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Enabling university educators to equip students with inter- and transdisciplinary competencies

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Abstract

Purpose

Inter- and transdisciplinarity are core concepts in almost all ESD competence frameworks and curricula. To equip students with inter- and transdisciplinary competencies is highly demanding for educators. Educators must not only know how to teach students such competencies, but need to be experienced in inter- and transdisciplinary research and must have some technical knowledge about inter- and transdisciplinarity. The paper shows how university educators can be supported in their teaching.

Design/methodology/approach

The paper is a case study based on research and on experiences in interdisciplinary teaching and in supporting educators in their interdisciplinary teaching.

Findings

The paper presents a competence framework of interdisciplinary competencies to guide university teachers that has been developed, implemented and refined in interdisciplinary study programmes belonging to the field of ESD. It shows how the professional development of educators could be addressed referring to the experiences in these programmes. The measures presented consist for one thing of interdisciplinary processes among the educators and of measures directly supporting educators in their teaching for another thing.

Originality/value

The case study the paper refers to is of special value first, because the experiences are based on long-standing research and on two decades of experiences. Second, because considerable efforts were made to deliver coherent and consistent interdisciplinary teaching in which interdisciplinarity was not only a teaching subject for the students but showed by the educators as well so that the educators involved did not only talk about competencies for inter- and transdisciplinary collaborations but also set an example in their own doings.

Keywords

Interdisciplinarity, transdisciplinarity, interdisciplinary teaching, teaching interdisciplinarity, teaching transdisciplinarity, interdisciplinary competencies

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Paper

1. Aim and structure of the paper

The aim of this paper is to share a case of good practice in developing educators' competencies in interdisciplinary teaching. It is based on roughly two decades of experience in developing and delivering teaching programmes belonging to the field of ESD that aimed at equipping students with the competencies needed to successfully engage in inter- and transdisciplinary activities. These teaching programmes being inter- and transdisciplinary right from the beginning with regard to the involved educators, the enrolled students, and the discussed topics is crucial to the case presented in the paper. Thus, the paper does not discuss how to introduce inter- and transdisciplinarity in teaching programmes because the educators were sensitive to the importance of inter- and transdisciplinarity in the field of environment and sustainability and willing to engage in such teaching. The paper rather shows what can be accomplished and what challenges remain under favourable conditions.

The case presented in the paper has not been accompanied by systematic and comprehensive empirical inquiry with regard to the experiences and perceptions of the educators involved. The 'data' relied upon are documents that have been developed for direct practical usage by educators such as teaching materials, didactic frameworks, course programmes, assessment grids etc. for one thing, and minutes of meetings, colloquia and retreats for another thing. The latter have not yet been systematically analysed. Empirical data are available though with regard to how students assessed the single courses and the whole teaching programmes, and these data allow us to state that the teaching programmes were not only well received by the students but were also successful in equipping students with inter- and transdisciplinary competencies. The paper shows that successful inter- and transdisciplinary teaching cannot be achieved without 'backstage-effort' and suggests possible measures.

The paper is organised as follows: In section 2 it is shown which framework of competencies with regard to inter- and transdisciplinarity informed the teaching programmes. In section 3 the

teaching programmes are presented, and in section 4 it is displayed how the professional development of the educators involved was addressed and how the educators were supported in their teaching. To conclude, section 5 discusses how the experiences made might be transferred to other teaching programmes and what challenges remain unanswered.

2. Inter- and transdisciplinarity—competencies students should acquire

Inter- and transdisciplinarity are core concepts in almost all ESD competence frameworks and in a vast majority of ESD curricula (e.g. Lozano, 2010; Rieckmann, 2012; Sterling, 2011; Wiek et al., 2011; 2016). Issues of sustainable development cannot adequately be addressed by a mono-disciplinary approach, and often they require the integration of knowledge experts within academia do not have. An inter- or transdisciplinary approach is highly demanding and requires special skills. Students should learn how to constructively interact with members of other disciplines and non-academic fields of practice and how to design and manage inter- and transdisciplinary projects.

To define the competencies students should acquire more precisely we suggest two complementary approaches: In one they are deduced from the special quality inter- and transdisciplinary collaborations should meet, in the other they are deduced from the special challenges in such collaborations. In the subsequent sections we describe these two approaches and the resulting framework of competencies.

2.1. Special quality to be achieved in inter- and transdisciplinary collaborations

The terms 'interdisciplinarity' and 'transdisciplinarity' are not only of a descriptive nature just capturing specific features of research. Rather, both terms express quality requirements such research has to meet and these quality requirements determine what is asked of (future) scholars planning to embark on this kind of research.

We conceive interdisciplinarity as the collaboration of scholars of at least two different academic disciplines aiming at common results (e.g. Defila and Di Giulio, 1999; 2001; 2015). In doing so we define interdisciplinarity research to be research performed by a team in which the individuals represent different disciplinary perspectives and not by a single person (such a 'team-definition'

is endorsed by a wide range of scholars, e.g. Andersen and Wagenknecht, 2013; Holbrook, 2013; Klein, 2010). In interdisciplinary research the result is the common result of a group achieved by dealing with different persons having different disciplinary expertise and by integrating these. We conceive transdisciplinarity in turn as a special format of interdisciplinarity, where, in addition to scholars from different academic disciplines, (future) users contribute substantially to the research (that is, they are not just a source of information, data and/or feedback). In the terminology of Mobjörk (2010) this would be "participatory transdisciplinarity" in contrast to "consulting transdisciplinarity". Furthermore, (future) users are not stakeholders but experts with a specialist expertise in a field relevant to the research; following Collins and Evans (2002) we call them "experience-based experts" (or "non-certified experts") while the participating scholars are "certified experts" with a specialist expertise in a field relevant to the research. Consequently, in transdisciplinary research the result is the common result of a group achieved by dealing with and integrating the expertise of experience-based experts and of certified experts (for a more in-depth discussion see Defila and Di Giulio, 2015). Compared to a mono-disciplinary approach, both an interdisciplinary and a transdisciplinary approach claim to deliver 'added value' in leading to insights that could not be gained and give access to questions that could not be approached by a mono-disciplinary approach resp. by an approach based on scholarly expertise only.

