Towards competence-oriented learning in rural development: Transdisciplinary Student Team Investigation in Mexico, Colombia, Nicaragua and China

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Abstract: *Transdisciplinary research approaches are gaining ground among the efforts of universities to fulfil one of their central tasks investigating societal problems and contributing to solutions. In parallel, there are ongoing debates and trials on more competence-oriented concepts of university education. In the Latin-American – European network "Rural Society, Economy and Natural Resources - Integrating Competence in Rural Development" (SERIDAR) an integration of both approaches has been tried. Scientists and practitioners in rural areas have jointly elaborated research problems, which were then investigated – among other formats - with interdisciplinary teams of students within study programmes related to rural development and agricultural sciences. These projects had dual purposes: conveying essential professional competences to students and generating knowledge for and with participating rural actors. Evaluation by these actors was very positive; students and faculty gave a favourable assessment but also found various challenges and different solutions for them. This article provides academic staff with insights into the didactic concept, tested and adapted in several countries according to local conditions, among them Mexico, Colombia, Nicaragua and China/Germany. Results of a comprehensive evaluation and systematisation process on local and international level are presented, with conclusions on factors and conditions necessary for the implementation and integration of transdisciplinary and problem-based student team research into university curricula as well as on this format as an element of collaboration among universities and societal stakeholders. It contributes to the discussion and reflection among lecturers and universities on competence-based curriculum development and on strategies to increase regional relevance of academic education.*

Keywords: *transdisciplinary education, learning processes, competence-oriented curriculum development, systematisation, transdisciplinary student team research*

Introduction

The need for training complex problem-solving competencies in higher education and the SERIDAR approach

The quality of education for students of agricultural sciences determines their professional capacity to tackle complex problems in their field of work. It becomes apparent that this relates not only to the knowledge to be acquired but particularly to methods, attitudes and practices to be mastered (Lacki, 2003; Sarandón and Flores, 2010). Hence, and this is the challenge, more holistic professionals need to be trained with a pluralistic vision of food, production and socio-culture, with sensitivity regarding human and social problems of rural families and the capacity to understand and interrelate technical, economic and social issues (Lacki, 2003) in the local and global context (Ramón, 2010) - in short, complex problem-solving capabilities.

Study programmes in rural and sustainable development need to consider that governmental and academic institutions, enterprises and civil society organizations intervene in processes of rural transitions. Interventions and proposals for solutions imply confluence and dialogue

of different disciplines and collective action of local stakeholders. They further require the deployment and co-development of different knowledge types: technical, empirical, scientific, practical, abstract and local (Nicolescu, 1996; Morin, 2006; Luengo, 2012); systems knowledge, target knowledge and transformation knowledge are needed for analysing, developing and implementing (pathways to) new solutions (ProClim, 1997).

Although study programmes have already taken up such competence needs in the formulation of their learning outcomes, we have observed that the learning activities (lectures etc.) often do not yet match these ambitions and consequently fail to ensure that students are able to acquire the competences mentioned in the programme learning outcomes. It is obvious that developing this wide array of competences requires different didactic approaches, such as described e.g. in Riseman et al. (2005), Steiner and Posch (2006), Larsson et al. (2009), Biggs and Tang (2011), Fiege (2012) and Wilhelm et al. (2015).

Seven universities in Mexico, Nicaragua, Costa Rica, Colombia, Ecuador, Spain and Germany have partnered in the EuropeAid-funded project "Rural Society, Economy and Natural Resources – Integrating Competences in Rural Development" (SERIDAR). It aims at increasing local relevance of university research and education through transdisciplinary networks in selected Latin American regions.

In order to bridge the gap between the academic and non-academic knowledge systems, university staff have integrated themselves in local stakeholder networks involving various types of actors like farmers' groups, youth, peasant women, NGOs, GOs, academics. Round-table meetings and other joint events are organized to elaborate and prioritize locally relevant knowledge needs and possible topics for research and capacity-building activities, to be integrated into research programmes. Research topics are then taken up in thesis work of students, in the joint doctoral programme and possibly also in larger international research projects. At each university, a liaison person was responsible for facilitating this process. The development and experiences with these transdisciplinary networks are discussed in Hofmann-Souki et al. (2014a).

Various research and education activities in SERIDAR hence follow a transdisciplinary approach, for example problem-based student team research projects as a practice-oriented learning activity within different study programmes. The term transdisciplinarity refers to joint problem-solving approaches by academics and practitioners within research processes which involve strong interaction, exchange and co-production of knowledge (Steiner and Posch, 2006; Hollander et al., 2008; Hirsch Hadorn et al., 2008) aimed to contribute to both societal (Polk, 2014) and scientific progress (Jahn et al., 2012). This involves both interdisciplinary integration (i.e. integrating research of different disciplines) as well as science-practice interaction (Wright Morton et al., 2015).

For most of the universities in the SERIDAR network, these transdisciplinary student team research (TdSTR) projects constitutes a new element in their study programmes, and therefore are planned and implemented as pilot projects for testing purposes. As mentioned before topics of the pilot projects have arisen from a process of negotiation with local actors in the networks the universities participate in (see Hofmann-Souki et al. 2014a). Departing from real-world problems in rural areas, the approach constitutes a proposal for aligning certain learning activities with the competences to be developed by professionals in rural development and farming. At the same time, it allows universities to deliver on its responsibility towards local communities and society. Lessons learnt from implementing TdSTR projects are shared in this article.

