow. Csikszentmihalyi's assertion that involvement is achieved, when challenges and skills are balanced, was empirically supported too.

The procedure for this project is observations of the participants, while involved in their respective competitions, and informal interviews in-between, where notes were taken. The involvement was in fact increased, so that the participants talked about the issues during lunch breaks, and afterhours. The interviews also showed that the state of this competition increased interest, because it was something new and different.

Mihaly Csikszentmihalyi's theory of flow is applied as a means to understand the subjective experience, which makes up this involvement, because it offers a concept to operationalize the quality of subjective experience.

The project concludes with suggestions to changes that could improve the educational setting.

0.2 Resumé

Dette projekt er et forsøg på, at forstå den grad af engagement, der genereres ved ingeniørkonkurrencer, og se i hvilket omfang denne form for aktivitet med fordel kan inkorporeres i universitetets pensum.

Det empiriske studie for at understøtte dette projekt, er præstationen ved to ingeniørkonkurrencer, udført af teknologistuderende i et internationalt miljø. Observationer og uformelle interviews med de studerende, der deltog i disse begivenheder, blev analyseret, og flere af flowelementerne blev dokumenteret, eksempelvis styringens paradoks, klare mål og feedback, og koncentration om den foreliggende opgave.

Ørsted Andersen's observationsskema blev brugt til at operationalisere oplevelsen af flows subjektive natur, siden koncentration er en god markør for oplevelsen af flow. Csikszentmihalyis påstand om at involvering opnås, når udfordringer og færdigheder er balancerede, blev også underbygget empirisk.

Proceduren for dette projekt er observationer af deltagerne, mens de var involverede i deres respektive konkurrencer, sammen med uformelle interviews, hvor der blev taget noter. Engagementet blev faktisk øget, så deltagerne talte om emnerne i frokostpauser og uden for den skemalagte arbejdstid. Interviews'ene viste også, at konkurrencen øgede interessen, fordi det var noget nyt og anderledes.

Mihaly Csikszentmihalyis flowteori er anvendt som et middel til at forstå den subjektive oplevelse, som skaber dette engagement, fordi det tilbyder et begreb, der kan operationalisere kvaliteten af subjektive oplevelser.

Projektet slutter af med forslag til ændringer, der kunne forbedre uddannelsesrammen.

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And finally I would like to thank my mother for the support and inspiration, not only during the thesis, but during my whole life. Thanks for everything, mum!

Lyngby, December 2007

Jesper Laen Sørensen

A. Divergent part

1. Introduction

1.1 Purpose & problem formulation

The Board of European Students of Technology (in short *BEST*) is an international student organization within Europe, promoting understanding, respect, cultural exchange, and not the least knowledge between the different countries' universities involved in this student organization. Every season, be it winter, spring, summer, or autumn, the student organizations in the different universities among other things organizes courses or other events on education. And a fairly new initiative is to organize engineering competitions within this international framework. Since I had the opportunity to participate in two of these international engineering competitions, it seemed like the perfect opportunity to test the theory of flow in practice, while at the same time investigate an alternate way of learning. This time it would not just be sitting down at a lecture, or be pacified in a classroom, but be involved in a dynamic event with the bonus of having students from other countries present to.

Therefore the purpose of this thesis is to document the level of involvement generated therein with the use of the theory of flow. And thereby find new and interesting ways in which to improve the educational setting.

1.2 Structure of the report

The master thesis is divided in 2 main parts with 8 chapters in total.

The first part will be the divergent part, where the concepts and theory is expanded and illustrated. The second part is the convergent part, where it will be described whether the cases match the concepts and theory in two international engineering competitions.

Chapter 2 is the first part in the divergent part of the thesis. Here the concepts of flow and creativity will be described.

Chapter 3 will begin with a description of the international student organization BEST. Furthermore the two international engineering competitions are described in detail.

Chapter 4 is the first part of the convergent part of the thesis, and contains reflections on the scientific methods and the choice of data production method, as well as the observation form. The analysis of the two international engineering competitions takes place in chapter 5. This is done from the observation form described in chapter 4 with the addition of informal interviews with the participants.

Chapter 6 lists the results from the practical cases derived in the analysis. Chapter 7 outlines the conclusion, and the project is evaluated in chapter 8.

1.3 Motivation for choice of subject

This project comes from a desire to delve into the magical world of flow. Flow to reenergize your daily living. My personal concept of flow, before delving into the matter more thoroughly, is to be *in the zone*. A state of mind where everything seems to *flow*. You do not think about what you do. You just do it. And you are so involved in this state that everything else seems unimportant. Only your current activity matters. And in this state you are so in tune with your surroundings that you begin to discover elements you did not know existed. You begin to create new things, ideas, or concepts. Your creativity is heightened. And creativity is another subject of my interest. The power to create something new, something fresh, something innovative. Creativity is also being aware of new possibilities. To keep your eyes open for opportunities. To be aware of possibilities in creativity, and the flow it creates, when the innovative forces works.

This is something that has fascinated me ever since I was a little boy. To solve puzzles, to play football, be engaged fully in an activity, in something giving, in something involving, where time just seems to flow.

However, for some reason this state seems to be present more often, when playing some sort of game or competition. And it is also mostly from my childhood that I remember feelings of flow. But why is that? Is that because children are just better disposed for this state, is it something in our education that affects us in a negative way, or something completely else?

This is but some of the reasons why I wanted to write about and deal more thoroughly with this subject. And that is the reason for writing this report.

1.4 Relevance of subject

This subject is very interesting seen from an educational point of view. At the present universities and other educational institutions are mostly confined to the lecture-way of learning. And this can be good enough in many cases, if there is an element of interactivity. If this is not the case, and the lecture is done directly from the teaching materials, this kind of lecture can be directly de-motivating [Cohn & Stoehr, 2000].

It has been documented from many sources that if you do not apply what you learn in practice (*learning by doing*), for instance in lab-work, then only a small amount (if any) of the taught material actually sticks in the memory.

An engineering competition is a way to make engineering students work on a subject in a practical setting. You experience firsthand that what you have learned is applicable in practice. Furthermore, there is an increased possibility to meet students from other fields of study, and not only learn something from them, and vice versa. You also see a given problem from other points of view, while enlarging your network.

In a world of globalization, where even cow meat is being transported from Brazil to Danish consumers, and where it is possible to manufacture virtually everything cheaper and more efficient in other parts of the world, the main focus in a country like Denmark has to be on creativity and innovation. If we cannot compete on areas such as price and efficiency, we must simply make a better product. The quality has to be higher; sometimes breaking bounds of what we find possible. In other words we have to innovate. And one of the tools for doing so is the ability to combine (existing) ideas in new ways. The engineer of the future has to be able to work in cross-functional teams, dealing with people, whether they are technicians or non-technicians. And working like this at the university prepares students for their future work, while having the other benefits listed above.

All of this sums up to (international) engineering competitions being one way of not only preparing the students, but also help their future employers, with the challenges faced in the globalized

world, by heightening the potential creativity, innovation, knowledge transfer, and communication among the students, while enhancing their quality of life.

2 Scope of scientific theory

The expansion of the scientific theory will begin with a short introduction to positive psychology, which will be followed by a more thorough description of the concept of flow and creativity.

2.1 Positive psychology

What is a good life? What makes life worth living? These are but some of the questions that the positive psychology tries to answer [Seligman & Csikszentmihalyi, 2000]. The interest in these questions is not new, and it is not the core of positive psychology. Big thinkers and philosophers like Confucius and Aristotle have already tried to account for what constituted 'the good life' centuries before our calendar.

What makes the positive psychology special however is the following combination:

A wish for the psychology to be a more thorough study of the human, which consider both good and bad aspects, a demand for this study to have a high scientific quality, as well as an ambition for a mutual and productive relationship between theory and practice. Furthermore there needs to be a basic positive view of humanity, and the ambition to find better and more scientific explanations than the home-spun philosophies can produce.

Positive psychology is a relative new 'movement'. The event that clearest marked the beginning for this, was Martin Seligman's speech as President for the *American Psychological Association* in 1998 [Seligman, 1999]. Here he claimed that psychology had neglected to fulfil two of the three basic objectives that it had before the Second World War, that is to treat mental illness, make people lives more productive and fulfilling, as well as stimulate growth and development of talent. It was pointed out that psychologists had become proficient with working on mental disorders and illnesses, but had neglected to deal with mental well-being and human strengths and thereby ignored a great deal of ordinary people's lives. At the same time it was established that a lot of progress and prevention of diseases can be achieved by focusing on and investigate positive aspects of people's lives.

The speech was founded on conversations with Mihaly Csikszentmihalyi, among other persons, and a guiding committee and a *Centre for Positive Psychology* at the University of Pennsylvania was established. Ever since numerous articles have been published, and the area has gotten its own handbook [Snyder & Lopez, 2002], and its own journal: *Journal of Positive Psychology*. Even a Danish network for Positive Psychology has been founded.

A more integrative and pragmatic definition of positive psychology has been given by Linley et al [Linley et al, 2006]. Here it is suggested that positive psychology is the study of optimal human function. This could e.g. be what characterizes the individuals that are very competent at their work, or have an especially gratifying personal life.

Positive psychology at the subjective level is a field about valued subjective experience: contentment, well-being, satisfaction (past), and flow and happiness (present), and hope and optimism (future). At the individual level, it is about the positive individual traits – interpersonal skills, aesthetic sensibility, perseverance, originality, the capacity for love and vocation, courage, spirituality, high talent, forgiveness, future-mindedness, and wisdom. At the group level, it is about the civic virtues and the institutions that move individuals toward better citizenship: civility, tolerance, responsibility, altruism, nurturance, moderation, and work ethic [Seligman, 2002].

According to a lot of magazines it is relatively simple to become and stay happy. In contrast to this a great deal of the positive psychology has shown that this is all but simple. One of the most central explanations on this condition was given by Brickman and Campbell in 1971 and goes by the name *the Hedonic Treadmill* [Brickman & Campbell, 1971]. This suggest that people quickly adapts to new circumstances and situations. This is one of the phenomenal abilities of adaptability the human possess. The human is placed in a new situation, and quickly sets new goals, but adapts to these. This ability can be an advantage, since humans can find a sense of purpose even under very difficult conditions. Opposite this research shows that grand economical success not necessarily breeds grand happiness. Regardless if people experience big personal losses, e.g. in the sense of severe injuries or interpersonal ones, or win some millions in the lottery, they more or less transit to the original level of happiness [Brickman et al, 1978].

Basically the positive psychology argues that well-being not only is an absence of illness. Just by overcoming a depression, there is no certainty that you thereby achieve a special fulfilling existence. At the same time it is the concept that focus on a person's constructive qualities can prevent diseases, be a contributing factor in fighting an actual illness and help to prevent relapses.

In this context it is assumed that psychological problems among other things are founded in an unconstructive use of or lack of development of personal abilities. And it is suggested that a model that focuses on actualisation is used [Joseph & Linley, 2004]. This conceptualization takes a holistic view on well-being as well as psychopathology and lets the clients inner voice be the truth that is followed. In the positive psychology the view on people is one, where the human is seen as a creature driven by socially constructive forces, and an idea that all people can blossom if they are given the right conditions.

2.2 Flow

An extension of positive psychology is the theory of flow. The theory of flow was created by Mihaly Csikszentmihalyi. He was born in Hungary in 1934, and raised in a bilingual home. During a stay in an Italian prison camp during the Second World War, his time was used on playing chess. And for the first time he experienced the intense enjoyment and focus, he was later to investigate in his psychological research. He has lived his adult life in the United States, where he is a professor and researcher at the Claremont Graduate University in California. Here he and some of his co-workers founded the Department of QLRC – Quality of Life Research Center, which is a non-profit research organization, where concepts like creativity, flow, hope, courage, optimism, satisfaction are imperative. The focus is on the positive and forward-looking of the human psyche, one concept being the theory of flow.

And the interest for the theory of flow has increased in the last couple of years. Previously the main interest has been from types such as elite athletes. But now the concept has been taken in by management and organization, and many journals and newspapers show results and articles on the subject as e.g. Annika Ipsen's article on flow in the journal Ingeniøren [Ipsen, 2007]. And the theory has shown to be useful in not only these areas, but in all areas anywhere, by anyone. Flow is something *everybody* can experience. On top of that it is interesting that no country has a local version of the word *flow*. *Flow* is simply flow everywhere.

2.2.1 What is flow?

Csikszentmihalyi himself describes flow as a state, where you are so engaged in an activity that anything else is unimportant. A state of optimal experience. These experiences are so joyful that you are willing to execute the activity, even if it exposes you to danger or have big economic expenditures. The flow state is experienced as meaningful no matter what activities that triggers them.

Paul Farley, a writer describes it like this:

…being 'in the zone' when you're writing well is pleasurable, effortless, and anything can and often does bubble up from God knows where. It's like you're conducting an orchestra of everything that is the case with you, what you've done, who you've loved, what you've seen and read, all the sensory data you've stored: there are different sections which can all play together in concert, which normally wouldn't. [Magma 34, 2006]

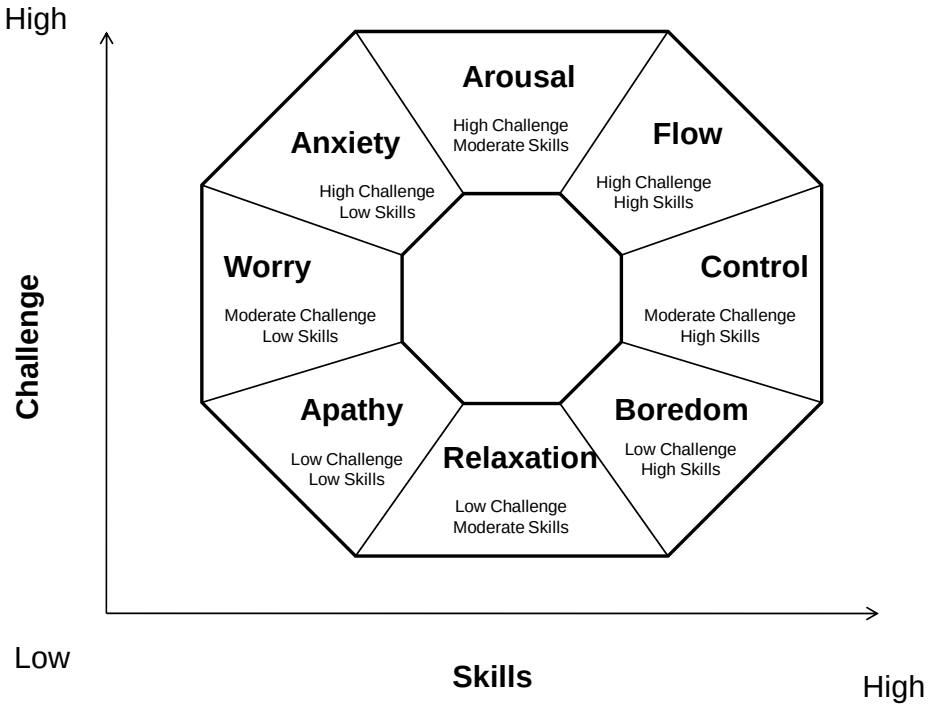
This state of flow is characterized by involvement, focus, and concentration. You are completely there in the present. Hours becomes minutes, and vice versa. The given activity that triggers flow is so giving and driven forward by an inner motivation that the activity becomes a goal in itself. That is why Csikszentmihalyi uses the word *autotel* as a description of the character of the activity. Autotel is from Greek. Auto = self and telos = goal.

