Promotion of interdisciplinary competence as a challenge for Higher Education

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Abstract

Interdisciplinary co-operation, no matter whether in research or in teaching, makes high demands on all participating players. To reach a shared understanding is the main goal and, at the same time, the major challenge. In interdisciplinary work contexts, experts with different qualities, varying knowledge bases and disciplinary perspectives come together. The extent to which an understanding is possible depends on the ability to exchange knowledge in such a way that it becomes part of a common knowledge base, as well as on one’s own perception of the problem. Therefore, all persons involved must be aware of being both expert and layperson at the same time. Furthermore, they need to accept the perspective of all those who are foreign to their subject during the communication process. The ability to work and to communicate in an interdisciplinary context does not arise all by itself but may be promoted during the academic education. The dimension of knowledge integration will be described in the following, with recourse to psychological research about expert-layperson communication and regarding assumptions about the adoption of perspectives. This paper shows that interdisciplinary competency and the ability to solve complex problems can be promoted at universities. This is illustrated by the case study of the “Sustainability Study Programme”.

1. Problem Statement

In the context of literacy and education, the principle of interdisciplinarity needs to be given substance, especially against the background of the concept of sustainable development. Today, science has to meet the challenge of generating knowledge that satisfies the complexity of present problems. Also, such knowledge needs to involve the know-how available across society and thus existing beyond scientific limits (Becker 2003; Nowotny, Scott, Gibbons 2001). This “new” knowledge is basically structured in a different way (see fig. 1) and may only be generated in interdisciplinary research alliances. Such knowledge or know-how does not remain within the scientific community but has to be absorbed within different educational contexts. In addition, it must be a major objective of future educational schemes.

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from…	to…
simplicity	Complexity
singularity	heterogeneity and hybridism
linearity	non-linearity
unity and universality	unifying an integrative processes
Fragmentation	connection, collaboration and consequence
	boundary blurring and crossing
boundary formation	long-term
the short-term and ephemeral	
analysis and reduction	synthesis and dialogue

Fig 1: The way in which knowledge has to be conceptualised in the future (Thompson Klein 1998, paragraph 14)

In kindergartens, elementary schools and institutions of higher education, or in professional training: everywhere, we look for suitable methods and contents to understand and practice interdisciplinary ways of working. Rather, the attention should be focused on the competences necessary to initiate interdisciplinary communication. The question is how to stimulate and enhance the ability to pass on knowledge in a way that enables people with different academic backgrounds to integrate it into their own set of acquired knowledge? To restrict oneself exclusively to the level of general communicative abilities of a rhetorical kind is certainly not enough.

In order to enhance the competence for an interdisciplinary dialogue, possible connections to existing knowledge need to be created. For this purpose, it is necessary to start with material and themes relating to the different areas of knowledge of the people involved. In addition, the structural features of the different disciplines need to be considered. As a result, the people involved are enabled to see their own perspective reflected. Accordingly, such processes require a flexible framework which is adjusted to different target groups and which may be filled as required. University is the obvious choice for a place for the development of interdisciplinary competence, since different faculties and departments are usually combined there. In the framework of academic education, possibilities for “unconventional thoughts” may be provided, such as to study interdisciplinarily and in parallel with the actual course of study. Thus, those involved will be trained to “handle” different disciplines.

2. Theoretical Classification

First, it is necessary to clarify certain terms in order to differentiate between inter-, trans-, and multidiscplinarity etc. According to Brand (2000, 14), the different approaches may be distinguished as follows:

Disciplinary research refers to problems arising from the particular discipline.

Multidisciplinary research refers to a topic lying transversal to the disciplines. Different disciplines work on its different aspects with their respective methods. Afterwards, these partial results may be connected additively in order to display the diverse facets of the topic.

Interdisciplinary research applies to a common problem that alludes to several disciplines and thus represents a “disciplinary interface”. Therefore, scientific insight is not gained through the “bare combination of disciplinary particularities” (Mittelstraß 1987, 155 own translation). Rather, new knowledge structures are established by the integration of different disciplinary perspectives, theories and methods. In addition, the insights gained in joint problem analysis and problem-solving may be reflected within the respective discipline. Thus, interdisciplinarity becomes a medium of self-reflection. Therefore, the added value consists in the extension of the scientists’ ability to perceive problems and in their gaining awareness about the achievements and limits of their own discipline. At best, this will intensify the respective disciplinary identities.

