

A portfolio of new approaches and teaching practices

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Programme	Erasmus+
Key-Action	
Action	
Main Objective of the OI	To produce a portfolio (toolkit) of new teaching and learning methods, approaches, policies and practices for rail skills development.
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Report/Output Type	Learning / teaching / training material – Toolkit
Language used to fill in the form	EN
Beneficiary Organisation Full Legal Name (Latin characters)	KUNGLIGA TEKNISKA HOEGSKOLAN (E10209479, SE) UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA (E10209458, IT) TECHNISCHE HOCHSCHULE WILDAU (E10188671, DE) SVEUCILISTE U ZAGREBU (E10209270, HR) UNIVERSIDAD DE MALAGA (E10209121, ES) ZILINSKA UNIVERZITA V ZILINE (E10209360, SK) EURNEX e.V. (E10246848, DE)
WP1 Start Date	2021-04-18
WP1 End Date	2022-03-17

Output Identification	IO4
Output title	A Portfolio of New Approaches and Teaching Practices
Description of the intellectual output	<p>This Intellectual Output (IO4) includes a portfolio (toolkit) of new teaching and learning methods, approaches, policies and practices for rail skills development.</p> <p>To produce this Intellectual Output (IO4) we employed an innovative multi-disciplinary approach including a combination of methods such as state of the art surveys and reviews, collaborative learning activities with stakeholders/associated partners, analysis of methods for continuous quality improvement of rail higher education provision, modelling of a rail specific curriculum, collaborative approach for developing new methods for rail skills development, incl. validation and exploitation of results, with a particular focus on innovation in rail higher education.</p>
Start Date (dd-mm-yyyy)	18/04/2021
End Date (dd-mm-yyyy)	17/03/2022
Available Languages	English
Available Medias	
Leading Organisation	ASTON UNIVERSITY (E10209108, GB)
Description and division of work	<p>AU coordinated the development of this Intellectual output (IO4). For the development of this Intellectual Output, the following tasks were completed:</p> <p>Task 4.1 Structure and Framework: set up the structure and develop the framework of the portfolio. It identified the main pillars including job categories and rail university degree programmes and training courses.</p> <p>This task was led by AU and completed collectively by KTH, DICEA, EURNEX, TH WILDAU, UNIZA, UNIZG, UMA.</p> <p>Task 4.2 Analysis of the current methods and development of new methods for skills development for every rail job category identified by WG1. This task was developed with input provided from WG 1. Led by DICEA with strong support from AU, and all partners: KTH, AU, EURNEX, TH WILDAU, UNIZA, UNIZG, UMA, this task was completed collectively.</p> <p>Indicative content includes:</p> <ul style="list-style-type: none"> - Revise, reflect, innovate, and improve the skills development approach in higher education. - Revise, reflect, innovate, and improve the teaching and learning environment. - Revise, reflect, innovate, and improve the role of the teacher in rail higher education. - Revise, reflect, innovate, and improve the 'Classroom Assessment Techniques'. - Revise, reflect, innovate, and improve the course-related and teacher-related student feedback. - Revise, reflect, innovate and improve the curriculum design and the mixture of teaching and learning methods (placements incl.) embedded in it; - Revise, reflect, innovate, and improve the assessment method for every rail subject-specific module. - Revise, reflect and elaborate on the benefits and importance of implementing research - based teaching and learning for rail skills development. - Revise, reflect, innovate and improve the carrier prospect for every graduate in any European country. <p>Task 4.3 A portfolio (toolkit) of new approaches and teaching practices for rail skills development. This task was led by AU and completed collectively by KTH, DICEA, EURNEX, TH WILDAU, UNIZA, UNIZG, UMA.</p> <p><u>Specifically:</u></p>

	<p>AU brought innovative approaches and professional practices from its own portfolio and the UK and demonstrated the potential of these approaches and practices for innovating the current rail-orientated university degree programmes and training courses. For the purposes of this task AU mostly covered rail courses and subjects currently running at Aston University within the University programmes of ESSCM department.</p> <p>KTH contributed to the development of this intellectual output by reviewing the existing teaching and learning methods in their rail related courses and proposing changes to the learning objectives, activities, and examination that have the potential to improve student deep learning according to the existing pedagogic literature. KTH will cover primarily topics related to rail vehicles, vehicle dynamics, wheel-rail contact, and maintenance.</p> <p>DICEA worked towards innovative methods for rail higher education in areas of railway superstructure, freight and passengers' terminals, environmental impact and energy management.</p> <p>EURNEX contributed to the development of new teaching and learning methods as well as teaching material about Intermodal freight transport, with a special focus on the railways provided the mode's central role in the delivery of the service.</p> <p>TH WILDAU integrated their expertise in developing innovative approaches for modernising higher education for rail operations, signalling and control.</p> <p>UNIZG will contribute by offering new designs and mechanisms for teaching and learning rail pricing, ticketing, access charges and slot allocation.</p> <p>UMA covered all crucial aspects of vehicle dynamics and maintenance as well as behaviour of pantograph.</p> <p>UNIZA contributed knowledge about new teaching and learning methods for rail transport economics and rail passenger transport services quality.</p>
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1- Introduction

Higher Education Institutions (HEIs) are implementing a series of education strategies aimed at continuously improving the teaching and learning processes in their institutions. In line with the aim of the ASTONRail project's IO4, Figure 1 provides Aston University's education strategy for the years 2021-2025.

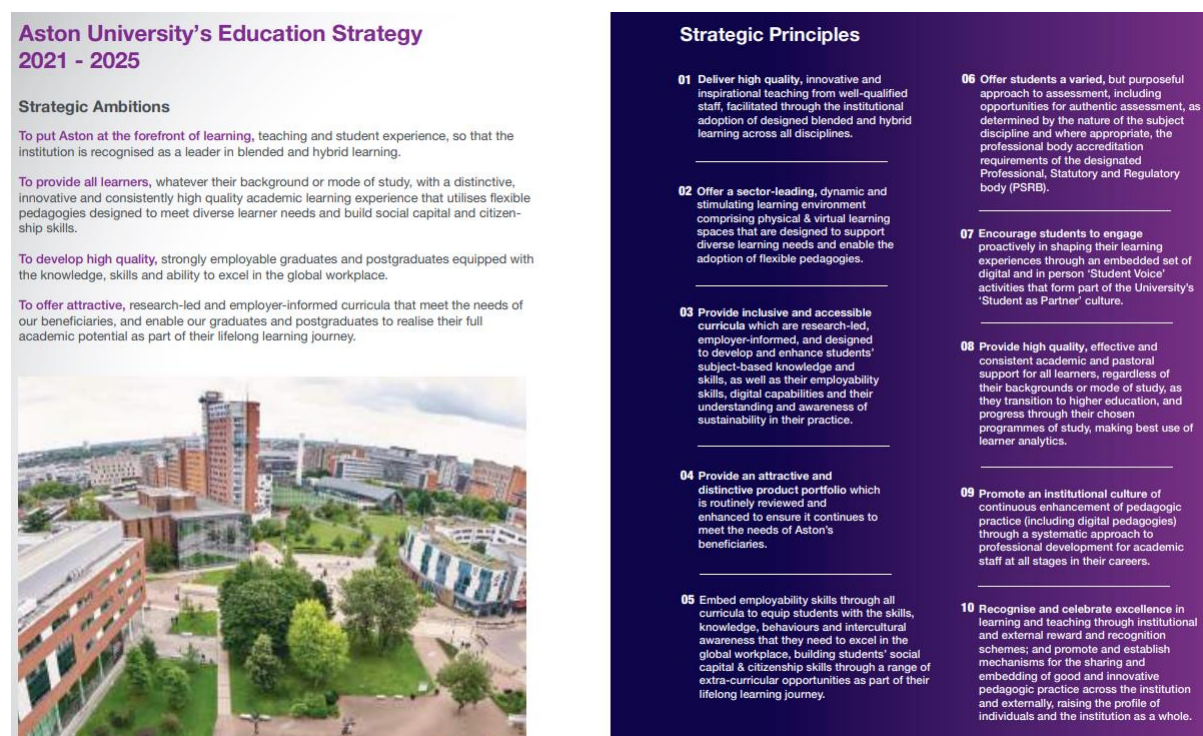


Figure 1 Education strategy at Aston University (source: Aston University Website)

For the development of the ASTONRail portfolio, we employed the slogan: Innovation in rail high education that works.

The following seven (7) development goals have been set up to outline the structure and design the framework of the ASTONRail Portfolio, (see Figure 2):

1. Employ an innovative multi-disciplinary approach including a combination of methods.
2. Improve the classical skills development approach in higher education, which is: listen, stop, reflect, write and give feedback.
3. Identify the role of the teacher, when and where the teacher should be acting as Director, as Leading Learner, as Nurturer and as Facilitator?
4. Improve 'Classroom Assessment Techniques', course-related and teacher-related student feedback.
5. Identify and establish the right balance between different teaching and learning methods, including:
 - i. "Information acquisition and knowledge construction "
 - ii. "Teacher-centred learning and student-centred learning "
 - iii. "Lectures in classrooms and practical in laboratories "
 - iv. "Distance learning and self-studies "
 - v. "Exam-based assessments and project/course work-based assessment "
 - vi. "Student mobility and distance learning".