The special quality inter- and transdisciplinary research has to meet can be summarised by the terms of 'consensus', 'integration' and 'diffusion' (e.g. Defila and Di Giulio, 2001 as well as Gibbons et al., 1994; Klein, 1990):

- *Consensus*: Those participating have to arrive at a shared problem framing, at joint research objectives they all equally want to reach, at shared research questions and at a joint understanding about the theoretical and methodical approach for dealing with these questions. They also need to develop a common language. Consensus does not mean individuals should abandon their different perspectives and replace them with a 'group-perspective' or that their different perspectives should dissolve into just one perspective. Rather, they have to develop a shared point of view—and a shared point of view is not an identical point of view but one all of them to a certain extent can identify with and are prepared to proceed from and to relate their findings.
- *Integration*: The research must lead to common outputs (results and products), that is, those participating have to develop common answers to their shared research questions by integrating, from the very start, the findings from the different disciplines and/or fields of practice involved. To this end, findings and approaches have to be selected in terms of

their contribution to the common answers, they have to be reprocessed, related and integrated. The common result is the integrated knowledge produced in this process, the so-called "synthesis".

- *Diffusion*: The results of the research need to be disseminated and their reception by the audience promoted. As a rule, the audience of inter- and transdisciplinary research is neither disciplinary nor purely scholarly. Therefore the channels of dissemination have to be different from the disciplinary ones, and the results have to be 'translated' to make them accessible to the different target audiences and their perspectives.

From this quality point of view the competencies individuals involved in an inter- or transdisciplinary project need can be summarized as follows: First, they need competencies enabling them to contribute to the processes in such collaborations (such as being able to name one's own distinct contribution, to relate to other perspectives, to negotiate appropriate criteria of scientific validity, to choose, 'translate' and reprocess approaches and findings etc.). Second, they need competencies endowing them with the theoretical and methodological expertise enabling them to design and manage such processes (encompassing such tasks as developing common goals, arriving at a shared problem framing, implementing methods of knowledge integration, developing a common language, settling conflicts of interest and handling team dynamics etc.).

2.2. Special challenges due to the 'clash of cultures' in inter- and transdisciplinary teams

Even if all participants are engaged and favourably disposed towards a common outcome, inter- and transdisciplinary collaborations do not always go smoothly. There is a rich body of literature dating back at least to the 1970s showing what can go wrong in such projects. The analyses of several case studies revealed that there is a type of problems having in common that they all are caused by the disciplinary socialisation of scholars (for a more detailed account on how we proceeded see Defila and Di Giulio, 1996; since then the body of case studies has grown considerably, but the typology still holds true).

Interdisciplinary collaboration is collaboration of people belonging to different disciplinary 'cultures' and having different worldviews. By 'worldviews' we do not mean the political opinion of a person but his/her specific way of perceiving and structuring the world whilst being informed by all those elements making up a (disciplinary) academic profile (e.g. Di Giulio, 2010; O'Rourke

and Crowley, 2013), such as choice and description of phenomena, value system, epistemological interest, terminology, body of theories and methods, as it developed through his/her academic biography and was transmitted and reinforced by the 'culture' of his/her scientific community. Scholars bring into the collaboration the socialisation going along with their expertise—that is what interdisciplinarity is about. In interdisciplinary collaborations the very sine qua non of interdisciplinarity frequently leads to the following problems (for a more detailed account see Defila and Di Giulio, 1996; 2006):

- *Misunderstandings and claims of definition:* The knowledge being part of the disciplinary expertise (theories, technical language, basic assumptions etc.) is at least partly tacit knowledge, sometimes not even recognised as being specialised disciplinary knowledge by the bearer of this knowledge. What is common ground within one's own discipline may not be known or may even be doubted in another. Problems emerge if tacit knowledge is not recognised, explicated and 'translated', if technical terms and theories are not understood or are misinterpreted, if individuals are not willing to depart from their own terms, theories and assumptions but instead claim these are the only ones appropriate.
- *Divergences defining the object of investigation and research questions:* Part of what scholars within a discipline acquire is an understanding for which aspects of (pre-scientific) phenomena should be considered in investigations, how these aspects relate, how they are described correctly, and which kind of research questions is to be asked in inquiries. Conflicts arise if individuals are convinced that only their selection of aspects and only their questions will lead to significant findings and cannot think of other aspects and questions as being justified.
- *Divergences in choice of methods and criteria of scientific validity:* The methodological approach of how to deal with questions, how to solve problems, how to proceed correctly and the notion of what kind of outcomes to produce differs between disciplines. Similarly, the criteria by which the scientific character of an investigation is established and the validity of results is asserted are discipline-specific. Once again, problems emerge if individuals are unwilling to let go of what they consider the correct approach, if they have difficulty accepting other methods as equally expedient or if they spend a great deal of energy arguing about the criteria of scientific validity to adopt.
- *Prejudices and imperialisms:* Most scholars have at least a vague notion of what some other disciplines are doing, the sources of such notions being their own school education, grey literature, friends, Wikipedia, superficial reading of publications, reports in media, public lectures etc. Therefore, most scholars have some expectations of what some other disciplines are capable of and what they are supposed to accomplish. If such superficial

knowledge is not recognised as mere conjecture which may well need to be revised, it may turn into prejudices and unrealizable expectations of what others can contribute to an inter- or transdisciplinary project. Conflicts tend to erupt when individuals overrate the merits of their own discipline while underrating the merits of other approaches or when they perceive disciplines as competing and not as complementary.