Objectives and research questions

There are common problems with respect to academic teaching in most universities including those participating in the above-mentioned project on rural development. However, the conditions under which the universities, lecturers and students operate are not the same. Hence it cannot be expected that one envisaged solution is similarly suitable in each case. While we have put forward a common overall didactic concept and method, TdSTR, it was to be expected that implementation would mean adaptation, and that a comparison of the

results and experiences made in the different universities/countries would yield valuable insights into the method's effectiveness as well as possibilities for its improvement. This may help faculty in the field of sustainability science and rural development to better answer the needs of students and of actors in rural development with whom they collaborate. Moreover, it may offer a tested model for integrating educational activities for students with ongoing or planned transdisciplinary research processes of faculty.

The objective of this article is therefore to contribute with a tested transdisciplinary learning format to the discussion and reflection on strategies to increase regional relevance and pedagogical fit of higher education in the fields of sustainability and rural development.

Pilot projects in four countries are analysed in this paper, focusing on the following research questions:

1. What characterises TdSTR projects as implemented in the four countries?

2. What are the conditions necessary for this form of teaching-learning to be successfully implemented?

3. What are major challenges and how may they be overcome?

4. What are the central conditions, components and activities for the TdSTR projects to serve the users of their research results (in our case actors in rural development)?

First, the TdSTR approach used in the network will be described. The methodology of systematisation used is explained in the following section. The pilot projects and evaluation results are described in brief before discussing outputs of the systematisation regarding the four research questions.

The didactics of transdisciplinary Student Team Research

Transdisciplinary research implies that ideally two parallel joint learning processes are created: a learning process regarding the production of the research output as well as a learning process regarding the personal and joint capacity of all involved to do transdisciplinary research (Lang et al., 2012; Roux et al., 2017). Both learning processes follow the principle of iteration which implies that participants learn from reflecting on their experiences and then develop new concepts for action (and research), based on that reflection (Kolb, 1984).

This inherent learning focus also allows for integration of students into the process (Posch and Steiner 2006). The questions and problems developed within the TdSTR methodology are preferably derived from a knowledge need of practitioners and aim at creating a concrete output for specific users who demanded the study (Hofmann-Souki et al., 2014b). As such, they may be part of a larger transdisciplinary collaboration process of university staff and practitioners. TdSTR projects have two purposes: a) development of students' professional competencies in methodological-analytical, knowledge-related as well as in social dimensions, and b) to contribute with useful knowledge to and support joint learning in local stakeholders' development efforts. This transdisciplinary approach differentiates the chosen methodology from conventional PBL, and it has important implications in all phases of the course (Hofmann-Souki et al., 2014b).

This dual purpose of TdSTR implicates that objectives for the pilot projects are formulated on two levels: learning objectives for participating students, and research objectives for the investigation to be done. Based on these, learning activities need to be offered that ensure students are able to reach these objectives, as stipulated by Biggs and Tang (2011) regarding constructive alignment in teaching. The didactical concept and its foundations are further described in Hofmann-Souki et al. (2014b).

In essence, the pilot projects include between 4 and 13 students, often from different study programmes, and are usually supervised by two or three lecturers of different disciplines. Practitioners as users of the outputs have an essential role in different project phases. Facilitated by the lecturers, the student groups plan and implement the projects, which implies to clarify the purpose, the intended outputs as well as the use of the outputs by

different stakeholders. The students then elaborate the theoretical and analytical framework, plan and implement the methodology for obtaining and analysing the results (with a strong component of local users' participation), as well as present them in a way useful and applicable for the users and as required for university assessment. During their work group members need to plan and act collectively and individually, communicate within an interdisciplinary and transdisciplinary context and reflect on the result elaboration and group processes that evolve (Hofmann-Souki et al., 2014b).

The role of lecturers is that of observers and facilitators of joint learning, in particular in conceptualization and reflection phases. They ensure scientific quality of the work, appropriate communication with the stakeholders involved, spaces for reflection and feedback, and examination of those results which are included in student assessment. Some specific input is usually given mainly as methodological trainings on research methodologies or teamwork techniques.

A similar approach is described in Posch and Steiner (2006) for the application of transdisciplinary case study research. Acknowledging the positive impact of that approach in sustainable regional development, the TdSTR methodology may be used in similar or other problem settings, as it is designed to fit into the underlying transdisciplinary processes of which the TdSTR studies should form an integral part.

Methodology

The concepts of the pilot projects had been elaborated on the meta-level of the international working group in two joint workshops in 2012 and 2013, respectively. It had been clear from the beginning that after their implementation, the universities would need to decide whether or not to continue with such a type of learning activity within their curricula, and if so, how to institutionalise and improve them. But how could we know in how far the innovation was successful, so as to justify its institutionalisation? And beyond that, what can be learnt about transdisciplinary didactics in the field of sustainability? An analytical framework was constructed where elements of evaluation were embedded in a methodology based on systematisation of experiences. This methodology is described and discussed in more detail in Hofmann-Souki et al. (2014b); hence, we present here some basic aspects only.