6. Link teaching and research (**research-based teaching and learning**)
7. Develop and demonstrate a deep understanding of the informed practice and critical reflection from the teacher's, the stakeholder's and the student's perspectives.



Figure 2. A visual Illustration of the seven ASTONRail portfolio development goals

1.1 - Learning in Theory

Learning theories are based on behaviourism, cognitivism, and constructivism. In every one of these categories, learning occurs differently, see Figure 3. For rail higher education of good quality, a combination of all three categories should be employed.

Learning theory	Behaviourism	Cognitivism	Constructivism
Best for teaching:	Task-based learning involving lower-order thinking skills.	Problem solving involving higher-order thinking skills.	Solving ill-defined problems involving higher-order thinking skills.
Role of the instructor:	Present learners with structured material (stimulus) and prompts for the right response.	Provide learners with strategies that allow them to connect new knowledge to existing knowledge.	Aids learners in exploring topics and coming to their own understanding by asking questions.
Role of the learner:	A blank slate, a passive participant to stimulus-response.	An active participant, engaged in transforming, rehearsing, storing and retrieving information.	An active participant, building interpretations of the world bases in individual experiences.
How does learning occur?	When learners transfer stimulus-response to more general and new situations.	When learners retrieve information and apply it to a new or different situation.	When learners use their knowledge in a real-world situation.

Figure 3. Learning theories in a table, adapted from CL4001, at Aston University

1.2 - Forms of Learning

There are two widely spread forms of learning: *Teacher-centred learning (TCL)* and *Student-centred learning (SCL)*, see Figure 4. It is not proven which of these two forms should be broadly employed to enhance rail skills development and improve the quality of rail higher education provision.

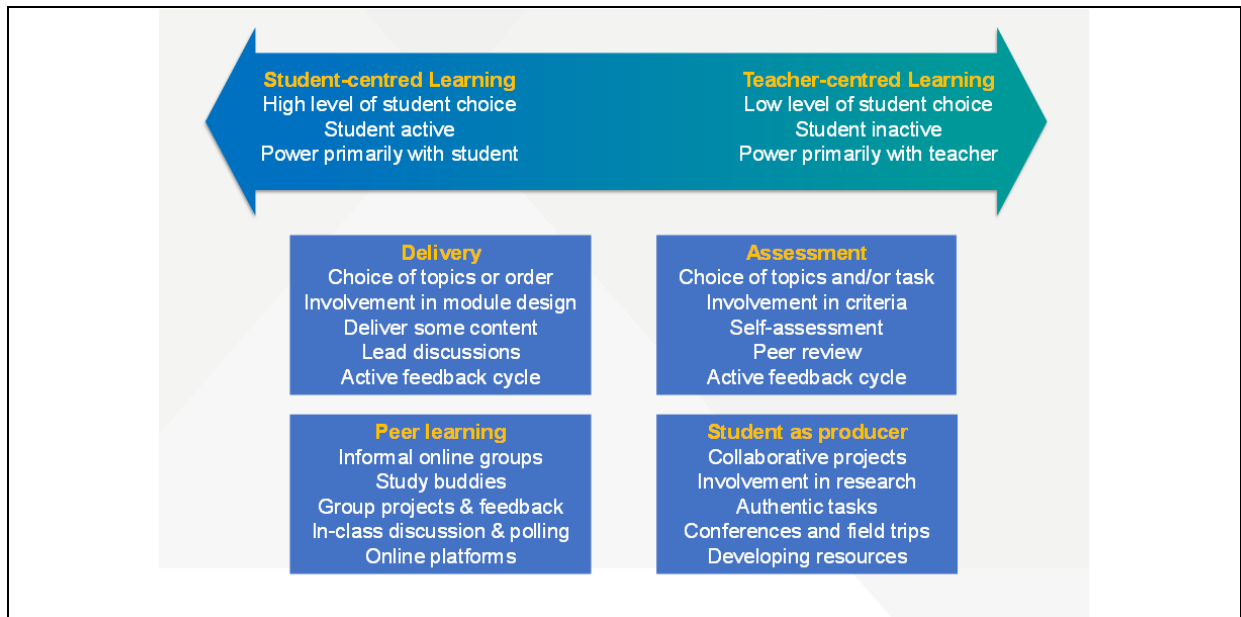


Figure 4. Involving students to enhance and innovate higher education provision, adapted from CL4003, at Aston University

1.3 - Teaching Approaches (Stances)

According to Erica McWilliam's pedagogic stances, there are three widely spread teaching approaches in Higher Education Institutions (HEIs), see Figure 4:

- 2 Sage on the stage
- 3 Guide on the side.
- 4 Meddler in the middle.

For rail-focused subjects, practical and lab-based exercises should also be included to enhance the student experience and build concrete knowledge.

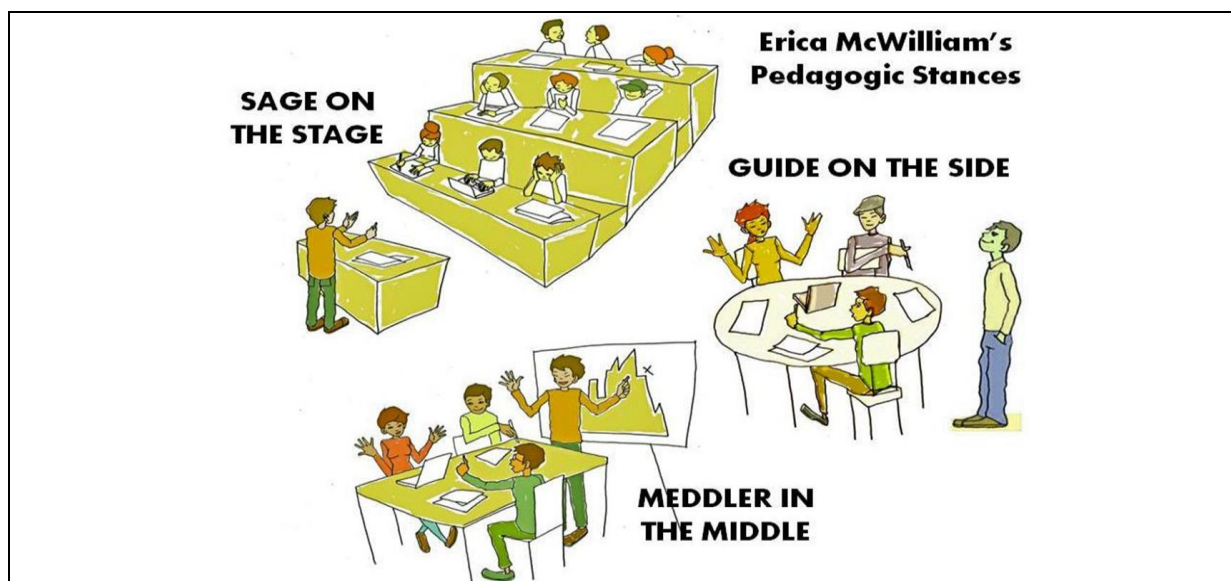


Figure 5. Erica McWilliam's pedagogic stances, McWilliam, Erica L. (2009) *Teaching for creativity: from sage to guide to meddler*. *Asia Pacific Journal of Education*, 29(3), pp. 281-293.

1.4- Teacher's role

The quality of a learning outcome is strongly dependant on both the form of learning and the role of the teacher within it.

For different teaching and learning stances, the teacher's role can be different. The teacher can either act as Director, or as Leading Learner, or as Nurturer or as Facilitator. Every one of these roles require different function, method and approach. See Figure 6.

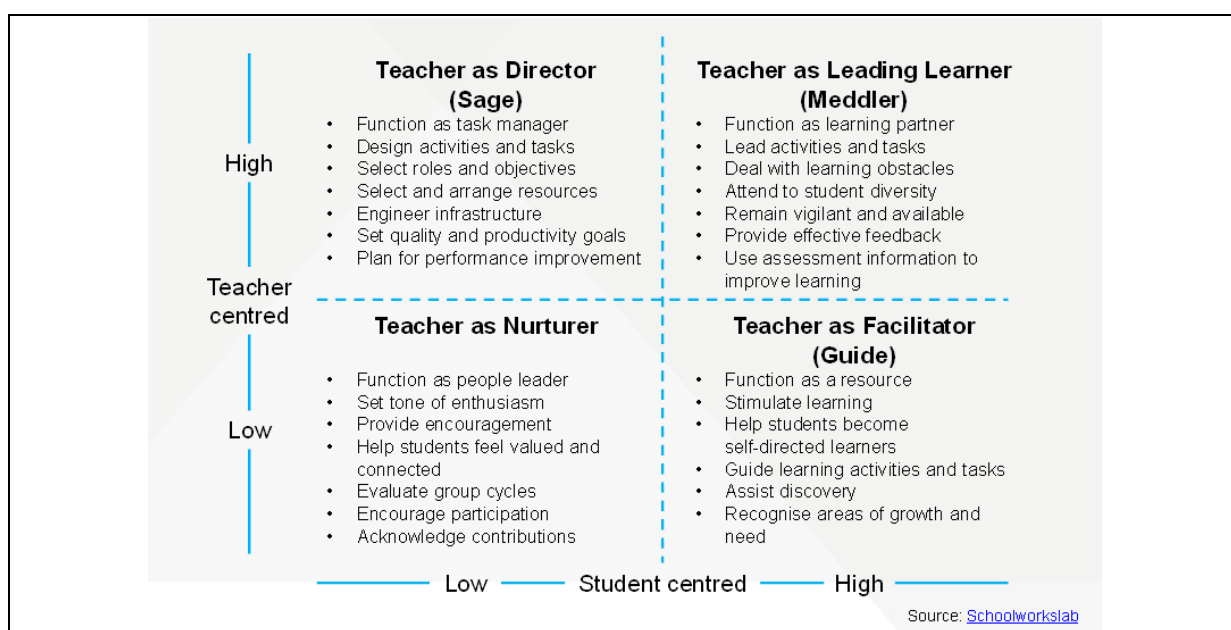


Figure 6 Different Roles of the teacher in a table

2- *AstonRail Toolkit*: Policy ➡ Strategy ➡ Resources ➡ Training

In this section every partner has contributed to a specific learning area which has been recommended by Workpackage 3 WP3. The table below provides a detailed information on what is essential and should remain unchanged in the current approaches and teaching practices for rail skills development in the subject areas. In addition to what can be updated, suggest Step changes/ Improvements in the Curriculum's (programme, course, session).