Similar problems due to the 'clash of cultures' caused by worldviews emerge in the interaction of certified and non-certified experts (e.g. Di Giulio et al., 2016), because fields of practice and the non-certified experts belonging to these fields have their specific 'culture' and worldviews consisting of bodies of knowledge, sets of preferred methods, criteria of sound proceedings, rules of behaviour etc. as well.

From this 'clash of cultures' point of view the competencies individuals involved in an inter- or transdisciplinary project need can be summarized as those competencies enabling them to know about the relativity of their own worldview, to step back from it when this is appropriate, to leave the comfort zone of the worldview they are familiar with and to relate their way of thinking to other worldviews. This kind of competencies has been boiled down into the saying that interdisciplinarity is not that much about knowing others but primarily about knowing oneself by Hoyningen-Huene (1988). Thus, an engagement in one's own professional identity is a prerequisite for a fruitful exchange with other worldviews in inter- and transdisciplinary constellations. Additionally, there are, of course, some personality traits being conducive for inter- and transdisciplinary collaborations such as an attitude of pluralism and curiosity when being confronted with other approaches.

2.3. Special challenges due to a missing transmission of knowledge on inter- and transdisciplinarity

There is another type of problems well documented in the case studies since the 1970s having something in common: problems caused by lack of knowledge on inter- and transdisciplinarity leading to poorly designed and managed inter- and transdisciplinary projects (for a more detailed account see Defila and Di Giulio, 1996; 2006). These problems corresponding to the abovementioned quality requirements of inter- and transdisciplinary research are:

- *Inadequate theoretical foundations*: Often individuals participating in inter- and transdisciplinary research are unfamiliar with the available scholarly knowledge about

inter- and transdisciplinarity. In many cases there is neither a systematic acquisition of knowledge of how such collaborations work, nor a reflective consolidation of experiences made. Often participants' knowledge remains patchy and amateurish and their course of action is quite random and haphazard.

- *Lack of methodological know-how:* Often individuals participating in inter- and transdisciplinary research are not sufficiently familiar with methods that lend themselves to achieving consensus and integration. In such circumstances, the collaboration does not lead to an outcome that is superior to what could have been achieved by separate disciplines working alongside each other.
- *Problems of coordination and planning:* Often, discipline-specific procedures and working patterns are inadequately clarified, leading to incompatible planning. Because the processes of achieving integration and consensus are not given appropriate attention insufficient resources are allocated for them. Moreover, the contributions may not be sensibly planned, coordinated and harmonised or the decision-making procedures may be unclear.
- *Problems relating to group dynamics:* The significance of team dynamics in research projects is often underestimated. As a consequence, team building is not encouraged in a sufficiently professional manner and conflicts may not be recognised and avoided.

The lack of knowledge being the main cause of this type of problems is due to the fact that knowledge about inter- and transdisciplinary collaborations is gained in communities not necessarily communicating with each other (e.g. tobacco research, medicine, sustainability sciences, public health, biodiversity) and is thus not passed along—knowledge is fragmented, and the wheel has always to be reinvented. This is even accentuated through the drifting apart of the group of scholars practising inter- and transdisciplinary research and the community of scholars investigating inter- and transdisciplinarity, a phenomenon that increased during the last years (Defila and Di Giulio, 2015). From this missing knowledge point of view the competencies individuals involved in an inter- or transdisciplinary project need correspond in large part to what has been written in section 2.1. Additionally, individuals should be able to draw on available scholarly knowledge about inter- and transdisciplinarity in such way that their course of action is reasoned and state of the art.

2.4. Competencies for inter- and transdisciplinary collaborations

Our framework of competencies students should be endowed with in academic teaching is based on the special quality and the special challenges going along with inter- and transdisciplinary research. In a number of research projects, one of them a Delphi study involving university educators, we defined two groups of competencies (e.g. Defila et al., 2000; some of these competencies have been pointed out by others as well, e.g. Eagan et al., 2002; Godemann, 2006; Hansmann et al., 2009; Feng, 2012; Fortuin and van Koppen, 2015; Misra et al., 2015):

- (a) Competencies aiming at a fruitful exchange and interaction between worldviews in inter- and transdisciplinary processes
- (b) Competencies aiming at a professional approach to the designing of inter- and transdisciplinary processes

(a) Competencies aiming at a fruitful exchange and interaction between worldviews in inter- and transdisciplinary processes:

- Being familiar with one's own disciplinary worldview. This relates not only to the perception of (pre-scientific) reality and to how objects of investigation and research questions are constructed, but also to the disciplinary body of knowledge, to the set of commonly used methods, to the values and epistemological interests, and to the social rules of one's own scientific community.
- Being willing and able to reflect all elements making up one's own academic profile (entailing the knowledge about which elements are crucial), to recognise them in the acts of others and to engage in a joint reflection of these elements.
- Being aware of the relativity of one's own way of approaching (pre-scientific) phenomena, that is, of the aspects included resp. left out in investigations and theories, of the consequences of the basic assumptions and theories informing the production of knowledge, of the kind of validity produced through the methods preferred, and of the limits of the insights produced. This entails the ability of relating one's own way of thinking and acting to that of other experts from inside and outside academia.
- Being able to spell out the achievements and boundaries of one's discipline, to define one's own disciplinary contributions to a complex issue and to relate these to achievements, boundaries and contributions of other experts from inside or outside academia.
- Accepting scholars from other disciplines and experience-based experts as equal and adapting to collaborating with individuals from different fields of expertise.

