TRAINING STUDENTS TO CROSS BOUNDARIES BETWEEN DISCIPLINES, CULTURES, AND BETWEEN UNIVERSITY AND SOCIETY: DEVELOPING A BOUNDARY CROSSING LEARNING TRAJECTORY

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ABSTRACT

The competence to work together and co-create with others outside one's own scientific domain, institute, and/or culture, is a critical competence for future engineers to respond to emerging global challenges. In this context, Boundary crossing (BC) competence is crucial. In a university-wide Comenius Leadership project we currently develop BC learning trajectories for various study programmes that aim to foster BC competence development by explicating and aligning BC learning activities. Within the context of this project, we focus on *disciplinary, cultural,* and *university-society* boundaries, but consider these to be exemplary for other boundaries.

Our fundament is the boundary crossing theory of [1] and its four learning mechanisms (identification, coordination, reflection, transformation) representing catalysts for learning. In this concept paper we explain, what boundary crossing competence is, why it is important for engineers, and what steps to take towards BC competence development in a study programme. In our oral presentation we will explain how we operationalised these mechanisms into concrete educational tools: the BC-rubric for explicating learning across boundaries, a blueprint learning trajectory, and a tool to be used in teacher teams to identify BC learning activities in curricula. We will share examples of BC learning activities and their alignment into curricular learning, and how we aim to assess and monitor the implementation of the BC learning pathways and their effects on students and teachers.

This concept paper gives a solid fundament for engineering educators to critically reflect on how they explicitly address, coach, assess and further develop students' boundary crossing competence required for the engaged engineer.

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1 BOUNDARY CROSSING: AN INTRODUCTION

Boundary Crossing (BC) competence is regarded as one of the major competencies of future engineers to respond to emerging global challenges. In this concept paper we define BC Competence as the ability to recognize, seek, appreciate and utilize the tensions arisen when different perspectives and positions come together. To contribute to students' BC competence development and to further improve and implement boundary crossing experiences, a three-year university wide project was granted a Comenius Leadership Fellow. This Comenius project aims to (1) develop a conceptual foundation for the development of BC competence, (2) design and implement learning pathways, and (3) compile a BC toolbox for and with lecturers, course coordinators, and management.

This conceptual paper aims to answer the questions "what is boundary crossing competence", "why is boundary crossing competence important for future engineer", and "how can BC competence be supported and strengthened in academic education". In Annex 1 we provide examples of boundary crossing learning outcomes, activities and two learning trajectories developed by two of the programmes participating in the Comenius project. These examples aim to make the theoretical concept more tangible in educational practice.

2 WHAT IS BOUNDARY CROSSING AND BOUNDARY CROSSING COMPETENCE?

A boundary is a tension or challenge experienced when people from various practices (e.g., a discipline, culture, or organisation) meet or interact [2]. One can experience such a tension or challenge for instance when collaborating in a project with a diverse group of people. When boundaries remain implicit and the 'other' perspective is ignored in favour of one's own perspective, interaction and collaboration are hampered. When boundaries are made explicit and the 'other' perspective is placed side by side or even integrated within one's own perspective, interaction and collaboration are facilitated and sought for, and the creation of new, transformative outcomes are made possible. BC is needed to enhance collaborative processes, to change routine behaviour or procedures and to come up with new ideas, products, or solutions. As such, boundaries and boundary crossing create great opportunities to learn and BC can contribute to the personal development of those involved in the learning process [2].

BC competence refers to the *ability to cross boundaries between one's own and others' practices and perspectives with the aim of making new connections, learning from 'the other' and co-creating new practices* [1] (see Box 1). Crossing boundaries requires the people involved to explicate and explore the boundaries, to engage in a constructive dialogue, in order to integrate various perspectives and to develop new hybrid or transformed practices.

Box 1. Definitions

Boundary Crossing	Efforts people take to collaborate across different practices and perspectives.
Boundary Crossing Learning Mechanism	A process evoked by boundaries that can enhance learning across boundaries.
Boundary Crossing Competence	Knowledge, skills, and attitude that enable a person to recognize, seek, appreciate and utilize boundaries

3 WHY IS BOUNDARY CROSSING COMPETENCE IMPORTANT FOR ENGINEERS?

BC competence is crucial for engineers able to address global, sustainability challenges. Providing access to clean water, increasinf the use of solar energy, managing nutrients cycles cannot be achieved by individuals or single agencies, neither can this be done within one discipline or culture. Facing these grand or wicked challenges requires multi-, inter- and transdisciplinary approaches in international and multicultural contexts. It requires bridging academia and society, disciplines, cultures, and perspectives. BC competence is crucial in such settings. Universities that aim to deliver graduates who are able to help resolve these grand challenges, should focus their education not only on a particular study domain; they should also train their graduates to become good “boundary crossers” (see Box 2); they should train their graduates to be able to collaborate and co-create new practices with a wide diversity of people.

