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Co-operation Management as a Part of Engineering Education

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Zusammenfassung

"Co-operation Management as a Part of Engineering Education" ist ein Beitrag zur International Conference on Engineering Education in Sustainable Development (24./25.10.02 in Delft, Niederlande).

Die folgenden Überlegungen bauen auf Erfahrungen in zwei interdisziplinär arbeitenden Institutionen auf, in denen Sozial- und Ingenieurswissenschaftler/-innen in Forschungsprojekten und in der Ingenieursausbildung zusammenarbeiten. Theoretisch beziehen sie sich auf soziologische Theorien zu modernen Gesellschaften, auf Erkenntnisse aus der Wissenschaftsforschung sowie auf psychologische Aspekte der Erkenntnistheorien.

Zentrale Hypothese ist, dass Ingenieure, die im Themenfeld „Nachhaltige Entwicklung" arbeiten wollen, im Rahmen ihrer Ausbildung Elemente des Kooperationsmanagements erlernen sollten. Wichtige Qualifizierungsziele des Moduls Kooperationsmanagements sind:

1. Wissen: Einen Überblick über die gängigen Probleme in Kooperationsprozessen und die besten Problemlösungstechniken zu kriegen.
2. Fähigkeit zur Reflexion: In der Lage zu sein, eigene Dynamiken und Gruppendynamiken zu reflektieren.
3. Fähigkeit zur Intervention: In der Lage zu sein, ausgewählte Methoden des Kooperationsmanagements selbständig anzuwenden.

Summary

"Co-operation Management as a Part of Engineering Education" is a contribution to the International Conference on Engineering Education in Sustainable Development (24./25.10.02 in Delft, The Netherlands).

The following ideas result from experiences in two interdisciplinary institutions, where social scientists and engineers co-operate in engineering education or in research projects. They are theoretically based on sociological knowledge about modern societies, insights from research on the nature of science, and on psychological aspects of recognition.

The main thesis is, that some aspects of Co-operation management might be useful in engineering education in Sustainable Development. Main educational goals of a module "co-operation management" are:

1. Know-how: To get an overview of the common problems and the best problem-solving methods in co-operation processes.
2. Ability to reflect: To be able to reflect oneself and the group dynamic.
3. Ability to intervene: To be able to apply selected methods in co-operation processes.

Inhalt

The following ideas result from my experience in two interdisciplinary institutions[1], where social scientists and engineers co-operate in engineering education or in research projects. They are theoretically based on sociological knowledge about modern societies, insights from research on the nature of science, and on psychological aspects of recognition. Theses are:

1. The concept of sustainable development is, as an integrating approach, a response to the differentiation of modern societies. But, until now, it has not been successful. The aims, logics and rationalities of different systems, actors, disciplines, or institutions are not being re-integrated in an equilibrium but jockey for position as much as they ever have. So, co-operation often turns into clashes.
2. This happens for (among other reasons), because people are hardly capable to comprehend their model of the world as what it is: Just their own model of the world! We live in different scientific realities, and what we conceive as real is unfortunately rather closely connected with our personal psychological patterns. Being aware of that is one basic requirement for successful co-operation.
3. Engineers are often credited with certain psychological patterns - fear of uncertainty and loss of control, escape from emotions, technology as compensation for human deficiencies -, that are reflected in their scientific paradigms: Control, domination, predictability. But, SD needs non-hierarchical discourses, social experiments with great degrees of uncertainty, and the revision of subject-object-relations. Therefore, (not only) engineering education should include modules, that reflect on their specific scientific, cultural and psychological background and introduce methods of co-operation management.

1 Research on Sustainable Development: A microcosm of societal problems and conflicts

The idea of a sustainable development arose from the field of environment and development studies. Nowadays it is discussed as a multi-purpose remedy for the problems of modern, that means, differentiated societies. My experience with research on sustainable development topics has shown me the demanding challenges it presents for scientists, businessmen, politicians and others. Nevertheless, there is no way beyond it. The challenge for modern societies is to re-integrate the objectives of the differentiated partial systems: economy, politics, science, nature and culture for example. One basic idea of sustainable development is, that ecological, economical, social and political aspects must be brought into some kind of equilibrium during every action or decision. The different objectives have to be optimised in their relation to each other instead of maximising one at the expense of another.