Table 1: ASTONRail portfolio (toolkit) of new approaches and teaching practices for rail skills development.

Organizations / Universities	subject areas/ Focus areas	Essential and to remain unchanged in the current approaches and teaching practices	Suggested updates/changes/improvements in the current approaches and teaching practices
Aston University	Rail safety and security	<p>Level: BSc - Rail transport module</p> <p><u>Module Structure/</u> Form of delivery: a set of lectures, in-class teaching, followed by a 2-hour closed book exam on campus.</p> <p><u>Essential/</u> to remain unchanged:</p> <ul style="list-style-type: none"> • Student-teacher contact hours. • In classroom learning to present and discuss key theoretical aspects of rail safety and security • Well-structured lectures with examples to demonstrate the impact from unsafe and unsecure rail operation and system management. • Introduction of key standards of crashworthiness and rail vehicle design. • Lectures on rail traffic rules, level crossings and basic aspects of signalling to ensure that trains are kept apart at safe distance • Possibilities for students to attend the lectures remotely through online platforms 	<p><u>Form of delivery:</u></p> <ul style="list-style-type: none"> • Both Task based learning and Problem solving could be included in the module T&L activities. • Students could be tasked to develop projects to design rail vehicles subject to safety interior and crashworthiness requirements. • Defined problems with traffic rules and level crossing can be set up and offered to student to analyse and solve. • Students could work either individually or in groups. Such activities could contribute to skills assessment. <p><u>Form of assessment:</u></p> <p>A 2-hour closed book exam in the end of the module could be replaced by a 24-hour open book online exam, during which students will be asked to answer 4 detailed questions out 6. Submission of exam should be online via a suitable platform.</p>

		<p>Level: BSc - Transport Foundations Module</p> <ul style="list-style-type: none"> Module structure: The teaching involves 4 hours of delivery per week (2 hours of lecture of non-quantitative concepts and 2 hours of seminar/tutorials for practical/quantitative concepts). Each week students are given task to be completed by the next week. In return some quick feedback (summative feedback) will be provided. The tasks are not marked <p>Assessment: A two-hour exam covering some general or strategic concepts</p>	<p>Form of assessment: The assessment could be split in two parts: A two-hour exam (unchanged) covering some general or strategic concepts. <u>In addition to,</u> A coursework based on a case study (group work) covering more professional learning outcomes. (2000 words). Ideally, each year the case study could be sponsored by a rail company. A prize for the best coursework could also be given to students. The “size” of the coursework task can depend on the module number of credits (15 credits: 2000 words).</p>
KTH	Rail vehicles technology, vehicle dynamics and maintenance.	<p>Level: MSc - Topic: Rail Vehicles Technology</p> <p>Module Structure: regular lectures + course-long project task in parallel. Study visit. Invited lecture. <u>Essential/ to remain unchanged:</u></p> <ul style="list-style-type: none"> To keep the face-to-face interaction, the variety of topics is very interesting and having different lecturers for each one is great, small student groups create very interactive regular lectures To examine calculation of vehicle performance. To keep the parallel setup where Project Task and lectures go in parallel, it synergises well and increases the engagement of the students in the individual topics 	<p>Form of delivery could be updated and enriched: The whole course could be more centred around the Project Task. That needs: Better synchronising lectures and project task by spreading the work more or having Q&A sessions earlier or more often. The project is "top heavy", a large part of the work is done in the first few weeks, before the concepts have been properly studied in class or project help hours start. Reducing the time dedicated to lectures and using that for other things: practical exercises, Q&A sessions, advanced topics, this can be achieved by flipped classroom, but with a limited setup / amount of knowledge that is pre-recorded</p> <p>Change 1 - Create short, pre-recorded videos on Key Concepts, one for each lecture, about 10-15</p>

			<p>minutes long. Then students go into the actual lecture with this "known", and can start directly with more advanced topics, and use those "saved" minutes for exercises or more discussions, depending on the specific lecture</p> <p>Change 2 - Re-structure the Project Task and the order of the lectures so that the introductory lectures are already valuable for starting to work on the technical basis.</p>
	Rail vehicles technology, vehicle dynamics and maintenance.	<p>Level: MSc - Topic: Vehicle Reliability, Availability and Maintainability</p> <p>Module Structure/ Form of delivery: one industry invited lecture (2*45min) in the Rail Vehicles Technology course, plus one assignment.</p> <p>Essential/ to remain unchanged:</p> <ul style="list-style-type: none"> To include this in some way, students don't have contact with this at all in their studies To keep the invited lecturer as an experienced branch member <p>Continue to feature an assignment to introduce students to a practical application of concepts - only one guest lecture feels decoupled and does not give you depth on the topic</p>	<p>Form of delivery could be updated and enriched: Reduce the "density" of the lecture by ideally spreading it over more hours, or limiting the scope of what is said if not possible.</p> <p>Introduce maintenance concepts earlier in the module for a smoother transition, at the moment it is quite independent and not integrated.</p> <p>Integrate the assignment more clearly within the Project Task to create a more tangible link between the two.</p> <p>Change 1 - Pre-recorded lecture with basic concepts for reducing the weight, rail vehicles related content during the lecture</p> <p>Change 2 - Project task specific exercise</p>
	Rail vehicles technology, vehicle dynamics and maintenance.	<p>Level: MSc - Topic: Rail Vehicle Dynamics</p> <p>Module Structure/ Course: Rail Vehicles Technology, 9 credits, regular lectures, exercises, industry lecture, small tasks bigger project task</p> <p>Essential/ to remain unchanged:</p> <ul style="list-style-type: none"> To keep face to face interaction, same as SD2307 	<p>Form of delivery could be updated and enriched: "Lectures feel a bit ""disconnected"" from each other, the link is sometimes hard to see or understand in particular when lecturers change. Sequencing the lectures or splitting the topics differently could be an area to look into. At the moment there is a clear split between the</p>

		<ul style="list-style-type: none"> • Study in detail all rail vehicle dynamic phenomena. • To keep parallel exercise sessions and help from teaching assistants • Different specialised lecturers are great explore the variety of topics, if the lecturer is expert in that topic, it helps motivate the students and gives confidence on the course content <p>Have the scaled-down track model to demonstrate guidance effects.</p>	<p>theoretical 1st half of the course and the railway-applied second half.</p> <p>Exercise sessions are not always related to coursework, it could be of great help to increase the link between the two, while making the job of the teaching assistant potentially easier (there won't be as many impromptu questions about coursework from students).</p> <p>Possibly increase the industry relevance of the topic, also the ties to specific companies</p> <p>Change 1 - restructure lectures, exercises and tasks to be more aligned. Use a setup similar to the SD2307 but with independent bits of exercises and tasks, well synchronised.</p> <p>Change 2 - include more and better hands-on mock-up models for studying different concepts - design and create small physical setups that demonstrate Key Concepts such as equivalent conicity, guidance mechanisms, geometrical profile matching, stiff/flexible bogies, etc.</p>
	Rail vehicles technology, vehicle dynamics and maintenance.	<p>Level: MSc - Topic: Railway systems overview</p> <p>Module Structure/ Challenge based railway systems design, 7,5 credits course, weekly seminars and workshops around Design Thinking, student-led project in parallel.</p> <p>Essential/ to remain unchanged:</p> <p>New course, keep a project/challenge-based course in the program, different from all the existing lecture-based ones.</p>	<p>Form of delivery could be updated and enriched:</p> <p>The course has strong ties with Delsbo Electric Student competition, which shares many similar objectives and features could be of benefit for each party. Students would feel rewarded for working on a university project (Railway engineering students are the only ones who currently cannot earn credits from a railway based project, unlike vehicle/electrical/thesis students), and Delsbo could thus find members to recruit more easily. It also creates more motivation for taking part in this</p>