Box 2. A good ‘boundary crosser’

- considers what expertise is needed to successfully perform (in) a project (challenge, assignment, or task);
- is aware of his/her own identity and qualities, but also sees what the limitations are of his/her own perspective and qualities;
- is open and actively searches to contact and learn from other people (i.e. people from other practices, cultures, disciplines, or organisation) and sees the advantage of using these people’s perspectives and expertise;
- facilitates and stimulates the collaboration of people involved in a project;
- empathizes with other people’s perspectives, interests, or ideas, also when they differ from his/her own;
- explicates how various expertise, multiple perspectives, and interests are used and integrated in a project to deliver a better result;

- sees tensions not as something to avoid at all cost, but as a potential source of learning, creativity and change;
  learns from the BC experience and encourages other people to reflect and learn as well.

4 BOUNDARY CROSSING LEARNING MECHANISMS

Boundaries evoke processes that can trigger learning. Learning is meant here in a broad sense as a change in thinking that results from a form of dissonance [3]. It may result in better acknowledging and appreciating one's own expertise and perspective, but also in adopting new approaches or new ways of doing something or co-creating something new. Effective BC requires efforts and skills from the people involved. Four learning mechanisms are essential in crossing boundaries: *identification, coordination, reflection* and *transformation* [1].

- *Identification* - Identification is becoming aware of one's own expertise as well as of one's own assumptions, values and principles and of how they influence the way one sees and interprets what is going on. Identification is also about recognizing that your way of seeing and interpreting of what is going on can be different from the way others do. For students, identification is important, because it enables them to better specify who they are, what their expertise is, and what their personal norms and values are in relation to those of others. As such identification might contribute to appreciating other people's expertise and perspectives, and to the learning potential of boundaries.
- *Coordination* - Coordination refers to effectively collaborating. It refers to finding means and procedures to effectively work together. Coordination implies that students initiate and organise meetings with relevant people (other students, municipalities, companies), make working agreements, and seek ways to effectively communicate across various practices/boundaries. Boundary objects, that is tools that can facilitate more effective communication across practices (like a portfolio, notes, a collaborative designed mind map) can be helpful in this stage.
- *Reflection* - Reflection refers to perspective making and taking. It refers to trying to see the world or one's own practice through the eyes of somebody else, such as a student with a different cultural background, or the client of a consultancy project. Reflection enables students to widen their perspective. It contributes to students' appreciation of a variety of perspectives and practices and willingness to learn from each other's perspectives.
- *Transformation* - Transformation refers to change in action or practice as a result of judging and utilizing a variety of perspectives and expertise; it refers to really doing something new or differently, such as changing personal behaviour as a result of appreciating and incorporating a new norm, value, or perspective. Transformation also refers to collaboratively, co-creating new concepts, new routines or procedures, new, hybrid practices, or innovative solutions.

The four learning mechanisms are illustrated in Figure 1 including questions asked when adopting or triggering the learning mechanism.

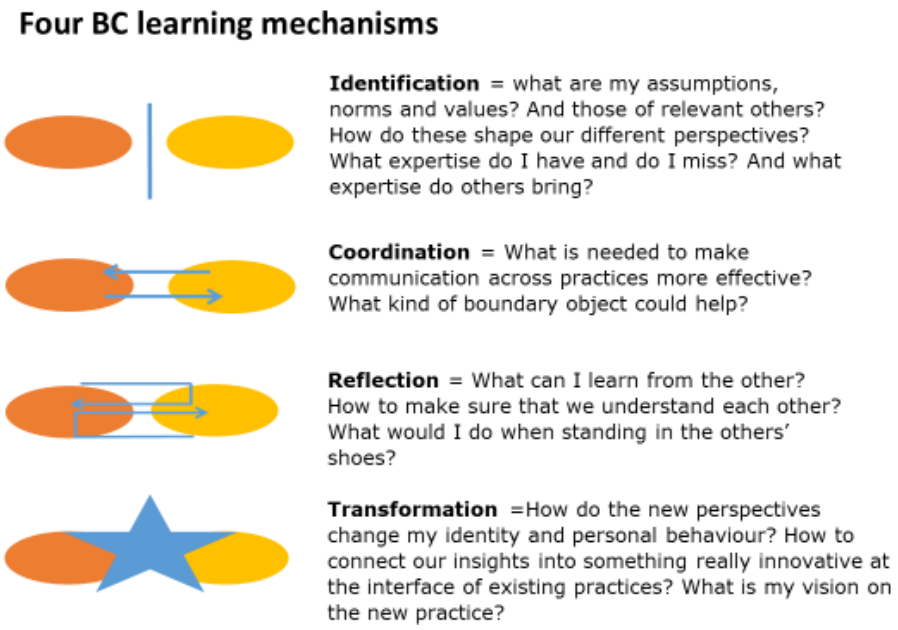

Fig. 2. Boundary crossing learning mechanisms and related questions (based on [4])