I'd like to give you an example: The problem we have to deal with is a federal road in northern Germany with a lot of fatal accidents because of heavy truck

[1] The Centre for Technology and Society of the Technical University Berlin and nexus – Institute for co-operation management and interdisciplinary research.

traffic, cars driving too fast and the accompanying dangerous overtaking manoeuvres. There are different opinions on what to do. Civil engineers propose to extend the road to a highway, because two lanes in each direction will make overtaking safer and straightening the course of the road will ease high speed driving. Unfortunately the road is surrounded by a nature reserve with some very rare birds, which are not only protected by law but also forcefully represented by local and national nature preservation organisations. Therefore politicians and planning staff suggested constructing the highway some kilometres out of the nature reserve. That would be acceptable, at least for the nature activists, not for the farmers who are cultivating fruits in the affected area. Because until now the actors were not able to find an agreement, a court has to weigh up the life of the potential accident victims against the life of the rare birds and the economic interests of the farmers. The court has been considering their ruling for nearly two years. And I'd like to call them lucky, that until now no sociologist is involved in the decision-making. A sociologist would argue, that constructing more highways will on the long run not solve but aggravate the problems, because sustainable development needs a slowing down instead of an acceleration of societal processes. One could also ask why more neighbourhood groups or truckers are not involved in the negotiations. And: I didn't mention the international dimension of sustainable development. Before voting for the highway we should have carried out the "Chinese-test" as some of my colleagues call it: What would happen, if the Chinese did the same? Is it internationally compatible?

This real-life problem set into the context of research on sustainable solutions shows us some characteristics of the SD research[2]:

1. Sustainable development is more problem-solving than theory-building research.
2. Therefore it is interdisciplinary and transdisciplinary, that means, different disciplines are working together with non-academic participants in the project team.
3. It is high complexity-research.
4. Besides facts and findings it has to deal with interests based on normative orientations, which combines the classical aim of science – finding the truth – with negotiation processes.

Inter- and transdisciplinary research on SD-topics – some findings

Each of these characteristics provokes problems and conflicts in the joint research process. Because societal conflicts are transferred into the project team, the team has to cope with several integration tasks. Actual findings in

[2] When I am talking about research, it is just an exemplary job area of SD. Most problems and conflicts I am referring to occur in different contexts as well.

the evaluation of inter- and transdisciplinary research[3] refer above all to the following difficulties:

Conflicts of Interests: The financial and temporal resources of the academic partners in research teams are, compared to the non-academic partners, much more extensive. This leads to different schedules and levels of intensity in the research process. Non-academic partners bring economic and political considerations into the projects, while the academics try to avoid subjective and normative aspects in their research.

Opposing ideas about the way and the goals: The central goal of the non-academic partners is the solution of a given problem. So they are eager to produce knowledge, which is immediately applicable. The concentration of one central goal simplifies the co-operation process, but forces the academic partners to stand back in their disciplinary interest in order to reduce complexity. While the non-academic partners prefer pragmatic ways to reach their goal, the academics need to work systematically and verifiably.

Careers and professional experiences: The requirements and the rewards differ significantly between careers in and outside of the academe. While non-academics are rewarded for developing and implementing solutions, academics need to publish in established disciplinary periodicals. There is no common understanding of the nature of scientific research, when non-academic partners are involved.

The role of project management: Project management, as it is practised nowadays, is overloaded with three tasks and inconsistent roles: Leadership in the organisational management, partnership in the contribution of contents and independence in the mediation. Few people combine the different skills, and even if they do, the project partners hardly agree on the switching between the different roles.