			<p>new module, as the competition aspect is a somewhat unique and exciting perspective.</p> <p>Change 1 - coordinate and synchronise the course content with a realistic application in the Delsbo Electric student competition</p>
	Rail vehicles technology, vehicle dynamics and maintenance.	<p>Level: MSc - <u>Topic:</u> Rail Vehicles</p> <p><u>Module Structure/</u> Delsbo Electric student competition</p> <p><u>Essential/ to remain unchanged:</u></p> <ul style="list-style-type: none"> To keep this project running <p>Involving KTH professors/PhD students is very helpful and engaging, it should continue</p>	<p><u>Form of delivery</u> could be updated and enriched: Directly increase the ties with the challenge-based rail system design module.</p> <p>Change 1 - coordinate and synchronise the course content with a realistic application in the Delsbo Electric student competition (same as above)</p>
	Rail vehicles technology, vehicle dynamics and maintenance.	<p>Level: MSc - professional (open) - <u>Topic:</u> Railway systems</p> <p><u>Module Structure/</u> Railway Group Seminar (0 credits) set of presentation lectures on the research at the KTH Railway Group, open for professionals, students are invited.</p> <p><u>Essential/ to remain unchanged:</u></p> <ul style="list-style-type: none"> "To keep this event available for students to see KTH research and to mingle with industry partners "Continue to invite a large number of professionals "Having a few instalments throughout the year is good. "Keep inviting students, ""attendance rate"" is very high among them: almost everyone who can do so attends the event, the concept is already a success 	<p><u>Form of delivery</u> could be updated and enriched: This is not officially a learning activity but is something with high student engagement. The format could be more dynamic. Having one presentation/lecture after the other can be harder to follow as the topics are very complex especially in the eyes of students.</p> <p>For example, there could be one fewer lecture and a greater gap between the two to leave more time for discussion with professionals.</p> <p>The presence of students changes the dynamic of the seminar. Students are interested in the mingle/industry part, so increasing or improving this would be good. Linking or showcasing career paths is also interesting.</p> <p>Change 1 - propose measures for increasing student and industry engagement, e.g. basic name tags and more time for mingle, but also more</p>

		Keep it a hybrid event even outside of covid context, it is practical and increases engagement even from different countries.	advanced concepts: continue in the afternoon as a small fair; or a student-focused workshop/brainstorming session/flash hackathon on different topics steered by the program responsible or some senior lecturer, where industry could be invited.
DICEA	Railway infrastructure, freight and passengers' terminals, environmental impact, and energy management	<p>Level: MSc (Transport Systems Engineering) Topic: Railway infrastructure, included in a Railway Engineering module (Language: English) Module structure/Form of delivery: a set of lectures, practices, and seminars. Essential/ to remain unchanged:</p> <ul style="list-style-type: none"> • Lectures in classroom learning to present and discuss key theoretical aspects (geometrical alignment, superstructure performances by typologies, constraints on operation, maintenance management); • Practices in classroom targeted to the application of concepts in design and operational phases: rehabilitation of an existing line and constraints for operation joined with parallel approach to vehicles with final targets on capacity assessment and timetabling. • Seminars on ongoing research topics (by PhD students and/or teachers from other universities) • Oral exam (part of the global exam on the module) including presentation of practices. 	<p><u>Form of delivery</u> could be updated and enriched:</p> <ul style="list-style-type: none"> • Planning of a dedicated technical visit with task assignment to groups and final students to students' presentation (<i>meddler in the middle</i> teacher role). • Moving some theoretical lectures during the visits by using 1:1 physical example. • Involvement of extra-academic teachers bringing experience from the field. • Systematic involvement of teachers from other universities in a more osmotic multi-voice teaching.
		<p>Level: MSc (Transport Systems Engineering) Topic: Freight and passengers' terminals, included in a Railway Engineering module (Language: English)</p>	<p><u>Form of delivery</u> could be updated and enriched:</p> <ul style="list-style-type: none"> • Extensions of dedicated technical visit to a freight terminal with approach similar to the present one: task assignment to groups and

		<p>Module structure/Form of delivery: a set of lectures practices and a technical visit.</p> <p>Essential/ to remain unchanged:</p> <ul style="list-style-type: none"> • Lectures in classroom learning to present and discuss key theoretical aspects (passengers stations functions and layout, marshalling yards and other freight terminals operation, capacity of simple nodes and complex stations); • Practices in classroom targeted to the application of concepts in design and operational phases: rehabilitation of stations on an existing line and constraints for operation joined with parallel approach to vehicles with final targets on capacity assessment and station timetabling. • Technical visits in groups to rail passenger stations with a focus on superstructure, layout, signalling, operation and accessibility with students-to-students final presentation. • Oral exam (part of the global exam on the module) including presentation of practices. 	<p>final students to students' presentation (<i>meddler in the middle</i> teacher role)</p> <ul style="list-style-type: none"> • Moving some theoretical lectures during the visits by using 1:1 physical example. • Involvement of extra-academic teachers bringing experience from the field. • Systematic involvement of teachers from other universities in a more osmotic multi-voice teaching.
		<p>Level: Post-MSc (Rail Infrastructures and Systems Engineering)</p> <p>Topic: Railway superstructure, included in a Superstructure and Fixed Plants module (Language: Italian)</p> <p>Module structure/Form of delivery: a set of lectures and practices</p> <p>Essential/ to remain unchanged:</p> <ul style="list-style-type: none"> • Lectures in classroom learning to present and discuss key theoretical aspects (functions and components of superstructure, theoretical 	<p><u>Form of delivery</u> could be updated and enriched:</p> <ul style="list-style-type: none"> • Planning of a dedicated technical visit with task assignment to groups and final students to students' presentation (<i>meddler in the middle</i> teacher role); • Moving some theoretical lectures during the visits by using 1:1 physical example. • Systematic involvement of teachers from other universities in a more osmotic multi-voice teaching.

		<p>modelling, installation and maintenance, advanced diagnostic systems) with 50% coverage by extra-academic teachers from infrastructure managers and industries bringing practical experiences from the field.</p> <ul style="list-style-type: none"> • Practices in classroom targeted to the application of concepts to wheel-rail interaction. • Oral exam (part of the global exam on the module) including presentation of practices. 	
		<p>Level: Post-MSc (Rail Infrastructures and Systems Engineering) Topic: Freight and passengers' terminals, (Language: Italian) Module structure/Form of delivery: a set of lectures practices and a technical visit. Essential/ to remain unchanged:</p> <ul style="list-style-type: none"> • Lectures in classroom learning to present and discuss key theoretical aspects (functions of freight and passengers stations, dimensioning methodology of layout by typology, accessibility and station buildings, design and operation of marshalling yards and intermodal terminals, capacity assessment, traffic simulation, interaction with urban land use in surrounding areas) with 50% coverage by extra-academic teachers from infrastructure managers and planners bringing practical experiences from the field; 	<p><u>Form of delivery</u> could be updated and enriched:</p> <ul style="list-style-type: none"> • Extensions of dedicated technical visit to a freight terminal, task assignment to groups and final students to students' presentation (<i>meddler in the middle</i> teacher role). • Moving some theoretical lectures during the visits by using 1:1 physical example. • Systematic involvement of teachers from other universities in a more osmotic multi-voice teaching.

		<ul style="list-style-type: none"> Practices in classroom targeted to the application of concepts to the design of a simple passengers station. Technical visit at a passenger station with focus on layout, operation and accessibility. Oral exam including presentation of practices. 	
		<p>Level: Post-MSc (Rail Infrastructures and Systems Engineering) Topic: Environmental impact assessment, (Language: Italian) Module structure/Form of delivery: a set of lectures and practices. Essential/ to remain unchanged:</p> <ul style="list-style-type: none"> Lectures in classroom learning to present and discuss key theoretical aspects (interaction between infrastructure and environmental systems, externalities and carbon footprint concepts, assessment of impacts during construction and operation, energy management by eco-driving and timetabling optimization) with 50% coverage by extra-academic teachers from infrastructure managers bringing practical experiences from the field and teachers from other universities. Practices in classroom targeted to the interactive assessment of carbon footprint by simulators. Oral exam including presentation of practices. 	<p><u>Form of delivery</u> could be updated and enriched:</p> <ul style="list-style-type: none"> Planning of a dedicated technical visit with task assignment to groups and final students to students' presentation (<i>meddler in the middle</i> teacher role). Moving some theoretical lectures during the visits by using 1:1 physical example. Systematic involvement of teachers from other universities in a more osmotic multi-voice teaching.
UMA	Vehicle dynamics	<p>Level: MSc (Industrial Engineering) Topic: Railway Technology, dedicated module (Language: Spanish) Essential/ to remain unchanged:</p>	<p>Papers discussion: students could be organised in groups to improve their communication, collaborative and discussion skills (active learning-guide on the side).</p>

