

Transdisciplinary Bachelor Course Connecting Business and Electrical Engineering

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Abstract

The OTH Regensburg has a broad variety of study programs in technical, business, social and health sciences. Up to now, there is no integral connection in the bachelor curricula between business and technical faculties except for some small subjects. The scope of this project is to develop a new course specialization, which connects engineering and business thinking. Electrical engineering students should learn basics of business science and how managers think. Business students should vice versa learn fundamentals of engineering and how engineers solve problems. Students from both faculties work together in projects where they act like start-up companies developing a new product and bringing it into the market. It is seen a transdisciplinary effect: These projects gain innovative results between the disciplines compared to student projects of one isolated discipline. Evaluation results from the first two cohorts indicate high student satisfaction, high learning success as well as directions for further improvement.

Keywords: *Engineering Education, Business Education, Transdisciplinary Education, Project Based Learning.*

1. Introduction

The OTH Regensburg offers study courses for technical subjects in many different areas and in addition business and social work programs. The Faculty of “Electrical Engineering and Information Technology” is one of the biggest faculties in this area in Bavaria with about 1.400 students and 35 professors. It offers three bachelor programs, which were changed some years ago to allow more flexibility for the students to select specialization courses during their last two semesters. The Faculty of “Business Studies” offers also application orientated education with about 40 professors and 1.800 students in several bachelor and master programs.

2. Motivation and Study Goals

Our world is becoming more and more complex and therefore for industrial projects, labor is divided within teams, typically between people with diverse specializations and educated in different disciplines. This represents also a challenge for higher education institutions, as they are required to transform their education (Holley, 2009) to prepare students for this working environment (Holzer, Bendahan, Cardia and Gillet, 2014). Education in interdisciplinary teams has been shown to be a very effective means for achieving this goal with different approaches (Taajamaa et al., 2014; Bailleu, Kröger, Menge and Münchow-Carus, 2015). Therefore, in 2013 an interdisciplinary student project was set up developing the technical and marketing concept of a short wave amateur radio transmitter (Batz, Pauser, Wagner, Fuhrmann and Niemetz, 2013). At the beginning of the project, students from different disciplines had problems to understand each other. After this initial phase, a highly motivated team formed with excellent working results. It is also often seen in industrial projects that conflicts arise between employees from different disciplines due to misunderstandings. To address this challenge in education, both faculties started a new specialization within existing bachelor programs to obtain a closer relationship between engineering and business. Students from business studies learn to understand basic approaches of engineering while students from electrical engineering obtain an understanding of basic management concepts. The goal of this program is to educate graduates for bridging the gap between these two different disciplines for a better understanding and therefore a more effective cooperation in companies (Niemetz and Fuhrmann, 2017). To achieve this goal, students get knowledge about technology and innovation management as well as concepts of intrapreneurship and entrepreneurship.

3. Curriculum Development

3.1. Management for Electrical Engineering Students

About four years ago, the Bachelor “Electrical Engineering and Information Technology” curriculum was rearranged to gain more flexibility for the students in their higher semesters to choose preferred topics. In the sixth and seven semesters, they can choose nine modules from a catalogue of technical electives. When choosing two modules from the business studies curriculum for electrical engineers (see Table 1), students can obtain the additional specialization “Engineering and Management” on their bachelor diploma.

Table 1. Module Overview - Management for Engineering Students

Module Name	Hours/Week	Credits
Entrepreneurship and Innovation Management	4	5
Seminar in Technology, Entrepreneurship and Management	4	5
Business Simulation for Engineers	4	5

The first electrical engineering students start with this management specialization in Summer 2018. Up to now, there are no evaluations and results from this part of the study concept.

3.2. Engineering for Management Students

Business students can choose in their sixth and seventh semesters from one of nine study options to deepen their knowledge. A new option “Engineering and Management” was introduced in 2016 to teach business students engineering principles and connect them with engineering students in joint projects. The course overview of this specialization can be seen in Table 2 (OTH Regensburg, 2017). It starts with the courses “Entrepreneurship and Innovation Management” and “Seminar in Technology, Entrepreneurship and Management” in the sixth semester to lay a theoretical basis for the lab work “Technical Project” and the lecture “Fundamentals of Engineering” in the seventh semester.