Both evaluation and systematisation constitute collective learning processes. Main objective of the evaluation was to understand how the pilot projects have been implemented, how well the method has functioned and how participants value the learning process and results. Systematisation, in turn, focuses on analysing the experiences and on the process as a whole; it is not limited to the project logic itself, allows to link several aspects and may include dimensions beyond those covered in the evaluation. It promotes reflection, reconstruction and critical interpretation of experiences (Berdegué et al., 2007; Jara Holliday, 2012) and thus helps to achieve broader but systematic learning. Implementing pilot projects represents a form of introducing a practical experience for the lecturers to be learnt from, systematising the experiences offers a methodology for making the experiential learning explicit and transparent. Hence, the data generated in the evaluations was then analysed in the systematisation phase, using the framework explained below and guided – among others - by the research questions mentioned above.

Five basic phases are distinguished in the process, involving different actors in each step. They are summarised in Table 1. In the preparatory workshop (Phase 0) the key persons to be involved in the different phases were identified as well as the respective point of departure (initial situation at each university, context, and delimitation). The objectives and a list of criteria were developed. Based on the criteria, a small team of participating lecturers elaborated indicators, directed at different target groups.

Table 1. Steps in the systematisation process, stakeholders involved and methods used

Phases in the syste-matisation process	Actors involved/targeted	Description and scope of methods
0. Definition of status quo, preparation of procedure and analytical framework	12 Lecturers implementing the pilot projects, some decision-makers on curriculum development	An international team with professors from the universities integrated to the SERIDAR project, developed a workshop for the design of a guide with eight criteria and 32 indicators for systematisation.
I. Evaluation of each pilot project	Around 265 Local actors who are the users of the pilot project outputs and with whom the initial agreement had been made 32 Participating students 12 Participating lecturers	Each of the 4 work teams per country evaluated the pilot projects regarding their results at the national level. Different means were used, such as instruments of participatory evaluation, especially focus groups, interviews. Anonymous questionnaires with rating scales and open questions (for students) for triangulation. Feedback of users of the project.
II. Systematisation per university	12 Participating lecturers Other lecturers who are responsible for the study programmes	From the review of project documents, an assessment of the scope of each pilot project was made. The information obtained was triangulated to identify matches and inconsistences in the results.
III. Systematisation on international level (across participating universities)	12 Participating lecturers Other lecturers who are responsible for the study programmes SERIDAR's project Board (steering committee)	A new international workshop allowed to socialize and analyse the results of the systematization by country, in a whole global exercise. This analysis was made based on the guide of 32 indicators.
IV. Discussion and publication of results	All of the above, and further interested persons and organisations	

Phase I involved a description and evaluation of each project (components, activities/actors, resources, results, difficulties encountered, unexpected results, opinions on future application and sustainability) and yielded data at the level of each pilot project. Data was collected through anonymous evaluation questionnaires for students as well as through individual and/or group interviews with all participant types. Profound analysis of the data started in Phase II at each university (covering one or two pilot projects). Both the evaluation and the systematization were based on the proposal of Chávez-Tafur (2006) that differentiates the phase of description and analysis of the experience based on analytical criteria and indicators.

Indicators had been defined for the following criteria:

a) Learning by students, faculty and local actors
b) Usefulness and quality of the various results – for the local actors and for the theoretical and methodological debate in the SERIDAR network
c) Level of implementation of the transdisciplinary and participatory focus
   • Roles, level of participation of every type of (university and non-university) actor
   • Achievement of the principles and valuation of the process, commitment for follow-up
d) Level of implementation of the TdSTR methodology
e) Usefulness and satisfaction of the training course (i.e. of the capacity-building modules within the pilot projects on participatory research methods and teamwork techniques)
f) Achievement and effectiveness of the process (phases, schedule)
g) Costs and time invested (in relation to the results achieved, the learning progress and in comparison to other formats of teaching and research)

h)   Overall evaluation: Effectiveness of the transdisciplinary PBL methodology in relation to the specified objectives

Analysis across countries was continued in Phase III in an international workshop. Preliminary conclusions and recommendations were derived there, too. In-depth qualitative content analysis of evaluation data was performed. Results of an external evaluation of the overall SERIDAR project (Berlanga and Hernández, 2014) served as additional input for data triangulation.

In this article, we present and discuss results of the systematisation focussing on four selected questions, as described in Chapter 1. We assume that those are of most interest to a wider public, in particular to faculty who consider introducing transdisciplinary learning formats into higher education curricula.

Description of pilot projects and main results

Given the wide array of aspects included in the evaluation and systematisation framework and the limited space available here, we present below the most important results (of Phases I and II) only.

Depending on the structure of the study programmes, projects were conducted in different formats, ranging from six-week-full-time to nine-month formats running in parallel to other courses. At UNAN and HU students received credits for participation, whereas at UN and UACH it was an activity additional to the regular courses of the programmes.

