

Development of the “Complex Project” course in the transport engineering education

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Abstract

In the paper we discuss the course history, the basic goals and principles defined at the beginning, and we talk about its methodology. For the “Complex project” course the main parts of the lecturer’s job are the detailed preparation of the project tender, the operative support of the students’ work, and they also have to perform the mid-semester and end-of-semester evaluations. Continuous progress is controlled by milestones laid out throughout the program. The effectiveness of the “Complex project” can be determined based on the previous years, and the future possibilities will also be examined. Besides elevating the level of education from the students’ perspective, at the same time it also improves the lecturers’ competences.

Keywords: *Practical course; intergrated specific professional knowledge; project tender; teamwork; presentation and Final report; complex evaluation system.*

1. Introduction

The “Complex Project” course is part of the syllabus for the bachelor program for transport engineering. This course can be taken after completing the general studies, the basic and specialized professional courses. This methodological course intergrates the theoretical knowledge gathered in the previous courses and focuses on solving complex transport engineering problems.

This course has been around for 15 years. Since its introduction it has evolved and has gone through experiments and changes. However, its upward trajectory is constant and its usefulness is apparent on higher levels as well.

This paper examines the fine tuning of these educational methodologies from the beginning stages to the present. It mentions the definitive changes of educational structure, and it introduces future developmental plans.

2. The general introduction of the “Complex Project” course

In this section we discuss the course history, the basic goals and principles defined at the beginning, and we talk about its methodology in general.

2.1. Historical overview

Until the 2000s there was no practical course that intergrated the specific professional knowledge in transport engineering training. Design and operational control tasks only occurred as side projects in profession-specific courses, without any correlation. These include track design, schedule design, vehicle scheduling, software, etc.

During the curriculum developments of the new millennium, an idea came about to create a course that integrates the profession-specific knowledge. For its design we took inspiration from national and international examples. One of these was the project-based program of the university in Duisburg where the courses were built on solving a tasks set out at the beginning of the program. Due to the wider spectrum of transport engineering, the time constraints made this deep level of integration impossible, but we collected ideas from these principles. On a national level we found examples in the transport design programs where students worked on real-life design projects. We were not expecting these types of projects at the outset, but the ideas gave us a good starting point.

Similarly to the educational system in its entirety, the online learning that came about during the pandemic required significant methodological developments. Despite the technical challenges, positive changes happened, e.g in the methodology of task allocation that will be explained later.

2.2. The goal and general methodology of the course

As we outlined above, the goal of this course is:

- To develop the ability to use the theoretical knowledge in practice
- To recognize the interference of design processes and methods in complex tasks
- To be able to follow and carry out entire design processes
- To highlight the importance of teamwork and performance-based benefits
- To prepare for the autonomous planning of the thesis by going through the research methodology together, and to also prepare for the thesis debate by practicing presentation techniques.

Generally design tasks are created to be worked on by student groups for an entire semester. Groups are made up of 3-4 students. In our experience teamwork is not realized in groups with less than 3 people, and groups with over 4 people leave little room for each individual student which gives way for potential passivity.

The topics of the tasks are based on the two main areas of transport, road (local public transport) and rail, and students can choose based on their interest. Each topic has a responsible lecturer as a team lead who coordinates the groups' work. The in-person "contact lessons" are designed to be 4 hours/week, so 56 hours over the 14 weeks of the semester. For the successful completion of the project, students also need to work on the project individually which makes up about 50% of the overall effort.

The syllabus for the semester consists of consultations, project work outside of the classroom, and presentations.

3. Details of the teaching method

For the "Complex project" course the main parts of the lecturer's job are the detailed preparation of the project tender, the operative support of the students' work, and they also have to perform the mid-semester and end-of-semester evaluations.

3.1. The structure of project tenders

Over the years we worked on various project topics, but the structure of the project tenders was standardized in the early years. It's important that the design process should focus on the complex effects of problem-solving, meaning that beside traffic design, the projects involve technical, legal, economic, environmental and sociological aspects.

