Marin Marinov
Janene Kay Piip
Stefano Ricci   *Editors*

Sustainable Rail Transport 5

Skills Development, Education and Leadership in the Railway Sector

Springer

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Editors

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Skills Development, Education
and Leadership in the Railway Sector

ASTONRAIL

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Springer

Editors
Marin Marinov
Engineering Systems and Supply Chain
Management (ESSCM), Engineering
and Physical Sciences (EPS)
Aston University
Birmingham, UK

Janene Kay Piip
JP Research and Consulting
Port Lincoln, SA, Australia

Stefano Ricci
Dipartimento di Ingegneria Civile, Edile e
Ambientale (DICEA)
Sapienza University of Rome
Rome, Italy

Foreword by Prof. Mark Robinson

I am again grateful for being asked to provide a Foreword for the latest volume in the Sustainable Rail Transport series, and we are now up to Volume 5. This is a remarkable achievement and is testament to the editors' drive and stamina that keep the enthusiasm for such a worthwhile task. Well done Dr. Marin Marinov, Dr. Janene Kay Piip and Prof. Stefano Ricci and congratulations on your drive and commitment. Your access to authors in the rail sector is impressive and no doubt they agree to produce such fine papers because of your charm and powers of persuasion.

The concentration in this volume on Skills Development, Education and Leadership in the Railway Sector is extremely timely. Volume 5 is really well-constructed commencing with a review of Railway Education and Skills which leads nicely on to the rail sectors expectations, requirements and gaps. There is a good emphasis on teaching practices and the perspectives of young people before coming on to education standards for the really critical aspect of Rail Education.

The area of education and training is crucial, and it is imperative that people in a rail environment have received adequate training to carry out their role safely and correctly. In addition, qualification is important so that competent people are able to demonstrate their competencies in key areas. This training is more than just an industry requirement, and it can unlock life-changing opportunities with a career in rail. Training can make a big difference to individuals, particularly as technology, industry standards and working practices evolve.

Training should be seen as an investment for the business, its staff, potential staff and the wider industry. When developing training programmes, companies should consider the skills needed to properly maintain complex infrastructure and technically advanced vehicles. Their goal should be building a long-term workforce that is in tune with both organizational values and the future of the railway. Staff training and education is a continuous process. There are a variety of roles and responsibilities in the rail industry, and the approach should be to attract, recruit and retain talented individuals, making these opportunities available to them. By training people at the beginning of their rail career you can instil the appropriate ethos and values in them. It starts with the senior management team, and they should be supportive of a training strategy to create a pathway for new learners. They must be committed to developing

and upskilling the workforce, and with everyone pulling together and management leading the way, we can create a supportive, empowering environment, in which staff are able to grow and thrive.

Looking ahead, we need to anticipate changes in demand and adapt training, education and teaching delivery to meet the needs of an evolving industry. It's all about equipping staff with the skills they need to engineer the rail infrastructure of tomorrow.

I commend the editors on the production of Sustainable Rail Transport Volume 5, as it highlights and builds on rail's existing approaches to skills, development, education and training with the challenges coming in future well-addressed.

Prof. Mark Robinson
Director of NewRail and Professor of
Rail Systems Engineering, Technology
Lead for Newcastle
University's Centre of Research
Excellence in Mobility and Transport
Newcastle upon Tyne, England, UK

Foreword by Artur Fojud

I am honoured to provide this Foreword for Sustainable Rail Transport Volume 5, and thank you to the editors for approaching me. In my role as Head of Research and Innovation at the UIC, the International Union of Railways, I have a keen interest in Skills Development, Education and Leadership in the Railway Sector.

My background is, as Researcher, providing innovative solutions and trend analysis specializing in analysing key trends and signals of change and indicating their implications in shaping innovation strategies and improving the process of research and innovation activities. I have benefited from more than twenty years of experience in public purpose projects, conducting academic research on the quality of public space from the user's perspective. More broadly, this includes the impact of architecture, urban design and engineering solutions applied to the user experience (including well-being and quality of life). Now, I am UIC Head of Research and Innovation.

As the worldwide railway professional association, UIC leads this innovative and dynamic sector, helping its members find solutions and opportunities. The UIC plays an important role for its members in professionalizing the research and innovation process, including fostering innovation-oriented and evidence-based leadership that appreciates the value and need to shape new skills through education, training and mentoring.

UIC published its "Vision of Rail in 2030" in December 2021. Indeed, there is, for the first time today, a unique momentum for a radical modal shift from road and aviation to railways worldwide. Adaptation to climate change is becoming a major concern, shared worldwide and the urgency of which has been recognized by the Intergovernmental Panel on Climate Change (IPCC).

