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In the course of their academic education, students move deeper into scientific thinking and away from practice. Teaching transdisciplinarity, we benefit from higher-level students’ increasing disciplinarity but have to build longer links to practice.

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Connecting Students to Practice

In 2013, the Department of Environmental Systems Science (D-USYS) of ETH Zurich established the Transdisciplinarity Lab (Td Lab). One of the TdLab’s first tasks was to bundle and coordinate the teaching of the transdisciplinary courses in the department (Moser et al. 2013). The effort was needed because the courses dealing with transdisciplinarity at the BSc, MSc and PhD/postdoc levels had been developed over the last decade by different groups and lecturers, without establishing an overarching and coordinating framework. In the meantime, we designed a set of courses that span the undergraduate to the doctorate levels. This set of courses adequately exposes students at different levels and from various curricula to the challenges and opportunities of transdisciplinary research. For some students, these courses offer continuing, sequential opportunities in transdisciplinary research for sustainable development; for others, they are a one-time encounter. Below, we briefly outline how we teach the transdisciplinary approach to sustainable development at the BSc, MSc and PhD/postdoc levels. A detailed overview of the learning targets of each course is given in Pearce et al. (forthcoming).

The basic idea motivating the courses (table 1) is that we familiarize students with transdisciplinarity corresponding to the particular stage they are at during their educational “journey” into scientific thinking. In the BSc and MSc programs, students are gradually introduced to the scientific understanding and framing of sustainability issues. In the BSc and MSc programs, students are gradually introduced to the scientific understanding and framing of sustainability issues. At D-USYS, the two BSc degrees (Agricultural Sciences, Environmental Sciences) provide students with a broad range of basic knowledge, mostly in natural sciences, and to a lesser extent also in technical and social sciences and humanities. In the MSc degree program, students specialize in one of nine majors (in agricultural sciences: Agricultural Economics, Plant Sciences; in environmental sciences: Atmosphere and Climate, Biogeochemistry and Pollutant Dynamics, Ecology and Evolution, Environmental Systems and Policy, Forest and Landscape Management, or Human Health, Nutrition and Environment).

Referring to Fleck’s (1986) concept of thought styles and thought collectives, the BSc program introduces students to the general thought style of environmental or agricultural sciences. The MSc program introduces students to a more specialized thought style and thought collective, such as that of Ecology and Evolution. This process of specialization continues with PhDs and postdocs, who, as members of the thought collective, are not only deeply familiar with the thought style but are also able to produce new insights according to the thought collective’s rules.

If furthermore science and practice are conceived as the thought styles at the two ends of a continuum (Pohl et al. 2017), then students move from the BSc to postdoc programs deeper into the thought style of science and further away from that of practice. The aim of our teaching is to link science to practical problem solving. This means that the higher a student’s level of educa-
tion, the more our courses benefit from his or her scientific thinking, and the longer the bridge we have to build back to practice.

**BSc Level: Introducing Transdisciplinarity**

At the BSc level, students enroll as high-school graduates (Maturanden) for their first year at ETH Zurich. High-school graduates have broad knowledge in various fields, such as biology, chemistry, arts, or languages. However, these students usually are not familiar with cross-field collaboration, systems thinking, stakeholder engagement and design thinking, which are all central for our transdisciplinary approach to sustainable development. We address the four topics as follows:

**Cross-field collaboration.** To become an expert already in the first semester, students have to research one of six aspects of the course’s overall topic. This year’s topic, for instance, was *Recycling of Building Materials in Switzerland*. Three of the six aspects in which to become an expert were “technologies”, “norms and regulations”, “substance flow analysis of recycled concrete”. In the *Synthesis Week* during the semester break, we mix students in groups of six. Each student is now the group’s expert for one aspect, and cross-field collaboration can start. The first collaborative task is to develop an overall picture of the topic and to identify problems within the overall picture to work on in the second semester.

This is how we prepare students early on for interdisciplinary collaboration.

**Systems thinking.** The idea that things are connected to each other, and that intervening in a system might have unintended consequences is a key element of the transdisciplinary thought style, as well as of the department’s thought style. Students are introduced to systems thinking in many ways and courses. We use Vester’s (2002) qualitative system analysis approach as an entry point to systems thinking in the first year, mainly because this analysis integrates various kinds of data from a broad area of perspectives intuitively and transparently.

**Stakeholder engagement.** Students get in contact with stakeholders several times during our BSc course. Our main goals are that students approach stakeholders as practice experts and that they meet the stakeholders on equal footing. In the second semester, we let students contact the stakeholders and organize the meetings on their own. But we provide them with organizational support and an example of how to get in contact. We also make them aware that nobody is waiting to answer their questions.

**Design thinking.** In the second semester, we go far into practice by asking students to develop measures for addressing the problems the students identified. We introduce students to design thinking.1 We let them formulate problem statements to clarify the stakeholders’ needs, build prototypes of measures, test the prototypes with stakeholders and use the feedback to improve the measures.

**MSc Level: Enriching the Scientific “Back-pack” for Sustainable Development**

At the MSc level, students have spent three years at university, and they have been introduced to a particular disciplinary specialization. Environmental and agricultural MSc students are usually eager to use their acquired knowledge to address sustainability challenges. We make use of this readiness in our elective minor *Transdisciplinarity for Sustainable Development* as follows:

**We use the diverse expertise students have acquired.** The students in our department come from two different masters and nine different majors (see above). However, our students are mostly trained in analyzing and modeling sustainability issues. Therefore, we try to include students in environmental engineering and spatial planning as well, who are trained in developing technological solutions. As the students work mostly in groups, they can experience interdisciplinary collaboration. One of the key challenges, however, is to find a match between what the stakeholders need and are

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1 For example, [www.dschool.stanford.edu](http://www.dschool.stanford.edu).