Transdisciplinary research refers to problems outside the scientific world which may only be solved by scientists in co-operation with experts in possession of practical experience from outside the academic world.

2.1 Communication in inter- and transdisciplinary co-operation

The definitions above describe the requirements for inter- and transdisciplinarity, but they do not say anything about the obstacles which need to be overcome to achieve them.

Experiences show that interdisciplinary research projects often fail due to communicative and methodological problems. Some major reasons for this are (Defila, Di Giulio 1999, 111):

Communication difficulties arise due to the lack of a common language. There is no consistent use of terms, which may be of different meaning in different disciplines.

Disciplinary expertise cannot be made understandable. This results in communication problems between the participating parties and leads therefore to possible misunderstandings.

Values, standards and scientific criteria of the respective disciplines clash with each other and thus lead to target and value conflicts.

Every single discipline makes a claim to the objective acquisition of insight and is hardly open for the other disciplines. At times, this is a matter of the lack of willingness to get involved with different perspectives.

There are no self-contained methods for inter- and transdisciplinary co-operation. This may result in a methodological problem as every discipline has its own range of methods at hand and will hold fast to it. In addition, scientific methods need to be combined with the methods and procedures of players with practical experience.

Co-operation in groups may entail conflicts and thus result in a disruption of the communication and work processes (team problems).

The central goal of any interdisciplinary dialogue is to try to achieve an exchange of expert knowledge and to reach an understanding among the participating players. The latter is at the same time the basic requirement for interdisciplinary co-operation, and it is the fundamental problem, as all participants of such a dialogue usually possess a different store of knowledge. “The ability to estimate other people’s knowledge is generally regarded as a central prerequisite for effective communication” (Bromme, Rambow, Nückles 2001, 317). The exchange of knowledge may therefore not be taken as simple knowledge transfer: The exchanged knowledge needs to be integrated in the knowledge-structure of the respective dialogue partner, thus resulting in “new knowledge”. This alone will lead to an extension of perspective and problem perception. This process of knowledge integration creates a common cognitive frame of reference for all participants. Processes of knowledge integration are of high significance as they form the basis for communication. Without a commonly shared understanding of central terms and their contexts, neither an exchange of knowledge nor any discovery of new insights will occur during the interdisciplinary dialogue. Terms and perspectives which are not made clear may result in misunderstandings and, in addition, may inhibit the process of understanding. Even a lacking or limited willingness to get involved with different perspectives, or the inability to explain one’s own perspective, will inhibit or even prevent the construction of a common knowledge base and thus communication itself.

The Clark’s communication theory puts the aim for a commonly shared frame of reference (“grounding”) into the centre and regards it as the basis for a successful process of understanding. According to Clark (1996; Clark, Brennan 1991), the communication between two people may be seen as a more or less coordinated adjustment of single actions (“joint action”). Clark compares this with a waltzing couple: the dance may only come to a glamorous conclusion when the two partners harmonize perfectly. Thus, he wants to point out that co-ordination and harmonizing of each person’s knowledge is central for a successful communication and for the achievement of common goals (Clark 1996). Successful communication does not simply mean the formal correctness of the actual act of speech (not to interrupt, not to speak at the same time, etc) but a synchronization of the respective knowledge. This act of synchronizing is necessary since communication can only take place inside a collectively shared frame of reference (“common ground”), that is, a collectively shared “intersection” of knowledge: “Two people’s common ground is, in effect, the sum of their mutual, common, or joint knowledge, beliefs, and suppositions“ (Clark 1996). This “common ground” is in a permanent process of enlargement when the partners bring new information into the communication process and when this information is accepted by their interlocutor.