5 BOUNDARY CROSSING COMPETENCE: A GENERIC ACADEMIC COMPETENCE

BC competence is a generic competence that can be applied in a variety of contexts, in and outside academia, when faced with a variety of boundaries. Typical for the academic context are challenges that emerge from being educated in a particular scientific domain or operating in an academic context. When studying at a university, students engage in a particular practice, they learn scientific paradigms, theories, methods and approaches of their own study domain. When they advance in their studies, they usually become more specialized and more advanced in their academic practice. Often, they don't realize this until they experience challenges in collaborating with people from another disciplinary, cultural, or educational practice; until they experience boundaries. Academics can also experience boundaries when they collaborate with people from outside academia, when they need to translate scientific knowledge to laymen, or when they are involved in a policy debate (e.g., on climate change or vaccination), and have to defend the importance of scientific knowledge and approaches.

Within the context of the Comenius Leadership Fellow project, three kinds of boundaries have been identified as exemplary: *disciplinary, cultural* and *university-society* boundaries. Obviously, these are not the only boundaries that one can encounter. These boundaries have been selected because they explicate a specific context to practice BC competence. As such they can help programme management and lecturers recognize the necessity to address BC in their courses and to include

learning activities that address the BC learning mechanisms. By letting students practice the use of the BC learning mechanisms in a variety of learning situations, they become better equipped to deal with any kind of boundaries they will be faced with in their future lives.

Boundary crossing can happen at the institutional, interpersonal and intrapersonal level [4]. Boundary crossing at the *institutional* or organisational level (i.e. when organizations of organizational units interact and consequently redefine their characteristics or identity) is beyond the scope of this paper. Boundary crossing in this paper focusses on learning from and with people from other practices at the interpersonal or intrapersonal level. BC at an *interpersonal level* is about interaction among people from different practices, such as researchers, students, or stakeholders with diverse backgrounds, aiming to collaboratively integrate different perspectives into new ideas, practices, innovations. BC at the *intrapersonal level* relates to the personal development of a student. By incorporating ideas and new perspectives from other practices, a student's identity, being, or behaviour might change. BC at the intrapersonal level influences a students' thinking, doing, and communicating [4]. Both interpersonal and intrapersonal boundary crossing is, or should be, part of engineering study programmes.

6 TRAINING BOUNDARY CROSSING COMPETENCE

Engineering education might offer already a variety of opportunities to practice BC. Often students from various educational backgrounds and from all over the world jointly follow lectures or collaborate in group or lab work. These students might experience boundaries when they collaborate with students from other study programmes, or from other nationalities or cultures, or when they collaborate with non-academic stakeholders. *Offering students a setting* in which a variety of boundaries can be experienced is, however, insufficient to enable fruitful BC learning. Just putting students in an intercultural group and expecting that magic will happen, is naive. Sending students on a field trip will not automatically result in students experiencing the differences between their perspectives and those of companies, consumers, or other societal actors, and thus not automatically turn into a meaningful BC learning experience. *BC competence development requires explicit support and reflection*. Just like any other competence (e.g., academic writing), BC competence needs to be explicated and trained; it needs to be practiced and developed throughout a university study programme [5,6].

Students can develop their BC competence by engaging in a variety of learning activities that require them to apply the four learning mechanisms in a variety of situations. These situations can (should) differ in the *type of boundaries to cross*, the *number of boundaries*, the *'difficulty' of (crossing) the boundaries*, and probably the focus on more or less mechanisms, e.g. Identification (I), Coordination (C), Reflection (R), or Transformation (T).

It is important to note here that not all courses in a study programme need to go through all the four I-C-R-T learning mechanisms. Moreover, these I-C-R-T learning

mechanisms do not have to be experienced in sequential order, and transformation does not have to be the ultimate learning mechanism for every course. In some courses, for example, focussing on identification might be a desired learning outcome. In such a course, students learn to get to know themselves, their strengths and weaknesses and they learn to entangle the qualities that are needed for solving the problem at hand, and thus they learn to adopt the identification mechanism. In another course, students can be stimulated to start off with envisioning an ideal future (i.e. transformation) and then to examine how their various disciplinary backgrounds can be used in creating this ideal picture (i.e. identification and reflection). Although not all four I-C-R-T learning mechanisms need to be addressed in a course, it is important that they are *all explicitly addressed several times and in a variety of learning situations throughout a curriculum*.