(b) Competencies aiming at a professional approach to the designing of inter- and transdisciplinary processes:

- Being familiar with the special quality requirements of inter- and transdisciplinary collaborations and being willing to commit to them, being familiar with main scholarly knowledge explaining the functioning of inter- and transdisciplinary interactions, and being able to search for scholarly findings about inter- and transdisciplinarity when appropriate (entailing knowledge about the scholarly debate and about what kind of questions could have been the subject of inquiries).
- Knowing what kind of special challenges and problems might occur in inter- and transdisciplinary collaborations and how to deal with them appropriately, that is, being able to prevent problems, being able to timely recognise emerging problems, and being able to solve problems in case they are not avoidable.
- Being able to design expedient and state of the art processes of consensus-building and integration and to implement appropriate methods aimed at developing a shared problem framing, common goals and questions, integrated results and products and being willing and able to engage in such processes and to contribute to them.
- Being able to 'translate' and reprocess the results produced for the benefit of a non-specialised audience inside and outside academia. This entails being willing and able to explicate tacit knowledge of one's own discipline and 'translate' it for those not belonging to the same community.
- Being able to effectively support an efficient communication and collaboration in a team and organise it to the satisfaction of all involved.

A degree programme that sets out to qualify students to work across disciplines should equip students with these competencies. Additionally (and ideally), teaching should support students in developing *personality traits* such as those mentioned above. Conducive traits are a pluralistic attitude, curiosity towards how others think and act, tolerance and acceptance when being confronted with the worldviews of others, not being afraid of leaving one's own comfort zone, and readiness to engage in debate and in the development of common results in a group. Finally, teaching should further students' interest and skills in learning about fields other than their own, in viewing "research problems and questions holistically from distinct vantage points", and in "reading journals and books from different fields" as pointed out by Misra et al. (such interests and skills belong to what Misra et al. 2015, p. 2f call "TD attitudes", "TD conceptual skills", and "TD behaviors").

These competencies cannot be acquired by a purely theoretical approach nor by a purely "learning by doing"-approach. Rather, to acquire them students need appropriate spaces allowing for practical experiences and at the same time for well-structured reflections of these experiences (see also e.g. Feng, 2012; Godemann, 2006). In providing such spaces it has to be kept in mind that students do not necessarily want to (and do not have to) become experts of inter- or transdisciplinarity in terms of themselves doing research on this matter—inter- and transdisciplinarity are primarily of instrumental value to them allowing them to conduct successful inter- or transdisciplinary projects. Hence, practical experiences should not be a dry run but have to be linked to the topics the students are primarily interested in deepening their knowledge—put into the terminology of curriculum development: the development of these competencies should be embedded in the students' major or minor subject.

Teaching such competencies is highly demanding for university educators (see Barth and Rieckmann, 2012; Feng, 2012). They have to provide for practical experiences and for that they need a scholarly expertise in the subjects dealt with in the corresponding exercises (such as sustainable development, sustainable consumption etc.). At the same time they need to be experienced in inter- and transdisciplinary research, they must have some technical knowledge with regard to inter- and transdisciplinary collaborations gained from the scholarly debate (enough to be able to appropriately select and present it in teaching), they should themselves have the inter- and transdisciplinary competencies students should acquire, and they should know how to teach such competencies and how to coach students in attaining them. Finally, in order to provide for practical experiences, courses have to be attended by students with different disciplinary backgrounds, and this in turn implies that university educators have to be able to deal with a heterogeneous group of students.

Thus, implementing the framework of competencies we developed goes hand in hand with answering the question of how university educators can be enabled to equip students with inter- and transdisciplinary competencies and how they can be supported in their teaching (this does apply not only to our case of course: see e.g. Barth and Rieckmann, 2012). For roughly twenty years we¹ were co-responsible for study programmes at the University of Bern belonging to the field of ESD where we implemented and refined this framework of competencies and where quite some importance was attached to the issue of professional development of educators.

¹ In the remainder of this paper 'we' and 'our' sometimes refer to us as the authors, sometimes to us as part of the team whose experiences we describe in the paper, and sometimes to us as those in charge of some of the processes that took place within this team. We did our best to make it easy for our readers to sort it out and apologize if we did not always succeed.

Before expanding on how we did that (section 4), we will first shortly present these programmes (section 3).

3. General Ecology at the University of Bern: An example of degree programmes designed to impart students with competencies for inter- and transdisciplinary collaborations

From 1992 until 2013 the Interdisciplinary Centre for General Ecology (IKAÖ) provided degree programmes in General Ecology at the University of Bern.² "General Ecology" belonged to the broad field of sustainability studies but focused upon human-environment-interaction (for a more detailed account see Defila and Di Giulio, 2007). It endorsed an inter- and transdisciplinary approach in research and teaching as well as in its institutional organisation (on average the academic staff consisted of 20 scholars from more than 10 different disciplines, student assistants not counted). It was conceived as a field of research and teaching to which any academic discipline should have the possibility to relate and to contribute and therefore it was not meant to replace existing disciplinary approaches to environmental issues. Instead of aspiring to become a discipline in its own right, it aimed to preserve inter- and transdisciplinarity and to contribute to their professionalization.