Research objectives were formulated in close collaboration with practitioners, based on locally perceived problems. In the Latin American cases they were a result of discussions within the local networks into which supervisors had immersed themselves. In the case of HU, the study project was designed as part of a larger transdisciplinary research project that built upon an even longer-term relationship with local stakeholders in China, so that the research objectives were oriented towards serving the research team, feeding into the overall project's objectives. All projects were application oriented.

Agreements with the practitioner partners were made in all cases, though differing in aspects and scope. In some cases (UACH, HU) the research concepts elaborated by the students were approved by the partners before the empirical research phase started. Besides the involvement of practitioners in data collection, results were discussed with them, so that they received an outside view on their situation. Final deliverables were agreed in accordance with their requirements (see e.g. Aenis et al. 2013). In most cases the practitioners were also involved in evaluation of the pilot project, both regarding results and process of the collaboration, as stipulated in Acevedo et al. (2013).

Characteristics of the four study projects are summarised in Table 2.

Table 2. Main characteristics of the study projects analysed

Institution	Project topic	Stu-dents	Lect-urers	Local actors	Main factors shaping the project?
					Position of the project within the training plan
UACH - Mexico	Water management for cattle raising in the mountains	6	2	75	It represented an additional project under review to be included in the master's program in Regional Rural Development
HU - Germany and China Agricultural University	Village Perspectives on Rubber Cultivation	13	4	55	It constitutes a regular course of the HU 'programs as an elective module named "Study Project".
UN - Colombia	The multifuncionality of the irrigation distritct El Triángulo	8	2	70	The pilot was developed as a special project offered to students of different

	del Tolima					university programs.
UNAN - Nicaragua	Use and management of water in the ecoforestry system	5	4	65	It constituted an additional project to the training programs developed in extra time of students and teachers.

At its campus in Chiapas, the Autonomous University Chapingo (UACH) implemented the study project within its M.sc. in Regional Rural Development (UACH-MCDRR). Students having backgrounds in anthropology, veterinary medicine, animal breeding, sociology, tourism and informatics, furthermore two lecturers of rural development and a scientist of ecology, at the side of farmer families from five communities within the Biosphere Reserve La Sepultura in the Sierra de Villaflores, Chiapas. Research objectives were 1) the identification, through participatory analysis, of social water management practices – rules and agreements which the farmers have for water use and distribution; 2) establishing the status quo of water bodies as well as a critical path for water management for cattle raising in the mountains.

At the Institute of Agriculture and Horticulture of Humboldt-Universität zu Berlin (HU), Germany, the study project was planned as part of a transdisciplinary multi-stakeholder research project on sustainable rubber cultivation in southern China (SURUMER). This meant that part of the users of the research results were researchers themselves at Chinese and German universities. The other user of the results, Nabanhe Watershed National Nature Reserve (NRWNNR) Authority, was the main local collaborating partner, the nature reserve administration in the research region in Southern China. Msc-student participants originated from the USA, Mexico, Malaysia, Germany and China, they had different disciplinary backgrounds, under the supervision of lecturers from extension and communication science as well as agricultural economics divisions. The task was to perform a stakeholder analysis of rubber cultivation in the research area as a baseline study for further research activities within the larger SURUMER project. The research objective was to generate an understanding of the different stakeholder groups, their characteristics, communication networks, interests and problems perceived with relation to rubber cultivation in the Nature Reserve.

National University of Colombia (UN): An inter- and transdisciplinary team composed of students of sociology, political sciences, geography, agricultural engineering and agronomy, two professors of agricultural sciences with farmers developed a participatory study project about the Irrigation District of Triángulo del Tolima, which is a large-scale irrigation scheme of the Ministry of Agriculture. The structure is being constructed in settlement zones of indigenous people and peasants, and may put at risk the survival of these communities in case a mono-productivist plan is imposed and the various functions are nor recognised and valued that the territory fulfils in the lives of these communities. Research objective was a joint understanding of the multifunctional characteristics of the communities´ agricultural systems in the territory of the Guaguarco rivershed, highlighting the potentials and limitations for the planning of rural development programmes with a territorial focus for the district.

At the National Autonomous University of Nicaragua in Managua (UNAN-Managua) the project has been implemented in the semiurban region Pochocuape. Research objectives included: a) understand the status quo of the water resource; b) understand the organization of actors; c) characterize the practices and tendencies of water use and their impact on production systems; d) jointly elaborated alternative solutions that satisfy the water needs in the territory. Undergraduate students of economics and agricultural economics participated, as well as lecturers of agronomy, economics and residents of Pochocuape.

According to the external evaluation of the overall SERIDAR project, the beneficiaries – both students and practitioners – had a very positive perception of the pilot projects. Students valued the increase of teamwork and applied research skills, of their capacity to become involved with local actors, and of developing self-confidence. Practitioners positively valued

the research results and the trustful relationships created with the research teams. They actually demanded continuation of the collaboration in such projects. From the perspective of supervisors, the experience was generally positively valued. However they had difficulties regarding the necessary resources and/or to fit the projects into the curricular logic (except at HU). According to the evaluators, the approach forms an important alternative for producing knowledge and competences, if faculty and students are trained in the didactics and in participatory research methods. They further stress the strengthened role of the university in society.

Country-specific results are summarised in Table 3.