7 HOW CAN BOUNDARY CROSSING COMPETENCE DEVELOPMENT BE SUPPORTED AND STRENGTHENED IN ENGINEERING EDUCATION?

BC competence development can happen ‘anytime anyplace’, also outside the classroom in all kind of extracurricular activities such as *Studium Generale* or student challenges, but also in sports, music clubs, or when diverse students are living together. However, simply being confronted with boundaries, does not mean that students utilise these boundaries to learn, co-create or develop. As we said before, a more natural response of many people will be to avoid tensions without crossing them. To ensure, that all students develop BC competencies, BC competence development should be embedded in their study programmes. Seeing boundaries as learning opportunities and BC competence development requires structured and explicit attention in assignments, courses and curricula [7]. BC competence needs to be *instructed*, *practised*, students should give and receive *feedback* on their BC competence, and their BC competence needs to be *assessed*, preferably in a variety of courses.

To develop BC competence within a study programme a *BC learning trajectory* can help. A learning trajectory consists of: (i) learning outcomes, identifying several levels of boundary crossing (= the what) and (ii) a series of aligned learning activities to which students are exposed to in order to develop towards these levels of boundary crossing outcomes (= the how). Such a learning trajectory includes instruction, practice, feedback and assessment. To acquire BC competence, it helps when students are exposed to a variety of BC situations (i.e. different contexts, different types of boundaries) to learn to recognise boundaries (of any kind or type) and learn how to handle them in a good way. *Learning activities* that explicitly address BC learning mechanisms and trigger BC competence development are thus needed (see Box 3).

Box 3. Heuristics for boundary crossing learning activities [8]

BC competence development requires:

- Experience, being involved in addressing a real-life complex issue and applying disciplinary and interdisciplinary methods, techniques, and procedures to integrate solution-oriented knowledge.
- Close collaboration in a team of which its members have a diverse (e.g., disciplinary or cultural) background.
- Explicit moments of perspective switching (e.g., specialist, integrator, stakeholder).
- Field work, to integrate classroom-based knowledge in a specific context, to transcend disciplinary knowledge, and to experience the 'complexity' of reality.
- Interaction with stakeholders outside academia and facing the differences in norms and values held by the societal actors and oneself.
- reflection on the research process, the role of science and the role of norms and values in addressing a societal problem.

The questions below are meant to trigger programme committees, programme directors and lecturers' thinking about boundary crossing within their curricula. They are meant to trigger their thinking about what boundaries they want their graduates to be able to cross, where and how boundaries and boundary crossing is part of their programme, and what (new) learning activities can be designed to explicitly address the I-C-R-T learning mechanisms at various stages of the programme. Thereby, these questions help to work towards a BC learning trajectory that fits a specific educational programme.

1. *Doing an inventory of current BC experiences in a curriculum*:
   - Where in your study programme are boundaries present?
   - Are these boundaries utilized as learning opportunities?
   - Are explicit learning activities used to help students crossing the boundaries? If so, which ones?
   - Is BC instructed, practised, is feedback given, is BC assessed?

2. *Identifying boundaries*
   - What boundaries do you expect your graduates to be able to cross? And thus, what boundaries should your students be confronted with during your study programme?
   - Which boundaries do you want your students to practice crossing?
   - Does your programme aim at developing BC at interpersonal or at intrapersonal level, or at both?

3. *Selecting courses that will explicitly address the I-C-R-T learning mechanisms*:
   - Which courses are suitable for *instructing* students on BC and BC learning mechanisms; which ones for *practicing* I-C-R-T learning mechanisms; which ones for giving and receiving *feedbac*k; which ones for *assessing* BC competence?

- Which courses are suitable to develop BC at interpersonal level? Which courses are suitable to develop BC at intrapersonal level?

4. *Developing new learning activities that explicitly address the I-C-R-T learning mechanisms, including instruction, practice, feedback, and assessment.*
   - How can you change existing learning activities to make more explicit use of already present boundaries?
   - What new learning activities can you design?

Once these questions are addressed, learning activities and assessment tools need to be developed. One of the outcomes of the Comenius project is the development of a toolbox for learning activities and assessment tools. Some examples are presented in Annex 1, more practices will be shared in the oral presentation.