The conception and character of "General Ecology" was reflected in the degree programmes: The degree programmes in General Ecology were conceived as minors only, that is, students had to attend a 'normal' disciplinary major, otherwise they were not allowed to enrol in General Ecology. They were open to students of all disciplines and provided them with a qualification in addition to their main subject. Consequently, in delivering the degree programmes in General Ecology strong emphasis was laid on relating the educational content to the students' major subjects and on complementing the students' competency in their discipline by enabling them to inter- and transdisciplinarily approach complex issues belonging to the field of General Ecology. Students learned to apply their disciplinary knowledge and skills in an inter- and transdisciplinary context and to design and contribute to inter- and transdisciplinary processes. The fields the students originated from were as broad as Biology, Business Management, Computer Science, Economics, Educational Science, Geography, Geology, German Studies,

² The IKAÖ has been closed by the end of 2013 due to strategic decisions of the university. Some of its tasks have been transferred to another centre of the university, the Centre for Development and Environment (CDE), and some of the experiences we made have been implemented in their degree programmes along with those staff members of the IKAÖ that changed to the CDE.

History, Human Medicine, Islamic Studies, Law, Philosophy, Physics, Political Science, Psychology, Mathematical Statistics, Media Studies, Modern English, Remedial Teaching, Social Anthropology, Sociology, Spanish, Sport Science, and Theology.

Four degree programmes in General Ecology were offered, three bachelor minors (15, 30, 60 ECTS credits), and one master minor (30 ECTS credits). The structure of these programmes can roughly be summarized as follows (the single elements were, of course, tailored to the master- resp. bachelor-level):

- Series of lectures (master and bachelor) introducing students to theories, concepts and findings essential to issues of human-environment-interaction and sustainability originating for one thing from the natural sciences, the humanities and the social sciences and for another thing from the interdisciplinary discourse (in case of the latter with special emphasis on theories allowing to relate disciplinary approaches, so-called "bridging concepts"), and encompassing an introduction to the history of the societal and of the academic debate about environmental issues and to how they interrelated.
- Seminar (bachelor only) where students read key works of the societal and of the academic debate about environmental issues and about sustainability.
- Seminar paper (master only) where students analysed environmental issues from the perspective of their own discipline by identifying how their own discipline would reconstruct and approach one chosen issue and which disciplinary theories and findings they could contribute.
- Seminar (master only) where students worked in interdisciplinary teams and by applying an integrated analysis-tool analysed environmental problems combining knowledge from the different disciplines represented in their teams.
- Field trips (master and bachelor) and field placement (bachelor only) introducing students to the perspective of experience-based experts and to how environmental issues were perceived and dealt with in different fields of practice.
- Project work (master and bachelor) where students in interdisciplinary teams and based on a rather broad outline of a topic (each team chose a different one) independently designed a research plan they subsequently implemented (duration on bachelor-level 3 months, on master-level 8 months). This course was accompanied by a seminar specifically devoted to theoretical and methodical knowledge about inter- and transdisciplinarity (depending on the chosen topic the projects on master-level were interdisciplinary or contained transdisciplinary elements also).

- Lectures and seminars (master and bachelor) allowing students to gain a specialised expertise in one environmental topic by attending a certain number of courses (disciplinary or interdisciplinary). The students chose the topic themselves as well as the courses they wanted to attend. The courses were 'normal' courses offered by the different faculties.

To sum it up, in the degree programmes in General Ecology different facets of interdisciplinarity came into effect:

- One of the major goals of the programmes was to equip students with the competencies needed for inter- and transdisciplinary collaborations to be successful.
- The students had different disciplinary backgrounds and corresponding teaching and learning cultures. Although the composition of subjects varied from cohort to cohort, the spectrum of disciplines always was very broad and encompassed humanities, social sciences and natural sciences.
- The single courses within the programmes addressed knowledge from different disciplines as well as knowledge originating from the interdisciplinary discourse.
- In delivering the courses scholars with different scientific backgrounds and corresponding teaching and research traditions were involved (some of them worked for the institute responsible for the programmes, others did not).
- The educators mostly taught students whose disciplines differed from their own. Hence, they were constantly confronted with a situation where the students did not share (and sometimes not acknowledge) their perspective; the students did not necessarily understand what appeared self-evident to the educators unless it was laid out very carefully. The challenges of interdisciplinary collaboration thus existed not only among the educators and among the students, but also between the educators and the students.
- Not all the educators had the same level of experience with inter- and transdisciplinary collaborations, and for the large majority of them inter- or transdisciplinarity was not a topic of research, that is, most of them had no scholarly expertise in inter- and transdisciplinarity.

4. Measures suitable to support educators in teaching inter- and transdisciplinary competencies

With a view to enabling the educators involved in delivering the degree programmes' courses we had to find a way of dealing with the abovementioned facets of interdisciplinarity. A first assumption we proceeded from was that not every single educator could and should develop an expertise in inter- and transdisciplinarity and in teaching competencies for inter- and transdisciplinary collaborations. The second assumption was that the whole group of educators involved in the teaching could be looked at as being an interdisciplinary team committed to a common goal and collaborating to achieve this goal by engaging in a process of consensus-building and integration and by individually contributing to the joint task (with some members being more intensively involved than others). The third assumption was that considerable effort would be necessary to make the vision implied in the second assumption to become reality for one thing and to deliver coherent and consistent interdisciplinary teaching in which interdisciplinarity was not only a teaching subject for the students but showed by the educators as well for another thing (Feng (2012) for example confirms not only this assumption but also the necessity of the interdisciplinary collaboration among the educators involved). These assumptions proved to be helpful in guiding our activities and in designing measures enabling university educators to teach students inter- and transdisciplinary competencies.