Table 3. Core achievements, challenges and surprises highlighted in the evaluations

	Core achievements	Main challenges	Surprises
UACH – Mexico	Widened perspectives and specific applicable knowledge created together with practitioners	Short time frame available in the study programme limited the elaboration of results	Increased motivation of student and staff to work with rural communities
	All participants highlight strongly increased transdisciplinary communication and teamwork skills	Roles were not always clear for everyone	Gender sensitivity and tolerance towards diverging ideas found to be a challenge even though participants were well-meaning
	Most students feel capable of doing a small problem-based research project	Research objectives had to be agreed in bilateral instead of multilateral meetings, at the end not all communities agreed with the specific research objectives elaborated	
	Staff considered effort and cost invested in the PP to be adequate		
	Space for reflection among staff created, new TdSTR activities planned	Learning objectives on leadership could not be achieved	
HU/CAU - China	Students succeeded to plan and implement the project under conditions of considerable uncertainty	Large group size and distance to study location made collaboration difficult	Students were surprised how much effort and diligence are needed for qualitative research
	Results evaluated as valuable by users	Participation of individual farmers was restricted in the Chinese institutional system	Interest of practitioners in the project rose with time
	All students stressed high learning achievement in teamwork and methodological-analytical skills	Differences in opinion between lecturers and some students about the timeliness and extent of inputs form lecturers	
	Higher work satisfaction for lecturers		
UN - Colombia	Students gained skills to structure, plan, implement and evaluate a research project with the methodology practiced	The lack of time and resources in order to work more with the community	The high participation of representatives of the communities involved since the preparation of the project
	They also gained capacity for group work, moderation techniques and interdisciplinary communication skills	Despite the enthusiasm of the students, their academic occupations prevented them from participating more than in the planned activities	
	The students reinforced satisfactorily their commitment and aptitude for extension and joint learning with farmers		
UNAN - Nicaragua	Lecturers observed largely increased knowledge of students on research methodology and on the multi-faceted realities of rural communities. Existing theoretical knowledge validated	Composition of research team remained disciplinary due to organisational limitations	Through its approach the project served to re-discover reinforce existing participatory activities with the communities and the commitment of all actor groups
	All participants attested clarity about their role in the project and could contribute accordingly	Learning achievements of students were unequal due to the large variation in their points of departure and the role assumed in the project	Despite withdrawal of international aid, new partners and sources of funding for activities with rural communities were discovered on the way
	Lecturers have learnt to serve as facilitators	Effective horizontal coordination; Managing differences in opinions, approaches and expectations: creating trust in the process	
	Noticeable advances in building relationships among actor groups, although still room for improvement	Lecturers have varying capacity	

Community members have learnt about their own water system through reflecting on students' research and external view, knowledge served for making plans	for facilitating team research	The ongoing process of curricular renewal acted in favour of including TdSTR
	Insufficient resources for extended participation and analysis, planned achievements needed adjusting to available time, costs covered through external sources	

Analysis and discussion

Here the case-based results are analysed across countries – following Phase III and IV of the systematisation - and discussed with a focus on the research questions formulated for this article.

What characterises TdSTR projects as implemented in the four cases?

The aforementioned characteristics of the projects are in line with principles of transdisciplinarity (Hirsch Hadorn et al., 2008; Brandt et al., 2013). In such participatory projects learning processes are developed both regarding the research topic and the collaboration (Hirsch Hadorn et al., 2008). However, as students were involved in these pilot projects, their learning advances constituted another layer in these processes.

Specific learning activities included training workshops on teamwork techniques, communication and/or participatory methods, and in the case of UACH practitioners also participated in these trainings, at UNAN training was organised for faculty, too. Joint learning was possible if all participants, including lecturers, adopted a reflective attitude within the participatory approach followed (Hollaender et al., 2008; Luengo, 2012). This included joint construction of knowledge as students shared and discussed their research concepts and later-on their findings with all participants. Practicing inter- and transdisciplinary communication became therefore a central feature in all pilot projects.

However, due to the small scope of the pilot projects, limited resources and the small number of students engaged, there were no separate disciplinary subgroups investigating different aspects of the problem, and the outputs therefore did not lend itself to a full interdisciplinary synthesis as described e.g. in Posch and Steiner (2006). Results helped to fill knowledge gaps and stimulated the science-practice knowledge exchange, but – although implementation-oriented – were mainly restricted to analysis, sketching possible solutions in some cases. This highlights the need to define the objectives and expected outputs in accordance with the capacities of the research team. Larger topics could then be split into two consecutive projects, for example.

What are the conditions necessary for this form of teaching-learning to be implemented?

It emerged that the initial condition for guaranteeing the success of this method is a thorough understanding by faculty of the different teaching-learning paradigm – a paradigm that according to Gorghiu et al. (2015) represents an effective form of working with students, supporting them to develop abilities in different curricular domains. This paradigm requires the generation of capacities in the scientist lecturers for facilitating student teams, mastering new methodologies (selection and implementation of participatory and transdisciplinary research approaches) and forms of communication (interdisciplinary mutual understanding, generating trustful environments, assertive dialogue with farmers, conflict management).