Clark’s “Common Ground” theory is suitable for the debate about an interdisciplinary dialogue: first, it indicates the knowledge of the communication partners and, second, it concedes the interacting partners’ assumption of its existence as a central factor for the success of communication. In his approach, Clark emphasizes that the success of communication depends on the extent of information everyone involved has about who possesses what knowledge. Following this logic results in the assumption that communication problems arise from incorrect or diverging assumptions about the knowledge of the respective dialogue partner (Bromme 2000).

The basis of any interdisciplinary co-operation project needs to be the harmonizing and adjusting of a “common ground”. “Sustainability” for example is an open approach that can be interpreted in a variety of ways. Hence, in order to create a starting point, it is necessary to explain the foundations and references of one’s own understanding to all involved parties. In doing so, it is not a matter of complete unification of understandings, but to clarify the pre-conditions which form the basis for any

sort of choice. It is fundamental to formulate the understanding of interdisciplinarity as well as the expectations arising from it, in order to synchronize them from the outset.

2.2 Expert - Layperson Communication

Interdisciplinary communication is characterised by knowledge asymmetries which are the result of co-operation between experts from different disciplines. These experts are at the same time laypersons in those disciplines in which they are not educated. Bromme defines expert as "a person with training in a particular field who is able to tackle complex problems because of this training and additional practical experience" (2001, 317). The psychological research in expert-layperson communication (ELC) concentrates on the difficulty of understanding. This difficulty arises during the dialogue due to the different knowledge backgrounds of the involved parties. Thus, the concept of ELC offers interesting points of contact between knowledge communication and knowledge integration in the context of interdisciplinarity, even though this approach was developed for conversation situations in everyday life and not for the scientific context. Communication in the frame of an interdisciplinary dialogue – that is, between people with different academic backgrounds – may be called communication between expert and layperson (Bromme 2000; Bromme, Rambow 2001). The distinguishing feature of *expert* and *layperson* is not one of value or merit, but merely indicates that the layperson is not systematically educated in a discipline where the expert has extensive knowledge.

The layperson is in fact affected by a certain problem – just as the expert is – but he neither has the education nor the institutional background for independent problem-solving. The central point here is that experts not only possess more knowledge about their discipline than the layperson, but their domain-specific knowledge about that certain topic is differently structured. The intention of expert-layperson communication is not (!) to align the layperson's (novice's) level of knowledge with the expert's one in the course of time, as it is in an instruction situation between master and apprentice. Rather, the goal is a mutual information exchange in order to enable all participants to make a choice based on information.

Referring to the constitution of an interdisciplinary project team for the work on specific questions (e.g. taken from the topic spectrum of sustainability) the consequence is as follows: in a communication situation, experts with different backgrounds take the role as experts (for their respective discipline) and layperson at the same time. Furthermore, the allocation of the *expert* or *layperson* role is variable, depending on the actual topic, and it may change during the conversation depending on the main focus.

2.2.1 Structural characteristics of expert knowledge

From a cognition-psychological point of view, expert knowledge is a complex, specifically structured meshwork of cognitive and meta-cognitive contents, which – in general – is organized by discipline. Consequences arising from these structural pre-conditions cannot be overcome by general rules of communication (Bromme, Jucks, Rambow 2003). Based on different experiences and on different levels of knowledge, peoples' opinions and their perception of certain issues differ substantially from one another, as do their interpretive patterns of events and situations. The communication process needs to meet the challenge of a successful understanding between people, who, when it comes to the actual topic of conversation, carry systematically different scientific perspectives and everyday-life perceptions. The central point beyond the difference of knowledge contents is that the process during which the respective knowledge is developed is to be understood as "Enculturation into an expert community" (Bromme et al. 2003, 96 own translation) that is, besides mere expertise, a question of methods of thinking and problem-solving and of disciplinary means of communication etc.

The development of expertise and thus the focus on a specific disciplinary perception usually results in a sort of "tunnel vision" that narrows the view for different perspectives. Knowledge elements which are to be introduced into an interdisciplinary dialogue are therefore embedded in a complex framework of references.