Basically, we proceeded along two complementary paths we will present in the subsequent sections: One path was to have interdisciplinary processes among the educators leading to a common understanding of the goals, character and content of the degree programmes, the other was to implement a series of measures directly aimed at supporting the educators in their teaching. Our approach stood the test, that is, we were successful in offering the students interdisciplinary programmes they valued and teaching them competencies for inter- and transdisciplinary collaborations (we do know due to studies in which we traced our students and asked them about how they assessed our programmes with the benefit of hindsight; e.g. Kaufmann-Hayoz and Lauper, 2012).

4.1. Facilitating interdisciplinary processes among the educators

One of the interdisciplinary processes among educators led to an agreement on the special quality of interdisciplinary teaching and to a commitment to meet these quality criteria. The quality criteria agreed on were informed by the special quality interdisciplinary research has to meet:

- *Synthesis*: In interdisciplinary teaching disciplinary approaches should remain clearly discernible but at the same time they should relate to a shared overarching problem/question, thus leading to an integrated point of view with regard to this problem/question. Interdisciplinary teaching is more than simply teaching theories, findings, and methods from different disciplines. Instead, the theories, findings and methods presented should be justified by their contribution to an overarching problem/question, be it one pertaining just for one course or for a whole series of courses. The contributions of the different disciplines to the overarching problem/question as well as the 'added-value' of integrating them has to be explicitly named (instead of leaving it to the students to detect it).
- *Common goals*: The participating educators should be convinced all learning objectives make sense, are relevant and valid, and they should all be able and willing to contribute substantially and identifiably to their achievement. To allow for that the learning objectives have to be detached from a single disciplinary perspective but at the same time unambiguous enough so that arbitrary interpretations can be excluded. The learning objectives belonging to individual lessons within a course and those belonging to individual courses within a series of courses should be derived from and geared towards overarching learning objectives and they should be aligned. The contribution of a lesson, of a course and of a series of courses to the overarching learning objectives should be clear at all times—to both educators and students.
- *Shared problem framing and language*: The topics treated in the single courses and lessons have to be selected and defined in such a way as to allow for specification and reconstruction from different disciplinary perspectives, thus ensuring that all educators involved and all students can identify with them and relate their own disciplinary worldviews. Both educators and students should refer to a common language and a common theoretical basis. To this end a common conceptual framework should be established. This framework should be referred to in the lessons and courses either by using the respective terms and approaches or by showing how they differ from those used.
- *Valuing disciplinary perspectives*: The single courses, the series of courses and the whole degree programmes should represent an appropriate spectrum of disciplinary perspectives. Care should be taken to also include disciplines that do not at a first glance appear to contribute most obviously to the topic. In this way, students can be shown that it may be worthwhile to combine disciplines innovatively and that promising contributions may come from disciplines that they may not have prioritised. In teaching disciplinary

theories, findings and methods the primary goal should not be that students not belonging to the according discipline reach the same level of expertise as those belonging to it, but that students recognise the basic approach of this discipline and are able to value its contribution and to develop reasoned expectations on scholars belonging to it. This implies to focus not only on the disciplinary theories, findings and methods that are taught, but also on how these approaches differ from each other, on how they complement each other and on the question whether there are any incommensurabilities.

The second interdisciplinary process among educators led to overarching didactic frameworks for everybody to refer to. These frameworks provided a binding guideline for educators when they proceeded to designing and planning lessons and courses. The single courses were packaged to series of courses, and for each series of courses (these units were called "module") one such didactic framework was developed, including the criteria to be used in the assessment of students. The development took place in the interdisciplinary team of those educators working for the institute responsible for the degree programmes. The external ones, that is, those not working for the institute were given the didactic framework valid for them and had the possibility of giving feedback, but basically they had to adopt it. When planning and delivering their lessons and courses educators had to refer to the didactic framework for the "module" their lessons and courses belonged to, and key elements such as learning objectives were communicated to the students as well. Care was taken to avoid unnecessary details in the didactic frameworks, so that they left sufficient scope for the educators to dynamically adapt and bring up to date their teaching content. The didactic frameworks encompassed the following elements:

- Learning objectives, defining what students should learn in the series of courses as a whole and in the single courses (depending on the courses' structure even in different parts of single courses).
- Topic(s) to be treated and specifications of teaching content, conceptual framework to refer to as well as criteria to use and how to proceed in identifying disciplinary theories, findings and methods to be discussed in the series of courses as a whole and in the single courses (depending on the courses' structure even in different parts of single courses).
- Didactic principles and teaching methods to be applied in the single courses (depending on the courses' structure even in different parts of single courses).

- Assessment of students, including procedures and criteria to be used provided in the format of assessment grids (to ensure a comparable application of these criteria, comprehensive tests were performed leading to a wording of the single criteria having the potential to be understood by educators from different disciplines and to be easily used by educators of any discipline).
- Administrative procedures regarding communication with students, provision of teaching material etc.

Both processes were meant to establish a shared and integrated understanding of what and how students should be taught in the degree programmes in General Ecology in order to deliver coherent and consistent teaching. They also should ensure that the educators involved did not only talk to the students about competencies for inter- and transdisciplinary collaborations but also set an example in their own doings. Finally, the intensive interdisciplinary debates among the educators should endow educators with a more in-depth knowledge about their own disciplinary worldview and at least to some degree about the approaches, achievements, and limitations of other disciplines as well. These goals were achieved. Due to these processes educators were provided with a common basis for their actions and the different teaching elements were prevented from drifting apart. The processes contributed to a mutual understanding among the educators, and they raised the educators' awareness with regard to their own disciplinary worldview but also with regard to the performance, approaches and quality criteria of their colleagues' disciplines. Finally, the products developed, such as the didactic frameworks and the corresponding assessment grids, allowed for a transparent communication with the students and allowed students in turn to see how individual lessons and courses were aligned, what they should learn in the different courses and by what criteria they were going to be marked.