Our experiences appear in the consciousness as information, according to Csikszentmihalyi, and the quality and content of our life is dependent on the information we allow access to the consciousness. It is therefore possible to enter a happier state of mind, if you can control this information, and thereby alter the content of the consciousness. You control this information through attention and this attention is thereby a tool to better the quality of one's experiences. On account of this the attention is like energy you control yourself. A concept Csikszentmihalyi designates mental energy [Csikszentmihalyi, 2005a].

2.2.2 The Flow–diagram

Being in a state of flow means being in tune with ones surroundings. You adapt to the given situation you are in, and unconsciously you generate energy for recreation.

What this means is illustrated in the following figure:



[Csikszentmihalyi, 2005b]

The optimal flow experience is created when there is a balance between the challenge and skills of the person, while both of these are over a certain level [Johnson and Wiles 2003].

Boredom is experienced when the skills are larger than the challenge(s) faced. In the opposite situation first worry and then anxiety is experienced, when the challenges are way above ones competences [Csikszentmihalyi, 2005b].

Apathy is experienced when competences and challenges are balanced, but on a very low level. A feeling of being inadequate is present. But when there is equilibrium on a high level, relative to the prerequisites of the person, there are optimal conditions for the complete focus, or flow, to emerge [Sharafi et al. 2004]. The pianist experiences flow, when the piano play takes his entire repertoire. The salesman experiences the same, when a big contract is being initiated, etc.

It is in these situations with clear goals, instant feedback, and equilibrium between challenges and skills that the optimal focus figures and the mental strength is stronger. An hour can suddenly feel like minutes, and vice versa, where distracting thoughts and feelings are buried.

The illustration also shows what could be done to achieve personal growth. E.g. the area *control* is not a negative place to be at. It is possible to be satisfied with and feel happiness in this situation, but one might risk a drop in concentration, since the skills are above the given challenges. So what can be done about it? The level of the challenges has to be increased [Csikszentmihalyi, 2005b].

At the other end of the optimal flow experience is the area *arousal*. It is by no means impossible to be energetic, but to get *in the zone* – another expression for being in the state of flow – an increase in competences is necessary relative to the challenges faced.

These three zones: *control, arousal, and flow* are all beneficial for personal growth. Opposite this are the zones with *worry* and *anxiety*. Here the risk is that a person in this situation will try to avoid new challenges, or withdraw to a lower challenge level, when a feeling of inadequacy is present [Csikszentmihalyi, 2005b]. The same was concluded in a survey on the staff at one of the departments at the Technical University of Denmark (DTU) [Sørensen, 2006].

But the flow-zone is no zone of stability despite complexity and joy. At a given time the current situation will either be too dull, since it is always similar assignments that are worked on or the same level of intensity that is needed, or dissatisfaction will emerge, since a feeling of inadequacy is present. The motivation for the activity will then encourage the person to get back to a state of flow, but now on a higher level than the current flow situation. This dynamic explains why flow creates growth and new inventions.

Even though flow can progress the development of new competences and challenges, this is unfortunately seldom the case. Often people will leave their mental focus to be regulated by commercial sit-coms, TV-series or TV-shows, due to stress or indifference.

However this can be altered. As previously mentioned flow can appear in any situation, so by following a few steps the quality of life can be immensely improved. This can be done by making sure that the prerequisites for flow are present, for instance by having clear goals, feedback, and equilibrium between challenges and competences.

In brief: Take charge of your own life. Organize your life so you will have time for the good experiences.

2.2.3 Flow at work

Csikszentmihalyi discovered the experience of flow in activities linked to free time. But he wanted to know the extent of this. And interviews with surgeons confirmed that experiences of flow were not limited to free time. Even though it could seem as if outer sources of motivation, like money or prestige, in professional reputation and high social status, then this was not what drove the motivation of the surgeons. When the surgeons were given the question on, what they liked the most about their job, most of them replied that it was the importance of the surgical practice itself [Csikszentmihalyi, 1975].

This is not unique for surgeons. A good example on this is the story of Joe [Csikszentmihalyi, 2005a].

Joe worked at a factory that produces railway carriages. Because of the loud noise near the big hall, where most of the workers stayed, communication was between them was close to impossible. Therefore most of the workers were uninspired during the work day, and mostly thought about closing-time. But not Joe. Joe that had worked the most of his life at the factory had made it a virtue to investigate, apply and repair every single instrument in there. He loved learning new stuff. So he was happy every time a new instrument got broken. This meant that there was a new challenge to deal with. So every time something broke, Joe got called. And most workers at the factory were convinced that the factory would not function without Joe.

So even though it is easy to find experiences of flow in top sports and elite working frames, then the research on flow shows that the same experiences happens to all types of people no matter their social cultural frames. Also in daily situations [Csikszentmihalyi, 2005b].

2.2.4 Negentropy and mental entropy

Csikszentmihalyi describes two states of mind. Mental entropy and negentropy [Csikszentmihalyi, 2005a]. Mental entropy is when all your mental energy is seized for keeping an inner order, and thereby does not give the possibility to focus outward. It is feelings like anxiety, stress, boredom, sorrow, etc. that creates this mental entropy. The opposite is the case with positive feelings like happiness. Here mental negentropy is created, where focus is not centered on oneself, but projected outwards. Negentropy is like the flow-state, and entropy is the opposite.

Ørsted Andersen describes it like this:

You can say that choosing to direct your attention towards a certain activity is the same as having an intention with something or set a goal in some context.

How long and how intense we can keep this attention, is a question about ability as well as motivation. But all of that – to focus, to keep your attention, to set goals, to be motivated – is a sign of negentropy.

[Ørsted Andersen, 2006, own translation]

2.2.5 The autotel personality

Csikszentmihalyi designates the personality that can see potential threats that the world has to offer as enjoyable challenges, as *the autotel self* [Csikszentmihalyi, 2005a]. This type of person is engaged in whatever is going on, and is seldom bored. And this type of person has the ability to:

- acknowledge challenges
- array clear achievable goals
- pursue objectives that are recognized as sensible
- make decisions
- follow feedback from self-controlled actions

[Csikszentmihalyi, 2005a]

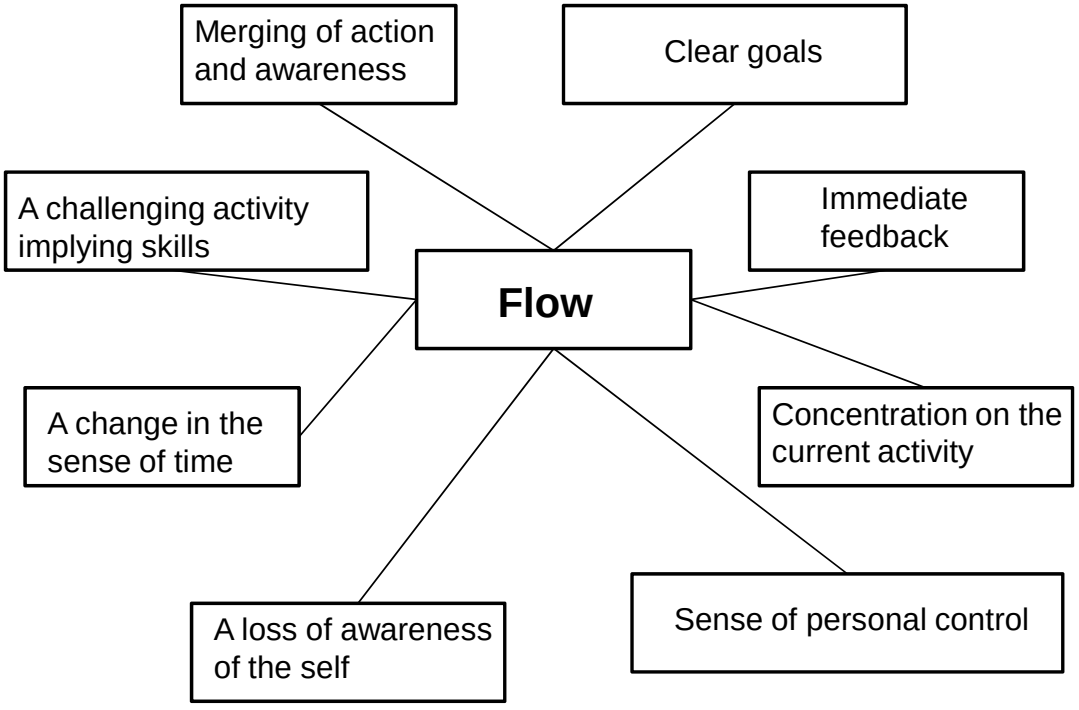
The ability to concentrate and the ability to be engaged, are two concepts that Csikszentmihalyi connects, because in this way distracting factors are eliminated, and it is possible to concentrate fully on the approaching activity [Csikszentmihalyi, 2005a]. In other words to be able to direct the attention towards a given activity, and be able to keep an engagement through concentration. And hereby a paradox is illustrated. What happens is that the *self* returns in a stronger fashion, by this complete engagement in achieving the objectives for the activity. These immediate experiences can be enjoyed if they are guided in a direction, so it *is experienced* as enjoyment instead of anxiety.

2.2.6 The eight elements of optimal experience

Research in the area of flow shows that all flow-experiences, even within different areas, are experienced in a similar fashion. And the same goes for differences in culture, gender, age, level of education and social class. This means, according to Csikszentmihalyi, that the psychological circumstances that makes this flow-state possible, are the same no matter where in the world one might be [Csikszentmihalyi, 2005a].

He lists eight points that characterizes the flow-experience, and these will be explained in detail:

Eight elements of Flow



[Csikszentmihalyi, 2005a]

2.2.6a A challenging activity implying skills

Pleasure and enjoyment are two concepts that Csikszentmihalyi makes a clear distinction between. Pleasure is a condition that can be achieved without investing mental energy in it. This makes it casual, in contradiction to enjoyment that can only exist if mental energy is fully invested in the given activity [Csikszentmihalyi 2005a].

And enjoyment is not something people normally experience when they relax. It is a mental state that is reached, when a given activity demands one's skills. A challenge where you as previously mentioned invests your mental energy. And these activities are normally recognized by having a frame and a clear goal. In the given activity there should be equilibrium between ones skills and the challenges you face, for the optimal experience to be reality. If this equilibrium is not present, the assignment will be seen as meaningless.

Competitions are often situations, where this form of enjoyment can arise. But it is important to underline that enjoyment only arises as long as skills are developed. If the only purpose of the competition is to knock down the opposition, this type of joy does not appear. Activities or skills should not only be seen as something physical. Other forms of challenges can also create flow, for instance reading. Here you have to be able to handle the symbolical information in the form of letters forming words, and words forming sentences. It involves an understanding of the given language, that you are able to put the words into pictures, and understand the underlying context, and eventual irony, that may be in the plot storyline.

Many everyday-doings can be converted to flow-activities, if they can be turned into a personal game [Csikszentmihalyi, 2005a]. The possibility for activities to be more joyful, according to Csikszentmihalyi's research, is to add more complexity to them by making the challenges bigger.

2.2.6b Merging of action and awareness

This point concern the situation, where you are so focused on the activity that everything else seems unimportant at this time. You are not disturbed by thoughts that question the given activity. You *just do it*. And no matter the level of stress of the activity, physical as well as mental, it is experienced effortlessly [Csikszentmihalyi, 2005a]. Because the purpose of getting into the state of flow is to stay in this flow-state, which indicates that flow is a process oriented condition more than a result oriented.

2.2.6c Clear goals & immediate feedback

Two factors of the highest importance to get into the state of flow are clear goals and immediate feedback. The purpose with feedback is all the time to be aware where you are relative to the achievement of the given goal. And this feedback should preferably be constructive and non-humiliating.

The goal, or the goals, can be of both concrete and abstract character. The placed objectives must not be too big compared to ones capabilities, since this leads to anxiety and perhaps stress, but not too small either, since this will quickly lead to boredom. There should be equilibrium between challenges and skills, for flow to emerge. There are many types of feedback, some faster than others. The windsurfer will quickly get confirmation as to whether he can or cannot surf on the water. It is something else with the farmer that has to wait for months, and is dependent on the weather, before he gets confirmation on whether he has done a good job or not. But the essential thing is the message about the achievement of one's goal. That is what is important [Csikszentmihalyi, 2005a]. It is connected with an enjoyment to any form of feedback, as long as it is bound to the activity in question [Csikszentmihalyi 2005a].

2.2.6d Concentration on the current activity

What is often mentioned in connection with flow is the exclusion of unpleasant thoughts and worries. It is because the activity that generate flow, demands total focus. The current activity seems to fill the entire space and irrelevant information is left out from one's thought pattern [Csikszentmihalyi, 2005a]. It is clear that the more difficult an assignment is, the harder it is to concentrate about it. But if you like what you do, the motivation is present, and the concentration will automatically come. Through a focus of concentration you learn to control the mental energy, which is the 'most important fuel for thinking' [Csikszentmihalyi, 2005a].

2.2.6e Sense of personal control

The enjoyment does not emerge by being controlling, but by *exerting control*, or have the possibility to do so. And this can only be achieved by giving up total safety. It is only when the result is not certain that it is possible to find out whether you exert control or not [Csikszentmihalyi, 2005a].

Concrete examples on this are activities, where people risk their lives, e.g. firemen or race drivers. Here the person must have developed adequate skills to deal with the given challenges. It requires a thorough preparation. And here it is more about the ability to minimize risk by thorough preparation that makes people experience control than foolhardiness [Csikszentmihalyi, 2005a]. The bigger the complexity the activity or activities has, the bigger the exertion of control you have to deliver.

The place where paradox of management emerges is in that moment, where you are so focused to put yourself in this condition of flow, that it is not possible to direct your attention towards other things. You lose the control, and develop an addiction [Csikszentmihalyi, 2005a]. Activities that create flow can appear very addictive, and cause an addiction, similar to that of narcotics. It is to be understood as if the activity, by being a voluntary made choice, suddenly becomes a necessity that can intervene in other activities.