This system is the consequence of scientific socialization. It is complex and for the most part automatic. Hence, it forms the basis of an integral part of perception which is taken for granted. This knowledge is for the most part implicit and needs to be externalised in order to integrate it into the aforementioned process of "grounding". Communication with people foreign to one's own discipline requires the anticipation of the "alien" perspective. There is generally the risk that experts presume that their partners share large parts of their own framework of references – that, from the start, may result in a basis for dissent (Bromme et al. 2001). Therefore, the ability to adopt different perspectives forms the central cognitive category for interdisciplinary communication (Bromme et al. 2003).

2.2.2 Perspective adoption in interdisciplinary dialogues

In the framework of interdisciplinary work contexts, people with completely different perspectives get together to work on certain questions. Perspectives are opinions, mental attitudes, values and

particularly cognitive structures that are connected to different experiences and to a different collection of knowledge.

Perspective adoption may be understood as the process of understanding a person against his or her specific background. From a developmental-psychological point of view, the adoption of the partner's perspective requires two mental processes: first, a concept of foreign perspective must actually exist – that is, we have to accept that the other person has a different perspective of something. Second, the mental process must take place, which virtually simulates and anticipates the different perspective.

We cannot talk about perspective adoption until both requirements are fulfilled. Generally it must be mentioned that the perspectives of communication partners differ in many aspects (gender, origin, etc.) and that these differences must be dealt with in the communication process. We may assume that perspectives are more strongly influenced by the expertise/experience of a specific person. Thus, a basic requirement for an inter-and transdisciplinary dialogue or the development of collective solutions is the existence of a specific set of ideas about what the partner "carries along" as his framework of references. According to Flavell (1985), perceiving the perspective of one's dialogue partner and focusing on it is a general limitation of human information processing and thus a disturbance variable in the communication process. In the context of inter- and transdisciplinary communication, it is a striking matter of knowledge asymmetry, due to the co-operation of actors from outside the scientific world and representatives of different disciplines.

The problem increases exponentially when experts with completely different structures of thinking and working meet and scientific knowledge is to be shared that generally features a high degree of complexity. The required anticipation of the partner's perspective and thus the perspective adoption is considerably more difficult against the background of such communication situations. In addition it might happen that the expert loses himself in his expert knowledge and thus overstrains the intake capacity of the so-called layperson (Nückles 2001).

The question remains to what extent an expert – given the availability of his own proven and tested perspectives – may succeed in acknowledging his interaction partner's perspectives, and how the layperson's anticipated perspective can then be transformed into a verbal representation suitable for a layperson during a communication situation. A survey by Rambow (2000) about the communication between architects and laymen offers interesting insights on the assumption that the ability to change of perspective is of high relevance for the ability to communicate in layperson's terms. Besides the empirical validation of this assumption, the survey points out another problem: during the attempt to communicate in layperson's terms, people will draw the false conclusion that it is sufficient to translate the technical terms, that is, to solve the so-called "technical mumbo-jumbo". To do without certain terms or to operate with word-to-word translations is not sufficient. Experts overestimate the knowledge about subject-specific issues and believe laypeople to have a certain knowledge that does not exist. In general, there is a tendency for humans to often miscalculate the distribution of single knowledge elements (Nückles 2001). Concerning everyday knowledge, we tend to orient ourselves on our own standard when we try to estimate our dialogue partner's level of knowledge. The "social desirability of knowledge", that is, the "make believe" of possessing expert knowledge, may lead to a false interpretation of the knowledge level. This occurs when laypeople themselves use technical terms or pretend to understand them. We can assume that the significance of social desirability concerning certain knowledge areas should not be underestimated, particularly in communication situations in inter- and transdisciplinary contexts. Sometimes, different scientific traditions come into contact with each other and the image of professions is part of the assumptions mentioned above. A possible "power gradient" in communication situations is closely connected to this, as equality is not necessarily a given from the beginning. Thus, knowledge may not be expressed unrestrainedly, which again inhibits the formation of the "common ground".