Those difficulties in inter- and transdisciplinary research are interconnected, one leads to another. If the rising or the hidden conflicts are not discussed and solved, they impair the whole research process. This is so much the worse, because evaluation showed, that a successful integration of different logics and approaches improves the theory formulation as well as the applicability of the results. Two main recommendations for transdisciplinary research are: First, co-operation management is an important determent in the success of the research project. Further professionalization is necessary. Second, academics should undergo additional training in methods and forms of co-operation management.

So – conclusion Nr. 1 – sustainable development requires, that we learn to co-operate with others. That means, we have to respect different views and interests, we have to withstand the complexity which co-operation creates, and last but not least we have to cope with different personalities, behaviours and cultural backgrounds in the co-operation process. Often this is the most tiring part. Why is it so difficult? I'd like to turn your attention on a specific but

[3] The following chapter refer to findings of Hollaender/Loibl/Wilts 2002.

central point of co-operation processes: We live in different realities. Most of us are not aware of it, and even when we are, we don't communicate our underlying assumptions, values and preferences.

2 Different scientific realities as a key to mutual comprehension

It is as uncomfortable as it is exciting, that in every mind different worlds exist. I always wished I could just one day look at the world with someone other's eyes. That is, at least until now, impossible, but I guess engineers are working on this problem too. Having an idea about what is going on in the mind of my engineering colleague can be the first step to comprehend his conception and approach to any given problem. The second step is to accept his reality as just as „true" as mine. Once that is done we can try to co-operate.

How can I access ideas about the different realities we are living in and working with? In the Centre for Technology and Society we started a number of workshops, in which we are trying to identify our different styles of scientific inquiry on the one hand and our personal behavioural patterns on the other hand. We are looking at two aspects: (1) How closely are personal patterns and inquiry styles connected? (2) What happens if different styles and patterns come together? In this process we are supported by a professional coach, who introduced a typology of different inquiry styles[4].

Before I expand on the distinctive features and the resulting four types, let me talk about typologies. There are two kinds of people in the world: those who believe there are two kinds of people in the world and those who don't. I hope I belong to the second group. That means: The following typology should help us to organise some of the complex patterns by which humans behave. Real people do not fit into any one type precisely. No one type is more desirable than the others, every style of inquiry has both strong and weak points. And last but not least, typologies differ from each other in the choice of the main distinctive features. So, the typology I'd like to present to you is not "the one and only" but fits best to outline the psychological background of different inquiry styles and the coherent problems of co-operation. It is based on the psychological types of C.G. Jung (1972). According to Jung, individuals can take in information from the world either by sensation or intuition (dimension of information and orientation), and can reach a decision either by thinking or by feeling (dimension of the evaluation and decision-making process). The poles of both dimensions are more or less antithetical to one another and as a result individuals tend to develop a preference for one of these two modes. Figure 1 at the following page gives an

[4] Reichwein 1992, basing on Mitroff/Kilmann 1978, Southgate/Randall 1981 and C.G. Jung 1972