And it is here the neutrality of the flow-theory is illustrated. Flow in itself is not something morally good. It does not include any form of pedagogical normativity. Goebbels for instance was probably in a state of flow, when he was calculating, how to logistically kill the most Jews during Holocaust. The flow-theory in itself is not an answer to which pedagogic or political objectives you should array [Knoop, 2005]. Csikszentmihalyi himself writes: ”Enjoyment is not on *what* you do, but on *how* you do it.” [Csikszentmihalyi, 2005a]

2.2.6f A loss of awareness of the self

Mental energy is used daily in the efforts on maintaining a self-image that the surroundings cannot challenge. A lot of resources in the form of mental energy are used in an effort to keep a self-image, and to tell yourself that you are good enough, if others i.e. make fun of one’s intelligence or appearance.

But when you are in the state of flow, when you are in a situation of optimal experience, you lose your awareness of the self. The self is engaged during this flow-situation. It is not a passive omission of the self. Instead the flow-experience demands that all of the mental energy is directed towards the activity. This means that there is no time or place for soul-searching, and the ego disappears. You become one with the activity, and the result is mental negentropy, that is order in the consciousness [Csikszentmihalyi, 2005a].

"Increasingly in our time--this is an inevitable result of collectivization--it is the organization man who succeeds. And he is characterized by the fact that he has significance only if he gives up his significance." [Rollo May, 1967]

2.2.6g Alteration of the sense of time

This is the part that involves the phenomenon, where the time flies. The phenomenon where hours feel like minutes, and minutes feel like seconds, and vice versa. Flow-activities do not have to be time limited, but can be so. Many work situations demands that you can keep track of time, and thereby keeping track of time can become a competence that is part of the flow-activity [Csikszentmihalyi, 2005a]. This means that it is a parameter in the flow-activity, but not something you direct your attention towards because of boredom.

2.2.7 Flow & ZPD

Prentsky describes the state of flow like this:

In the flow state, the challenges presented and your ability to solve them are almost perfectly matched, and you often accomplish things that you didn't think you could, along with a great deal of pleasure.

[Prentsky, 2001]

Csikszentmihalyi's theory on flow and Vygotsky's theory on *Zone of Proximal Development* (ZPD) both deals with how knowledge and skills can be developed. It is the collaboration with the environment that contributes to your development, Vygotsky believes. It could be collaboration with a competent person (e.g. a mentor) that develops your abilities [Vygotsky, 2004].

Ørsted Andersen suggests when ZPD and flow can be linked together. If you begin with a situation in which a competent person helps with reaching the state of flow with an arrangement of the environment, to give it the possibility of experiencing flow, so good chances are created at the same time for this person to reach the ZPD. And by being in the ZPD, the possibility of getting into the state of flow is bigger [Ørsted Andersen, 2006].

Vigotsky's concept of the *activity theory* can be related to the flow-theory [Bedny & Meister, 1997]. According to Vigotsky *actions* must be understood as goal-directed, intrinsic motivated activities that use different tools, and shows in different *activity forms*, like games, teaching, and work [Nardi, 1966]. The tools Vygotsky operate are to be understood in a very wide sense. For instance theory, languages, social conventions, etc. [Illeris, 2001]. Flow-activities is likewise considered as goal-directed, and characterized by a high degree of intrinsic motivation. Transferred to the theory of flow Vygotsky's concept on tools can be understood as skills you have, and your ability to focus attention towards the activities you are engaged in.

2.2.8 Collective flow

Csikszentmihalyi primarily describes the concept of flow as an individually subjective experience. But in an interview on flow with Jørgen Lyhne [Lyhne, 2005], the musician Peter Bastian describes his experiences in musical contexts as collective flow - that is a situation where the entirety constitutes more than the sum of the individual parts:

Then I am the guy who plays. But the interesting thing is that I have no recollection of 'I compared to them'. There is only a common sound image, where we are completely together, and we are completely one. (…) it is an expression for a synergy-flow. Where the entirety is indescribably much more than the sum of the parts. [Lyhne, 2005, own translation]

Peter Bastian mentions collective flow as a contributing factor for getting in contact with creative and intelligent parts of yourself that you otherwise would not know about. If you are in a situation of common energy and collective flow, then it contributes to lift the individual.

As an example he mentions a time, where he was in a jazz club called Lizard Lounge in Boston, USA. He was there with a friend. And his friend's teacher – George Garzone, an Italian saxophonist - played here, and had done so the last 28 years with his trio every Monday. A lot of his students were present, and there were a lot of musicians. The drum-player started playing a 'drone-like' rhythm, which meant that there was a very distinct hint to go in a certain direction. But when the saxophonist entered the music play, everything was free. All bets were off, so to speak. When the drummer played in one way, the saxophonist played in another, and vice versa. You could feel they knew each other inside out, and that they did not want to sound like a record. So every time they played something that sounded like something, they destroyed it. A similar way of thinking can be found in Carlos Castaneda's book "The Teachings of Don Juan" [Castaneda, 1996]

And as a musician, Peter Bastian says, you normally look for something recognizable in the music. You try to figure out, where the music is going. But at the Lizard Lounge this was impossible. They constantly changed the direction of the music, which meant that everyone among the audience at the Lizard Lounge had their awareness directed towards the same place. An experience of

completely being together. An attraction that you only feel when you are together with kindred spirits and have your focus directed at the same thing.

Mutual commitment is not just connected with our own competence, but also other competences. It uses what we do, and what we know, as well as our ability to join meaningful connections to what we do not do, and what we do not know – that is to other people's contribution and knowledge. [Wenger, 2004, own translation]

Wenger does, with his social theory on learning, show that the requisite for *communities of practice* is a joint commitment compared with common repertoire and *actions*. Through this participation with others you can feel the collected group's performance, meaning, and identity, experienced larger than every participant's individual performance. In other words group flow.

2.2.9a Conditions that hinders flow

There are certain personal traits, some pedagogical and some workplace- and community-bound factors that hinders flow, according to Knoop [Knoop, 2005]. The personal traits that hinder flow are the ones that create mental entropy. It can be low self esteem, difficulties with concentration, and felt stress or monotonousness [Knoop, 2005]. It is in other words the environmental factors and not genetically conditional factors that are necessary to experience flow.

Within pedagogical frames it can be too tight a control from the teachers that prevent flow from happening for the students, if the students experience it like what have been taught cannot be used for anything. They are simply pacified.

...the easiest way of preventing flow from appearing in pedagogical contexts is to force people to learn something that seems unimportant, boring or too difficult – in a potentially humiliating way – and do it for a long time – because that will make sure that the subject is learned slowly and quickly forgotten. [Knoop, 2005, own translation]

Work related conditions that likewise prevent flow from happening could be lack of influence. This results in lack of engagement, irresponsibility and apathy.

2.2.9b Activities that creates flow

…man only plays when in the full meaning of the word he is a man, and he is only completely a man when he plays [von Schiller, 1909–14]

A natural part of the research on flow has centered on the activities that creates flow. The design of the activity has shown to be crucial for the experience of flow. It is activities that gives the opportunity to experience the before mentioned eight elements of the flow-experience.

It is often in structured activities as different forms of sport, games, artistic appearance and ritual events that flow figures. Games in particular are good examples of activities that create flow. Csikszentmihalyi himself mentions Caillois' classical typology as a platform for argumentation so that games give the opportunity to go beyond the regular boundaries of experience. Roger Caillois divides games, which he designates all forms of enjoyable activities, in four categories: agõn (competition), alea (chance), mimikri (simulation) and ilinx (excitement/dizziness) [Caillois 2001].

Another look on Csikszentmihalyi's model (see page 25) illustrates the natural balance between the challenges and competences [Csikszentmihalyi, 2005a].

The axis of the diagram consists of the person's competences and challenges. The flow-state appears, when there is equilibrium between the two parameters. And the further up this equilibrium is, the more complex the flow condition. Competences and challenges are as previously mentioned not static sizes. Every person is different and therefore you cannot set up an objective character on competences and challenges. And that is the limitation of the model, according to Csikszentmihalyi himself [Csikszentmihalyi, 1975]. Flow is a *fluid state*. A dynamic state. Only by constantly developing yourself can you experience flow.

2.3 The concept of flow

Below some of the possible views on the flow-theory are discussed. The validity and use of the flow-theory is subjected to critical observations.

2.3.1 Popular scientific theory

The concept of flow is just a popular scientific theory…

At first glance the flow-theory may seem like a home-spun philosophy or recipe for a good life, as seen in various weekly journals and –magazines. It may be like Ørsted Andersen writes, because of its connection to the positive psychology that is has got the reputation that it "*…smells like naïve, American overtly enthusiastic optimism and distant, Hollywood-like happy-go-lucky thinking."* [Ørsted Andersen, 2005, own translation].

Dalmyn that has reviewed *Flow – The Psychology of Optimal Experience* is not in doubt. He writes: "*Like the other humanistic psychologists, he [*Csikszentmihalyi*] is working within a system of thought loosely based on Stoic philosophy and neo-Platonism with some European Romanticism, some Indian and Oriental religion and some neo-hippie consciousness mysticism thrown in.*" [Dalmyn, 2004]

Dalmyn critizises the flow-theory for not contributing with anything other than common knowledge. The flow-theory favors complex activities, and it is Csikszentmihalyis' attempt to teach people from lower social layers to enter the flow-state, rather than sitting passively watching Television [Dalmyn, 2004].

Here Dalmyn shows his lack of understanding for the flow-theory. Flow-activities are evaluated from the criterion of the possibility to invest mental energy in it, *not* from the question of moral value. Television is mentioned by Csikszentmihalyi as an activity that does not trigger or set off flow, because the information the Television delivers is structured in a way, so that it requires a minimum of mental energy to follow the program. The Television is in that respect contributing to

keep troublesome thoughts at a distance, something a non-busy mind would otherwise be concerned about.

The potential banality of the flow-theory by only looking at the flow-diagram is commented by Knoop:

It can be with considerations like these that you are tempted to think that flow is so banal and obvious a phenomenon, that it is not worth a scientifically effort. But when you realize, how much we can learn as a society, since flow is so rare in the lives of many people, you can easily change your mind. [Knoop, 2005, own translation]

Several schools and institutions are still organized as factory-ideals, structured with the intention of mass-production of competence and well-being, which in the end has an inhibitive effect on the development of children [Knoop, 2002].

Csikszentmihalyi himself insists that the flow-theory is not a recipe on how to be happy. He points out that you should be careful with these kinds of recipes. It is not do-it-yourself books with directions for, what to do in order to be rich, powerful, popular, etc.

2.3.2 Behaviorism

The flow-theory is just behaviorism on new bottles….

The flow-theory originates from the humanistic psychology, which is in stark contrast to the behaviorisms way of understanding human motivation, as a predictable response on stimuli.

The humanistic psychology was founded as a counter-reaction to the existing psychological fundamental principles with roots in psychoanalyzes and behavioral psychology. The fairness of psychoanalyzes way of drawing conclusions from the sick individual to the healthy was questioned. The question asked was, if it should not be the other way around. And in relation to

behavioral psychology the humanistic psychology acted critically towards two conditions. The one was the natural scientific ideal, which completely disregarded the conscious processes of the human being. The other was that human behavior was mapped out from a psychology, whose foundation rested on experiments on animals [Halse, 1992].

The behavioral theories on motivation were not something Csikszentmihalyi found particular convincing, when it came to the question about, what the background for people's engagement in activities was. And his research shows the opposite of the assumptions on motivation than the behaviourism placed. People enact in an activity for the activity alone, not because of outer rewards or recognition [Csikszentmihalyi, 1975]. His studies of painters showed that as soon as the painters were done with a painting, they lost interest in it, and placed it in a corner, for never again to look at it. And the painters had no thought on selling or show these paintings to anyone [Csikszentmihalyi, 1975]. Behaviourism would otherwise have explained the painters' desire with the possibility of being able to sell the painting, or get another reward. But Csikszentmihalyi explaines it like this:

In many cases, the importance of this experience [flow] *is blurred by what appear to be the external goals of the activity (…) On a closer look, these goals lose their substance and reveal themselves as mere tokens that justify the activity by giving it direction and determining rules of action. But the doing is the thing.* [Csikszentmihalyi, 1975]

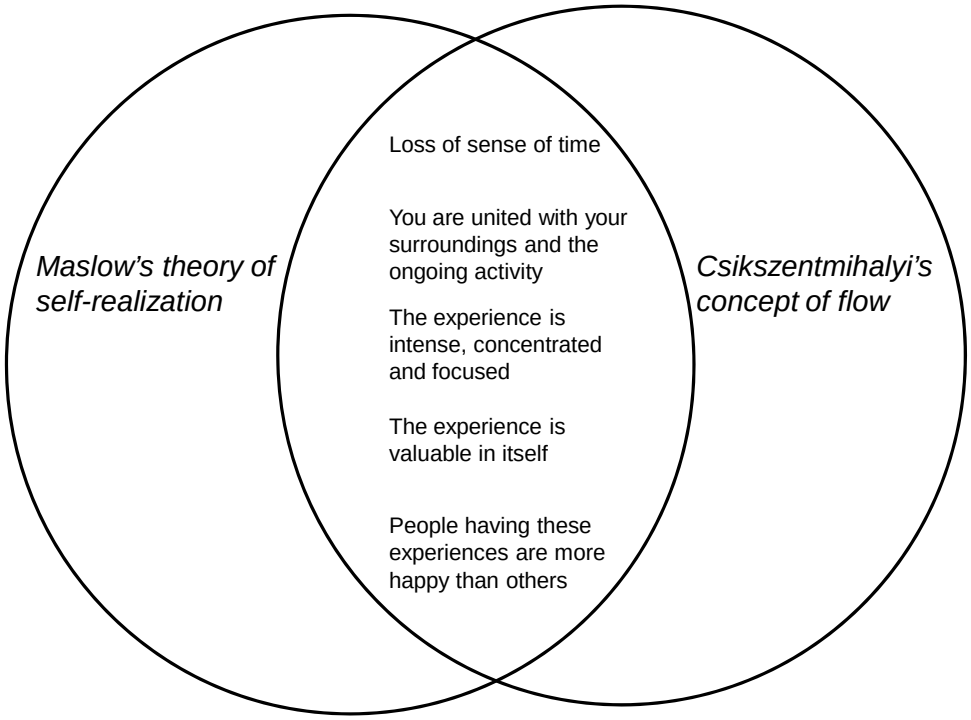
It is here the autotel nature of the flow-concept enters. The human behavior contains a vast amount of activities, where the goal of the activity is the activity itself.

2.3.3 Self-realization

What is the big difference between the concept of flow, and Maslow's theory of self-realization?

The difference is actually larger than you might think. Csikszentmihalyi was certainly inspired by more of Maslow's theories and concepts, and there are several overlaps. Ørsted Andersen outlines some of them:

Overlaps between Maslow's theory of self-realization and Csikszentmihalyi's flow-concept



But despite these coincidences between Maslow's and Csikszentmihalyi's concepts, there is, as Ørsted Andersen also remarks, a clear distinction. Maslow claims that to realize one's self, then some fundamental needs has to be fulfilled. Csikszentmihalyi claims the opposite. He believes that it is possible to neglect even basic needs, when in the state of flow [Ørsted Andersen, 2006].