Since interaction among the participants in the process is based on experiential, educational, and cultural dimensions that induce different types of knowledge and cognition (Vilsmaier et al., 2015), each of them need to take on specific responsibilities. The lecturers need to be proficient in elaborating learning objectives adequate to the study programme, plan-learning activities (including non-traditional ones) needed to reach these objectives, and support field

research. In each particular case, the supervisors need to be capable of identifying the best learning processes and generate appropriate settings for the investigation, as those may differ largely between projects. It is preferred that supervisors are permanent staff so that they may lead long-term processes of institutional learning at their institutions as well as transdisciplinary collaboration with actors of practice.

Hence it may require of faculty the willingness to depart from the conventional knowledge transfer paradigm towards passive students (Freire, 1998). Instead they need to allow all the involved to become conscious agents of their knowledge and their learning needs. Supervisors need to be able to facilitate the evolvement of learning processes among students and with practitioners. This capability of supervisors has been voiced as necessary condition by participating students as well.

The students interested in the experience come from diverse disciplinary and cultural backgrounds (see Ban et al., 2015). They understand that they need to assume a high degree of sensitivity and recognise the protagonist role of local community members; at the same time, they need to accept the responsibility of their own learning about methodological and theoretical aspects related to the research and the development of teamwork skills. When they decide to become part of a research team their full collaboration until project finalisation is required, which is challenging in cases where the study project remains additional to the regular curriculum and credits cannot be given for taking this course.

Since the local knowledge represents one of the most important ways of knowing in systems of small-scale agriculture (Munyua and Stilwell, 2013) it is relevant to highlight farmers´ participation; nevertheless, they decide for themselves how intensively they may participate. Most importantly, they need to be able and willing to engage in the joint formulation of the problem, objective and expected results of the study. Whatever their decision regarding the level of their participation, the research team needs to respect their readiness to do so. This results in divers models of collaboration that in any case need to consider the capacities of local actors and users of the results. The latter, in turn, need to accept that the study project has a second – educational - purpose, too, as stipulated by Fiege (2012).

Finally, there is an institutional commitment needed: Study programmes have to allow within their structure the allocation of time and credits to this type of teaching-learning activity, for both students and staff. This includes also the necessary capacity building in the initial phase, depending on the level of experience. Experience of the pilot projects showed that interest and support by higher-level staff is important, in particular when amendments in the study programme are necessary. Empirical work and participation of practitioners come at a cost. For pragmatic reasons, it is therefore helpful to concentrate activities on an easily manageable geographical radius. Finding financial resources requires time and commitment as well, an aspect which is dealt with in the following sub-chapter.

What are major challenges and how may they be overcome?

Table 4 gives an overview of the challenges which partners experienced in the design, and implementation of the pilot projects in various dimensions. Each partner analysed and reported various challenges and tested own solutions, however those challenges listed here correspond to the most common experiences. Solutions suggested constitute an outcome of the systematisation process.

Table 4. Challenges in the pilot projects and solutions found in the systematisation process.

Major challenges	Solutions found
Regarding the achievement of learning objectives	
Design appropriate learning activities that relate to the varied knowledge and experiences which participants bring forward	Ensure that learning objectives specified are realistic given the limits in possible resources and project design (differentiate in the formulation of objectives e.g. between "having an overview", "understanding", "being able to apply", etc.)
	Link the character of learning activities to these objectives: Design practical activities for those learning objectives that imply application know-how
	Encourage self-directed work among participants, giving them space to bring in and discover their knowledge and capabilities

	Turn students' questions back to the group instead of answering them as a lecturer, encouraging them to find own ways of learning
Achieve a common and good-quality result	Make explicit and discuss the learning objectives set by lecturers, and plan activities in a way that ensure students realistically reach these objectives
	Formulate the research problematic in a way that raises students' curiosity and motivates them to find solutions
	Ensure that important steps are made jointly (even if intermediate steps are delegated to smaller working groups): Discussion of problem situation, agreement on objectives, building of analytical framework, agreement on methods, discussion of findings, structuring the presentation the report, drawing conclusions
	Plan sufficient time for the elaboration of the theoretical framework as well as for the final outputs
	Ensure that credit points/marks are given, even if it is an elective course
	Ensure that team spirit is kept up (see below recommendations on collaboration within the team)
Regarding the resources required for implementation	
Establish sufficient time within the study programmes and the teaching duties	Divulgate activities and results of pilot projects within the universities and among decision-makers on curricula, in order to promote them as effective methodologies for reaching intended programme outcomes
Finding motivated and able teaching staff willing to engage in TdSTR	Plan study projects as integrated part of a larger research project, so that it serves two purposes for the participating staff and results may be used within further research activities
	Approach young and enthusiastic staff as co-supervisors in a first step
Necessity for supervisors to be proficient in didactics of TdSTR and teamwork techniques	Separate supervision responsibilities for the methodological trainings, for facilitating the process and for analytical conceptualisation, so that they may support each other but do not necessarily need to be performed by the same person
	Initiate round tables for exchange of experiences among staff who implement TdSTR projects
	Establish a capacity-building programme which integrates theory and practice of TdSTR as education strategy, adapted to the respective conditions in the University
Financing of transdisciplinary investigations	Plan and conduct study projects as part of research projects, so that the budget for empirical investigation and the transdisciplinary interaction with practitioners may be an integrated project activity
	Explore possibilities for collaboration with other institutions that may support transdisciplinary collaboration
	Promote the inclusion of TdSTR into the regular study programmes, using successful examples, so as to budget them in university funds
Justify the amendment of curricula or any additional costs for implementation	Encourage a reflection among faculty on the competencies which graduates need to have acquired during their studies, with a focus on methodological know-how and soft skills
	Design evaluation instruments which capture the needs of and benefits for target groups for the related learning achievements
	Create well-documented examples which illustrate the advantages of the approach
	Make visible the benefits of the method and the resources and activities needed for building the desired capacities of students and local actors
Regarding the collaboration within the team	
Reduce potential for conflicts that originate from differences in motivation, participation, background and abilities of participants	Establish transparency of expectations towards the project and the participants
	Encourage the group to find a solution in case some participants are more ambitious than others are. Agree if common or individual evaluation of students' results should be done by supervisors at the end
	Explicitly recognise individual contributions of people with different backgrounds, highlighting how the different abilities contribute to the common whole
	Encourage students to step into practitioners' shoes when evaluating their own work and behaviour
	Insist on a teamwork training at the outset of the project (with mandatory participation), and regularly probe for feedback loops during the project
Regarding the collaboration with actors of practice	
Matching the	Allow for much time for joint elaboration of the research objectives and expected