In order to exploit the opportunities of interdisciplinary co-operation, it should not be allowed to fail due to communication barriers. Besides the development of supporting methods and organization structures, the promotion of the ability to integrate knowledge, of perspective adoption and of a disciplinary self-reflection needs to be striven for. For successful interdisciplinarity, the focus should not solely be on practical experience and intuition, but a systematic promotion of necessary competences should be pursued. In addition, the subjectivity of the disciplinary perspective should become the matter of research. Accordingly, several authors point out that the necessity of inter- and transdisciplinary research alone is not sufficient for its successful realisation (Blättel-Mink et al. 2003; Fuest 2004).

3. The "Sustainability Study Programme" at the University of Lüneburg

The Sustainability Study Programme takes up the challenges sketched above and works to promote students' interdisciplinary competency. That is, to create an awareness of the possibilities and limits, the methods and approaches of their own discipline, and to communicate with people foreign to their subject in a way that enables the development of joint solutions. The starting point is

the concept of sustainable development and the ability for interdisciplinary problem-solving, since the latter is becoming increasingly important. The Sustainability Study Programme[1] started in the winter term 2004/2005. During a period of two semesters, it provides students with the opportunity to identify societal problems and global trends in an interdisciplinary dialogue, with reference to politics, economics, culture and social matters. Subsequently, solutions which require an interdisciplinary approach and exchange across different disciplines shall be developed. Expert scientists from different disciplines of the University as well as external experts from the field of practical application cooperate in this subject-spanning study programme. The expert knowledge of the participating disciplines, the different approaches towards a problem, and the subject-specific methods are integrated and thought through. The study programme is offered as a blended-learning course alternating between presence and e-learning phases. Through many different methods, alternating phases of group and individual learning, and through reflexive elements, further social and method competencies are to be implicitly and explicitly imparted. A multimedia-based learning environment is particularly suited to self-directed, explorative learning, and it offers (e.g. via internet) a wide range of networking and participation possibilities.

3.1 Framing the Learning Process

The approach chosen for the learning process within the study programme in Lüneburg may be broken down into six phases (Fig. 2). According to Barth, Godemann (2006 in print) the learning process can be described in six phases:

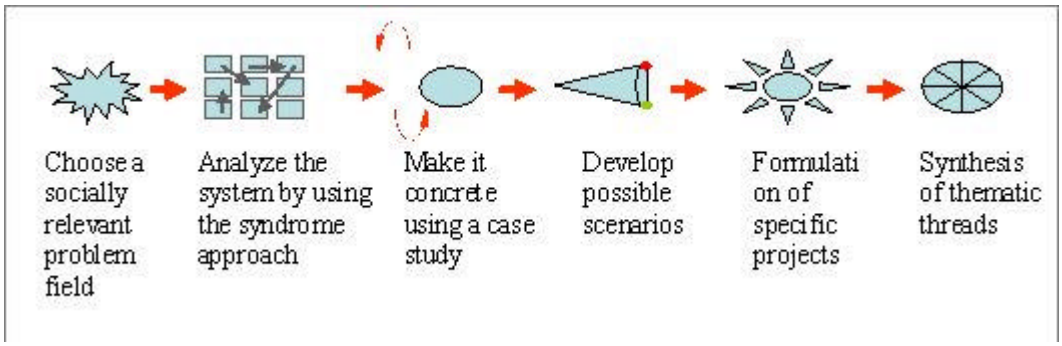

Fig. 2: Systematic approach of the study programme

1) Selection of a problem field relevant to society

During the preparation of the study programme, a ‘problem field’ relevant to society is chosen as a framework topic, and thereby the life-world reference is created. An interdisciplinary frame of reference is selected for collaborative, interdisciplinary learning and working that enables the acquisition of a scientifically inflected competency for action. At the same time, the connection of one’s own discipline to societally relevant questions is picked up as a theme.

2) Systematic analysis using the syndrome approach

Working with sustainability-relevant societal problem fields demands a networked approach and a consideration of the associated complexity from the very beginning.