		<ul style="list-style-type: none"> Field trips to relevant railway companies: e.g. visits to Malaga subway (Metro Málaga) and the maintenance headquarters of the national Spanish railway company (Renfe), located in Málaga. Professional talks by specialists in the field in seminars focused on key points on vehicle dynamics, pantograph-catenary interaction and superstructure maintenance. Papers discussion: each student selects a paper about a recent research topic on railway technology and vehicle dynamics. These papers are presented and discussed in class (active learning). Closed books exam about key theoretical aspects (90 minutes). Lectures in the classroom on specific points on vehicle dynamics (track, bogie, catenary, pantograph, rail contact, ...). Course assessment: written exam, oral presentations (paper discussion) and solving problem tasks. 	<ul style="list-style-type: none"> Practices in classroom and research laboratories targeted to apply theoretical concepts and learn to acquire vehicle dynamics measurements. Informal learning: You tube channel with videos about relevant, specific and additional information on vehicle dynamics prepared by the teaching staff of the course (e.g. problem solving, short practical examples, ...). Implement assessment guides on specific practical tasks to help students to prepare their reports and gain competency in oral presentations (self-guidance). Minor changes on course assessment: implement an oral exam instead of the written exam.
UMA	Maintenance	<p>Level: BA (Mechanical Engineering) Topic: Maintenance, dedicated module (Language: Spanish) Essential/ to remain unchanged:</p> <ul style="list-style-type: none"> Field trips to factories to introduce the students to maintenance techniques implementation and maintenance organisation: e.g., visits to maintenance headquarters of the national Spanish railway company (Renfe), located in 	<ul style="list-style-type: none"> Group work: students could be organised in groups to elaborate a course project on the practical implementation of a maintenance plan in a railway or vehicle maintenance company. It will contribute to enhance teamwork, problem-solving, critical thinking and collaboration skills (active learning-meddler in the middle). Informal learning: You tube channel with short videos with practical examples and technical

		<p>Málaga, and Malaga city bus maintenance workshops.</p> <ul style="list-style-type: none"> Professional talks by specialists in the field in seminars focused on key points on new maintenance technologies, maintenance strategies (TPM, RCM) and maintenance management. Lectures in the classroom on specific points on maintenance techniques and non-destructive testing applied to railway vehicles (e.g., vibration analysis, lubricant analysis, thermography, liquid penetrant, ultrasound, ...). Practices in the laboratory to deepen the theoretical aspects taught in class and reinforce learning with experimental tasks to apply what they have learned. Course assessment: written exam, oral presentations (paper discussion) and solving problem tasks. 	<p>aspects of maintenance related issues (e.g. poor maintenance consequences, advance maintenance techniques, success cases).</p> <ul style="list-style-type: none"> Implement assessment guides on specific practical tasks to help students to prepare their reports and gain competency in oral presentations (self-guidance). Major changes on course assessment: implement course project, practice examination, oral presentations assessment. Promote self-learning by favouring student's natural curiosity with innovative/attractive maintenance challenges.
TH Wildau	Rail operations, signalling and control;	<p>Level: BSc <u>Topic:</u> included in two modules in transportation system engineering program run at TH Wildau; (Modules: IT in transportation, Transport planning and operations) - Language: German <u>Module Structure/ Form of delivery:</u> a mixture of in-class lectures, exercises and lab practice lessons. Examination in one module: two "open book" homework (mini thesis) followed by a 1,5 hour written (closed book) exam on campus: Examination In the other module: 30 min oral exam; Case study for a public tender, short presentation of</p>	<p>Form of delivery could be updated and enriched:</p> <ul style="list-style-type: none"> Problem solving could be included in the module activities. More student group work can be offered to contribute to student's skills assessment. Possibilities for students to attend some lectures remotely through online platform Self-assessment mock exams or similar through the online learning platform Involvement of teachers from other universities in some lectures/modules (even on an

		<p>a “hot topic”, successful practical performance at a railway operation laboratory</p> <p><u>Essential/ to remain unchanged:</u></p> <ul style="list-style-type: none"> • Student-teacher contact hours. • Lectures in classroom to present and discuss key theoretical aspects and specific rules of rail operation and signalling. • Well-structured lectures with examples to demonstrate the role, functionality and impact of different systems and methods of rail operation and signalling and control. • Introduction of key principles and processes in safe rail operation in Germany and the therefore necessary actions from signalmen and dispatchers. • Exercises/Practices in classroom targeted to the application of the theoretical concepts presented in the lectures • Practical exercises in railway operation laboratory with original interlocking systems from different eras; • practical exercises in IT use for localisation of public transport vehicles as part of an Intermodal/Integrated Transport Control System (ITCS) • online platform for learning material • course evaluation through systematic student feedback • Technical visits at different transportation companies with focus on transport operation control facilities 	<p>international level to illustrate different philosophies for safe rail operations)</p> <ul style="list-style-type: none"> • getting back to technical visits as soon as these are getting feasible again • shifting the focus to ETCS (at least slightly) • more elective topics/modules • interdisciplinary group work with students from other programs (e.g., economics)
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		<ul style="list-style-type: none"> individual lessons by extra-academic teachers from railway industry bringing practical experiences from the field 	
EURNEX	Intermodal freight transport, with special focus on rail	<p>Level: MSc Topic: twelve-hour course included in the ‘pilot interdisciplinary university thematic courses’, a pan-European programme on Intermodal Transport. Module structure/Form of delivery: set of lectures, in-class teaching with no compulsory examination at end of course. Essential/to remain unchanged [since this is not a university module in itself, but a 12-hour course, it is not especially relevant to discuss the course format]:</p> <ul style="list-style-type: none"> Course content limited to the production side linked to logistics, not connected to economic/legal aspects (e.g., market characteristics, demand, supply, regulation, etc.). Masterclass lectures to transmit the most important elements of the course. 	<p>Any module on Intermodal Transport should include field visits to different intermodal nodes. The examination should consist in a practical case study as opposed to a conventional written exam. It is essential that students understand how improve the output of intermodal transport and be aware of the different elements which compose it beyond the engineering terms. Such case study could consist, for instance, in requiring that the student finds out and describes the process of transporting a container unit from Valencia to Berlin.</p> <p>Course content should increase its focus on</p> <ol style="list-style-type: none"> the different stakeholders within the Intermodal Transport production chain (e.g., shippers, forwarders, logistic providers, etc.), homologation and certification processes needed to overcome interoperability problems (e.g., standards definition) different types of legal documents required. <p>In general, more courses on intermodal transport have to be offered in European universities. The course should be given as a 6-credit full university module and differentiated and independent to the railway transport or logistics modules as well as compulsory for Freight Transport programmes.</p>

UNIZA	Rail passenger transport service quality	<p>Level: BSc (Rail transport management) Topic: Rail passenger transport service quality, (Language: Slovak / English) Module structure/Form of delivery: a set of lectures, practices</p> <p>Essential/ to remain unchanged:</p> <ul style="list-style-type: none"> • Lectures with an explanation of the issues using multimedia, with graphs and diagrams, demonstrations on examples from practice. • Discussion. Brainstorming. • Explanation and development of skills in processing tasks. • Lectures transformed into conceptual maps. • Practices on personal computers - case studies, staging methods (role playing), problem solving, design of research questions, processing of research data, analysis of research data, and creation of written research report. • Preparation of individual work of students in the laboratory and students organised in groups to elaborate a course project. • Professional talks by specialists in the field focused on key points on quality of services in railway transport, legislative background of quality approaches, methods of quality management used in practice. • Course assessment: Closed books exam about methods of quality management in passenger transport service (90 minutes) - written exam, oral presentations (paper discussion) and solving problem tasks. 	<p><u>Form of delivery</u> could be updated and enriched:</p> <ul style="list-style-type: none"> • Enrichment of teaching/learning with a personal visit to workplaces on the railway that deal with services in passenger transport. • Involvement more practitioners bringing experience from the field. • Informal learning, online channels with short videos with practical examples and technical aspects of the quality of passenger services. • Emphasize students' self-learning from foreign literature. • Systematic involvement of researchers (also foreign experience) from other universities/research centres.
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UNIZA	Rail passenger transport service quality	<p>Level: MSc (Quality management in rail transport) Topic: Rail passenger transport service quality, (Language: Slovak / English) Module structure/Form of delivery: a set of lectures, practices.</p> <p>Essential/ to remain unchanged:</p> <ul style="list-style-type: none"> • Lectures with an explanation of the issues according to the syllabus using multimedia, with graphs and diagrams, demonstrations on examples from practice. • Discussion. Brainstorming. Global 8D Method. • Explanation and development of skills in processing tasks. • Students organised in groups to elaborate a course project - Students tasked to develop projects to improve quality of passenger services and creation of written research report with oral presentation of the results. • Professional talks by specialists in the field focused on key points on quality of services in railway transport, legislative background of quality approaches, methods of quality management used in practice. • Informal learning, online channels with short videos with practical examples and technical aspects of the quality of passenger services. • Papers discussion where each student selects a paper about a recent research topic on passenger 	<p><u>Form of delivery</u> could be updated and enriched:</p> <ul style="list-style-type: none"> • Enrichment of teaching/learning with a personal visit to workplaces on the railway that deal with services in passenger transport. • Involvement more practitioners bringing experience from the field. • Systematic involvement of researchers (also foreign experience) from other universities/research centres. • Promote self-learning by favouring student's natural curiosity with innovative/attractive maintenance challenges. • Emphasize students' self-learning from foreign literature.
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		<p>service quality; papers are presented and discussed in class (brainstorming, active learning).</p> <p>Course assessment: Closed books exam about methods of quality management in passenger transport service (120 minutes) - written exam, oral presentations (paper discussion) and solving problem tasks.</p>	
UNIZA	Rail transport economics	<p>Level: BSc (Economics of railway transport 1, Economics of railway transport 2)</p> <p>Topic: Rail transport economics.</p> <p>(Language: Slovak / English)</p> <p>Module structure/Form of delivery: a set of lectures (26 + 39 hours), practices (26 + 26 hours)</p> <p>Essential/ to remain unchanged:</p> <ul style="list-style-type: none"> • Lectures with an explanation of the issues using multimedia, with figures and graphs, demonstrations on example - economics and financial indicator on rail transport operators and rail transport infrastructure manager. • Selective lectures with experts from practice (railway passenger and freight operators, rail infrastructure managers). • Comparative analysis – national and EU documents, directives, regulation. • Discussion, Brainstorming, Brainwriting by the themes of subject. • Paper presentation and discussion – each student prepare presentation to a predetermined theme, discussion in the classroom. 	<p><u>Form of delivery</u> could be updated and enriched:</p> <ul style="list-style-type: none"> • Informal learning, online channels (YouTube, podcast – discussions about transport policy EU, national). • Initiate students' interest in scientific information / results from available scientific databases. • Team working – analysis, calculation, synthesis of information and results. • Team working by selected theme – presentation, discussion – classmates, teacher, specialists in the field focused on rail transport economics.