specialisations in the research team with the problems put forward by actors of practice	results when preparing the agreement/contract, including limitations
	Seek the collaboration of experts within the university and of resource persons from outside, if necessary
Defining the role of the university regarding the intervention and the collaboration as a whole	Focus on long-term relations and trust building measures, starting with short-term tangible activities that may then lead to more complex collaborative engagements
	Carefully elaborate the knowledge problem within the complex problem setting which practitioners put forward – objectives need to focus mainly on knowledge generation, this corresponds to the role of the university
	Communicate clearly that a research project may help fill knowledge gaps and enhance joint learning, but cannot go far into implementation of *follow-up* activities within the communities (unless leading to a new joint project)
	Define the contributions and limitations of the university (staff and students) within the contracts or agreements

As expected, several of the challenges encountered are shared with regular transdisciplinary research projects, in particular those challenges related to collaboration and to making impacts clearly visible (e.g. Brandt et al., 2013; Siew et al., 2016). Other challenges – those that relate to the establishment of transdisciplinary PBL within the study programmes – are known from PBL introduction phases at universities (Riseman et al., 2005; Hofmann-Souki et al., 2011; Ban et al., 2015), with the added difficulty of the transdisciplinary aspect. Specific challenges of the TdSTR projects are conflicts of interest, limited resources within teaching, as well as the balance between scientific demands and pragmatism (see also Fiege, 2012). The "clients" (practitioners), in turn, need to understand and tolerate that the projects still constitute an educational activity, which means that students need space for learning and making mistakes, and that there are certain demands from the side of the university as well, especially when assessment tasks are concerned.

Assessment and grading deserve particular attention: Following the logic of Constructive Alignment, different learning objectives and activities also require a revision of assessment methods and criteria (Biggs and Tang, 2011). For most of the universities concerned TdSTR constituted an innovation to be tested and evaluated. University staff welcomed the possibility to link their research with their education activities. Working on real-world problems was seen as a motivating factor, but the responsibilities and commitment were felt to rest on their shoulders, too. The engagement has created very positive expectations at the side of local partners, and it is a constant struggle to serve these expectations, both regarding results and process of collaboration, while having to adhere to university standards and procedures, too. As a result, the time and efforts of the supervisors dedicated to the projects were relatively high. This is reduced with more practice and better established working relationships, as in the case of HU. The necessary funding is more likely to be found if broad synergies with other research or education activities can be found. Also the number of students involved varied a lot, and not always it was possible to mix students from different backgrounds as originally intended – sometimes as a symptom of existing organisational and personal distances between the different study programmes at a university.

However, it remains a big challenge in universities with research-oriented staff reward systems to introduce and reflect on complex teaching innovations in which application-related skills and know-how are consequently trained, and not only postulated as overall learning outcomes – often staff members have other career priorities. At the bottom line, the "reason d'etre" for study projects is not very obvious: Curricula are not consistently oriented towards holistic competency development. As universities are mainly value oriented and less goal-oriented organisations (Looss, 1996) staff may formulate ambitious learning outcomes (incl. competencies trained with such study projects) but there often is no consequent monitoring of goal achievement in this respect, and there are not necessarily any consequences in case curricula do not allow students to attain the competences mentioned in the learning outcomes. For the study projects to gain momentum it needs to be possible for staff to justify them with specific and binding learning outcomes to be served in each study programme. This requires universities' commitment to constructive alignment (Biggs

and Tang, 2011). Overall, experience shows that incorporating this form of inter- and transdisciplinary PBL is more difficult within existing study programmes than during the development of new ones, as can be well imagined.

What are the central conditions, components and activities for the TdSTR projects to serve the users of their research results (in our case actors in rural development)?