Table 2. Module Overview - Engineering for Management Students

Module Name	Hours/Week	Credits
Entrepreneurship and Innovation Management	4	5
Seminar in Technology, Entrepreneurship and Management	4	5
Technical Project and Supplementary Lecture	4	5
Fundamentals of Engineering	4	5

Entrepreneurship and Innovation Management

Principles of innovation management and related topics are taught. Models of processes, functions and stakeholders in innovation management, strategic planning, controlling, decision making, evaluation and ethical aspects of innovations are explained. Creative techniques and creativity within teams are important tools for developing new products. Entrepreneurship and intrapreneurship, founding lean start-up companies, managing products and market introductions, aspects of intellectual property are also parts of this lecture. Students learn to know the importance of innovation management for companies, understand innovation processes and their controlling. They learn about corporate entrepreneurship systems and their management, basic concepts of product management and production management, introducing technology with new products or founding new companies and protecting their intellectual property. Students work in teams, present and discuss their results. They know different creativity and innovation management techniques, can analyze and optimize or reorganize business innovation systems. Students learn to know consequences of decisions in innovation systems, can solve problems and calculate risks.

Seminar in Technology, Entrepreneurship and Management

Students learn start-up methodology, entrepreneurial marketing, developing and testing business cases with risk and reward analysis, they plan prices, production capacities, investments, costs, finances and market positions. They analyze industry structures and business models. After this seminar, students know business cases and can develop business plans. They know the interaction between technical demands and product specifications on the one side and business and sales demands on the other side. Students understand the roles of company founders, innovation managers and business plan processes. They know production and capacity planning, material flow planning and human resources planning.

Technical Project and Supplementary Lecture

In this lab course the seventh semester business students work together with fourth semester engineering students in small groups. Students have to create a common vision for a product to be developed. While the engineering students are following the goal to develop a technical solution for an engineering problem, the tasks for the business students are to develop a cost calculation, marketing and distribution concept for this product. All students have also to contribute to the organization of their team, e.g. by project target specification, work package definition and time schedule planning. At the end of the course, the teams are expected to present their results, design a poster and write an entry for the faculty internal Wiki.

Some of the projects are listed below:

- Automatic garbage can, which opens when a user approaches.
- Power pack charging device, which charges a power pack during riding by bicycle.
- Automatic flower pouring with humidity sensor.
- Tea timer for automatically pulling a tea bag out of a cup.
- Bicycle alarm system with GPS tracking.

In a parallel supplementary lecture, the business students learn basics about electrical components and circuits. The main lecture contents are

- basic electric circuits,
- electric voltage, current and power,
- binary and hexadecimal numbers,
- passive electric components and basic semiconductor devices,
- basic structures of printed circuit boards,
- development of finite state machines and
- differences between parallel and serial data transmission.

Students also train to handle electronic components and solder printed circuit boards by building up an electronic kit. In addition, questions regarding project work are clarified.

Fundamentals of Engineering

This lecture tells the students about typical engineering job profiles, like development engineer, quality assurance engineer, process, production, marketing and application engineer. Typical thinking processes and main tasks of engineers are explained. Students precisely analyze a task and develop an appropriate solution, work in teams and consider technical possibilities as well as cost restrictions. After this lecture, students should know about job profiles of engineers and their main working principles, the importance of

specifications and how to solve problems and describe solutions. They understand engineering thinking and are able to work together with engineers. Students know basic approaches in developing electric and electronic devices, and have obtained an understanding for the steps necessary to transfer prototypes into production. They learned about requirement, quality, project and knowledge management. Students know methods to develop time and project plans, judge critical project situations, can communicate and cooperate within a technical working environment.

4. Evaluation Results of the Technical Project Course

For Winter Semester 2016/17, one identical feedback sheet was used for engineering and business students. To get differentiated results, this concept was changed for the second cohort into two separate evaluation sheets with identical questions.

4.1. Winter Semester 2016/17

No evaluation differentiation was made between business and engineering students. The overall evaluation results were good; students were satisfied with the laboratory equipment and group size. Project complexity was not too high, practical relevance was visible and project goals were clear. The students were highly interested and they learned a lot during this practical course. Contacts to professors were appropriate, questions were answered and the atmosphere was good and motivating. Students were also asked to answer two additional questions especially about the interdisciplinary work in the project. The first question deals with the working climate between the faculties and it can be seen in Figure 1 that the perception of working atmosphere was very inhomogeneous. While some students were very satisfied, some others were not happy about group dynamics.

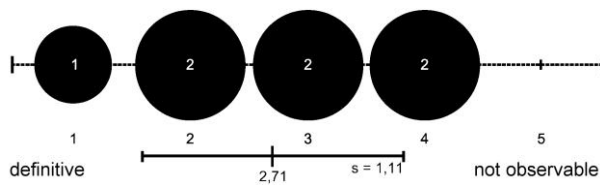


Figure 1. All students 2016/17: It is a constructive working climate between both faculties during the project.

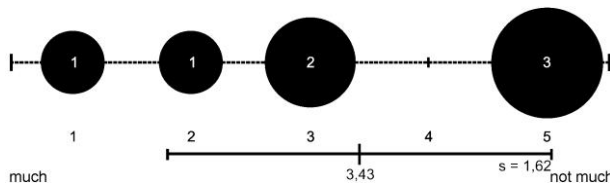


Figure 2. All students 2016/17: The amount I learned about methodologies and topics of the other faculty.