		<ul style="list-style-type: none"> • PC work - search and information processing, calculation of economic indicators. • Work on assignments – analysis, calculation, comments <p>Course assessment: Written and oral, problem solving, oral presentation of knowledge, discussion on the theme.</p>	
UNIZA	Rail transport economics	<p>Level: MSc (Economics of railway transport 3) Topic: Rail transport economics. (Language: Slovak / English) Module structure/Form of delivery: a set of lectures, practices.</p> <p>Essential/ to remain unchanged:</p> <ul style="list-style-type: none"> • Lectures with an explanation of the issues according to the syllabus using multimedia, with figures and graphs, demonstrations on example of rail investment projects. • Professional talks by specialists in the field focused on key points on rail transport investments projects. • Discussion, Brainstorming, Brainwriting by the themes of subject. • Critical analysis of rail transport investment projects – feasibility study, realization. • Work on assignments in the field of rail investment. <p>Course assessment: Written and oral, problem solving, oral presentation of knowledge, discussion on the theme.</p>	<p><u>Form of delivery</u> could be updated and enriched:</p> <ul style="list-style-type: none"> • Informal learning, online channels – comparison real project (feasibility study) vs. their implementation. • Team working – create the project (CBA methods) in real railway situation, presentation, discussions. • Working in groups on the problem – solve the problem, comparing solutions between groups, final results. • Student participation (passive) in a scientific conference in the field of rail transport economics. • Encourage the best students for scientific work – creating the paper to the scientific conference, special journal. • Course assessment: Oral – discussions on the rail transport economics topics – students ask and answer to the questions, the teacher evaluates both questioning and answering.
UNIZG	Rail pricing	Level: MSc	<u>Form of delivery</u> could be updated and enriched:

		<p><u>Topic:</u> included in a master study level of railway engineering that runs at UNIZG FTTS</p> <p><u>Module Structure:</u> Railway Transport Management</p> <p>Form of delivery for Rail pricing is a set of lectures, auditory exercises and seminars.</p> <p><u>Essential/</u> to remain unchanged:</p> <ul style="list-style-type: none"> • Student-teacher contact hours. • In classroom learning to present and discuss key theoretical aspects of rail pricing. • In classroom using of different calculation tools for rail pricing. • In classroom exercises with real examples; • Existing static online platform (Moodle) • Possibilities for students to attend the lectures remotely through online platforms 	<ul style="list-style-type: none"> • Included technical visit for students on-site for various rail pricing platforms • During the seminar student need to be organize in small groups (max 4) and proposed project for new rail pricing scheme for some concrete area in railway engineering with the teacher as the guide on the side • Introduce new approaches for pricing scheme calculation such as justice and equity pricing with teacher as meddler • Adding video materials that explained theoretical and practical side of rail pricing from different countries • Systematic involvement of teachers from other universities
	Ticketing	<p><u>Level:</u> MSc</p> <p><u>Topic:</u> included in a master study level of railway engineering that runs at UNIZG FTTS</p> <p><u>Module Structure:</u> Organizing Railway Passenger Transport</p> <p>Form of delivery for Ticketing is a set of lectures (10 hours), auditory exercises (8 hours) and seminars (4 hours).</p> <p><u>Essential/</u> to remain unchanged:</p> <ul style="list-style-type: none"> • Student-teacher contact hours. • In classroom learning to present and discuss key theoretical aspects of ticketing. • In classroom using of different platforms for rail ticketing. 	<p><u>Form of delivery</u> could be updated and enriched:</p> <ul style="list-style-type: none"> • Included technical visit for students on-site for various ticketing platforms • During the seminar student need to be organize in small groups (max 4) and proposed project for new ticketing options with the teacher as the guide on the side • Adding video materials that explained theoretical and practical side of rail pricing from different countries • Systematic involvement of teachers from other universities • Invite professionals with ticketing background from railway companies and transport

		<ul style="list-style-type: none"> • In classroom exercises with real examples. • Existing static online platform (Moodle) • Possibilities for students to attend the lectures remotely through online platforms 	authorities for discussion session with students
	Access charges	<p><u>Level:</u> MSc <u>Topic:</u> included in a master study level of railway engineering that runs at UNIZG FTTS <u>Module Structure:</u> Railway Transport Management</p> <p>Form of delivery for Access charges is a set of lectures, auditory exercises and seminars. <u>Essential/</u> to remain unchanged:</p> <ul style="list-style-type: none"> • Student-teacher contact hours. • In classroom learning to present and discuss key theoretical aspects of access charges. • In classroom using of different calculation scheme for access charges • In classroom exercises with real examples. • Existing static online platform (Moodle) • Possibilities for students to attend the lectures remotely through online platforms 	<p><u>Form of delivery</u> could be updated and enriched:</p> <ul style="list-style-type: none"> • During the seminar student need to be organize in small groups (max 4) calculate and discuss access charges in different countries with the teacher as the guide on the side • Adding video materials that explained theoretical and practical side of access charges from different countries • Systematic involvement of teachers from other universities • Invite professionals with access charges background from railway companies, infrastructure managers and regulatory authority for discussion session with students
	Slot allocation	<p><u>Level:</u> BSc <u>Topic:</u> included in a master study level of railway engineering that runs at UNIZG FTTS <u>Module Structure:</u> Railway Timetabling and Operations</p> <p>Form of delivery for Slot allocation is a set of lectures, auditory exercises and seminars. <u>Essential/</u> to remain unchanged:</p> <ul style="list-style-type: none"> • Student-teacher contact hours. 	<p><u>Form of delivery</u> could be updated and enriched:</p> <ul style="list-style-type: none"> • During the seminar student need to be organize in small groups (max 4) to create slot allocation with the teacher as the guide on the side • Adding video materials that explained theoretical and practical side of slot allocation • Introducing usage of railway model for simulation of slot allocation in the railway laboratories

		<ul style="list-style-type: none"> • In classroom learning to present and discuss key theoretical aspects of slot allocation. • In classroom exercises with real examples. • Existing static online platform (Moodle) • Possibilities for students to attend the lectures remotely through online platforms 	<ul style="list-style-type: none"> • Online connecting laboratories for slot allocation in different countries • Systematic involvement of teachers from other universities • Invite professionals with slot allocation background from railway companies and infrastructure managers for discussion session with students
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3- ASTONRail Framework:

The suggested framework has considered improvements in the **teaching methods, delivery, and assessments**. Table 2 presents the goals of each suggested improvements and how to achieve these goals in practice.

Table 2 ASTONRail framework:

	Goals	How	Practice
Teaching Methods	Employ an innovative multi-disciplinary approach	Including a combination of methods	<p>Lectures to introduce key concepts and approaches and to explain specific points on the course objectives</p> <p>Peer-teaching, stimulating within groups and group-to-group discussions before asking the teacher. Motivational storytelling, conversation, demonstration,</p> <p>Direct contact with practice through specific tasks, frequent/internal problems and case study for students to complete/solve. Additional activities in class and laboratories with specific tasks and challenges</p> <p>External/guest speaker, like invite professionals with railway background from railway companies, infrastructure managers, safety agencies, transport and regulatory authority for discussion</p>

			session with students that can help in promoting an intimate contact between students and distinguished professionals.
Learning Skills	Improve the classical skills development approach	which is: listen, stop, reflect, write, and give feedback;	Present, ask, discuss, challenge, reflect, collect, evaluate /interpret, critical thinking, collaborating, inspire, emulate, and assess
Teacher's role	Identify the role of the teacher	when and where the teacher should be acting as Director, as Leading Learner, as Nurturer and as Facilitator?	<p>Director when delivering Lectures to introduce key concepts and approaches.</p> <p>Meddler when students are asked to complete specific tasks; and challenges; The teacher can also be a Meddler in motivation and attracting students' attention, clarification and justification of the relevance of the topic.</p> <p>Facilitator when teacher prepares and uses supporting teaching materials, when frequent problems are given for students to solve; when gradually guides the student's steps or organises work in groups.</p> <p>Nurturer when challenging the students with a problem to solve. during the practices in labs. when organising activities so that each student is involved creatively and effectively in the learning process.</p>
Assessments Techniques	Improve 'Classroom Assessment Techniques'	<p>course-related and teacher-related student feedback.</p> <p>exam-based assessments vs project/course work-based assessment</p>	<p>-The outcome of each learning activity can be assessed.</p> <p>-Substitution of written and open-question exams to the completion of a project based on applying the courses' contents.</p> <p>-Examinations in a mix of tests during the semester with student-centred assignments and a final exam at the end of the semester (more teacher-centred, at least one individual non-group examination)</p>