Tackling real problems in local communities with a transdisciplinary approach is founded in the social responsibility of academic institutions in the search for feasible solutions benefitting the communities (Bodorkós and Pataki, 2009). In order to achieve this in our case, the SERIDAR project teams agreed that among the important measures was to draft agreements with local partners on objectives, responsibilities, scope and expected results that came out of negotiations between all parties. A very basic condition is the openness of both faculty and practitioners involved to jointly tackling the specific problems seen in the communities.

It was important that the expectations of all involved were limited to the agreements and that no unachievable commitments were made – something that would create disappointments and a negative perception by the community of the research team and the university. To limit the objective is perhaps the first and most important step; it is necessary to define the precise scope in order to align the expectations of the team with the existing possibilities of a study project.

In essence, a constructive way to generate research objectives with a purpose to create a win-win situation (Larsson et al., 2009) appears to be to identify knowledge gaps that prevent actors from generating and implementing new solutions and pathways. That means to elaborate how the partners intend to use the research results and new knowledge in their future work. Once this is clarified the expected results can be formulated in a way that they are useful for local actors, while corresponding at the same time to the needs of the curriculum (see also Fiege, 2012).

Furthermore, making explicit the necessary and the available resources for the project and how practitioners, supervisors, students and the university contribute ensures that the activities can be implemented in an appropriate and timely manner. Likewise, and as mentioned earlier, generating relationships with smooth communication, using a shared vocabulary and appropriate language allows a continuous and constructive dialogue between the parties. Our analysis therefore confirms the findings of Reed (2008) who conclude that overall, the outcome of public participation seems to be more sensitive to the manner in which group dynamics are facilitated, the communication with participants, the clarity of objectives and the quality of planning, rather than to the participatory tools that are used.

Finally, it is a shared experience of the universities that, while endeavouring to achieve the agreed objectives, a reflective attitude and flexibility are indispensable to account for contingencies that arise during the course of the project; in particular as learning leads to new perspectives on the problem investigated. This corresponds to a central feature of participatory processes (see e.g. Groot and Maarleveld, 2000).

Ideally, the transdisciplinary study project is embedded in long-term collaboration processes between the university and actors of the region. In this way, the projects may contribute to a broader purpose. This is the case if a long-term relationship is developed between the researchers and the communities with long-term plans for the presence of the university in the community. This could be through a series of research projects, facilitation or capacity-building activities, as could be achieved in all four universities.

However, beyond the relationship with the communities and users of the research results it is necessary to maintain a network of relationships with other organizations that could contribute directly or indirectly to the research. A shared achievement of our TdSTR projects was the strengthening of local networks; similarly other authors report that one of the most important results of university-community collaboration is its contribution to activate the work with local networks towards strengthening programmes on regional level (Bodorkós and

Pataki 2009); it represents an important condition for ensuring that the activities of academic institutions on local level have an impact and a future perspective.

Conclusions

Transdisciplinary Student Team Research represents a paradigm change in the conceptualisation of academic teaching and learning and offers new perspectives on problem-based research activities with rural actors. The systematisation of the four TdSTR projects has shown that implementing such an approach is possible in an academic context that values holistic competence orientation, as is usually the case for sustainability-oriented study programmes in rural development, agricultural sciences, resource management or related fields. Crucial aspects to focus on are the institutional support from high-level staff members responsible for curricula as well as appropriate capacity building of faculty who supervise the projects, in particular regarding TdSTR didactics, participatory research methods and teamwork techniques. Students must be encouraged to assume shared responsibility for the research process, together with practitioners and faculty. This in itself is motivating for all involved. However, experience showed that awarding credits to students is important if such projects are integrated into the study programmes, so as to ensure that both students and faculty are able to dedicate sufficient time and attention to the projects.

The approach offers the chance to better understand local problems of practice and places universities as collaborating actors in the problem-solving efforts of society. However, the scope, scale and depth of research need adjusting to the capacities of those involved. To have an impact they must therefore be an integral part of longer-term transdisciplinary processes.

As regards the role of practitioners, their participation in the definition of research problems and objectives is a key characteristic of transdisciplinarity, and formal collaboration agreements can be helpful if trust is yet to be established. Ideally, they follow an initial identification of expectations and capacities of all involved, assuring commitment and clarity of roles and expected achievements. Likewise, divulgation and joint discussion of project results is crucial for student learning and for maintaining long-term relationships with practitioners as the main users of the outputs generated.

Project teams have found different context-specific solutions for specific challenges that arose during project preparation and implementation. Such flexibility is necessary and effective solutions are more easily identified if faculty have immersed themselves in central paradigms of TdSTR.

Systematisation of experiences has made explicit both the processes and results of the projects and the learning achievements made regarding the TdSTR approach. Project evaluation by all participants has been a first necessary step, focussing on both process and results. The large number of focal points and indicators was a challenge, although initially agreed as necessary for systematic analysis. Further steps of the systematisation allow looking beyond the project achievement level: Surprising developments, innovative solutions and adaptation to local conditions were enlightening when comparing the experiences across countries.

Overall, lasting impressions, personal and professional development beyond the formal project logic have made these projects a rewarding activity for all participants and has motivated continued engagement.

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