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Annex 1: Examples of boundary crossing learning outcomes, activities and learning trajectories

To make boundary crossing more tangible, this section will display some exemplary BC-learning outcomes, learning activities and learning trajectories developed in various Bachelor and Master programmes of our University.

Exemplary learning outcomes

Boundary crossing learning outcomes are often, and can easily, be linked to the more content related learning outcomes of a course. The examples below show a variety of learning outcomes. After every learning outcome we will show 1) the name of the programme, 2) the year of study, 3) the addressed boundary crossing learning mechanism(s), and if applicable 4) the type of boundary at stake.

- Know what is interdisciplinarity in the food domain and recognize this for different phenomena (BSc Food Technology, year 1/period 1, identification, disciplinary boundary);
- Integrate theoretical and practical knowledge from various food science disciplines while considering the consumer perspective as well (BSc Food Technology, year 1/period 6, identification/transformation, disciplinary and university-society boundary);
- Communicate project progress with various stakeholders (BSc Food Technology, year 1/period 6, coordination/reflection, university-society boundary);
- Assess and analyse land use and water management issues from different academic and societal perspectives and bring these together (BSc International Land and Water management, Year 1/period 1, reflection/transformation, all kind of boundaries);
- Create additional value by combining biobased disciplines thus to apply an interdisciplinary approach (MSc Biobased Sciences, Year 2, identification/reflection/transformation, disciplinary boundary);
- Work as part of a multi-disciplinary and multicultural team and value the contribution of different perspectives in designing solutions for complex (environmental) problems (MSc Environmental Sciences, year 1/period 6, identification/coordination/reflection, disciplinary and cultural boundary).

Exemplary learning activities

We can also make boundary crossing more tangible in learning activities. Below we present some learning activities that can be integrated in any kind of course. They are described independent from a specific context or educational program. The table shows what type of boundaries are crossed, possible variations to the learning activity and the addressed boundary crossing learning mechanism(s) .

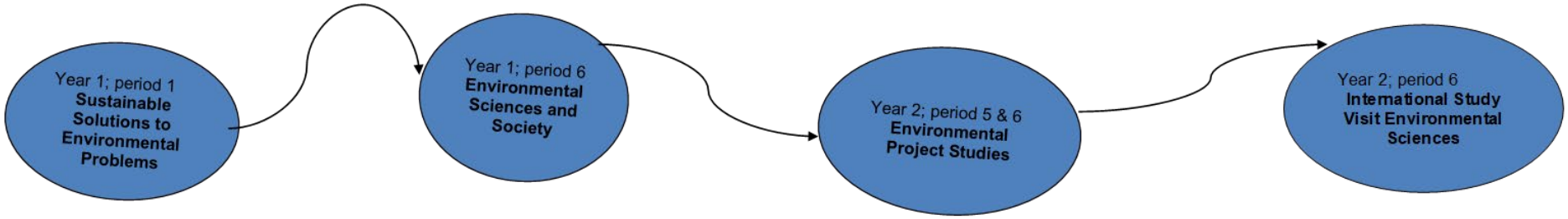
Title	Core of the activity	Boundaries addressed	Possible variation /addition
Debating different perspectives	Assign students roles of different stakeholders from who's viewpoint they participate in the debate	University-society Possibly different disciplinary perspectives	Let students prepare their own stakeholders perspectives more or less thoroughly with/without guiding questions BC-Learning mechanism: Identification, Coordination & Reflection
Exploiting cultural group diversity in a poster market	Take a controversial topic relevant to the course (e.g., animal welfare, Palm oil, water conservation) Let students from different countries/cultures explicitly elaborate on the topic from their national & cultural perspective. Every student prepares a poster. In a poster market session students share perspectives. After the market intercultural groups develop a shared poster showing the topic from all different perspectives.	Cultural and international	Provide guiding questions to be addressed on the poster Let individual students elaborate their own poster with new insights gained from the other posters. Ask individual students to express (orally or verbally) how their own national/cultural perspective is challenged by the others: how is your own opinion on the topic changed? BC-Learning mechanism: Identification, Coordination & Reflection
Including multi-perspectivity in field visits and excursions	Offer students a list of critical questions to be asked to the societal stakeholder they visit to identify the stakeholder's perspective on a course relevant topic	University-society	**A.** Prepare: Let students first explicate their own perspective on the topic: What do they currently know about this issue? How do they feel about it? **B.** Prepare: Let students individually or in groups prepare a list of critical questions to ask the societal stakeholder to grasp their perspective **C.** Afterwards: Let students together visualise trade-offs between identified perspectives (including their own) BC-Learning mechanism: Identification, Coordination, Reflection
The boundary crossing portfolio	Students reflect on their own experience and developments regarding interdisciplinarity. They will create a portfolio with reflection papers written at X moments during the study programme Students have to defend their reflection in a final interview.	Disciplinary	Other boundaries, relevant for the study program, can be integrated BC-learning mechanisms: reflection, (intrapersonal) transformation