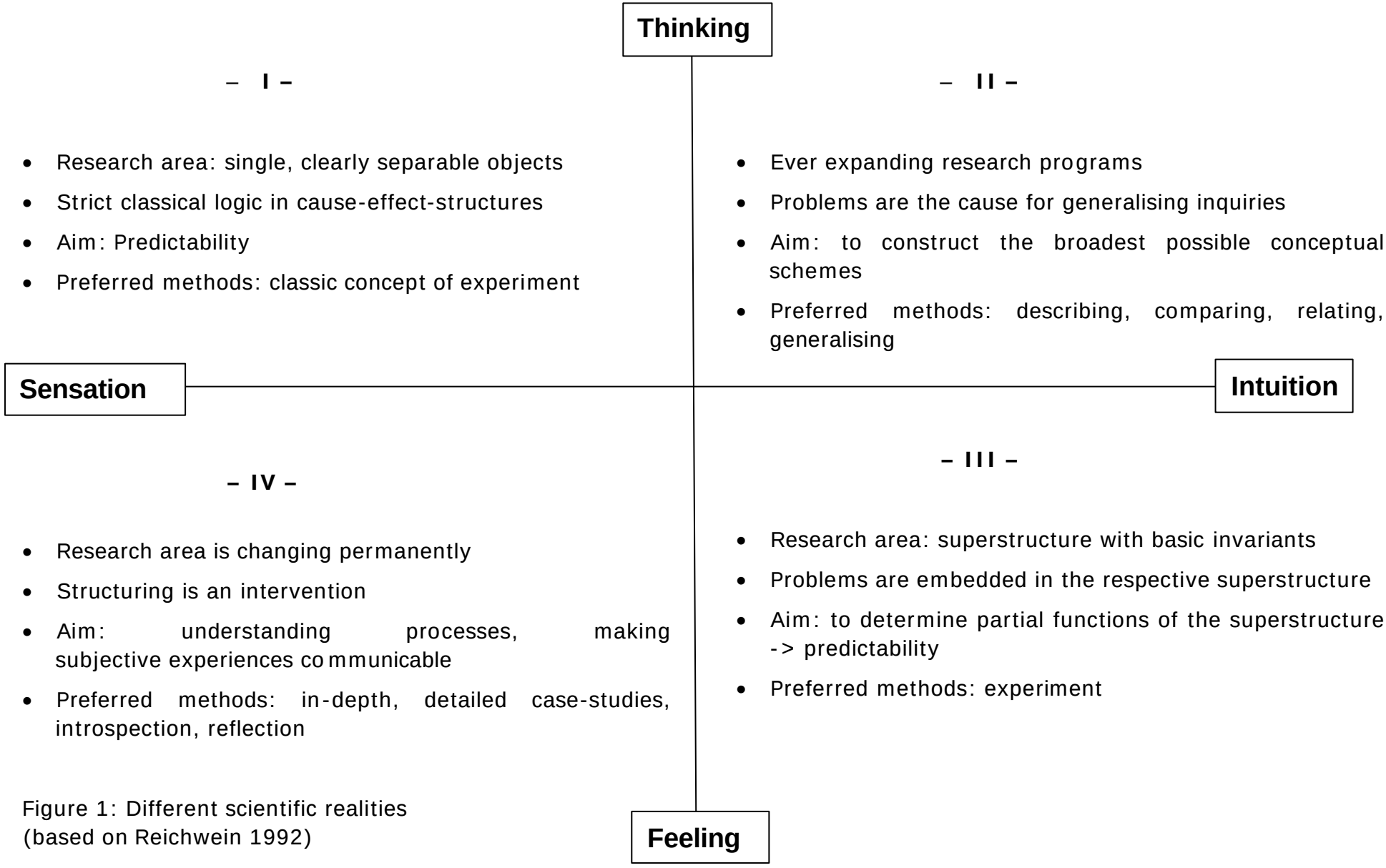

Figure 1: Different scientific realities
(based on Reichwein 1992)

overview of the four different scientific realities. Reichwein emphasises two main points (Reichwein 1992):

1. The existence of different scientific realities consequently means, that we cannot claim universal validity for our own scientific reality.
2. The separation between researcher and research object is no more a matter of course. Different views produce different results. Feminist scientists have proven this in varied studies.

Psychological aspects of the different styles of inquiry

In addition to the figure above I'd like to mention the psychological aspects of the four realities and inquiry styles[5].

Type I is striving for certainty. Therefore he reduces his environment to as few invariants as possible and straightens things out in cause-effect-relationships. He considers the world to be a manipulable object, which has to be dominated and controlled.

Type II is worried about his independence. Empirical data is interesting, but may also be a prison to her. She is always discovering new possibilities and opening new spaces. Her ultimate aim is to escape restrictions.

Type III has a similar need for certainty as type I. But instead of reducing complexity she constructs a superstructure, in which her reality is embedded. She is endlessly looking for further stabilising factors in order to eliminate inconsistencies.

Type IV is in a steady state of flux. You can not rely on him, and he doesn't rely on his environment. He does not want to commit himself to anything, so his research programme is ever changing. It might be an escape from responsibility.

The preferred scientific realities in our, that means: modern societies' cultural context are type I and type III. Engineers are mostly to be found in these two categories. More than any other, type I tends to deny that the other scientific realities are real, because their complexity is threatening to him.