			<p>-Only one form of assessment should be avoided (examples as following)</p> <ol style="list-style-type: none"> 1- The 2-hour closed book exam on campus to be replaced by a 24-hour open book online exam. 2- Face-to-face oral exam with full discussion on topics and frequent jump to different topics allows the best assessment of the awareness and the capabilities acquired by the students in a systemic, non-sectorial perspective. 3- All activities carried out by the students are considered in the final assessment, including individual and group work, practices, class work and the written exam.
Teaching Delivery mode	Identify and establish the right balance between:	<p>information acquisition vs knowledge construction.</p> <p>teacher-centred learning vs student-centred learning</p> <p>lectures in classrooms (theory) vs practical sessions in laboratories</p> <p>distance learning vs self-studies</p> <p>student mobility vs distance learning</p>	<p>AU: 50% information acquisition vs knowledge construction though lectures in classrooms (theory) vs practical sessions in laboratories; 25% Specific tasks for students to complete and problem to solve employing student-centred learning;15% self-studies; 10% distance learning and student mobility.</p> <p>DICEA: Percentages are depending on the topics. A very rough estimation for the concerned modules could be 1/3 lectures on theory, 1/3 practices, visits and problem solving, 1/3 individual study.</p> <p>UMA: The distribution between lectures, practices, seminars and visits is already established in the degree or master program. In general, the distribution is: 50 % lectures, 20 % practices/problem solving,10 % seminars,10 % visits,10 % student presentations</p> <p>UNIZA: 1. Presentation skills: assessment tool = Skill in presenting the results of own work and teamwork. Ability to lead the</p>

			<p>discussion in a professionally correct and socially appropriate manner. Independence in finding information sources. 30%</p> <p>2.Teamwork and communication: assessment tool = continual teamwork during the term 10%</p> <p>3.Ability to reflect: assessment tool = portfolio and feedback / knowledge of the content of practice: assessment tool = answers to individual questions written (30%) and oral (30%) exam</p> <p>UNIZG: At the whole master study program: Theoretical knowledge 50%, Exercises 20%, Seminars 20%, Laboratories 10%</p> <p>KTH: “examination for learning” is implemented in courses e.g. SD2307 where the objective of the exam is not merely to assess the knowledge, but also direct the student learning towards the key concepts in the course. Also as groupwork should be individually evaluated but in practice is not, an examination directed by the project task (groupwork) allows to ensure that all students are engaged in it as the gained knowledge will be used for the examination.</p>
	Link teaching and research	(Research-based teaching and learning);	<p>1-Students could be asked to research and design new rail systems that are safer and more secure. As a result, the students will be given a chance to explore their own ideas and acquire knowledge through rail research and systems design.</p> <p>2-Frequent contacts with PhD students and presentation of ongoing researchers would help them to better focus research topics and approaches and make it more familiar.</p> <p>3-Bring the research to the class: search for recent papers in the field and open discussion; related projects conducted by the</p>

			<p>academic staff are introduced to the students; experts in the field from the academia are also invited to the seminars.</p> <p>4-If possible, integrate students with little tasks in ongoing research projects</p> <p>5-Invite students to participate in conferences (in particular if an online participation is possible)</p> <p>Involvement of students in analytical surveys = in research directly in transport companies, information gathering for example for regions, municipalities, based on student training for conditions in practice.</p> <p>6-Including the students in field research such as: survey.</p> <p>Presenting and discussing scientific papers with students about important current topics</p>
From description to critical analysis	<p>Demonstrate a deep understanding of the informed practice and critical reflection</p>	<p>Bring in diverse perspectives: from the teacher's, the stakeholder's and the student's perspectives.</p>	<p>The teacher will experience all four educator's roles, acting as Director, as Leading Learner, as Nurturer and as Facilitator.</p> <p>The stakeholder will observe, contribute, and benefit as appropriate from a dynamic and multi-disciplinary skills development approach.</p> <p>The student will play an active part in the skills development approach the student will actively learn from a combination of teaching and learning activities. As a result, engagement and positive learning outcome will be ensured.</p> <p>The students should bring with them from the university the attitude to act in a multifaceted professional environment and the awareness that the differences in viewpoints themselves are always bringing cultural richness.</p> <p>The course teaching staff is focused on creating a learning atmosphere appropriate to the objectives of the modules. The</p>

			<p>competences of the course are key along with the student experience, focused on contents, theoretical issues, practical training, professional experience and research. Teachers assume a dynamic and adaptive role during the teaching process, being Director, Leading Learner, Nurturer and Facilitator.</p> <p>Students are challenged to actively question their learning. Students receive inputs from the academia, experts, railway professionals, other students and researchers. Critical thinking is encouraged in class and during the seminars and expositions. Active learning is still a challenge that needs to be favoured with new exciting and innovative approaches.</p>
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4- Analysis of the current methods and development of new methods for skills development:

To revise and improve skills development in the rail higher education, an analysis of the current methods was carried out in the project. As a result, development of new methods is proposed. The results are presented in Table 3 below.

Table 3: Analysis of the current methods and development of new methods for skills development in the focus areas presented in Table1:

	Revise	Reflect	Innovate	Improve
Skills development approach in rail higher education	<p>Current practice includes a set of lectures followed by a 2-hour closed book exam on campus</p> <p>Combination of lectures, practices, seminars, laboratories and technical visits.</p> <p>Student expositions.</p>	<p>Rather limited for the subject area in question</p> <p>New activities limited by the availability of resources, time and staff</p>	<p>Propose a combination of teaching and learning methods to be included in the practice.</p> <p>Extensions of technical visits with task assignment to groups and final students-to-students presentation (<i>meddler in the middle</i> teacher role)</p>	<p>Lectures to introduce key concepts and approaches.</p> <p>Specific tasks, Frequent problems for students to solve.</p> <p>Change from individual work to teamwork.</p> <p>Increase the number of practice sessions.</p>

			<p>Involvement of extra-academic teachers bringing experience from the field</p> <p>Involvement of teachers from other universities and practical activities in emergent technologies in the railway sector, connected with research when possible.</p> <p>Promote new ways of informal learning with digital platforms such as you tube channels, podcasts and streaming.</p> <p>Students are increasingly using and being attracted by these new approaches.</p> <p>Peer teaching methods</p> <p>Student-led workshops</p> <p>Online connection with different laboratories</p>	<p>Implement new approaches of self and informal learning: create a YouTube channel for railway studies.</p> <p>Recording of the lectures</p> <p>Improving soft skills of students.</p>
Teaching and learning environment	Classroom based in addition to Seminars, field/ technical visits, laboratories.	Classroom based is the only option at the moment. Advanced digital tools and more resources are required to effectively implement proposed new ways of self and informal learning. Field visits need “additional” time (at least more than classroom activities) and special	<p>Could be changed to include activities at round tables, libraries and online</p> <p>Moving some theoretical lectures during the visits</p> <p>Promote additional online learning on carefully selected concepts</p> <p>Moving some theoretical lectures during the visit, and</p>	<p>In addition to classroom-based teaching and learning activities at round tables, libraries and online could be included</p> <p>Take advantage of new digital tools for innovative teaching approaches.</p> <p>Improve the active role of students through feedback.</p> <p>Specific environment will help to highlight the importance of</p>

		arrangements in students' timetable to obtain knowledge from practice	include a later session based on students' feedback. Introduce compact technical visit (whole) days with various visits Rail transport companies Interconnection of theoretical and practice skills Informal communication with students.	interconnection of theoretical and practice skill (to understand problems in practice) Using VR
The role of the teacher in rail higher education	Sage on the stage at the moment. In addition to, meddler in the middle during students-to-students presentations	The only role currently. More teaching/technical staff are required to implement new teaching strategies for teachers the traditional and "easiest" way (we've always done it that way).	More roles could be envisaged when new methods of teaching and learning have been introduced. Extension of meddler in the middle role. Adaptive role of the teacher including all teaching roles based on class context. Extension of guide on the side role in case of introduction of problem based-learning methods.	Meddler in the middle and Guide on the side could be included when both task based and problem solving have been introduced. Teaching training on new digital technologies
The 'Classroom Assessment Techniques'	All student work is evaluated and considered in the final assessment (exam + practice + expositions)	Give more importance to classroom work and student participation in class integrate student-to-student feedback in teaching setting and use that for assessment	Include the student reflection on the class work in the assessment process of the course. Extend the Assessment Techniques by a systematic	Not only final assessment based on exams and reports, include student participation in class using tasks with open questions Bringing new modern idea into assessment techniques