Developing a concept map using colour coding	Student groups collaboratively develop a concept map on certain topics using colour coding: Step 1: individual concept map (blue pen) Step 2: elaborate 1 individual map with additions form other maps (red pen) Step 3: let students study the topic from a certain perspective (in books, articles, internet) Step 4: further elaborate the map with the theoretical insights (green pen)	Depending on the assigned perspectives in step 3.	A. Let students identify different disciplinary influences in their own perspective in step 1 B. let student draw an individual concept map afterwards, showing their (changed) own perspective <u>BC-Learning mechanism:</u> Identification, Coordination & Reflection

Exemplary learning trajectories

This final section shows two exemplary BC-learning trajectories as currently developed in two of the Bachelor Programmes participating in the Comenius Leadership Project. Both examples show the learning trajectory by visualising the line of courses that make up the trajectory. Per course, the addressed boundaries are described, next to the learning outcomes of the course and some examples of learning activities adopted in the course to explicitly address boundary crossing.

Boundary Crossing Learning Trajectory BSc Environmental Sciences



Course and its core theme	**Sustainable Solutions to Environmental Problems** Learning that the synthesis of social science and natural science helps to generate new interdisciplinary solutions to wicked environmental problems	**Environmental Sciences and Society** In this thematic course the Animal Consumption and Production Chain is used to show how knowledge from different scientific disciplines and stakeholders contributes to analysing, solving, and preventing environmental problems, and to creating sustainable solutions.	**Environmental Project Studies** A group-wise research project investigating an environmental issue emanating from professional practice. Due attention is paid to the societal aspects of the researched topics, the role of science, and the development of the students' own view on the approach of environmental problems.	**International Study Visit Environmental Sciences** Wageningen University students collaborate with students and staff of another university outside the Netherlands (Ukraine, Estonia) on a two week research project/case study. The main theme Restoration of semi-natural habitats/ Nuclear power is approached in a multi-disciplinary way.
What boundary / boundaries are addressed in the course?	Disciplinary University-Society Cultural	Disciplinary University-Society Cultural	University-Society More specific: Between the commissioner's assignment and (university) course assignment for a lecturer; Between different parties judging the research proposal/report (the commissioner and the lecturer);	Disciplinary Cultural

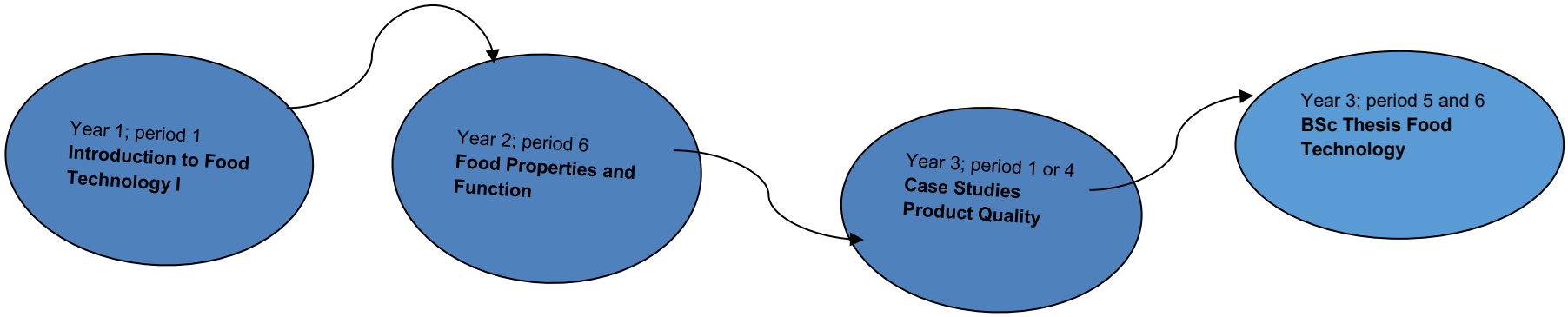
			Between theory and practice; Between different drivers or stakes, such as attention for environmental/sustainability issue versus an economic/financial issue; Between skills/knowledge/expertise from different students (based on background).	
What BC learning mechanism are addressed? ○ Identification ○ Coordination ○ Reflection (perspective making /taking) ○ Transformation	• Identification (of disciplines and stakeholders) • Coordination • Reflection • Transformation *All on a very basic level*	• Identification • Coordination • Reflection (perspective making and taking on stakeholder assignment and perspectives) • Transformation	• Coordination (communication with real life commissioner and stakeholders) • Reflection (on societal aspects of an environmental problem and team work)	• Identification • Coordination • Reflection
BC learning objectives of the course (as part of the complete set of learning objectives)	*1. understand that environmental problems need to be approached from different natural and social scientific disciplines;* *2. explain the features of interdisciplinary scientific research;* *3. analyse an environmental problem and integrate theoretical and practical knowledge (incl. stakeholder's perspectives) to develop a sustainable*	1. explain what Environmental Sciences is. *2. analyse environmental problems triggered by the Animal Consumption and Production Chain and the underlying societal trends, using visions, knowledge and methods from different (scientific) disciplines.* *3. evaluate how technological, natural and social sciences*	1. acquire experience with planning and execution of an environmental project; *2. acquire understanding of the societal context of environmental research and the societal backgrounds of environmental problems;* 3. are capable of collecting, processing and reporting of information; *4. are capable of co-operating in a group and can evaluate this co-operation;* *5. initiate and sustain contacts with their supervisor and commissioner;*	*1. evaluate multiple dimensions of an environmental problem abroad;* *2. collaborate within a group work, in consultation with experts from abroad, such as faculty members and students from the host institution and relevant stakeholders;* 3. apply knowledge, methods and tools of environmental sciences in a case study abroad;