In 1964 Maslow divided people in *peakers* and *non-peakers*. It was in an attempt to explain, why it was only possible for a small group of people to experience self-realization. It was only possible for *peakers* to experience self-realization [Csikszentmihalyi, 1975].

Csikszentmihalyi himself believed that a certain level of skills, adaptation and experiences of the challenges at the given activity are needed, before flow can be experienced [Csikszentmihalyi, 1975]. He emphasizes furthermore the upbringing - that is the environment you have been raised in. If you are in a level that promotes an autotel personality, it will be significantly easier to experience flow. One of the ways to describe this is through the narrative.

Jerome Bruner has dealt a lot with the narrative. According to him the objective for any pedagogical system is the support of the work with building up an identity. Bruner believes that you can only create an identity on the narrative plane. And that is why the schools job is to nurture and cultivate the narrative. Bruner's point is that it is only through stories that you construct your identity, and that it is through stories that a culture can deliver models for identity and action. The story becomes a fundamental concept, where cultures and individuals are created.

We are as humans endowed with a sense of narrative understanding. We know the chronology of a story with a beginning, middle and end, consisting of conflicts and relations between the involved, and we have an expectation that the story is build up in this fashion. Humans' desires and hopes originate from these stories, and this can be arranged through the symbols of the culture, whether it be language, art, drama, music, and also in the creating craft.

Bruner believes that it is important to see yourself in *alternative stories*, that we become capable of using our imagination and ability for conception to see ourselves in many possible stories. He believes that if you in an early age get the image of yourself set, and thereby your own story ("you should be a gardener, because your father is one"), then you run the risk of very quickly losing possible paths of development. In other words an early set story will make the individual less flexible compared to different paths in life, and thereby also lock the image of work related possibilities. The more locked your story is, the less willing the person is to change [Bruner, 1998].

A standard observation that covers all people cannot be made. And persons that have not developed the ability to get into the flow-state, will not benefit as much from an activity that has been planned after the principles of flow. The flow-theory opens up the door for experiencing flow in many contexts, and on many different levels. Work-related activities as well as daily activities [Csikszentmihalyi, 2005b].

2.3.4 Flow – a relative concept

Is the flow-state experienced in the same manner by all people?

Flow is a subjective phenomenon. What is experienced as flow by one person will probably not be experienced as flow by another one. That makes it difficult to operationalize in practice. Ørsted Andersen does not feel that the concept of flow covers everything, even though flow can be experienced very differently:

Flow is on the theoretical level a complex and not fully developed theory, but that does not make flow a rubber band concept, which can be extended to include one thing and another, or can be applied to anything that seems to resemblance it. [Ørsted Andersen, 2006, own translation]

Sutton-Smith criticizes so the flow-theory:

To say flow is universal is like saying that all peak sex is everywhere the same, and that "flow" is to play what orgasms is to sex. But who would be innocent enough of all the different contexts and acts that make sex meaningful to say something like that? [Sutton-Smith, 1997]

Here it is evident that Sutton-Smith has not understood the theory of flow. Sex cannot be used as an analogy to the experience of flow. Sutton-Smith presents *peak-sex* and flow as if both of them contain the same characteristics. Flow *is* an optimal experience, but not a highlight as Sutton-Smith's analogy to sex implies. Csikszentmihalyi himself rejects the analogy between sex and flow in this way:

To feel happy about sex the only thing required is to be healthy and willing. It takes no special skills, and in a short while, after having done the first experiences, there will only be a few physical challenges. But as it is with many other physical joys, then sex will also get boring in time, unless it is changed into an enjoyable activity. [Csikszentmihalyi, 2005a, own translation]

Sex is described as a pleasure of momentary character. Something you can experience *without* investing mental energy into it [Csikszentmihalyi, 2005a]. The difference is on the dynamical aspect. The state will not be enjoyable, until the characteristics of the flow-experience are added.

Flow-activities involve a feeling of discovering something new, or encourage to a higher level of performance. Ørsted Andersen describes flow as an effectual state of learning, and understood as attention, flow is the key to learning [Ørsted Andersen, 2006].

2.4 Creativity

The creative adult is the child who has survived - Ursula Le Guin

The psychologist Joy Paul Guilford more or less founded our times understanding of the concept of creativity. At the same time where Mihaly Csikszentmihalyi and Carl Rogers had their respective careers at University of Chicago, Guilford was full ahead researching in intelligence at the University of Southern California. His conclusion was that the total cognitive capacity of a person cannot be captured with the available intelligence-tests or intelligence-concepts. Therefore he himself invented a model of the human intellect that later founded the basis for the modern research in creativity.

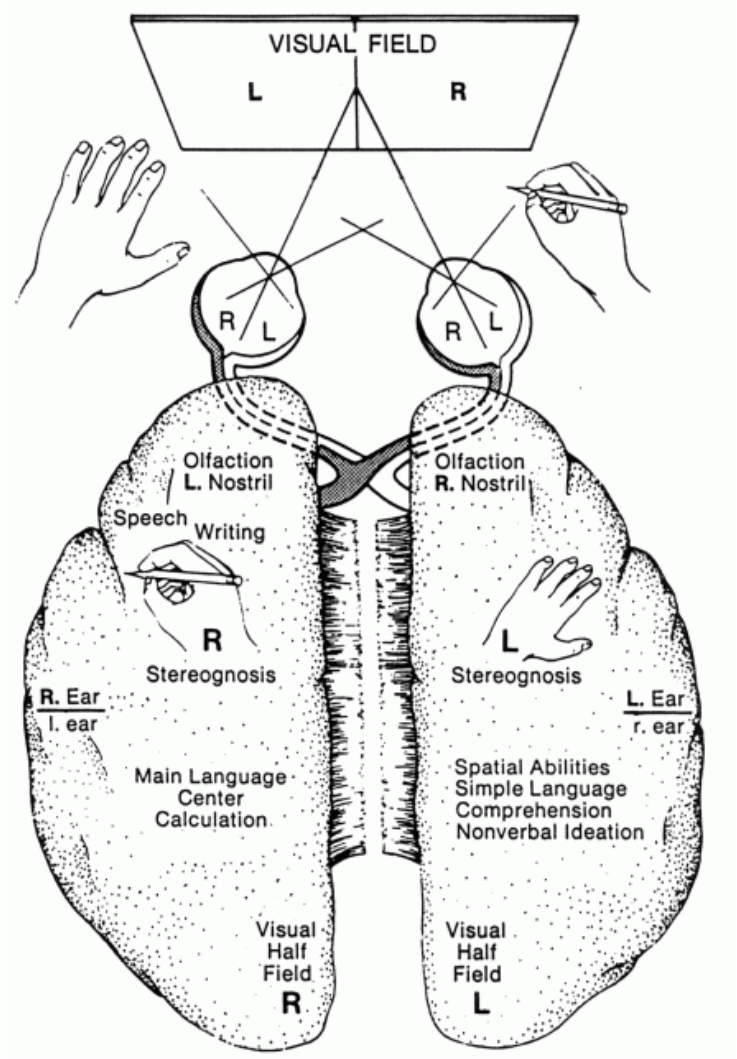
An important parameter in the *Guilford-model* is the distinction between convergent and divergent thinking [Guilford, 1967]. Convergent thinking is used to find conventional and expected solutions on problems or assignments. It is this form of thinking that the most intelligence-tests checks for, or analysis of the human cognitive capacity, whereas the opposite way of thinking, the divergent thinking, is not being checked. And it is precisely this way of thinking that is crucial when it comes to creativity. It is this form of thinking that makes it possible to find new view points on a given problem. It liberates you from set and monotonous solution strategies. You become capable of thinking in several different directions, use your imagination and find alternative options, new visions and invent divergent solutions.

Guilford tried to find a measurable creativity constant, so it would be possible, to develop a standardized creativity-test. He did not succeed, and nobody has been able to develop this so far.

This difference between convergent and divergent thinking became the starting point for a lot of inventions in the world of psychology. A good example of this is Roger W. Sperry that in the 1960's investigated whether the two cognitive processes were to be found in two separated parts of the brain. After this Sperry found out that the brain is divided in two separate parts, a right and left hemisphere. The two parts works in each their own way, and each part has their information. A discovery that revolutionized the world of psychology and neurology.

2.4.1 The hemisphere specialization of the brain

The brain is as mentioned divided in two parts. A left and a right hemisphere.



[Gade, 1998]

There is some division of mental processing between the two halves. Certain functions are lateralized. The left hemisphere deals mostly with communication. It deals with the auditive and written language. This part could be called the sequential brain half. The right hemisphere deals with melodies, faces, images, etc. And this part could be called the simultaneous or analog brain half. And it is in particular this part that is interesting, seen through the glasses of creativity. It has

been investigated and tested that a lot of people who has had accidents, where the right hemisphere has been injured, lose the creative talent related to e.g. playing backgammon or other games, compose paintings, taking photography's, etc.

Edwards characterized the two parts like this:

Characteristics for the left and right hemisphere

Left	**Right**
• Verbal	• Non-verbal
• Analytic	• Synthetic
• Symbolic	• Concrete
• Abstract	• Analogical
• Temporal	• Non-temporal
• Rational	• Non-rational
• Digital	• Spatial
• Logical	• Intuitive

[Edwards , 1979]

Since this discovery of the division of brain hemispheres the research in this topic has increased, and it continues to this day [Scientific American, 2005]. There is therefore valid ground for this division to be true. The right hemisphere deals with the divergent thinking, while the left hemisphere deals with the convergent thinking.

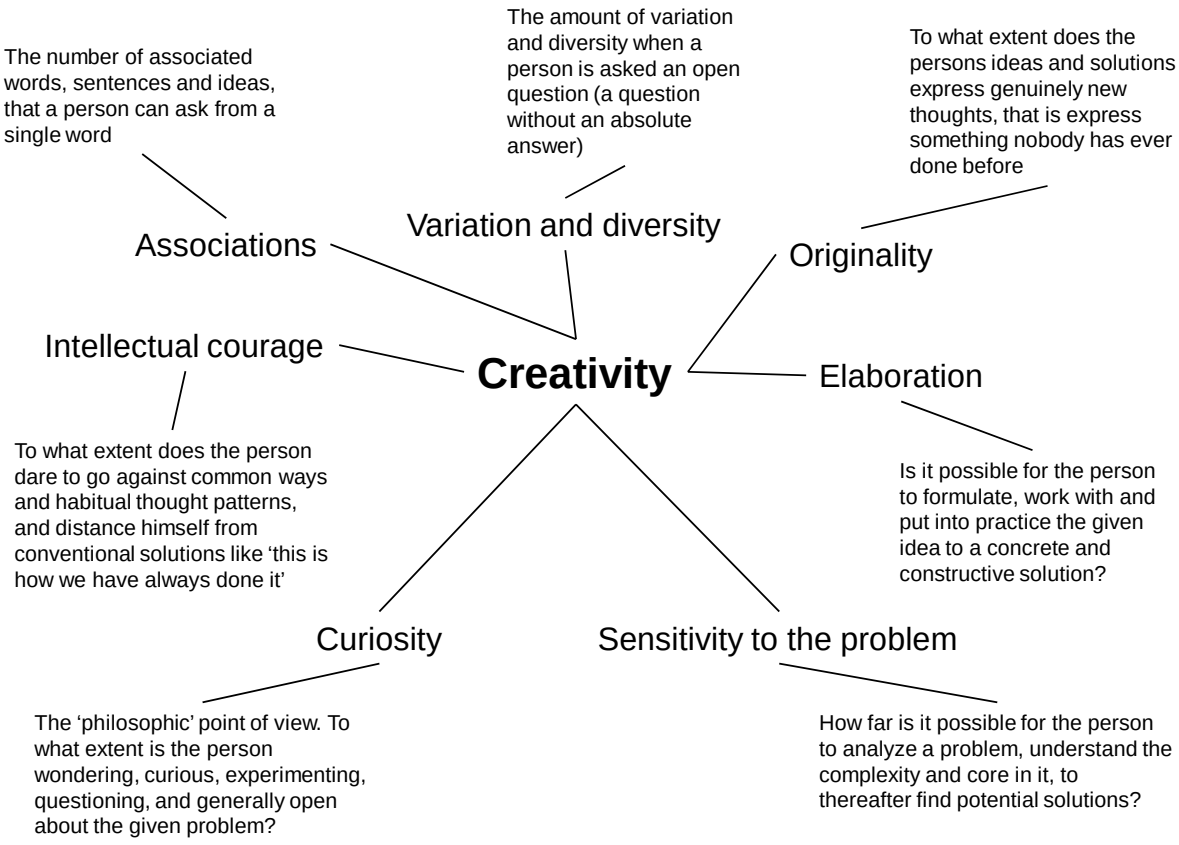
Susanne Freltofte calls the right hemisphere of the brain for the *balloon brain*, because of its capacity for accumulating different elements in collected bigger units [Freltofte, 1997]. On the other hand she calls the left hemisphere of the brain for the *binocular brain*, because of its ability for dealing with details, and manage them logical and analytically. An example of this can be, when you read a book. The left hemisphere of the brain handles the decoding of the collection of letters to words, and the words onto sentences, and fitting them into the grammatical context,

they are placed in. The right hemisphere of the brain accordingly handles the general insight in the story, what it is about, what the point or purpose of the story is, images, humor and sarcasm, etc.

Despite this knowledge about the division of the brains hemispheres, and thereby placed convergent and divergent thought process, creativity is still a more complex subject.

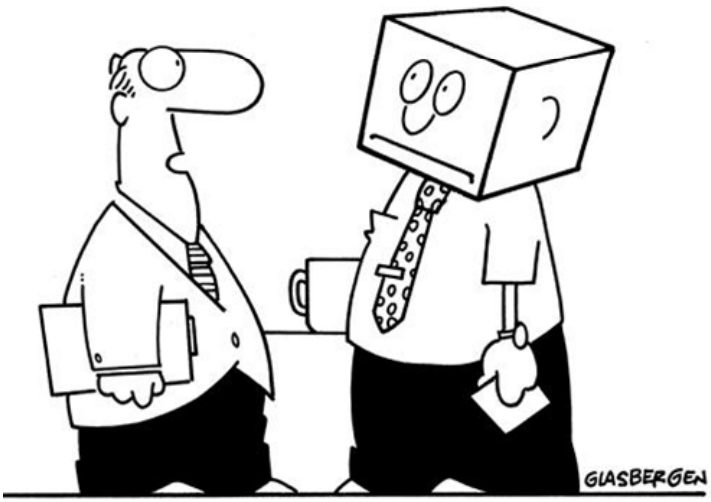
The creative abilities cannot just be released by focusing a hundred percent on the right hemisphere of the brain. Because despite the two-part division of the brain, the two parts work together! And exactly this cooperation, this integration between these two parts, creates the foundation for creativity.