	Current practice includes less/no student-to-student feedback as part of student performance assessment Student quality assessment of teachers	have to be well thought out and coordinated to avoid misuse Give more importance to communication and evaluation between students Grade of teacher reflecting quality assessment.	approach to use student-to-student feedback to improve student performance, in addition to using online assessment.	Student focus groups for quality assessment.
Course-related and Teacher-related student feedback	Mid-term student survey	Include a final course survey to get student feedback of the whole course activities	Topic-specific mid-term student survey	Final course survey
Assessment method for every rail subject-specific module	A 2-hour closed book exam on campus (writing exam) Oral exam positively considered for a systemic assessment	Rather limited. Quite diverse Increase the value of the assessment approach Better assessment of student knowledge	None at the moment Including students' opinions Use of several "small" assessments during the semester to equalize the exam pressure at the end of the semester.	Revise critically results from course-related feedback (course survey and reflective task) The teacher evaluates both questioning and answering.
Research - based teaching and learning for rail skills development.	None at the moment Seminars by PhD students and presentation of ongoing research Paper discussion based on research topics Lecture based on research results	Amiss Increase the connection between teacher's research activities on railway and class content Improvement of application Understanding of scientific research	Could be included in the practice Optionally introduced in the Master thesis Link teaching and research in seminar and laboratory activities Discussion about scientific papers during seminars	Task students to research and design new rail systems that are safer and more secure. Focus the paper discussion task and the laboratory activities on current teachers' research projects. Optionally student semester projects as part of ongoing research projects (more relevant in Master level than in Bachelor)

				Wider understanding of railway system future
Career prospect for every graduate in any European country.	<p>Average potential at the moment</p> <p>International Master taught in English with a large geographic coverage of students</p> <p>Class notes, presentations and visits to factories are restricted to a regional/national level.</p> <p>Cooperation during lectures with national/foreign rail experts (passive learning)</p> <p>Obligatory online connection between laboratories</p> <p>Generic explain of railway system functions</p>	<p>Content and networking opportunities rather limited to local practice, extra support for the out of the regional level.</p> <p>Teachers are not encouraged to internationalize the learning process.</p> <p>Time, resources and training are limited</p> <p>Digital technologies can help to create new teaching experiences outside the classroom and can enhance the connections between students at European level.</p> <p>Bachelor taught in German – > limitation for European mobility</p> <p>Improve the international activities of students</p>	<p>Flexibility in terms of module specification and access to networking events on European level</p> <p>More options for international internships</p> <p>More programmes (BA and MSc) are using new technologies to support content and teaching practice that can be used to overcome the current situation.</p> <p>These technologies contribute to inspire and motivate teachers.</p> <p>compulsory language (basic) courses in foreign language</p> <p>Stages students in foreign rail companies (longer durations of the stay)</p> <p>Boundaries are shifting to wider scope of railway knowledge</p>	<p>Students to be included in module spec revision.</p> <p>Students to be encouraged to participate in networking events.</p> <p>Institutions to be encouraged to dedicate more resources (economic and time) to reinforce the online learning with curated content</p> <p>Time, resources and training should be increased. Little tools are available for the teachers to promote international experiences.</p> <p>encourage students to use Erasmus program for study abroad</p> <p>Deeper practical and international skills</p> <p>Better understanding of railway system across all European countries</p>

5- Potential Challenges for Implementation:

To implement changes in any system, including higher education there are several challenges/strains that can be faced. In this WP, we categorized these challenges/strains into three groups: Change the approval process within the universities, Technology adoption and financial difficulties.

Figure 7 list the challenges/strains and introduces subcategories for each group.

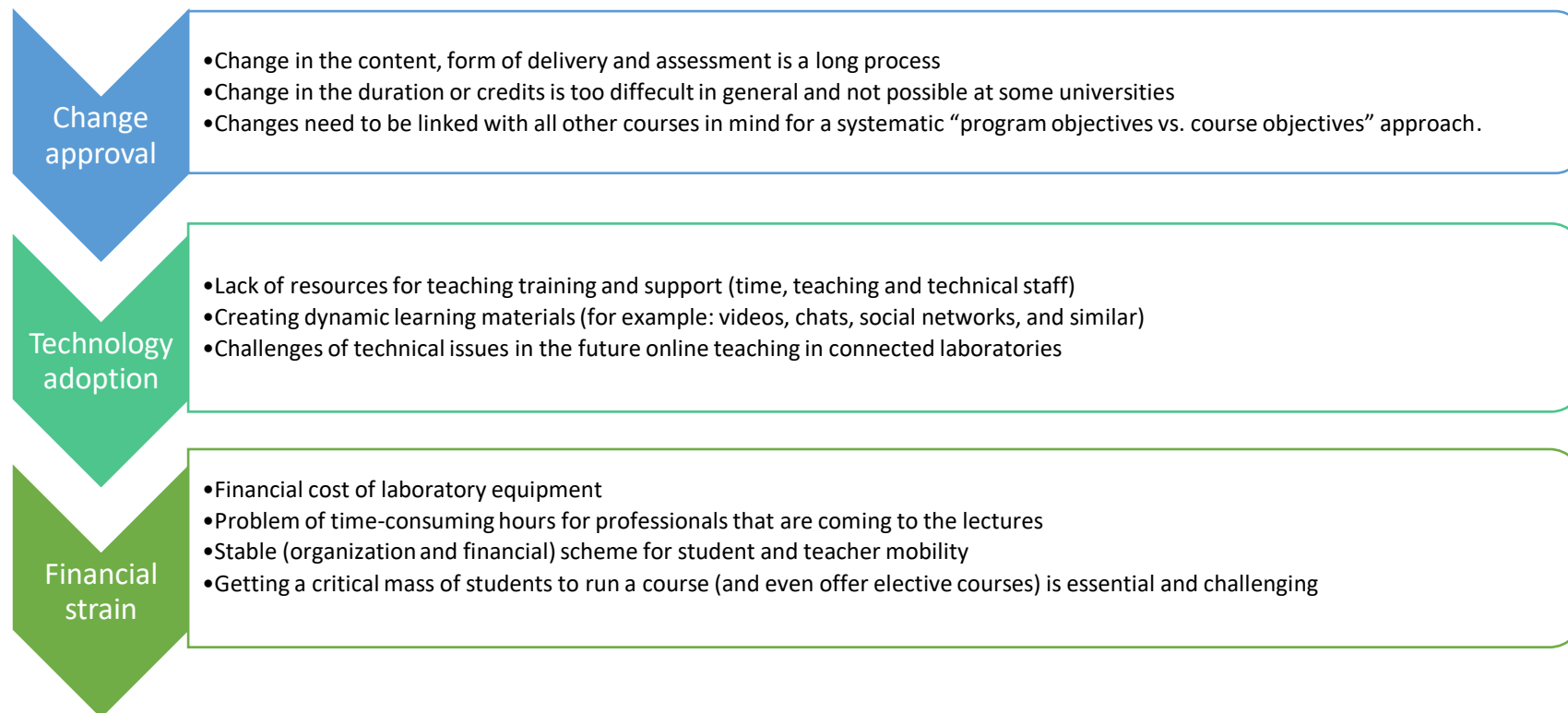


Figure 7: New methods implementation challenges

6- Conclusion:

As a result of WP4, the classical skills development approach in higher education, which is: listening, stopping, reflecting, writing, and giving feedback has been reviewed and questioned. Suggestions for improvements have been proposed and devised for particular subject areas within the railway discipline.

For a better-quality learning outcome to be achieved, it is compulsory for rail degree programmes to be taught and delivered in the right environment in which students take joy and pride in their skills and knowledge. At the end of the degree program, the graduates should all be equipped with the right skills to embrace prospective carrier in the railway sector in any European country. The key is to never lose sight of student interest, knowledge, and satisfaction. By comparing learning theories, we studied and identified the role of the teacher in rail higher education provision. We examined, defined, and confirmed the role of the teacher for different rail-specific subjects and types of delivery of teaching and learning activities.

New approaches to assess the quality of a learning outcome have been suggested with a focus on when and where the teacher should be acting as Director, Leading Learner, Nurturer, and as Facilitator. We also identified improvements in 'Classroom Assessment Techniques', course-related and teacher-related student feedback.

Suggestions for how to identify and establish the right balance between: "information acquisition and knowledge construction" and "teacher-centred learning and student-centred learning", "lectures in classrooms and practice in laboratories", "distance learning and self-studies", "exam-based assessments and project/coursework-based assessment", "student mobility and distance learning" have been proposed for specific courses in each partner institution.

We also discussed the importance of research-based teaching and learning in rail higher education and looked at the potential for promoting new initiatives and mechanisms to link teaching and research. Learning through research has a very positive impact on students' intellectual development. Hence, we looked for auditing, sharing, and enhancing good policies and practices for research-based teaching and learning that can be transferred and implemented to straighten rail skills development and rail higher education provision in the universities of the partner organisations and departments.

NB: The ASTONRail portfolio (toolkit) is a result of a strategic partnership and collective effort. As such it demonstrates a deep understanding of the informed practice and critical reflection about the current rail-focused university education provision from the teacher's, the stakeholder's, and the student's perspectives, showing a high level of awareness and applicability.