4.2. Measures directly aimed at supporting the educators in their teaching

As mentioned above, to complement the interdisciplinary processes among the educators we implemented a number of measures directly aimed at supporting the educators in their teaching. In the following we will present the three most important ones.

A first measure on the organisational level was to make sure the academic staff of the institute responsible for the degree programmes encompassed a research group primarily dealing with

issues of inter- and transdisciplinarity thus including the scholarly expertise about inter- and transdisciplinary collaborations right into the organisation. This group, which was led by the two of us, was responsible for one thing to design and facilitate the interdisciplinary processes among the educators and to develop a framework of competencies for inter- and transdisciplinary collaborations students should be equipped with. For another thing we had to deliver tailored professional development sessions when needed and to provide for a small stock of publications helping educators to familiarise themselves with basic knowledge about inter- and transdisciplinarity and about the scholarly debate on inter- and transdisciplinarity. Furthermore, we provided teaching material educators could use to integrate uncovering and reflection of disciplinary worldviews into their courses, that is, material helping educators to impart to students competencies belonging to the group (a) of our framework of competencies (Defila et al., 2000; similar teaching material has been developed e.g. by Repko et al., 2014).

A *second important measure* was to extensively install tandems, team-teaching, resource persons-systems and similar. In all courses of the degree programmes at least two scholars with different academic backgrounds were involved (some of them worked for the institute responsible for the programmes, others did not). Some of the courses were in whole or in part collaboratively planned and delivered by two educators (team-teaching in its pure form), in others one educator was responsible and others were associated for special issues or events or as resource persons the educator or the students could consult for defined questions, in others the different parts of the courses were assigned to individual educators having to collaborate with a view to coherently aligning these parts. Still in others collaboration was restricted to the assessment of students' achievements. In these cases written and oral achievements were assessed by two educators belonging to different disciplines thus ensuring that the evaluation was not biased by just one disciplinary perspective and relieving educators from the burden of deciding on their own whether they were disciplinary biased or not in their assessment. If disciplinary quality criteria were given considerable weight within an assessment, one of the educators in charge of the assessment had to belong to the same discipline as the student. In lecture series, in which the single lessons all were delivered by other (mostly external) educators, the single educators were carefully briefed on the overarching topic, on the contribution expected from them, and on what the previous and following educators taught so they could relate. Furthermore, a teaching assistant belonging to the institute attended the lecture series in order to help students in integrating and comparing the perspectives addressed by the educators and in order to give feedback to educators. Finally, the seminars specifically devoted to theoretical and methodical knowledge about inter- and transdisciplinary

collaborations (competencies belonging to group (b) of our framework of competencies) were entrusted to a member of our research group, that is, to someone with specialised scholarly expertise in this field.

A *third* important *measure* was the establishment of a peer-to-peer-coaching by the involved educators themselves. Meetings of coaching groups provided for a regular exchange where educators could discuss questions and problems they came along in their teaching. We had several such groups, that is, one for each course or series of courses, depending on the special challenges accompanying the respective course or series of courses. The educators involved constituted the respective group, and each group decided on its own how the exchange was to be organised, depending on the needs of the educators. Not all had intensive interactions. Having such a group was particularly important for educators involved in courses in which students conducted interdisciplinary projects, because the educators coaching these students' teams always had expertise in the issue investigated by the students but not necessarily in inter- and transdisciplinary collaboration. And although all of them had a tandem partner they valued the possibility of discussing the challenges of coaching an interdisciplinary team of students and dealing with their different disciplinary perspectives in the peer-group.

These measures aimed not only at providing a direct support for the educators and thus at easing their job, but also at providing a 'job-tailored' professional development of the educators. Educators had different opportunities to exchange and reflect their experiences, discuss their course of action, and get feedback and advise from each other. Due to that they adapted their competencies and acquired new ones—not through abstract considerations but through considerations with a distinct practical orientation. Discussing not only the questions and challenges they themselves came across but also those the other members in the peer-coaching groups met broadened their horizon of experiences and thus contributed to the development of their competencies. Furthermore, the proximity to the everyday experience of the educators allowed us to provide for tailored professional development sessions or scholarly inputs regarding theories and methods of inter- and transdisciplinarity. But most of all, all these measures were the factual proof to the educators that inter- and transdisciplinary teaching was taken seriously and that educators were allowed to be insecure in teaching heterogeneous groups of students, in teaching students belonging to other disciplines as they did and in teaching students inter- and transdisciplinary competencies.

5. Conclusions

Participating in projects with people from different disciplines or simply being introduced to knowledge from other disciplines do not automatically equip students with the required competencies for successful interdisciplinary collaborations (see also Feng, 2012). Rather, students have to be provided with special courses in which they are taught theoretical and methodical basics of inter- and transdisciplinary collaborations and in which they are instructed how to reflect their experiences and to learn from them (the importance of "well-designed learning settings" has recently been pointed out again by Fortuin and van Koppen, 2015, who investigated students' reflexive skills and show how they depend on learning settings). The same applies to teaching: Engaging in teaching in a multidisciplinary group of educators, having to deal with a group of students belonging to different disciplines and wanting to teach competencies needed in inter- and transdisciplinary collaborations do not automatically equip an educator with the required teaching competencies (see e.g. Feng, 2012). Measures aimed at 'training the trainers' are thus indispensable (as has also been pointed out by Barth and Rieckmann, 2012). Both, teaching students and enabling educators have to be based on research on inter- and transdisciplinarity. Accordingly, academic organisations wanting to offer teaching programmes equipping students with competencies for inter- and transdisciplinary collaborations have to make sure they have access to respective experts.