A final way of testing creativity has not been invented. But there are certain parameters, which can examine if you at certain moments and situations have been creative in actions or thought patterns [Hermann, 1996]:



[Kraft, 2005]

As previously mentioned creativity is obviously something we are all born with. But unfortunately this is suppressed by the many layers that we pass through in the educational system, and the life as a whole [Victor Vidal, 2004].



"Thinking outside of the box is difficult for some people. Keep trying."

Glasbergen, 2005

The prerequisites to promote creativity, mentally as well physical, are present in the childhood in the shape of games, toys, and teaching materials. But after the age of 10-12 the repression of this begins. After this point in time the desire to develop concrete and measurable competences, as it is found in e.g. courses in linguistic and natural sciences, dominates [Kraft, 2005]. But creativity is not reserved for practical-musical courses, even though these courses are dominated by creativity. Every course needs creative elements and students. This can perhaps explain the huge decline in courses that teach natural sciences. There simply are not enough wild and experimenting things in these courses. But if you are to teach creatively in these types of courses, and give insight into diverging elements, then you have to be very competent in the convergent part. One part presupposes the other. Without the structured and analytical left hemisphere, the creative ideas created from the right hemisphere are worthless. The greatest creative brains to ever exist were all masters in their respective field, from Leonardo Da Vinci to Niels Bohr. "Creativity involves all of the brain" [Kraft, 2005, own translation].

2.4.2 Csikszentmihalyi's take on creativity

Csikszentmihalyi considers creativity as a basic trait of the human. A trait that separates us from other animals [Csikszentmihalyi, 1996]. His research shows a general tendency with creative individuals, like the fact that they are good at using resources at hand to solve the given problems they face. This group of creative individuals is of a complex character that contains certain opposite traits. He does not call them individualist, but multituists [Csikszentmihalyi, 1996]. These opposite traits can be:

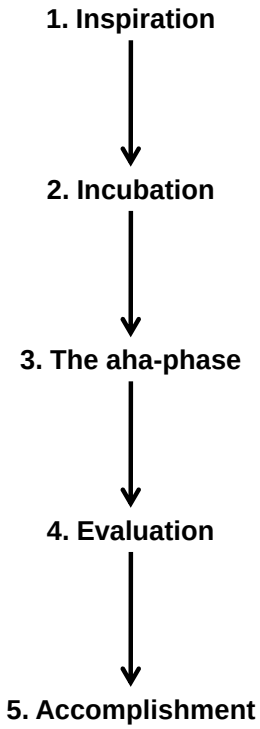
1. To be able to guide energy. Be tireless and very energetic, but periodically sleep and rest a lot
2. Have intelligent as well as naïve traits in their personality
3. Be both divergent and convergent. Playful as well as disciplined
4. Be visionary and full of fantasy at the same time as being realistic with both feet on the ground
5. Extro- and introvert
6. Proud and humble
7. Regardless of gender be in contact with both the feminine and the masculine part of the psyche
8. Be revolutionary and conservative
9. Objective and passionate
10. Be open and sensitive, an element that can bring big ups and downs

This shows that Csikszentmihalyi is on the same page with the mentioned tendencies in the research about creativity. Creativity involves and presupposes the opposite directed processes. At the same time creative individuals have a good memory and acquire a lot of basic(s) and trivia knowledge. And it is precisely this trivia knowledge that is a factor, for avoiding entropy (bad psyche). Where some have the need for passive sources, like TV and alcohol, to prevent the mind from slipping into entropy, there is a more autonomous tendency with people that fills their memory with skills and knowledge. They are better at creating an inner stimulant [Csikszentmihalyi, 1996].

2.4.3 The five steps of creativity

Graham Wallas was one of the first to propose a model of the creative process. He did so in *Art of Thought* from 1926.

A more refined version is the five steps of the creative work- or learning process according to Csikszentmihalyi's research:



1. *Inspiration*: The first preparation, where the interest is awoken
2. *Incubation*: The ideas slumber and are unconsciously nurtured
3. *The aha-phase*: An insightful and innovative phase
4. *Evaluation*: The 'realism'-part, where the ideas are compared to the reality
5. *Accomplishment*: The idea is worked on and carried out

This five-step model corresponds with other research on creativity.

Flow can appear in all phases. And paradoxically there does not have to be a correlation between what you do, and the ideas and thoughts you come up with. You can e.g. be in the middle of installing a fountain in the garden in one's free time, when suddenly you come up with an idea that can solve a problem at your work.

The interesting thing is that this is often the case. The creative ideas and a deep insight often emerge, while doing something completely irrelevant relative to the given idea. It is under the phase *Incubation* that the sub consciousness works in the background on a given problem or area. When an inspiration to an idea or a new product has first entered the consciousness, it does not get out again easily. Ward among others has accumulated empirical evidence that suggests that *incubation* aids creative problem-solving by getting rid of misleading cues [Ward, 2003]. If this part is skipped in the creative work-process, there is a risk of tunnel vision and fixation on inappropriate strategies of solving the problem [Smith & Blakenship, 1991]. The brain loves to work creatively. When it gets interesting input from the outside, it immediately goes into action by working on it from all sides. So if there comes any interesting input (Inspirations phase) in the shape of challenges, assignments, and problems, this input will then form the basis for the following incubation. In this phase (Incubations phase) that can easily take a couple of weeks, this new input will unconsciously affect the existing neural connections. Especially if the person performs a flow activity that gives conditions for a creative readiness. Then there will be opened up for change of existing neural connections and/or the creation of new ones. After this the connection to the consciousness is experienced as the 'aha-phase', where you suddenly get an unusual association, a good idea or new deep insight.

2.4.4 Low latent perception inhibition

In 2003 Shelly H. Carson from Harvard University arrived at some interesting results regarding the significance of something, she calls *low latent perception inhibition* [Kraft, 2005]. She analyzed creative students at the university, e.g. students that had written or published books or musical plays, and found out that these students had a so-called *low latent perception inhibition*. In brief this means that all people, to be able to concentrate and create a connection and meaning of all the data, that the sensory and cognitive systems receive all the time, has to have an automatic filter that strain off all irrelevant information. For instance it is not possible to read this report, if you at the same time should pay attention to everything that goes on around you, like sound-, light-, and moist conditions, fluctuations in temperature, etc. Resources and capacity are thereby released for the essential assignments, when this unimportant information is lead out of the cognitive system [Fredens, 2004].

But a too effective filter can have the opposite effect. Since creativity among other things is dependent on the ability to combine seemingly unimportant or incoherent data in new ways, for thereby creating unusual and maybe unique ideas, solutions and products, a too effective filter will filter away potential useful information.

2.4.5 Areas of creativity

Creativity is often considered as esthetic and practical-musical activities that lead to some sort of specific product. But as described here, creativity can also just be creative thought processes that among other things contain divergent thinking.

Csikszentmihalyi calls this *small creativity*, whereas *big creativity* is a creative action or thought, which has set lasting impression in the posterity. This could be a new form of philosophy or a cure for cancer. Likewise creativity can be referred to as a breeding project. This means that the objective for pedagogical effort, upbringing and education could be a form of *creative human* that contains personal qualities like openness, divergent thinking, independence, the ability to absorb, innovation, responsibility, etc.

Lined up creativity can be placed into three areas:

a. *Creativity as an advanced thought mechanism, containing e.g. divergent thinking*: an imaginative and experimenting solution, which incorporates open thinking and/or new ways of thinking. Creativity that is about finding solutions that goes beyond the given information [Bruner, 1989]

b. *Creativity as domain change*: domain is here to be understood as a specific field with own rules, procedures, concepts, theory and culture. An action, idea or a product that alters an existing domain, or forms a completely new domain on account of an existing, *that* is creativity [Csikszentmihalyi, 1996]

c. *Creativity as a breeding project*: Kupferberg at DPU (Danish School of Education) believes that creativity is the crucial breeding objective. It is characterized by the fact that the students learn to:

    - Think about and take independent initiatives
    - Engage deeply
    - Feel a personal responsibility

- Combine things in a new and different way

[Kupferberg, 2003]

2.4.6 Convergent and divergent creativity

Even though the modern concept of creativity is closely bound to Guilford's divergent thinking and Sperry's brain laterality, then newer research by e.g. Mihaly Csikszentmihalyi and Shelly H. Carson has shown that creativity is a very complex size, which is also based on convergent thinking. Convergent thinking is an integrated part of the creativity on the same scale as divergent thinking, and thereby equally important [Csikszentmihalyi, 1997].

A relative new research project, Powerful Learning Environments, between European and Canadian researchers, apparently points in the same direction. The development of creativity presupposes traditional professional competences [Bereiter and Scardamalia, 2003]. So these two professional directions – the traditional professional skills on one side, and a more all-round personal development as e.g. cooperation-skills and creativity on the other – is probably connected phenomena, and not the opposites, as they are usually thought to be.

The PISA-investigations (Program for International Student Assessment) created havoc a couple of years ago. And it was alleged that since Denmark is good in the areas of creativity, motivation, and cooperation, then it is okay to be less good in the professional areas. Whereas the Finns (that won the test, by the way) declared that since they were good in the traditional domains, then it was less important that they had a low score on areas such as well-being, motivation, and cooperation. But as mentioned above, there is no contrast between the two fields. The one does not have to be cultivated *at the expense* of the other, but instead as a *supplement*.

In Denmark we could possibly be better at the pure professional 'hard' competences *without* diminishing more socially oriented 'soft' competences. We might even improve both of them, since they are mutually combined. And the reverse could in effect be true for the Finns.

And if this is the case, that the two areas – creativity and professionalism – are connected, then maybe not only the talk about the PISA-test is mistaken, but also the debate about the whole composition of the educational system, where you on the one side have the traditional subject-centered upbringing (like one-sided focus on reading and calculating skills), and on the other side one-sided focus on the more soft competences, like cooperation, independence, and cross-functional work.

In that light a workplace could, to promote flow, be an area with:

- Supporting managers, instead of over-controlling or non-caring laissez-faire-types. In other words it is the manager's job to integrate a leader authority and guidance, while giving independence and influence to the employees
- More of the general flow-promoting factors
- A high professional level combined with a high degree of professional awareness
- The possibility for the employees to take independent initiatives
- Employees motivation goes from an external to an internal source of motivation

2.7 Conclusion

The chapters on flow and creativity are separated, but the two concepts should not be seen as opposites. They are not divided. They are interconnected. As Csikszentmihalyi is quoted for saying at a lecture at Claremont Graduate University:

You can be in flow without being creative, but you cannot be creative without being in flow.

Creativity presupposes flow. Creativity feeds of flow. So put in mathematical terms, creativity is a subset of flow. It is that simple. And that is why the concept of flow and understanding of how to reach this state and apply it to a practical setting is so important. And this is the main reason for examining the two international engineering competitions in Helsinki and Tallinn.

B. Convergent part

3. Engineering competitions

After the description of the work and writings on flow and creativity, this will be applied to two practical cases, which are two international engineering competitions.

All of what has been mentioned until now is fantastic, but until it has been applied to a practical setting, nobody will benefit from it. So now a more thorough investigation into and description of the outcomes of the international engineering competitions will begin.

But before this I want to describe the organization that has facilitated these events, and my personal involvement in this organization.

3.1 BEST

I love to break habits, meeting new people and building up relations. Therefore it was natural to join a student organization. And the choice fell on BEST. BEST is an abbreviation for *Board of European Students of Technology*, an organization founded in the year 1989, the year the Berlin wall was broken down. Decades of cold war had finally ended, and it was a new era and a time for a fresh start for Europe.

BEST is a non-political organization. Its purpose is to promote integration, understanding, unity, and education in Europe. This is also seen in the two main slogans for BEST, which are *Promote Europe among Europeans* and *Empowered Diversity*. And this is among other things done by utilization of thematic networks.

The fantastic thing about the environment in this student organization is that it gives you the opportunity to try out some of the things you learn, and learn some of the things you do not learn at the university. It could be described as complementary education. For instance the interpersonal competences you automatically learn, try out, and confirm or disprove, while

working with other people. It is simply a free playground. Here you can try out ideas or concepts without fearing the consequences, so you are better suited later on to avoid making the same mistakes in the 'real world'.

On top of that it takes place in an international environment, since BEST includes almost all of the European countries. Thereby it is possible to build up international relations plus the things you experience makes you better suited for dealing with differences in culture and/or mentality, so potential challenges or problems do not create conflicts.

I have now studied management at the Technical University of Denmark (DTU) for many years. As a member of BEST, and later on PR-coordinator for the Copenhagen Branch, I love to work with people. It is wonderful to try out in practice what you have learned in theory. Here you see what works and what does not work, and in which situations this is the case.

Even though you as a coordinator have things that must be made within certain deadlines, you need to exhibit a sense of situational leadership, since all work within the framework of BEST is based on voluntary manpower.

I had several options to write about. Since the concept of flow has fascinated me for some years now, I began considering the possibility of writing a theoretical thesis. And the amount of literature on the subject is vast. The point was to delve into the concept of flow, and investigate the origin of the eight elements of flow. Where they came from? Why these eight points and not others? Etc.

The problem however with writing a theoretical thesis is the lack of excitement in something only theoretical. Here I would be on safe grounds, but to stay in the state of flow I have dared to challenge myself. And when I had the opportunity to participate in engineering competitions, by being a member of the student organization BEST, I choose to use those events as practical cases for the thesis. And as the functioning PR-coordinator for the Copenhagen branch of BEST, it was natural to use these international engineering competitions that BEST offers as a foundation for my evaluation of flow.

3.2 Engineering competitions

An engineering competition seemed to be the perfect setting to test the flow-theory. Engineering students from different countries and cultures work on an assignment in cross-functional teams, and the competition with other teams of engineering students within certain rules and boundaries gives it an extra touch. All challenges that an engineer of the future may face. So this would be interesting also from an educational point of view. Would this kind of competition be so fun, involving, and educational, that it could spark new energy and lust for innovation and learning into the students?

Two engineering competitions were investigated and analyzed. *Lifting for higher potential* in Helsinki, Finland, and *BEClever* in Tallinn, Estonia.

The following will describe how the engineering competition was structured, and how it was played out.

3.3 Lifting to higher potential – engineering competition in Helsinki, Finland

This international engineering competition took place in Helsinki, Finland. The company KONE (the 4th biggest elevator company in the world) had in collaboration with a local student organization organized an international engineering competition, where the main objective was to create a new elevator less energy-consuming and dependent on conventional energy sources, and more environmental friendly.

3.3.1 The groups and supervisors

The groups were divided in teams of five members. And the groups were divided in different rooms. Some rooms were however one big room with a movable wall in the middle. Here the supervisors and a cameraman that covered the first part of the competition could, more or less uninterrupted and conveniently, witness us and bring us news about changes (newly made obstacles, which the participants were not told about before the competition) in the schedule.