The different realities rest on the historico-cultural background as well as on the personal development of the scientist. Every scientific product contains the scientist's biography (Reichwein 1992). Because we mostly are not aware of this fact, we are likely to believe, that our specific approaches, logic, aims, and methods are necessities instead of predefinitions. Consequently, a dialogue between the different types is difficult and often degenerates into power struggles.

So – conclusion Nr. 2 – the close connection between the style of inquiry or rather the scientific reality on the one hand and the psychological and historico-cultural background on the other hand makes the cross-over dialogues extraordinarily difficult. Nobody can just decide to change his style just as little he can just decide to be a stoical instead of a hysterical personality from now on. Thus, recurring the recommendations of Hollaender et al. (2002) I mentioned

[5] The following explanations are based on Reichwein 1992.

above, inter- and transdisciplinary researchers should undergo an additional training to be prepared for the complications during the research process. As we cannot expect, that introducing a module "co-operation management" into the syllabus solves the complex difficulties, I am convinced of the necessity of professional co-operation management in inter- and especially in transdisciplinary research processes. To widen the syllabus by a new module "co-operation-management" seems to me a necessary step, to support the research teams by co-operation managers a sufficient step to improve research on sustainable development topics.

3 Co-operation management – aspects, methods, examples

In the last part of my lecture I'd like to present to you some aspects of co-operation management, that might be useful in engineering education. But first, we should briefly stay with the question: What are the main educational goals of a module "co-operation management"? I distinguish three goals:

4. Know-how: To get an overview of the common problems and the best problem-solving methods in co-operation processes.
5. Ability to reflect: To be able to reflect oneself and the group dynamic.
6. Ability to intervene: To be able to apply selected methods in co-operation processes.

Know-how should be given/passed on in form of a lecture or a seminar with papers dealing with the different aspects of co-operation management. To reach the second and the third goal the students have to go through several trainings with practical exercises.

Know-how – For example: team-building

I already referred to the common problems in inter- and transdisciplinary research processes. Now I want to highlight just a few central starting points to avoid or solve the problems. The aim is to build up a team with a joint responsibility and to develop a group identity with defined intra-group-relations in order to find an agreement upon goals and priorities and to integrate the different logics and interests.

In order to do this it is helpful to know, that there are different phases in team-building processes: forming, storming, norming and performing[6]. During the "forming"-phase the members of the team are defining the tasks, the rules and the appropriate/suitable methods. During "storming" the tasks are rejected emotionally, which becomes obvious for example in conflicts between subgroups or in rebellion against the leader. "Norming" is a very important phase of the team-building process, because then, the members are talking frankly about their opinions and emotions. Consequently, new norms are set, the cohesion of the group gets closer, conflicts are settled, and co-operation is starting. In the phase of "performing" the team is actually working. The internal problems are

[6] Tuckman 1965, quoted according to Staehle 1999.

solved; the team has a functional structure that fits the tasks, so that the whole energy flows into the handling of the tasks. This description of the team-building process is again a typology. In real life the phases are dynamic and have breaks.

Hence, conflicts in co-operation processes are something very normal and, if managed professionally, something very helpful, if not a prerequisite for a successful co-operation between heterogeneous partners. If we are aware of this and if we have some conflict-management methods at our disposal, we don't experience conflicts as something threatening and don't give way to the impulse to flee from this uncomfortable situation. We are able to act and to reach a higher level of common understanding. And finally we know that only in the last phase we can judge the quality of our solutions. But to recognize the different phases and the nature of the conflicts we need the ability to reflect on ourselves as well as on our relations to others.

Ability to reflect – For example: Investigating biography

I consider the ability to reflect on oneself as the most basic skill in co-operation processes. For self-reflectivity there is no way beyond learning-by-doing. I already mentioned the coaching workshops, in which with the help of role plays colleagues try to recognize their scientific reality, their own behavioural patterns, and the way they interact and communicate with others. Another possibility for training on self-reflectivity is to use a biographical method. According to Bourdieu self-reflectivity is trying to discover oneself or the situation of the group in order to be subject of the situation, to change instead of being manipulated by it[7]. The following questions are very helpful for a biographical examination of oneself:

(1) What values and points of view onto the world were predominant in your family? What opinion did you have on it (identification, rebellion, ambivalence)?