A problem-oriented, interdisciplinary approach is required, which is to be understood as “a response to the needs of both science and society” (Gibbons 1994, 11). Such a systemic analysis is offered by the Syndrome Approach, developed by the German Advisory Council on Global Change. The Syndrome Approach represents the thesis that the Global Change in its dynamics may be ascribed to a manageable number of causal patterns in the man-environment relationship. The non-sustainable courses of these dynamic patterns are identified as syndromes of Global Change. This approach permits a structured, systemic understanding of complexity.[2]

[1] www.uni-lueneburg.de/studienprogramm

[2] With its “Syndrome Concept”, the German Advisory Council on Global Change presented and depicted a variety of central issues which do justice to the interdependence of (global) problems. On the basis of expert knowledge, global “clinical patterns” were identified which reflect critical changes (i.e. the global greenhouse effect, soil erosion). But the Advisory Council goes beyond a mere diagnosis of problems: it specifies trends which are relevant for the global change. These fundamental patterns of man-environment-relation apply to different levels: biosphere, pedosphere, atmosphere, hydrosphere, population, psycho-social sphere, organization of society and economy/technology. Interactions between these levels as well as typical patterns of interaction may be depicted – the so-called “syndromes”. The Syndrome Approach is interesting as starting point for an intensive debate about sustainability: first, it clarifies the central questions concerning the overall concept of sustainability. Second, this happens in a way that does not disavow complexity and

3) Substantiation with a case study

A further substantiation is required for a detailed analysis. For this purpose, a case study design is chosen and the specific syndrome characteristics of the case are analysed. The close scrutiny of this case is paralleled by the development of a collaborative knowledge base which is promoted by a learning platform. The use of a wiki-system as an open, cooperative author-system promotes the approach of collaborative knowledge management. The equal creative freedom of the many users facilitates participative elements during the generation of knowledge from the very outset. The illustration of complex sustainability topics with different interdependencies and cross-references may be realised by a sequential knowledge desegregation into many single web pages that are closely linked with each other (Barth 2005, 270). Dealing with the contents in cooperation with others – and the many cross-references involved – leads to the creation of active, collaborative knowledge.

4) Scenario development

Based on this deeper understanding of the case and its specific characteristics, the next step is to develop possible scenarios and desirable development paths. For this, the influencing factors identified via the syndrome analysis are reviewed with respect to future development. Development of the scenario requires both creativity and a well-founded estimation of future developments. Any formulation of a positive or negative scenario is based on the previously created interdisciplinary knowledge base. That is, the extensive gathering of the students' knowledge is taken into consideration at this stage of work.

5) Project proposals

After the students have developed possible development paths and identified desirable positive scenarios, the next task is to formulate concrete projects that contribute to some form of progress towards the positive scenario by aiming at and influencing the core parameters. This promotes a scientifically well-founded and thought-out procedure that strengthens students' action competency. In addition, the openness of the projects and their precise conceptualisation addresses the students' creativity.

6) Synthesis

Imbedding the chosen problem into the syndrome analysis demonstrates its networking and complexity. In addition, it becomes apparent that we must aim at the core point of a Syndrome in order to influence its development. The students' projects need to bear the characteristics of such "set screws" and be embedded in the Syndrome as a whole.