The supervisors consisted of three older students. Every group got one box with different remedies and only these remedies were allowed to be used for the given assignment.

3.3.2 Assignments

The engineering competition was in three parts, an introductory, an intermediate and an advanced part. The jury that selected the best project in the first part of the competition consisted of the three older students plus a responsible professor for the given workshop, we were permitted to use in connection with the assignments. The jury in the last two parts consisted of representatives from KONE.

The first part was just to shoot of as many ideas as possible and then make a small-scale model of the solution for thereafter be able to present and demonstrate the idea to the rest of the students and organizers.

The second part was to take one of the demonstrated ideas, develop it further, and then come up with a solution that gave an elevator, which used less energy, and in general was more environmental friendly, and had a minimum impact on the nature. This model would then also be made in small-scale for a demonstration for the other students and representatives from KONE.

The third part was somewhat different from the first two. The first part was meant to be a kick off for ideas and teamwork. The second part was meant to involve more in-depth working, where a concept was being worked upon, and a more thorough solution was made. But the third part was more professional. Here it was not enough to make a good solution. It also had to be cost-efficient. The exact problem formulation was:

Design a concept elevator, eventually integrated with the building, which has minimum energy consumption and minimum impact on lifecycle costs.

In other words make an elevator, which not only saved more energy than usual, but also cut down on the regular cost of maintenance. An elevator ready for the new millennium. Here it was not necessary to make a scaled version of the elevator. This was pure concept and design, but still involved the 'stress-factor' that there were only six hours to finish it.

3.3.3 Documentation and evaluation

The final documentation included:

1. Executive summary of the technical concept
2. Technical proposal structured in the following way:
    a. Presentation of the concept
    b. Functional and technical feasibility
    c. Economical feasibility
3. Power point presentation to present and defend the project to the jury

The first part had the constraint that the solution should be ready for demonstration purposes within six hours. The second part was to be ready for demonstration within twelve hours divided on two days. The third part was time-bound to a total of six hours.

In all the different scenarios the teams were made up of five students, all from different areas of expertise. The teams in the first two parts were the same, but they were changed for the third part. The winning team of the competition would be the one that did best on the following criteria:

- Energy savings during operation
- Energy savings during lifecycle
- Innovation and creativity
- Technical definition

Each criterion was given equal weight, but especially the first two were important, and a certain level of creativity and innovation was necessary to find a better solution than the existing one.

This international engineering competition was not only meant to be a fun event, but also to create a learning situation structured as a game, which the students' problem oriented group work brings forward, in addition to being a recruitment ground for KONE in search of new potential employees.

The schedule for the engineering competition can be found in the appendix.

3.4 BEClever – engineering competition in Tallinn, Estonia

The assignment in Tallinn was triple parted.

3.4.1 Team design by PKC Group

The first assignment was designed by PKC Group, an Estonian harness company. From now on this assignment will be named the 'harness-assignment'. The students were divided in groups of four members, the members being students from all parts of Europe, with different fields of study. The assignment was to make a harness and the sketch for it. There were two days in total to complete the assignment.

A harness is a collection of wires that goes from one connection to another. And every start-connection goes to a different end-connection. Therefore the challenge was to make it as logistically efficient and simple as possible to avoid unnecessary waste and complexity, and at the same time make it as easy as possible for the non-technical staff to make these harnesses from the made sketch. Finally the harness must of course work, which was tested by a machine that tested all the connections to make sure they worked. A small program was made for the test phase.

As the last part the harness and the sketch must be presented for the jury (three PKC Group representatives) and the other international students. The winner was the group that achieved the most points. The points are given from the criteria:

- Assembly drawing
- Completed wiring harness
- Assembly table
- Testing table
- Presentation
- and Teamwork

The first categories could potentially give the most points.

3.4.2 Case study by JOT-Automation

The second assignment was made in collaboration with JOT-Automation, an Estonian automation company. From now on this assignment will be named the 'gripping-assignment'.

The job was to make a gripping mechanism that could grab a cellular phone on a conveyor belt, without damaging the phone or its functions, and then put it on another belt for testing purposes. When the phone had been tested the gripping device must again grab the phone (without damaging the phone or its functions), and transport the tested phone to a belt either for passed or non-passed phones, depending on how the testing went.

It was not possible to change the system itself, whereby the phones were transported on the conveyor belt, or anything of that nature. It was only possible to change the gripping mechanism. And there were certain demands that the system should abide. First of the cellular phones were randomly oriented on the conveyor belt, so the gripping device was to abide these restrictions:

- Minimum dimensions: Length 80 * Width 35 * Thickness 6 (mm)
- Maximum dimensions: Length 150 * Width 60 * Thickness 20 (mm)
- Minimum weight: 53 grams
- Maximum weight: 300 grams

Furthermore there were conditions on which concepts that could be used. The gripping mechanism was restricted in these areas:

- No use of vacuum equipment (injector, vacuum pads…)
- CE-compliant safety (CE = Consumer Electronics)
- ESD-safe design (ESD = Electrostatic sensitive device)

There were twelve hours divided on two days to finish this project. And beyond a final presentation of the project, a minor report was to be written. This report should contain:

- Glossary of terms
- Short description
- Work description
- Functional description
- Which materials, components to use

The teams were still in the size of four members per group. But this time the group consisted of two international students, and two local Estonian students. This meant that there was a local touch in this assignment, which was quite interesting.

3.4.3 Team design - Movable bridge

The third assignment was to build a bridge out of pins. This actually showed to be a big challenge, since it should not only be stable enough to hold its own weight, but also be able to hold a remote control car. On top of that the bridge should be movable, meaning it should be able to open up in the middle so that a boat could pass through. This should be controlled by a small engine. There was in total seven hours to complete this assignment. Again the teams comprised two international students and two Estonian students.

The schedule for the engineering competition can be found in the appendix.

4. Methodical considerations

The purpose of this project is to reach an understanding of the engagement that a setting such as an engineering competition generates.

The following describes *how* the experience of flow and engagement are documented and analyzed.

4.1 Qualitative method

The qualitative method describes primarily the phenomenon itself, and its attributes, as thorough as possible, opposed to the quantitative method that often describes the spread of phenomena.

The qualitative approach is used in this project, since the focus of the project is the students' subjective feelings and experience of engagement and flow, seen and understood from the interviewed person's own perspective [Kvale, 1997].

The qualitative method is suitable to treat the appearance of phenomena in a given context that is difficult to measure, in this context the appearance of flow in the students' work-processes at an engineering competition.

4.2 Choice of data production method

To be able to ascertain how the engineering competition contributes to the students' experience of flow, it would be natural to use *the Experience Sampling Method (the ESM method)*, that Csikszentmihalyi uses in his research of flow. The ESM method is about contacting research subjects with the aid of an electronic calendar, make them register, where they are and what they are doing, plus evaluate their present level of flow. The ESM method however requires that the research subjects have to stop the flow-activity and document their experience of this, while it is still fresh in the memory. Another thing is that the ESM-technology is not at my disposal. Therefore the choice fell on observations from this competition, while it was on, plus following small interviews with the students that appeared engaged and committed to the work. The data production therefore consists of field studies.

The unrolling of the engineering competition in Helsinki was in groups of five. Each group was given an assignment dealing with the construction of a new form of elevator, less energy-consuming and more environmental friendly than the ones today.

In the engineering competition in Estonia, the groups consisted of four members at the various assignments that took place there.

4.3 Observation form

What must be observed to determine whether the students' experiences flow in connection with the engineering competition, needs to be defined. Ørsted Andersen has in *Flow og Pædagogik* made a form that can be used to determine and characterize the students experience of flow [Ørsted Andersen, 2002]. The form is founded on Csikszentmihalyi's characteristics of the experience of flow, and the formulation of it is in the following ten questions (own translation):

1. Can the student for a longer time period, e.g. minimum for half an hour, concentrate and keep all attention focused on a certain activity?
2. When the student is concentrated on a certain activity, does the student then feel that:
    a. All other thoughts are omitted?
    b. The sense of time disappears – the student nearly forgets time and place?
    c. It would take a lot to get the student removed from the activity again?
3. Does the student feel that the concentrated activity is pleasant?
4. Is the student intrinsic motivated to begin such a deeply concentrated activity?
5. Has the student got a high degree of tolerance towards outside interruptions and 'noise' compared to concentration on the current activity?
6. Does it help the students' ability to concentrate that there is feedback during the activity?
7. Does it help the students' ability to concentrate that there are clear 'game rules' - that is goals and boundaries for the activity?
8. Does it help the students' ability to concentrate that there has been an attempt to adapt the activity so competences and challenges match each other?
9. Does it help the students' ability to concentrate that there is high degree of empowerment - or a sense of feeling that this is the case?
10. Does the student express engagement with the activities that cause deep concentration and flow-like states?

Ørsted Andersen has discussed this form with Csikszentmihalyi who has approved the use of it.

But these questions are only meant as guidelines, more than asking each specific question to each person during the competition. Flow is a very complex feeling, and taking a time-out once in a while to ask these questions in a formal setting would disrupt the possibility of flow. And if it felt like another more informal way of asking a question similar to one of the above would be more constructive, then this was done instead.

5. Analysis

After the presentation of the flow-theory, an overview of creativity, the engineering competitions, and the methodical considerations, it is time to analyze the collected data. The main objective is to understand the engagement a competition like the engineering competition in Helsinki generates. The method will be to observe the people during the competition, and interview these people.

First the engineering competition in Helsinki will be described, and then the engineering competition in Tallinn will be described.

To illustrate how flow presents itself during the competitions, the observations and interviews that mostly show situations with the students' engagement in chapters that relates to the flow-theory's eight elements have been selected, divided, and analyzed. The eight elements of flow have been chosen as parameters, since they have been shown to be good parameters of the subjective feeling of flow.

5.1 *Lifting to higher potential* – engineering competition in Helsinki, Finland

5.1.1 A challenging activity implying skills

The engineering competition was developed for students at technical universities regardless of any specificity in region, country or culture. Actually the point of the competition (both of them) was to bring technological students from all over Europe together, and learn not only from the competition, but also from each other.

The question was if the given assignment showed to be too easy or too hard for the students, or it was balanced. If either of the first two situations was the case, the students' would lose interest for the competition.

The competition showed to be balanced in this area, since the students expressed that they felt their abilities were challenged in a high degree, mostly their interpersonal skills.

5.1.2 Merging of action and awareness

During the competition a student gave a description of a feeling of excitement, while being close to the final phase of the competition. This illustrates the paradox in the fact that you strive for reaching a goal, and yet wish you could continue forever. As Csikszentmihalyi writes, the purpose of flow is to continually stay in the state of flow [Csikszentmihalyi, 2005a].

The attention was especially on the presence of words and formulations that were related to the concept of flow, and it is worth noticing how the students describe the feeling of being engaged. They describe the feeling in expressions of the type *getting high* or *a real and profound joy*, more or less like described by Csikszentmihalyi [Csikszentmihalyi, 2005a].

An example is where one of the supervisors approached our group in the middle of the assignment of making the miniature model of the modern elevator, and took one of our team members with her. He was replaced by one of the members from another team. It was a part of

the challenge in the engineering competition. The different teams should be able to deal with the assignment, whatever challenges that occurred. It was one of the most active members of our team that was removed, so it was a bit of a challenge. And there was a bit of uneasiness afterwards. The challenge quickly showed however to be an unexpected advantage, because the new team member brought new knowledge and inspiration with him from his former team. So very quickly the concept was further developed. There became room for the new ideas. There was an atmosphere of profound joy. And the finished model reflected this.

This shows that the students' focus during this competition was narrowed down to the activity of the assignment, and used whatever resources and knowledge at hand to solve the assignment in the best way possible. And this shows the creative barometer too. To be able to make the best of what resources or equipment they had at a given time [Csikszentmihalyi, 1996].

Taking this into consideration, even though a person is involved in something and is able to focus on something during a longer time period, this does not necessarily mean that the person is in the state of flow. To determine if this is the case, more of the flow-theory's elements must be present.

5.1.3 Clear goals

There is no doubt with regards to this point. The goals were clear: Find ways in which to improve the current elevator. And the evaluation criterion was quite clear and understandable.

5.1.4 Immediate feedback

According to the flow-theory the way of the feedback is not that important. The important thing is that the students get the needed information on, whether they are on the right track or not. As shown above, the students all seemed to be aware of the overall goal of the competition that was to construct an elevator of the new millennium. The goals were clear and the way of evaluation likewise.

There was however a difference in way the feedback was given. In the first two parts the students got the feedback on what they did on the final presentation and afterwards. Here the representatives from KONE and other students could comment on the work. In the last assignment there was a delegate from KONE to answer questions during the competition.

The reason for not giving feedback on the work while in progress during the two first assignments was not to influence the potential idea generation for the solution. Of course the supervisors and/or representatives knew what was possible or not, either in production or cost-efficiency. But the main point of the competition was to find new and better ways of doing the same thing, namely transporting people from one place in a building to another. And even unfeasible or controversial solutions could perhaps give birth to new ideas that the company had not thought of before.

However, this showed not to be critical, as the students in the group gave feedback on other group members' work. The different members on the team, with their different areas of expertise, knew if something was feasible or not. Therefore the level of freedom in this competition was still so realistic based that unrealistic solutions and suggestions were not attributed to the final solution. There was however somewhat controversial elements in it.

But even though there was no feedback from the supervisors or representatives from KONE during the first two assignments (before the presentation), the students' gave relevant feedback to each other via their field of study. And this showed to be sufficient with surprisingly good results. During the last assignment, which was the most detailed and thorough one, the representative was very helpful.

5.1.5 Concentration on the current activity

This point deals with the investigation into whether the students were able to stay focused and keep all attention on a certain activity.

It was observed that the students in the group I was a part of were capable of both concentrating and keeping all attention focused on first the idea generation, and later transforming some of these ideas into a solution. They were very involved in the activity. The informal questions during the competition confirmed this trend. The students had most of their attention on the work from the beginning in the morning to the end in the middle of the afternoon – even during the lunch break.