At the beginning we were selecting from projects completed by the department and we updated or recreated them. Later, we assigned tasks recommended by fellow lecturers that focused on solving traffic-related problems. Sometimes even students recommended project

topics. These resulted in a wide variety of papers but it also meant that different groups had different levels of difficulty, so the comparisons and evaluations were not fair. To solve this issue we decided to assign the same tasks to multiple groups which resulted in a healthy competitive environment but also had the drawback of groups being able to copy sections from each other. The pandemic brought about a solution for this matter. Due to the restrictions, in-person planning meetings had to be minimized. We designed a framework task for both road and rail and put students in groups based on their hometowns, so they could work on them using their regional data. This meant the solutions were comparable due to sub-tasks being the same, but the locations examined were different. This proved to be a great solution so we kept it after COVID.

Upon the allocation of project tasks we provided detailed descriptions to students that gave clear boundaries for the research. The main elements of the tenders:

- Type of transport (road/rail)
- Project title (recently it’s been a general title, later specified by the location)
- Precedents (motivation)
- Project goal
- Main points of development
- Mandatory pieces of content
- Recommended analytical methodology
- Main evaluation criteria.

These provide a good support and basis for the project development process for the semester.

3.2. Operative project lead

Each group has a lecturer as the project lead. They do not take part in the project development, but they keep a close eye on their groups and provide occasional guidance.

Project leads take part in the introduction lesson where the tasks are explained, and they help with orientation and group dynamics by providing detailed information when needed.

Project leads help their group understand the task and draw up a plan for the entire semester. Based on the members’ competencies they discuss the strong points of each person and select which part of the task they would be responsible for. They divide tasks both horizontally (can be completed in parallel) and vertically (interlinked and cannot be completed in parallel). They list the required resources such as data compilations, maps, national and international literature, published plans and papers, etc as well as the contacts of institutions, associations and scholars they need to involve. They also take stock of the required technical assets such as surveys, traffic countings, recordings, interviews, IT requirements, modelling and

simulation software. Considering the succession of sub-tasks, they create schedule with a Gantt diagram as the basis of project management.

The students start their work based on the project plan which usually begins with location visits and bibliography research.

The usual structure of the design process consists of:

- Understanding the background
- Uncovering the problem
- Examining the reasons
- Exploring the possible solutions (analyzing existing designs, looking for example, etc.)
- Examining their applicability
- Developing individual solutions
- Rating versions
- Performing ROI and impact assessment.

During consultations students report on the completed tasks, rate their usefulness with the lecturer's help, and determine the next steps.

Project leads invite competent external consultants beforehand to gain access to corporate information that could help students with the project.

The project lead also provides assistance with the oral presentations. With those, it is important that:

- All students participate in the preparations
- They keep to the time limitations (but also use up the available time)
- They use the correct terminology
- They have an awareness about their gestures
- They pay attention to grammar and clarity.

Main points of the supporting Power Point presentations:

- Their layout design should be suitable for the topic
- The number of slides should be appropriate for the time limitations
- Visible fonts and figures
- Contrasting elements
- Animations (but not unnecessary 'fireworks')
- Practicing pointing techniques (with pointer, cursor).

The spoken and written content has to harmonize with one another (the presenter has to talk about what's on the figures and the written text has to support the spoken content). The project lead assists with the preparation of the written project paper. The paper has a set

length limitation and mandatory content elements. Its format is identical to the regular thesis format so that students can learn the formatting expectations early. The general matrix of the semester schedule is shown on Figure 1.

Groups	T e n d e r i n g			P r o g r e s s			I n t e r m e d			P r o g r e s s			F i n a l	
	C			P	C		I			C	P	C		
Grouprailwayn	o	n		r	o		n			o	r	o		
...	s	u		r	s		r			s	r	s		
Grouprailway2	l	t		s	l		e			l	s	l		
Grouprailway1	a	t		r	a		-			a	r	a		
Grouproadn	i	o		r	i		R			i	r	i		
...	n	s		p	o		e			n	p	n		
Grouproad2				r	s		p			s	r	s		
Grouproad1				s			r			s	r	s		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Figure 1. Semester matrix.

3.3. The evaluation process

Continous progress is controlled by milestones laid out throughout the program. The so-called progress reports (separate for road and rail) presented by the groups at $\frac{1}{4}$ and $\frac{3}{4}$ of the semester provide an update on the progress of the project. These are evaluated by all project leads. At the halfway point, all groups present a so-called Intermediate report in front of everybody. Groups present their current results with a Power Point presentation that serves as a rehearsal for the semester-closing presentation. Along with the project leads, students from other groups can also give constructive feedback. Besides points set forth in 3.2, professional opinions and individual requests can be added.