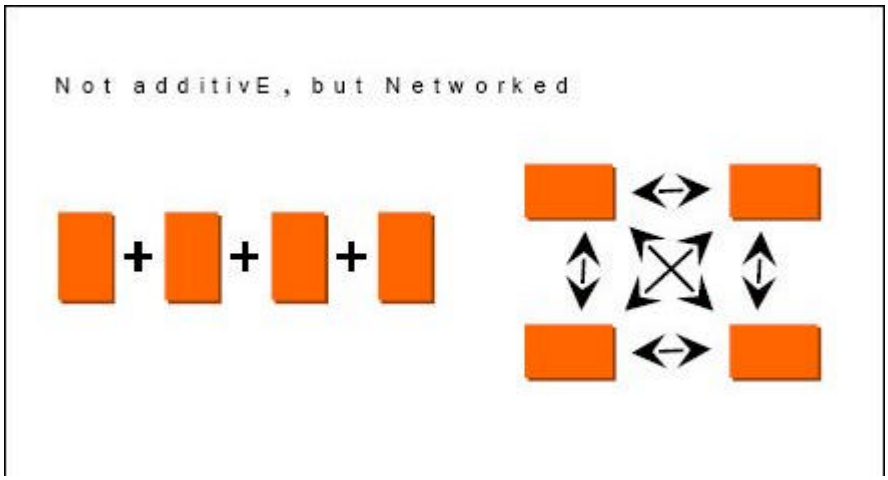

Fig 3: interdependence of the contents

interconnectedness but illustrates and explains these phenomena (see fig. 2). The starting point for a syndrome is not a specific environmental problem but a human activity which may very well cause different kinds of problems. Thus, the dynamics of ecological processes are not analysed in detachment from their context but always with an eye on human activity. Social processes, actors and places come to the foreground and may be analysed. Hence, these hitherto non-sustainable form of development may be described and form the basis for the development of sustainable models and courses of action.

4. Interdisciplinary aspects of the study programme

The context of sustainability reveals problems with complex characteristics that may not be managed via a simple cause-and-effect approach. Rather, sustainable problem-solving is about thinking in problem nets, something that is contrary to the prevalent thinking tradition. “The tendency to mono-causal thinking in effect chains, instead of effect networks, is not compatible with the necessity to think in networks. When humans encounter a deplorable state of affairs, they look for means of remedy. These means are generally valuated only in terms of their suitability to remedy this present state of affairs and only seldom in terms of their other effects, even when those may possibly cause even more deplorable states of affairs than those which are presently meant to be eliminated” (Dörner et al. 1983).

This way of thinking is emphasised during the Sustainability Study Programme and thus complements the thinking promoted in the individual disciplines.

In order to do justice to the integrative character of the concept of sustainability and at the same time produce knowledge applicable in the societal context, the Study Programme Sustainability focuses on the interdisciplinary acquisition of topics. This relates to the composition of the student group as well as to the choice of lecturers.

This leads to a very complex way of working on and solving problems, which lies outside the classical discipline-organised procedure. One discipline alone cannot provide the answer to the problem of sustainability. It is true that we need to know the basic scientific principles of an environmental problem in order to give a precise description. However, this knowledge is not enough to solve the problem, since the causes of the problem do not relate to natural sciences. They are anthropogenic, that is, they are caused by human action. Thus, the whole area of social science becomes significant.

Beside the claim for interdisciplinarity, we find the criterion of transdisciplinarity. Through cooperation between representatives of different disciplines and representatives of economic and societal practice, scientific and action-relevant knowledge is put on the same level.

Building on the theoretical considerations introduced in section 2, the Sustainability Study Programme will achieve the following contents: The aforementioned communication problems between layperson and experts shall become the object of reflection. Within this context, it is imperative to point out that in interdisciplinary co-operation, pools of knowledge will interact that are characterised by certain structural features and that are organized and affected by discipline. Here, the existence of a certain power structure may be of significance. That is, knowledge exchange is generally subject to socio-psychological influences (profession image) that may result in the existence of certain expectations and prejudices. In addition, the communication process itself should become the subject matter: In contrast to a rather technological sensor-receptor model of communication, it is central to understand human communication as the collective work on the development of understanding (Bromme et al. 2003). Thus, Clark’s common-ground approach of is taken up, the process of *grounding* is paid attention to and it is achieved in the interdisciplinary dialogue. A fundamental pre-requisite for the creation of a common ground – that is, the integration of knowledge – is the development of a general basic understanding of other disciplines, and actual experiences in co-operation with representatives of other disciplines. Both are possible in the course of the Sustainability Study Programme. The focus lies on the reflection of one’s own as well as of the partner’s perspective. Misinterpretation about the distribution of one’s own knowledge or discipline often leads to problems concerning interdisciplinary work. Hence this phenomenon becomes the subject matter. Eliciting the previous knowledge of all participants is fundamental in order to detect possible “failed concepts” and, if necessary, to reform or improve them. Here, it is of high significance to uncover the subjectivity of one’s own perspective as well as to reflect on the intentions behind one’s own comments. Thus it is possible to increase awareness of ambiguities that were expressed unknowingly.