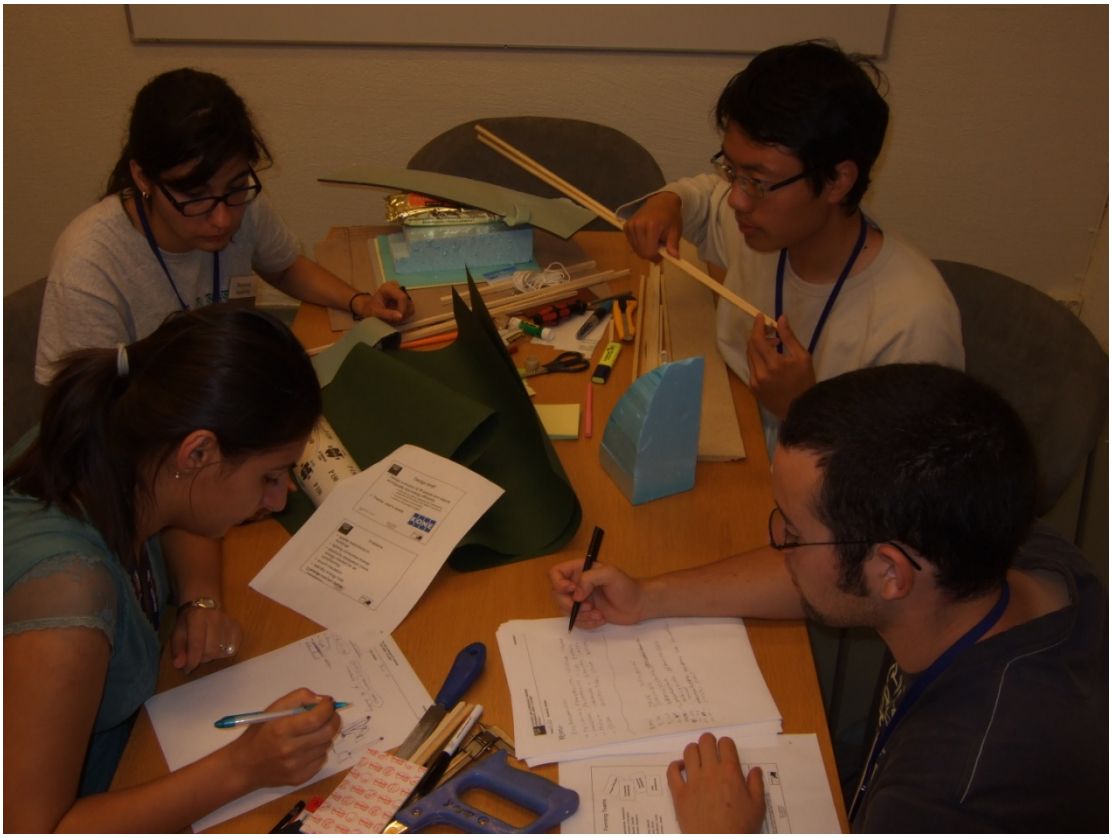
This point also deals with the students' tolerance for outside distractions and 'noise' in relation to keep focus on the concentrated activity.

As one of the challenges or obstacles one of the supervisors entered and told us that our elevator should be able to function without an external power source. There was simply a power cut in the building, where the elevator was supposed to be. This was no huge problem, since the elevator concept worked on until then did not rely on an external power source. It got its power from solar panels, a small windmill, and energy from discharged water from toilets and baths from the respective apartments in the building, plus the savings in power from a better programming of the control panel. Furthermore the elevator was located on the outside of the building, which left the expenses for light heavily cut down.

Another potential concentration-killer was the fact that the group's working area was located next to the working area of another group, only separated by a movable wall. There were some hefty noises coming from this other group, in the form of discussions and noise from constructing the elevator. Regardless of this the group did not take much notice of this, and focused on the work of the elevator. Sometimes the wall opened, given its flexible state, and at a time where the movable wall had been opened a bit, a group member closed it to prevent too much noise from entering the working area. But at other times no one noticed that the wall had opened again, because they were so engaged in the given activity that they did not care.

So the observations confirm the flow-theory's claim that only a limited amount of information gets access to the awareness, when you are in a state of flow, as per the *low latent perception inhibition* described by Shelly H. Carson [Kraft, 2005]. It shows that the students were capable of excluding even quite heavy disturbances from the surroundings, when they worked on the assignment given in the (engineering) competition. The students seemed to keep their focus and concentration on the solution of the assignments, no matter the source of disturbance, e.g. loud outbursts, high level of noise, etc. Furthermore the observations showed that some of the students actively tried to reduce the conditions in the surroundings that made it hard for them to concentrate on the activity.

Here it can be objected that some students are simply better to concentrate on a given assignment than others, and by only following some students, the full picture of the situation cannot be shown. But some of the observations showed that the same students exposed to the same disturbance reacted differently, depending on how engaged they were in the current activity.



5.1.6 Sense of personal control

This aspect must be seen in connection with the autotel aspect of the flow-theory. When the activity bears the goal in itself it is no longer under influence of a motivating effort. The observation form questions whether the student is intrinsically motivated, that is if the student takes initiative to and executes things by himself.

During the idea generation people became increasingly at ease with contributing suggestions. And members of the team came up with ideas with potential. When they felt that they could affect the final result, they became more involved. And often team members showed initiative by taking action if something was missing or incomplete.

But when asked, several team members expressed that it was not just the assignment or the setting of the competition that was motivating. It was also the newness of the event. The idea of trying something different and working in a semi-professional environment with a company was very appealing. Furthermore the application of the students' abilities showed to be a motivating

factor. One of the team members had actually thought about the assignment before attending the event.

The assignment in this engineering competition gave enough room for creativity, so that the team felt they could make a unique solution. And this awareness of being able to practice control contributed immensely to the feeling of not only motivation for working on it, but also the feeling of being able to control the direction of the solving-phase. There was an assignment, and certain tools for solving it. Other than that only time was an issue. Several team members expressed satisfaction with their level of control in this environment. The assignment gave room for a personal touch on the solution, which involved people to take initiative and deliver what they saw fit. Therefore the level of control felt by the members of the team was high, and especially the possibility for involvement and personal touch made the members take initiative more often, and be *pro-active* instead of *re-active*.

5.1.7 A loss of awareness of the self

Seldom have I participated in an educational event, where people laughed as much as on this. There was a constant flow of jokes and funny anecdotes, while people were focused on finding potential solutions to the assignment. Actually these two interrelated with each other, spawning new and funny ideas. A contributing factor was the excellent team work that occurred. There were no ego-riders, and people got surprisingly well on with each other. The atmosphere was light and relaxed, which resulted in a good climate. The team was simply acting as one.

5.1.8 Alteration of the sense of time

The flow-theory states that even basic needs are set aside when you are in a state of flow. This was something especially noted, since the students continued discussing possible solutions to the competition, even in the lunch break.

Already on the first day, the students in the group did not notice that the lunch break had begun. All students in the group were so consumed with trying to find new solutions on the elevator-problem, that the lunch was omitted. Whether this situation shows a change in the sense of time as the phenomena describes in the flow-theory can be discussed. A change in the sense of time is not only a question of being aware of the time of day, but equally the individuals experience of it, that is if the ongoing activity contributes to a change in the sense of time, e.g. *time flies*. The situation is perhaps more an expression for the students' concentration in the present case and then ties to the point on concentration on the current activity.

On the other side the students themselves points to a deviation from the normal. And the following days confirmed this trend. The times for having lunch varied a lot. The team members ate independently of the lunch breaks normal hours, and that could be an example of a change in the sense of time. But it could also be because of the structure of the work-process. The project-oriented way of working in this competition, with no specific hours that marks the transition between working hours and lunch breaks, could be the reason for that.

All in all however, the observations seemed to confirm the element of alteration of the sense of time as being present.

5.1.9 Conclusion

This engineering competition showed to be very well organized. There was an honest interest from the company (KONE) arranging the assignments for the competition. And this was a highly motivating factor. The teams I followed displayed a great deal of discipline. And this was most likely due to a likewise honest interest in creating new and creative solutions for the assignments. The teams were fully concentrated on the assignment, even off the scheduled hours. There was a lust for initiative, and all members were fully integrated in the team, working as one. They were so concentrated that they mostly did not take much notice of the noises from the other groups, and the obstacles the supervisors set up during the competition. On top of that everyone got on well with each other.

5.2 *BEClever* – engineering competition in Tallinn, Estonia

5.2.1 A challenging activity implying skills

As mentioned in the previous section the engineering competition was developed for students at technical universities regardless of any specificity in region, country or culture. The point of the competition (both of them) was to bring technological students from all over Europe together, and learn not only from the competition, but also from each other.

During the 'harness-assignment' it became apparent that nobody from the team had any knowledge about harnesses or this kind of 'industry'. However this was a challenge in itself, and quickly became a source of a lot of fun and joking about. The team worked a lot on this assignment, with figuring out what to do, and afterwards trying to make it as logistically simple and beautiful as possible. This showed to be a challenge in itself, and when asked it was especially the interpersonal and communicative skills that the participants felt were challenged, because of the coordination that had to be done. Even though the participants knew nothing about harnesses, they felt that their skills were challenged in a high degree, which was reflected in the enthusiasm put into the work phase.

The assignment with the movable bridge showed similar characteristics although a sense of more equality between the challenge and skills were evident.

The team gave the impression that the skills could have been challenged in the 'gripping-assignment, but were not, due to too harsh restrictions in the assignment.

5.2.2 Merging of action and awareness

Even though there was a bit of resentment initially towards the 'gripping-assignment', due to the perceived restrictions and lack of company interest, the group ended up working out not only one, but two final solutions. If there was not to be an encouragement from the company-side, then the group would make one for themselves. So after having delegated the tasks, the group went on with the job. However, I never really felt the students experienced a *real* sense of merging action and awareness during the 'gripping-assignment'. There were no observations that implied that this was the case, and the interviews with the members of the team supported this perception.

5.2.3 Clear goals

What were similar about the three assignments given in this engineering competition were the objectives. Besides a minor misunderstanding in the 'harness-assignment' with the, the goals for all the assignments were clear and understandable.

5.2.4 Immediate feedback

The feedback phase however was very different for the assignments in this engineering competition. During the 'harness-assignment', representatives from the PKC Group regularly visited the respective teams working on the exercise. Here they checked for the teamworking skills for the group, along with giving feedback on the work done until then. These regular visits gave the opportunity to get relevant feedback from the representatives on the work so far, which

helped the team on the way to solve the problem. If there were any questions, then these were answered in this session. Except for some broken English with the people from the PKC Group the communication was clear, and if necessary it was possible to get in touch with these representatives through the organizers of the engineering competition. This gave certain calmness to the team, which was quite visible.

This was not true for the 'gripping-assignment'. Here there was no feedback at all, except for the presentation. Combined with the (experienced) quite restricted form of assignment, it gave a negative element to this point. And this manifested itself in the form of frustration towards this exercise. However as seen from some of the other points, the team members did not give up mentally, and found new challenges within the challenge of the assignment.

The last assignment with the movable bridge was full of regular visits from the supervisors, which checked up on especially the level of teamwork.

5.2.5 Concentration on the current activity

There were a lot of interferences during the day, while working on the 'harness-assignment'. Most of the interruptions were made from organizers of the competition that gave a message about this and that. Three or four times during the day, the representatives from PKC Group entered the room, where the project was prepared, and inspected what the team had made until that hour, commented on it, and took note of the teamwork of the group (one of the things the teams were judged on). Regardless of this the group worked on uninterrupted. The team members obviously noticed the newly arrived, but it did not interfere with their concentration.

The only breaks in the concentration appeared, when there was a problem that could only be handled by the representatives from PKC Group. For instance one of the connections cracked during the connection of the harness, and since the team did not have the tools to solder it back on, the group had to wait until the people from PKC Group collected the connections, repaired them and brought them back to the team. Regardless of this though, the team found other things to work on in the project in the meantime, to avoid frustration and time-wasting.

A day in the computer-room illustrated the ability to keep concentrated. This was when working on the gripping-mechanism for JOT Automation. There were three or four teams in the room at the same time, each working on their different versions of the assignment. And in this process, there was of course much noise, different levels of volume, and a great deal of moving about.

Regardless of this, the group worked unhindered on their respective fields, that being research, making illustrations and figures, writing the report, etc. This dynamic environment actually seemed to be a better working climate for the team, since the mood became more relaxed, and it gave room for joking about with other groups.

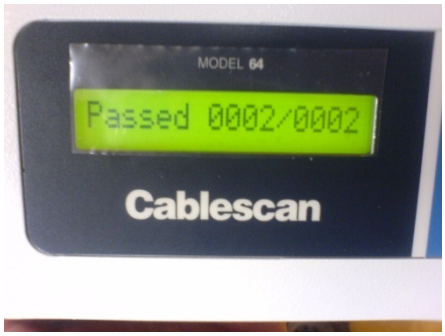
Another example of what could have been a potential break in concentration was when one of the wires was plugged in to a wrong connection, and could not be pulled out again without special equipment. Then the group again had to wait for the representatives of the PKC Group, and get them to get the wires out again. Despite these quite time-demanding delays, the group succeeded in finding other work to do in the meantime, so time-wasting was eliminated. The group constantly sought something to do, instead of collapsing and use the time just to wait.

Initially the concentration was a bit scattered with the 'gripping-assignment'. This was the case, because the team members felt that the restrictions concerning this assignment were too tight, and did not leave room for creativity. But this showed to be a challenge in itself, since the team members did not want to accept that. So instead of trying to just find a conventional solution to the problem, the students tried to find something spectacular, to avoid getting bored.

5.2.6 Sense of personal control

All team members were a bit confused initially, when they first heard about the 'harness-assignment'. It resulted in a certain uncertainty at the beginning, since the team did not really get anywhere until this could be settled. An organizer that helped the group with the practical stuff could not help either, as she had just heard about the assignment the same day.

After some time the group got to a plausible understanding of, what the assignment was about, and the group hereafter began with the real work. The motivation was first and foremost to get the planning done properly, so the rest of the work would become much easier. This showed later to be easier said than done, because the groups' planning was good in theory, but not in practice. For instance certain wires ability to bend was more rigid than anticipated. The group felt that they had the possibility to shape the solution anyway they wanted, and this perceived sense of control helped immensely with the aspect of motivation. The group was full of zest for working on this assignment, and showed a great deal of discipline for the competition. And this level of motivation was reflected in the final solution, where the finished harness quickly passed the test.



(Result from the testing phase)

The 'harness-assignment', which was about developing a new concept for a gripping mechanism, was slightly different. Here the motivation was low initially, because the group felt a lack of freedom to create a unique solution. It was only possible to change the gripping mechanism, not the system itself, or something else in the system. The group found a way to partly deal with this. What they did was find a new challenge within the challenge to add some excitement to assignment, namely look for unconventional way to make a gripping mechanism, and make two solutions instead of just one.

However, Knoop highlights in the chapter on the flow-theory, there are a number of conditions of personal, pedagogical, and work related character that prevents flow. Especially two of the conditions relates to the present point about self-determination. One of the points deals with pacification through too tight a control of the teaching schedule, the other deals with lack of influence [Knoop, 2005]. Regarding the teaching schedule you can consider the engineering competition as an example of a lecture that has a high degree of student control.

In the 'gripping-assignment' the team felt both pacified and experienced a lack of influence on the final result.

Knoop points to a connection between the involved personal engagement, and the following experience of responsibility [Knoop, 2005]. The responsibility follows the managing, and it goes both ways. That is why it is more difficult to feel a responsibility for the activity, if you cannot experience control. And this was the case in this assignment.