Figure 2 shows the interdisciplinary learning success with a broad spread of ratings. This feedback was not fully satisfying as a higher learning success between the disciplines was expected. In the free text evaluation, students asked for a better interdisciplinary preparation at the beginning of the project course. As a result of this feedback, a more detailed introduction was given at the beginning of the project course in Winter Semester 2017/18.

4.2. Winter Semester 2017/18

In this evaluation, the feedback sheets were separated between business and engineering students but identical questions were used. This gives the chance to see a possible heterogeneity between both student groups. The overall evaluation for the whole project course was very similar to the results from Winter Semester 2016/17. Students were satisfied with laboratory equipment, practical relevance and support by professors.

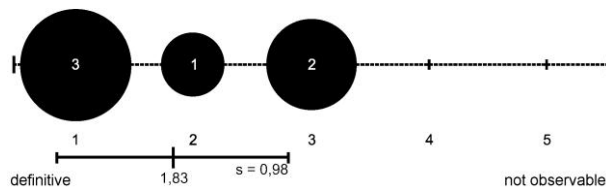


Figure 3. Business students 2017/18: It is a constructive working climate between both faculties during the project.

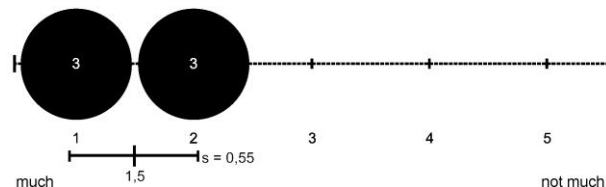


Figure 4. Business students 2017/18: The amount I learned about methodologies and topics of the other faculty.

All business students see a positive working climate between both faculties during the project work (see Figure 3) and had learned a lot from the engineering side (see Figure 4). This evaluation results indicate a high success for the concept of interdisciplinary projects. Some of the free text answers honor the high degree of freedom in their project work. Other business students wished to have more guidance by the professors during their project.

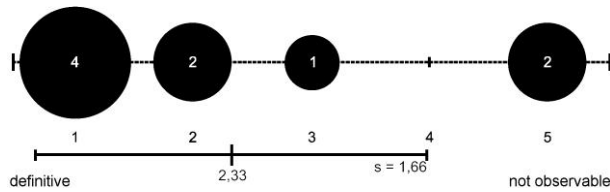


Figure 5. Engineering students 2017/18: It is a constructive working climate between both faculties during the project.

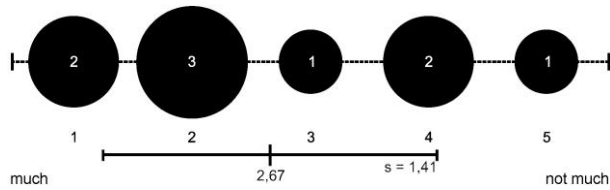


Figure 6. Engineering students 2017/18: The amount I learned about methodologies and topics of the other faculty.

Working climate (see Figure 5) and learning success from the other faculty (see Figure 6) were seen as positive by some of the students while others were obviously dissatisfied. The two dissatisfied students stated in their free text answers that they learned nothing from the business colleagues, the project management within the group was not satisfying and the business students were not very motivated in accomplishing their part of the project work. It is clear from the statements that this was caused by a teamwork problem within this specific group and is not a criticism of the interdisciplinary approach. Different expectations of the two student groups were observed: While the business students in this project had explicitly chosen this specialization and were already in their seventh semester shortly before their graduation, the engineering students were in their fourth semester in the middle of their bachelor education before choosing any specialization. Therefore, the motivations for the interdisciplinary projects were different for both disciplines.

5. Conclusion and Outlook

From the evaluation results, it can be seen that the satisfaction is very high on the business students' side but it needs some additional work to increase satisfaction for the engineering students, as they are too early in their study life to fully value the contribution of the other discipline. The interdisciplinary projects yield much more innovative and better results than projects, which are carried out by students of one faculty. It leads to the conclusion that a transdisciplinary effect is seen which creates additional project output. There were also discussions during the business faculty graduation ceremony 2017 where some graduates told about their further studies in a master program or their starting career as technology managers in industry. All of them were very satisfied with the program due to their great

success in getting an appropriate master program or an interesting and well-paid job. The first engineering students start in Summer Semester 2018 with entering lectures of business sciences. They will be also evaluated to develop this program further. The overall goal is to further develop and promote this specialization. It is seen as a great opportunity to connect both faculties closer and educate students for an interdisciplinary working life.

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