We are well aware of the fact that some of the measures we implemented are out of reach for many university institutes, but it is nevertheless possible to implement them by analogy. Not every institute can for instance afford a specialised research group for inter- and transdisciplinarity supporting the development of curricula and the educators in their teaching. But something every university and every institute could afford would be to commission experts to support and counsel faculties or institutes in designing and delivering courses aimed at equipping students with inter- and transdisciplinary competencies and/or to deliver special training courses for their educators (one example how this could be done is discussed by Barth and Rieckmann, 2012). To a certain degree it is a question of prioritisation. Something similar applies to team-teaching. Team-teaching is an ideal way of delivering interdisciplinary teaching, provided the educators collaboratively plan and deliver the courses and lessons. If educators adopt an attitude of simply sharing-out the sessions between them and each focussing on his/her own teaching input, the sessions will lack coherence and integration. A similar outcome can be expected if the educators do not attend and actively join in every lesson. Team-teaching

is costly both in time and money. In its pure form it can therefore only be implemented for a very small number of courses. But, to our experience a number of other teaching forms can be used that have a similar effect, such as assessment tandems, resource persons, peer-to-peer-coaching or teaching assistants accompanying courses and helping educators to relate and students to compare and integrate the different perspectives discussed in a course.

Something every institute can implement is to plan for interdisciplinary processes among the educators leading to a common understanding of the goals, character and content of the teaching and to educators acting as 'interdisciplinary role models' for their students. To our experience, this was the most important measure we implemented (we thus concur with the importance attached to that point by DeZure, 2010 and by Feng, 2012). To make it a success though two requirements are needed, an organisational context of mutual interest and an interdisciplinary staff of educators being willing to learn from other worldviews and to relate their own worldview to that of others. Such processes require a lot of engagement by the educators. But they do not only contribute to a high teaching quality, they can pay off in research as well, when sharing views with scholars from other disciplines opens up new fields of research and new research collaborations and/or gives new impulses for disciplinary research.

Some challenges remain, whatever measures are taken to make it easier for educators to cope. To our experience the most important ones are the following (for a discussion of challenges concerning the academic position of scholars engaging in interdisciplinary teaching see e.g. Pfirman and Martin, 2010):

Students must have enough opportunities, and enough leeway in choosing and substantiating topics for project papers and similar, to link the topics addressed in courses and their own disciplinary perspectives. Otherwise they cannot learn how to define and bring in their individual disciplinary contribution in approaching complex issues. To support students in building such bridges educators need, for one thing, a very broad and ramified body of knowledge they can activate in teaching. For another thing, they must transfer the responsibility of leading the way to the students, and they must be willing to get involved with the students' perspectives. To allow for that educators must be aware of their own pet subjects and pet theories and let go of them.

A related challenge for educators concerns their role in interacting with students. In interdisciplinary teaching educators often must refrain from the idea of knowing more than the students and treat students as experts of their own disciplines instead. This is necessary in

teaching settings where students shall develop the ability to take on the responsibility for representing their disciplines or where students have to bring in their disciplines into an interdisciplinary discussion and/or a project paper and similar—and the students' disciplines and those of the educators differ. In such cases educators do not teach, they coach. Furthermore, educators have to adapt to the idea of not always having the necessary technical knowledge needed to evaluate everything the students deliver in oral or written assessments.

One further challenge having to do with the relation of students and educators concerns the lack of interest students sometimes show when they should engage in discussions about disciplinary worldviews (an experience shared by Feng, 2012). Students as a rule do not yet possess fully fledged identities in their disciplines. Therefore, to engage in a reflection of their academic profiles is even more difficult for them than it is for experienced scholars. They may experience it as unsettling and in turn shy away from this kind of discussion. If the educators do not belong to the same discipline as the students it is difficult for them to decide what they can demand of the students, to support students, to endure students' resistance and not to give in to students' non-compliance too easily.

The last major challenge concerns the disciplinary identity of educators and the way they bring in their disciplinary expertise in interdisciplinary teaching. When covering complex issues in teaching, the body of knowledge that could be presented is basically infinite. Because of that, in interdisciplinary teaching as a rule every theory or other piece of knowledge that is addressed could be questioned and has to be justified (see also Feng, 2012). That is, educators have to (or at least must be able to) reason why something is of relevance far more than in a disciplinary setting where they can refer to a body of knowledge the disciplinary community estimates as crucial for future scholars. And in presenting disciplinary theories and findings to a heterogeneous group of students educators have to master the difficult task of doing so in a way not being tailored to a disciplinary public, but nevertheless being academic.

Our experiences refer to the specific setting of interdisciplinary minors where students are enrolled in different disciplinary majors at the same time. But they can be transferred by analogy to other settings such as majors where students either develop different academic profiles within the programme or to programmes at master level where teaching relates to the students' different main subjects they were enrolled at bachelor level.

In the scholarly debate, interdisciplinary teaching and teaching inter- and transdisciplinary competencies are often put in second place while the scholarly attention given to inter- and transdisciplinary research has considerably grown. We are convinced the two go together and the 'teaching side' merits further scholarly investigations in order to find out more about how to help educators to master the challenges in a state of the art way. In this paper we presented some tried and tested possibilities on how staff development and support of educators could be approached in practice for one thing and a research-based framework of competencies for inter- and transdisciplinary collaborations for another thing. Thus, we hope to contribute to this reconciliation of research and teaching.

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