	solution for this problem; 4. combine different sources of information and develop a synthesis; *5. identify how cultural perspective influence one's role in the group and one's take on environmental issues;* 6. write a clear and well-structured report; 7. present and defend the key features of the report.	*contribute to solving and preventing complex environmental problems.* *4. collaborate in a multi-disciplinary and multicultural team, including literature research, writing and field research, and communicating findings orally and in writing.* 5. explain what the specializations of the Environmental Sciences program are, the aims of these specializations and the possible professions.	6. train themselves systematically in conducting meetings, including the preparation, chairing, the writing of minutes, making an action plan and checking if appointed tasks have been accomplished; 7. are able to give an oral presentation of their results. They take care of a suitable form and substance of the presentation, of an appropriate use of audio-visual media and a satisfactory response to reactions from their audience.	*4. reflect on their experiences and lessons learned in international research collaboration and a new cultural environment*
BC learning activity (and/or assessment activity) in the course	*Excursion*: students cycle around Wageningen to visit different places and persons (municipality, NGO, involved inhabitant) related to the energy transition. Afterwards they are expected to reflect on the role and perspectives of stakeholders as well as their own. *Group assignment* to collaboratively: • develop a clear problem definition, highlighting the interrelated role of	*Lectures* by lecturers from different chair groups (social and natural sciences) sharing state of the art knowledge in their field of expertise and its relation to the central theme of the course. *Excursions* to various farms, a nature restoration project, and a representative of the regional government (province of Gelderland) to get a better insight in	Supervised *group research project* for a non-academic commissioner: writing a research proposal based on the problem as identified by the commissioner; collecting and analysing data; reporting orally and in writing. Collaborative *reflection on the societal context* of the research, to (i) explain the relationship with overarching environmental debates; (ii) clarify the societal context and impact of environmental research; (iii)	*Guest lectures* provided by experts from in- and outside the university, both in Wageningen and in Tartu/Kiev, to provide an introduction and state-of-the-art knowledge. Students are encouraged to prepare for these lectures and engage in discussions with the experts. *Practicals* to explore the study area and surroundings and learn

	technology, people, the environment, and various stakeholders. • analyze the problems in different ways, i.e., from the perspective of the natural sciences and the social sciences; • to develop a solution (synthesis); • reflect on the solution and its role in the energy transition; • report their findings in a group report and a presentation in a symposium. The group report assesses the student's ability to (a) collaboratively write a report on an interdisciplinary environmental problem on a specific scale (household, neighborhood, national, global); (b) develop a synthesis and solution using different types of sources; (c) reflect on the solution by referring to other scales and (d) work effectively in a team.	the environmental problems addressed in the course, and a better understanding of how the stakeholders deal with the various environmental problems. Students are expected to prepare questions with their group for the people they will meet prior to the visit. *Group assignment* "to provide an overview of the current and future environmental problems caused by the production and consumption of meat and to determine sustainable solutions whereby you take into account the interests, perspectives and considerations of the main stakeholders in the Animal Consumption and Production Chain" resulting in a written and oral report. *Training* on 'working in groups' and on 'giving an oral presentation'.	outline values and interests that may affect the methodology and outcomes of research; (iv) express a personal view on the problem studied and the interventions proposed to address this problem.	about ongoing research done by faculty members of the Estonian / Ukrainian University. *Intercultural competence training* to get insights in cultural differences. *Group assignment* aiming to: (1) carry out a joint research project/study, and (2) learn to collaborate in an intercultural team. Different nationalities and backgrounds are mixed to enhance the intercultural learning experience. *Reflection***:** student have to reflect throughout the course on their own behaviour, attitude as well as actual steps taken to overcome challenges, and write a reflection assignment. Assessment is on both content (presentations and poster) and process (participation, engagement, and the reflection assignments).