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**TABLE 1:** Transdisciplinarity Lab (TdLab) core courses in transdisciplinary research for sustainable development (EnvSci: curriculum in environmental sciences, AgrSci: curriculum in agricultural sciences). ECTS: European Credit Transfer System.

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>COURSE TITLE</th>
<th>TYPE</th>
<th>CURRICULUM</th>
<th>DURATION</th>
<th>ECTS</th>
<th>NUMBER OF STUDENTS (AV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSc</td>
<td>Tackling Environmental Problems (Umweltproblemlösen, course in German)</td>
<td>compulsory</td>
<td>EnvSci</td>
<td>year</td>
<td>10</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>Transdisciplinary Case Study</td>
<td>elective</td>
<td>EnvSci, AgrSci and beyond</td>
<td>semester</td>
<td>7</td>
<td>20–25</td>
</tr>
<tr>
<td></td>
<td>Transdisciplinary Methods and Applications</td>
<td>elective</td>
<td>EnvSci, AgrSci and beyond</td>
<td>semester</td>
<td>3</td>
<td>15–20</td>
</tr>
<tr>
<td></td>
<td>Sustainability Assessment</td>
<td>elective</td>
<td>EnvSci, AgrSci and beyond</td>
<td>semester</td>
<td>3</td>
<td>20–30</td>
</tr>
<tr>
<td>PhD/postdoc</td>
<td>Science Meets Practice (winter school)</td>
<td>elective</td>
<td>ETH Zurich and beyond</td>
<td>block of eight days</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement</td>
<td>elective</td>
<td>all ETH Zurich curricula</td>
<td>semester</td>
<td>2</td>
<td>10–15</td>
</tr>
</tbody>
</table>
interested in, and the methods and knowledge the students have in their academic “backpack”. Here, students have to show that they can adapt and quickly learn new methods and concepts – an essential skill for their future careers.

We provide Sustainability Learning Labs (SLLs). For some years, the MSc case study has alternately taken place in two SLLs (Krütli et al. 2018), one in the Mehr als Wohnen city district in Zurich and one in the Seychelles. The SLLs provide students with an inspiring, problem-oriented environment motivating them to achieve the learning goals while at the same time contributing to the needs of the partners from practice. We decided to collaborate over a period of several years with the same partners to potentially achieve and learn more about the long-term effect of our transdisciplinary projects. As a side effect, we can offer students who are looking for more transdisciplinary research in their MSc program the opportunity to do a master’s thesis or an internship to advance what they did in the case study.

We offer courses on methods. Some methods are specific for transdisciplinary sustainability research and are not provided by other courses in our department. In the course on transdisciplinary methods, for example, students can become familiar with soft systems methodology, scenario assessment or policy analysis. In the course on sustainability assessment, students learn methods such as social life cycle assessment and ecological scarcity. In addition, we address different concepts of justice and how they relate to sustainable development. In the winter school Science Meets Practice, participants experience community engagement as one core element of transdisciplinary research on the ground. We spend eight days in Waislikfen, a small Swiss community with around 360 inhabitants. The PhDs and postdocs have various disciplinary and interdisciplinary backgrounds (e.g., climate science, food science, water management). On the first day, the community major welcomes the participants and explains what the community is currently struggling with. Last year, the issue was “community amalgamation” (Genmeindifusion). The PhDs and postdocs were then asked to get into the details of community amalgamation and – in interactions with additional community members – to prepare and implement community engagement events at the end of the winter school. The events had to address one of the aspects of community amalgamation with which the community was struggling.

Introducing theories, case studies and methods of transdisciplinary research. The aim of the course Transdisciplinary Research: Challenges of Interdisciplinarity and Stakeholder Engagement is to introduce participants to the thought style and thought collective of interdisciplinarity and transdisciplinary research that goes beyond the organization of community interaction. Usually, neither the students nor their supervisors are aware that there is a rich body of scientific literature to learn from, to build on or to develop further. We discuss basic readings on transdisciplinarity. In addition, we face the main challenges of transdisciplinary research (organizing the research process, collaborating with different disciples, engaging with different stakeholder groups) and provide students with theories, case studies and methods they can use to understand and address these challenges in a reflected way.

Conclusion

In our department, the educational journey from the BSc to MSc to PhD and postdoc level familiarizes students with the thought style of a particular sub-community of agricultural sciences or environmental science. With our courses, we try to take into account where on this journey students are. In the BSc program, we make the students experts in a specific aspect of the overall topic. At the MSc level, we make use of their specialization and involve them from different minors or different MSc degree programs. At the PhD and postdoc level, specialization means familiarization with theories, case studies and methods of transdisciplinary research, and the thought collective of transdisciplinarians. One of the core challenges running through all the courses is that we educate students who will be involved in transdisciplinary research and students who will be working in other fields. For mainstreaming transdisciplinary research, both groups are important. For the latter, exposure to transdisciplinarity makes them aware of the importance of societal concerns for research and the respective challenges; for the former, how to deal effectively with the balance between scientific rigor and societal relevance is the core interest. Our teaching comes with the special burden of new students at all levels without any background in transdisciplinary research. Likewise, achieving depth becomes difficult, which we try tackling with individualized learning that accommodates different interests and competencies.

References