(2) What motivation did influence your choice of your discipline and your profession later on? Were there "commissions" of your parents? What was your opinion on it?

(3) Were there forming mentors in your professional development? Which values and which point of views did they represent?

(4) Did you have breaks in your professional career? How did they influence your present situation of working and living?

(5) How would you describe your present philosophy of life (values, political attitude, scientific reality, understanding of human nature)? To which social group do you feel you belong to now?

(6) Which fears and insecurities (uncertainties) are you experiencing in your present job situation? How do you cope with these emotions and sensations?

(7) Which ideas concerning objectivity and methods are you following? Which hierarchies do you see in the relation between your discipline and others?

[7] Pierre Bourdieu in an interview with Isabelle Graw (1996).

These questions can be answered in a written exercise, which the students can do for themselves and, if they like to, exchange with others. Another example of training self-reflectivity is practised by a colleague of mine in the context of a seminar on sociology of engineers. It is a very intensive course, that is spread over two weekend sessions, in which the students are confronted with themselves: their hidden aims, motivations, values, and philosophies. My job is to talk about the psychological and thinking patterns of male and female engineers – a quite delicate topic as you can imagine. If I just held a lecture on it, they would rebuff it, which is a normal reaction. Therefore, I turn the tables and ask them to answer the following question with only one word and write it one a card, that is pinned on a flip-chart. The question is: "What is the male aspect of technology?" And – astonishing or not – the collection of the answers nearly always focuses on central themes: domination, rationality, logic, power, predictability, control – the psychological aspects of the scientific realities I and II in the typology above. The students' reactions are similar over years. First they distance themselves from their answers and deny them as a striking description, later – which means between half an hour and half a year – they tend to accept it. Hence, during the seminar my colleague can see a development from denial to admittance, acceptance, and reflection – that's plenty!

Ability to intervene – For example: conflict management and negotiation

Finally I 'd like to present to you an excellent technique of conflict management and negotiation. It is developed by the "Harvard Negotiation Project" (Fisher/Ury/Patton 2000), which has been investigating professional, private, large, and small negotiations for years. The result is called "The Harvard concept of negotiation" and rests on some basic principles:

- Problems must be separated from persons.
- In the centre of attention are interests instead of positions.
- It is necessary to look for negotiation results, which are profitable for all parties.
- All parties have to agree upon neutral criteria for the evaluation of the negotiation results.

The key perspective to a successful problem-solving is to regard the negotiation parties neither as friends nor as enemies but as problem-solvers. The key act is defining the problem in a way, that all parties are interested in a solution. What the problem consists of is always a decision of the persons involved and rarely an objective fact. The following three are the main steps of the negotiation process:

1. The joint definition of the problem, which has to be formulated as a question of "how...". This is the most difficult step.
2. The collection of alternative solutions without evaluating them.
3. Looking at the alternatives considering the problem and choosing the one, all parties can live with.

You can use this method for several purposes in different phases of a co-operation process. For example, it is helpful for finding an agreement about the way to reach already defined goals, which is one of the most important conditions for a successful co-operation. Even if you have forgotten to start by finding a consensus on joint goals and are confronted with severe problems in your project team, the Harvard concept can still help. Just use it as a method of conflict management!

Conclusion Nr. 3: Engineering students in sustainable development should have at least heard of the full range of topics and methods of co-operation management. But their courses should include training and exercises in some specific aspects: To recognise their own styles of inquiry and their own scientific reality, their own personal patterns, their own career biography. In addition to this, they should experiment with role plays in order to experience the interpersonal dynamics between different styles and patterns. They should not leave the university without the ability to reflect on themselves. Only if they are practised in critically perceiving themselves, can they develop the capability to value conflicts with others as opportunities to create a deeper and ultimately more successful co-operation.

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