The exchange of scientific knowledge is generally characterised by the use of technical terms. This aspect becomes more important considering the fact that every discipline has its own technical terms and uses a specific vocabulary. As described above, a mere translation and exchange of these technical terms is not adequate. Instead, the study programme tries to promote the understanding that technical terms cannot simply be translated into everyday speech. Rather, they form the constitutive elements of the thought and argumentation structure of a specific discipline. Understanding the basic vocabulary is central. In addition, the role of the communication channel will be considered. The students are invited to choose recipient-oriented media for the portrayal of the different knowledge areas. For example, the use of maps and photographs leads to a specific communicative effect and is therefore more suitable for certain contents than e.g. a written presentation. The study programme is supported by a virtual learning platform, i.e. interdisciplinary communication during the periods of physical presence (seminars, lectures) is different to the

computer-based communication[3]. These special features are reflected and the potential of these means of communication is used (e.g. for the process of "grounding").

Thompson Klein (1996) recommends an iterative procedure for the process of knowledge integration, in which attempts at interdisciplinary synthesis alternate with disciplinary assessments. One possible solution would be to clarify all those technical terms that are necessary for the analysis of a certain problem area (e.g. a certain syndrome) in such an alternating process. The explanations need to be made accessible for all participants, resulting in the creation of a "common ground".

At the moment, students of different disciplines who take part in the study programme exchange their views on the different possible perspectives concerning the syndrome "suburbia" (city development) via the virtual learning platform. There are many promising internet-based approaches which may help to overcome the knowledge divergence arising from interdisciplinary co-operation. One example for the process of knowledge integration is the software-tool "WIKI", a "discussion and collaboration server" whose specific strength is to collect and combine information. This tool may be used as a "Team Communication Tool" to externalise implicit knowledge as well as for the joint development of knowledge and of a culture of "knowledge sharing". WIKI may be described as virtual encyclopaedia in which any user may get actively involved. For example, the term "sustainability" is defined and added to this dictionary by one user. This definition may be edited and completed by any other user. The first definition is not lost but stays visible. Thus, the course of the definition process stays traceable. By using this platform for interdisciplinary co-operation projects, the process of "grounding" can be enhanced appropriately. A term may be defined from different perspectives. In addition, all participants will notice which aspects are added and omitted respectively. This may result in a definition that will be acceptable to all participants, or the different discipline-specific definitions will be shown in a traceable way. Thus, WIKI may be used as "discussion server" or structured knowledge base.

Conclusion

Several authors point out the problems of inter- and transdisciplinary research co-operation, and make clear that the necessity of inter- and transdisciplinary research alone is not enough (Blättel-Mink et al. 2003; Fuest 2004). We may assume that the ability to engage in inter- and transdisciplinary co-operation does not emerge all by itself, but needs to be integral part of education in order to fulfil the necessary requirements for such a project. Coping with complex problems is not only coached in the context of inter- and transdisciplinary sustainability research, but also in other interdisciplinary, co-operative projects.

Steinheider and Burger (2000) minutely analysed the aspect of co-operation in interdisciplinary teams in an explorative survey. In general, the three steps of co-ordination, creation of a common knowledge base ("grounding", according to Clark), and knowledge integration form the basis of this study and are validated by means of interviews. The result was that all three aspects are fundamental for interdisciplinary co-operation. In addition, it turned out that the creation of a common understanding base (grounding) is of particularly high significance and that earlier experience with co-operation facilitates the project work. At first sight, this result is hardly surprising. However, it is not enough to take such earlier experience as a warranty for successful projects, or to rely on their existence.

It was already suggested that interdisciplinary competence does not only arise from practical experience but should be an integral part of any education, as it is intended in the Sustainability Study Programme.

To date, academic teaching is characterised by disciplinary structures that result in a certain socialisation of the university graduates. Universities are divided into faculties, education is bound to established patterns. There are hardly any interdisciplinary offerings which could enhance the required competences. The experiences which are currently made in the course of the Sustainability Study Programme are empirically validated. Thus, they may be helpful for the development of further offerings in support of interdisciplinary competence.

[3] For comparison of presence learning and internet-based learning, please see Breuer 2000. For „Lernen zwischen Experten und Laien im Netz" ("learning between experts and laymen in the www"), see Bromme, Jucks 2001.

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