The course requirement is divided into 2 parts:

- Preparation and hand-in of the project paper by the required due date
- Presentation of the results at the Final report, and persuading the client.

The final evaluation will be determined by a ratio of 60% paper and 40% presentation. Both have a complex evaluation system with points given for certain sections. The format of the papers is checked by the course lead, 10 points can be given. The project lead evaluates the content and can give 50 points. The Final report is evaluated by all present project leads. They can give up to 40 points, and the average of all points given will be taken into account.

The sum of the above give the base of the point for each group, so maximum $10+50+40=100$ points. This is multiplied by the number of students in the group (3 or 4), and that is number that will be divided among the student. The points give to each person will be determined by the group. When they hand in the paper, each member also hands in a evaluation sheet where

they rate their team member’s work throughout the semester by dividing 100% among them. For each individual the average of the received % will be considered (to avoid cliques the project lead can overrule ratios). The points given to each student will be determined by distributing the total score of the group by the % received. These pre-determined criteria will give the final mark to the students.

If a group hands in their papers after the deadline, a “penalty” is taken by deducting x% of the points.

4. Evaluating the course

The effectiveness of the “Complex project” can be determined based on the previous years, and the future possibilities can also be examined.

4.1. Statistics

During the 15 years between 2008 and 2022, 562 students worked on 148 projects in 148 groups. The evolution of participants and topics by year can be seen on Figure 2.

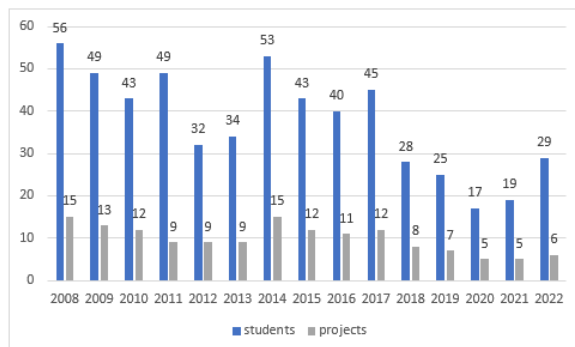


Figure 2. Number of students and projects 2008-2022.

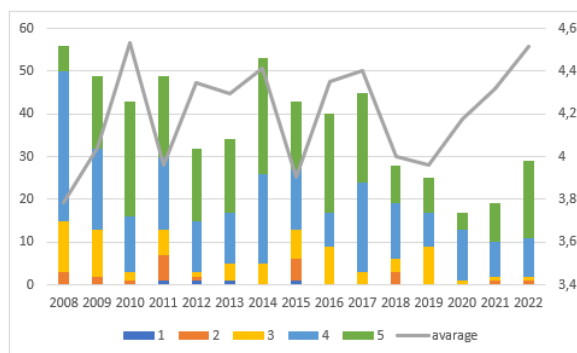


Figure 3. Grades and course averages 2008-2022.

Due to the practical nature of the course, the final grades and group averages are higher than for theoretical courses. In fact, the only ones who failed the class were the no-shows. The distribution timeline is shown on Figure 3. Over the course of 15 years the course average has been 4,20 (on a scale of 1 to 5) which show that the student were well prepared and enthusiastic.

4.2. Developments moving forward

It is apparent that the methodology is continuously improving. As a next step, along with tasks offered by our department, transport corporations will send us project plans. Students can apply for these and they will be available for 2-3 groups. We will provide a high level of guidance from the project leads and the groups will compete with each other to come up with alternative solutions. Lecturers will give presentations on the procedures that are deemed highly useful for the potential solutions. Students will separately present their progress every 3 weeks. The client company will take part in the semester-ending evaluation, and the group they find the best will receive a prize.

We have developed a continuation for this bachelor’s course for the master’s program. Students will already be familiar with the process of project development, so they will learn how to lead and coordinate projects.

5. Conclusion

This course significantly facilitates the transition between theoretical education and practical application.

It provides a tool for acquiring the methodology that is required for understanding, creating and debating the thesis for each individual person.

Compared the results of the students at the final exam and thesis, we found that the marks are significantly better than before the introduction of the subject “Complex project”.

It lays a foundation for the master’s program and improves the professional recognition on the program.

Besides elevating the level of education from the students’ perspective, at the same time it also improves the lecturers’ competences.

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