The great thing about the 'harness-assignment' was that even though the group controlled the tempo, the representatives from PKC Group regularly visited the teams and gave good advice and relevant feedback on how to proceed further. The team felt that they could shape the solution however they wanted, under the guidance (and not control) of the representatives from the PKC Group. And it resulted in the members of the group feeling that they had control, and could manage control. This degree of autonomy resulted in the group making a battle plan to structure the work so the assignment could be finished in the given time.

However the 'gripping-assignment' with JOT Automation was another story. Here the team members felt a loss of control, since the assignment was too restricted. The students gave life to many ideas on how to change the system overall to make it smarter, but only the gripping mechanism was to be changed. This lead to a feeling of unimportance and boredom.

In the last assignment with the movable bridge, the team had a feeling of total control. This combined with the playing element of building it, led to a feeling of not only being able to exercise control with the outcome, but having fun in the meantime.

5.2.7 A loss of awareness of the self

It was very interesting to observe the group in the last assignment in the competition. This was the assignment with the movable bridge. The enthusiasm shined from the faces of the participants. Maybe this was due to the fact that the main competition was over. This assignment was just to finish the event, and have some fun with it. And fun there was. The electrical engineering students had already begun to 'nerd around' with the electronic gear, while the construction/design and the management student were contemplating on the most stable and artistic solution for shaping the bridge. The group worked as one all along.

A time during the movable bridge-assignment, one of the participants who was an electrical engineering student gave a deep sigh and a resigning gesture with his arms, and gave an impression of regret over the fact that he had not used the motor (removed from a remote car, which all the groups had been given) in another way. Now it was too late. He had already disassembled the motor to adjust it for another purpose. He was so occupied with this that he did not noticed the reactions from the people around him.

5.2.8 Alteration of the sense of time

During the assignment with the harness, more team members expressed that the time had suddenly passed very quickly. This was especially the fact on the last day where the project had to be finished.

It was different with the 'gripping-assignment'. Here most members indicated that the time went on very slowly. This was perceived initially as if the group had just been very quick in nurturing and

developing a solution, but it cannot be neglected that all members were aware of the time a lot of the time.

During the assignment with the movable bridge, the feeling was the same as the one in the 'harness-assignment'. It was so funny and involving an assignment that the participants were so focused on their work, that on more than one occasion, people expressed that more time had passed than anticipated.

5.2.9 Conclusion

The assignments in the engineering competition in Tallinn were much diversified in the experience of flow.

The first assignment consisted of making a working harness as logistically simple and efficient and a sketch for it that could be understood by non-technicians. None of the participants had any prior knowledge in this field, which resulted in an initial minor unsettlement. However, the support, feedback and general interest and enthusiasm from the representatives from PKC Group immediately heightened the motivation of the involved participants.

The exercise was well organized with clear goals, a clear timeframe and relevant tools, etc. All factors that made the involved students experience flow, while working on the assignment. However it was the general perception that the challenge was a bit higher than the skills of the participants, but not too much, and this just gave an extra appetite for making a good solution.

It was another story with the assignment with the gripping-mechanism. From the very beginning of this exercise, the group was somewhat de-motivated. When given the assignment, the members of the group felt that they only had a slight influence on the final result.

This was a bit paradoxically, because this could potentially have been the most 'giving' assignment of the three. It was a concept-assignment, where it was possible to delve into the subject, and not be limited to what could be made in a physical model. But comparing this assignment to the one provided by KONE, it is clear that this is mainly due to the (perceived) harsh restrictions on the

assignment. And perhaps the feeling of lost potential was a factor too, a sense of 'what could have been'. As mentioned this could have been a very interesting assignment, most probable the most interesting of the three. But this was not the case. And the added sense of non-present interest from the company that provided the team with the assignment de-motivated the team members even more.

It was a fun and refreshing experience - especially to meet students from other countries, and the team members got along very well with each other. However the flow-experience was ultimately non-present.

The assignment with the movable bridge was very fun and liberating. All the group members exhibited signs of being in flow. The focus in and ability to keep concentration on the job was present, along with the other elements. The group not just acted as one. They were one.

6. Results

This chapter will present an overview of the different results.

The projects empirical foundation comes from two engineering competitions, *Lifting to higher potential* and *BEClever* that took place in Helsinki and Tallinn. By analyzing observations of and interviews with students from the engineering competitions, the presence of several of the flow-elements was documented.

As a mean to measure the subjective experience that engagement is, Csikszentmihalyi's theory of flow has been applied along with Ørsted Andersen's observation form.

When the students' got involved in the competition, they were so concentrated that they were capable of excluding even quite hefty disturbances from the surroundings. Some students tried actively to reduce the conditions in the surroundings that prevented them from keeping the concentration on the activity, which is taken as a result for their engagement in the competition. And concentration is a good catching marker for the experience of flow. The students' descriptions of engagement in formulations as "feeling high" or a "real and profound joy" resembles Csikszentmihalyi's qualitative interviews. And especially one student's description relates to the flow-theory's point on merging of action and awareness, since it deals with the paradox in striving for a goal and yet wishing that you continue with the activity forever.

Most of the time there was a suitable balance between challenges and skills, which resulted in an increased engagement. It was however far more difficult to document a change in the sense of time. The problem- and project oriented work form could be a possible explanation on the situations, where the usual time patterns are broken.

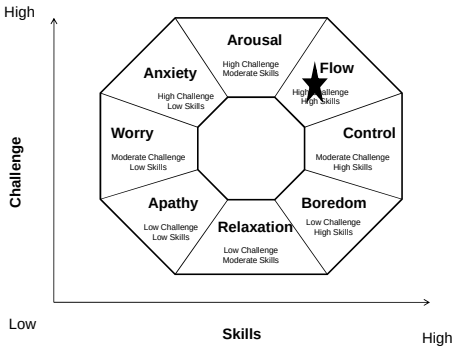
Concentration is not difficult to promote, as the students have voluntarily applied for this event, and want to use their abilities for creating something. But the competition needs to be well-structured, and the elements and goals of it need to be well-defined and clear, so confusion and/or frustration are avoided. The assignment should not be too constrained or too loose. It should be well-structured, but still give room for a personal touch.

This was certainly not the case with the assignment from JOT Automation (see fig. 3 next page). The restrictions on this assignment were perceived as being too tight (justifiable or not), and the total lack of engagement from the involved company did not help motivation-wise. There was a sense of control/boredom due to the fact that the students felt that the assignment was too easy. It was shown that even though this assignment somewhat lacked room for the personal touch, the students themselves took charge, and made the assignment make room for this. And this in itself was a motivational challenge. Even though several of the other flow-elements were present, the feeling of flow was not present in this case.

The opposite can be said about the other assignments in both engineering competitions, as shown on the next page (see fig. 1 and 4). Here the students were clearly on several occasions in a state of flow, which resulted in creative and alternative outcomes. This was enhanced by the level of perceived interest and guidance from the supervisors. Furthermore the level of the assignments fitted well with the level of skills the students possessed. Especially the engineering competition organized in collaboration with KONE showed to be so well arranged that even the representatives from the company seemed to experience flow. The students' different areas of expertise showed to be a large contributing factor in creating competent solutions. The only exception from this was the assignment from PKC Group (see fig. 2). Here the team did not know what to do in several situations, and needed help from the representatives.

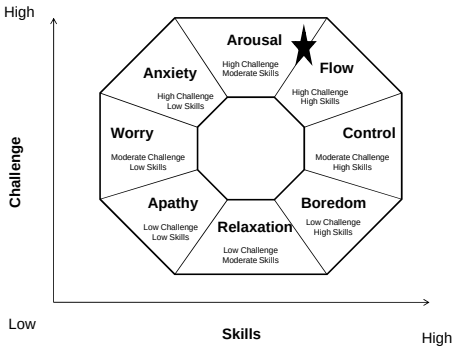
Illustrated on flow-figures the outcomes of the assignments in the international engineering competitions were:

KONE elevator (fig. 1)



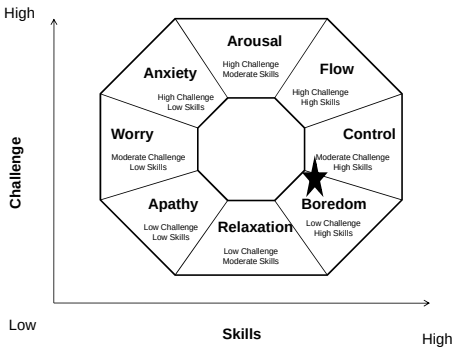
[Csikszentmihalyi, 2005b]

PKC Group (fig. 2)



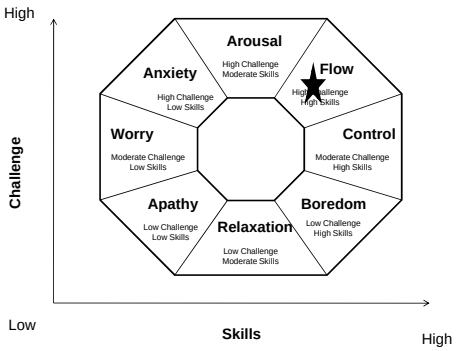
[Csikszentmihalyi, 2005b]

JOT Automation (fig. 3)



[Csikszentmihalyi, 2005b]

Movable bridge (fig. 4)



[Csikszentmihalyi, 2005b]

There is only one flow-figure for the assignments made by KONE, since the experience was very similar in all three parts of the assignment.

7. Conclusion

The question in the start of the chapter about the description of the two engineering competitions was:

Would this kind of competition be so fun, involving, and educational, that it could spark new energy and lust for innovation and learning into the students?

And the short answer is: Yes.

The purpose of this thesis is to get an idea as to what extent the positive effect of engineering competitions would justify a place in the university curriculum.

There is no doubt that engineering competitions under the described conditions are conducive for the engagement of the students. The experiences from Helsinki and Tallinn documented that participation in the engineering competitions engage the students more than the additional education, which among other things expressed itself in the fact that the students also dealt with the assignments outside the scheduled hours.

The analysis show that participants in well-organized engineering competitions experience flow.

At the same time it is illustrate that the composition of engineers from different fields of study in an engineering competition heightens the creativity. The students cooperate and learn from each other. And not only the possible solutions, but also the enjoyment to afterwards deal with assignments not exactly within one's own field of study are enlarged.

The students' narrative story expands, as well as their potential future directions in life. If you look upon the challenges for future engineers, this is perhaps the most important lesson to be learned. The future that involves increased globalization and mobility magnifies the demand for flexibility, knowledge about several fields of study, and the ability to communicate with other branches of engineering and non-technicians, maybe in other countries. This was the also the general consensus on the 6th ASEE Global Colloquium on Engineering Education in Istanbul in October 2007, I attended.

But this presupposes that the organizers have defined clear goals, and give immediate feedback and guidance. Furthermore there has to be an assignment, something new that the students have not tried before, along with the possibility to develop new relations with people from different cultures that have not met before.

An added bonus when working in an international environment, is the insight you get into other cultures work habits and –forms, plus the added network. It makes it easier in the future to understand and deal with potential conflicts and challenges that may occur in an international context.

The so-called soft skills acquired should not be neglected. The engineering-studies mostly deal only with technology and the application of technology. There is much more focus on the product (producing candidates) than on the process (learning). This is illustrated in the very few courses (if any) there exist on communication, cross-functional and cross-educational teamwork, and creativity. A course of action that in the long run can be hazardous, because exactly these "concepts" are pivotal in the world of tomorrow [King, 2006].

Here engineering competitions is one of the options for creating a more whole engineer:

An engineer that has tried to apply what he has learnt in a practical setting. An engineer that has worked in cooperation with other students (maybe from other fields of study and/or other countries) on a common goal. A student that has stepped forward and presented his work and taken responsibility for it.

There are just a few possibilities of gaining these abilities in the university years, e.g. participation in lab-work, research, extra-curricular activities (like student organizations) or work.

It is not suggested that the concept of engineering competitions is the new Holy Grail. But considering the challenges engineers will face in the future, it would be a shame not to give them at least the possibility to choose this learning environment on an equal scale with many other courses, e.g. as a three-week course. There simply are too many benefits, as seen from the practical cases in this thesis, to completely disregard it.

8. Evaluation

When the opportunity of writing about engineering competitions came along, I concentrated on investigating the experience of flow in the engineering competitions, and the possible benefits of incorporating this kind of course in the curriculum of the university. Thereby I have not made it easier on myself, but more present and insightful. That is, I have learned of the process.

In short my experiences in writing this thesis can be explained in the following analogy:

I originally thought of making a strictly theoretical thesis on the flow-theory. This would have been a safer journey, because others have described this before me.

Instead I dared to bring my experiences from two international engineering competitions, and compared this to the theory, which gave me another insight. I experienced flow in the described activities, and again when I wrote about them.

Many students go through their university years working only on theoretical problems within one field of study. Imagine what would happen if they tried to apply their skills in a practical cross-educational setting?

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LINK: www.glasbergen.com

(Visited the 5th of December at 10.34)

Appendix

Schedule for the engineering competition *Lifting to higher potential* in Helsinki, Finland:

Lifting to higher potential, Helsinki, 16th to 27th of August 2007						
	17th	20th	21st	22nd	23rd	24th
	Friday	Monday	Tuesday	Wednesday	Thursday	Friday
8		Breakfast				
9	Breakfast	Bus to KONE	Breakfast	Breakfast	Breakfast	Breakfast
10	Training at Machine	KONE DAY Official opening, company presentation,	Case Study	Case Study	Team Design	Team Design
11						
12						
13	Lunch		Lunch	Lunch	Lunch	Lunch
14	Trainings		Case Study	Case Study	Team Design	Team Design and Case Study presentations
15						
16						
17		Back to Otaniemi				
18			Dinner	Dinner	Dinner	
19		Dinner				

Schedule for the engineering competition *BEClever* in Tallinn, Estonia:

	Autumn Course 2007 in Tallinn, 7-17 November						
	Thursday	Friday	Saturday	Tuesday	Wednesday	Thursday	Friday
	08-nov	09-nov	10-nov	13-nov	14-nov	15-nov	16-nov
9.00-9.30	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast	Energy day	Breakfast
9.30-10.00							
10.00-10.30	Teambuilding	BEC	BEC	Opening	Case studies		Team Design
10.30-11.00							
11.00-11.30				Case studies			
11.30-12.00							
12.00-12.30							
12.30-13.00							
13.00-13.30							
13.30-14.00							
14.00-14.30	Lunch	Lunch	Lunch	Lunch	Lunch		Lunch
14.30-15.00							
15.00-15.30	Opening Ceremony	BEC	presentation & competition	Case studies	Case studies		Team Design
15.30-16.00							
16.00-16.30							
16.30-17.00	BEC				presentations and competition		presentations and competition
17.00-17.30							
17.30-18.00							
18.00-19.30							
18.30-19.00							
19.00-19.30	Dinner	Dinner		Dinner	Dinner		Closing ceremony
19.30-20.00							
				Local Engineering Competition / TTÜ Noorte Inseneride Võistlus			