		Orientation on study and job perspectives after graduation, followed by an individual assignment.		

Boundary Crossing Learning Trajectory BSc Food Technology



Course and its core theme	**Introduction to Food Technology** Learning to know the disciplinary and societal perspectives related to food technology (case 'Ready-to-Eat Salad')	**Food Properties and Function** Co-create a food innovation and take into account the consumer perspective	**Case Studies Product Quality** Study a case from industry and suggest product and process quality improvements	**BSc Thesis Food Technology** Food Tech research incl. report and presentation
What boundary / boundaries are addressed in the course?	Disciplinary University-Society Cultural	Disciplinary Cultural University-Society	Disciplinary University-Society	*The BSc thesis might be used for a final assessment of students' boundary crossing*

				competence development. We are discussing whether and how we will do this.
What BC learning mechanism are addressed? ○ Identification ○ Coordination ○ Reflection (perspective making /taking) ○ Transformation	• Identification (of disciplines, stakeholders, and cultures)	• Reflection (on consumer perceptions) • Transformation (co-creation of a food innovation)	• Coordination (communication with real life stakeholders) • Reflection (perspective making and taking on stakeholder assignment and perspectives)	
BC learning objectives of the course (italic, red objectives as part of the complete set of learning objectives)	*1. know and/or understand the basic elements and concepts of the scientific disciplines that span food technology;* 2. know the disciplinary frameworks that are constructed from the basic elements and concepts; 3. know and apply the knowledge on a defined set of basic phenomena to explain and control properties of foods, within the context of one discipline; 4. understand and apply this understanding how to manipulate these phenomena; *5. recognize which phenomena of different disciplines are relevant to explain and control properties of foods, and point out their interrelationship(s) (i.e. identify interdisciplinarity)*	*1. integrate theoretical and practical knowledge from various food science disciplines taking into account the consumer perspective as well;* 2. understand the implications of changes in food product ingredients or processing on the final product properties; 3. understand the effect of chosen processing on food properties and -quality; 4. understand how food quality can be determined with appropriate sensorial and instrumental approaches; 5. understand the methodology and use of modern analytical techniques; *6. understand the ethical issues involved in*	*1. apply basic knowledge from various disciplines in food technology to define and improve food product quality;* *2. translate a question from society (company, institute, start-up, government) into a feasible scientific research project;* 3. search, understand and use scientific literature; *4. work in a team on a joint research project, using inter- and intrapersonal skills* *5. communicate project progress with various stakeholders* 6. scientifically report and present project results	

	6. use ICT-software programs; 7. *have insight in the overall context in which the food industry and its stakeholders operate.*	*innovation of food products and to apply this knowledge in practical situations;* 7. work in small groups and to plan, carry out and evaluate experiments to make an innovated food product and to present the results.		
BC learning activity (and/or assessment activity) in the course	Students visit a company and get the assignment to prepare for a set of questions to be asked to the company staff on stakeholders involved, stakeholders' roles, perspectives and mutual relations, job opportunities etc. Students report their findings as part of the final assignment for the course (including a visualisation of the stakeholder analysis and reflection on suitability of various job positions, and how their view on job opportunities developed over time during the course). Lecture on intercultural communication, and related workshop on finding out intercultural perspectives on various topics.	As part of their innovation assignment, students investigate the consumer perception of their innovation in a broad sense (e.g. health; cultural; economic). They interview real life consumers, and apply consumer perceptions into their innovation. In their final reports, students are required to describe how the identified consumer perspectives have been used/applied in their innovations.	Real life commissioner introduces the case to the students. During the case study, students contact the commissioner and other stakeholders (identified by themselves) to discuss their progress and findings. Finally they present the results to the commissioner. Commissioner and stakeholders are stimulated to translate the findings into follow up assignments (for these or other students). Students write reflections, both mid-way and at the end on how they assessed the commissioners feedback and how they used the feedback in their further work.	

	Additional exam questions: which disciplines are integrated in the Ready-to-Eat Salad? Do you consider this set of disciplines to be complete? Why yes/no? Which other disciplines should actually be integrated?			