It is reassuring to see that Sustainable Rail Transport Volume 5 is focusing on the issues and challenges that railway companies are facing relating to personnel competencies and skills, prompting them to rethink their learning and development strategies. A flexible, well-trained, motivated workforce is key for a competitive and innovative sector. This is absolutely in line with UICs focus on Expertise Development—Training. UIC has a Talent and Expertise Development Platform (TEDP) to:

- promote excellence in training through an exchange and best practice model,
- identify new challenges and solutions for learning and development and training technologies,
- participate in talent attraction and retention initiatives,
- share knowledge and resources.

Sustainable Rail Transport Volume 5 is certainly a useful addition to support the objectives of TEDP, our platform.

UIC's commitment to Skills Development, Education and Leadership in the Railway Sector can be demonstrated by some of our achievements and highlights. We are founding regional competence hubs in the UIC regions such as Africa, Asia and Middle East. We have held the UIC World Congress on Rail Training, Talent and Development. We have just implemented UIC Rail Academy. Importantly we have facilitated attendance of hundreds of railway employees, students at rail universities and other stakeholders to complete UIC training sessions either at UIC headquarters, at regional level or in online.

An important focus of the Research and Innovation unit at UIC is to foster infrastructure managers, railway undertakings and operators to promote the professionalization of the research and innovation process in which they actively participate by contributing significant resources. Innovative solutions and disruptive technologies only stand a chance of being successfully adopted if new skills are developed in parallel and railway personnel are continuously up-skilled in well-focused professional training and mentoring programmes. In this context, Sustainable Rail Transport Volume 5 is a very important part of building awareness about the role and needs for Skills Development, Education and Leadership in the Railway Sector. The topic addressed, at a time of such accelerated growth and innovation in the world of today, is extremely timely and crucial to boosting the quality and attractiveness of the railways.

I would like to congratulate the editors for publishing Sustainable Rail Transport Volume 5, focusing on skills development, education and leadership in the rail sector, and for recognizing the importance of this topic in today's world focused on innovation projects and the search for disruptive technologies.

UIC is supportive of Sustainable Rail Transport Volume 5 and proposes to work with the series editors and contributors towards our common goal: *developing the necessary educational tools to upskill the rail workforce.*

<div align="right">

Artur Fojud
Head of Research and Innovation
at International Union of Railways
(UIC, Union Internationale
des Chemins de fer)
Paris, France

</div>

Foreword by Prof. Ed Sweeney

I am delighted to see that Volume 5 of Sustainable Rail Transport has been published. The fact that another volume has been developed is itself a testament to the quality of the earlier volumes and the contribution that they made to the ongoing discourse in this hugely important field. I am also honoured to again be invited to provide a Foreword to what is another volume of extremely high quality. This high quality suggests that it will become an indispensable work for experts in the fields, as well as a valuable source of fascinating insights for non-expert rail enthusiasts like myself. For rail specialists involved in research and scholarship, as well as for those in professional practice, this volume provides a wealth of information and knowledge about key developments and trends impacting the sector.

The railway industry is a dynamic and challenging one. The COVID-19 pandemic of 2020 created a range of new challenges that the industry has been grappling with for a few years now. This is in addition to the challenges of operating in a market that has become more sophisticated, comprising passengers and freight customers with increasingly demanding value expectations. The wider business and regulatory environment is a complex one and subject to a high degree of change and unpredictability. Technology has continued to develop at a rapid rate, presenting rail professionals with an array of both opportunities and threats. The anthropogenic impact of transport and logistics processes is now widely acknowledged and understood with modal shift to rail from less environmentally friendly transport modes gaining much attention and traction. The publication of this volume is very timely in this context.

It is particularly pleasing that many of the chapters in Volume 5 of Sustainable Rail Transport are based on the innovative ASTONRAIL project funded by the European Union under the Erasmus+ programme. ASTONRAIL—**A**dvanced approache**S** and practices for rail training and education **TO** in **N**ovate **Rail** study programmes and Improve rail higher education provision—brought together eight partners from seven countries to focus on improving rail education and training as a key part of the innovation journey. Many of the key insights generated during this important initiative are showcased in this book. This is timely given the central role of people in the rail innovation process, in particular the need for new approaches to knowledge and skills development.

It is also important that rail policymaking is evidence-based and that innovation in the sector is based on the best available knowledge about operations, systems, technology and management. The high-quality research described in this volume is important in this regard. As with previous volumes in this series, the research that has been undertaken is characterized by high levels of rigour in the research methodologies and approaches adopted by scholars. This is vital as the development of deeper and richer insights into the complex phenomena under investigation needs to be based on research designs that are logical and systematic. However, this research excellence and academic rigour alone is not sufficient; it needs to be combined with a deep understanding of the evolving needs of the industry for the outputs to be truly valuable and impactful. I am delighted that this volume clearly demonstrates both academic excellence and practical relevance, with much of the work representing the fruits of effective academic/industry collaboration. The volume also demonstrates clearly that high-quality rail research requires truly interdisciplinary approaches. There is extensive used of multi-phase research approaches that adopt mixed methods of data collection and analysis. This is not without its challenges from a research perspective, but it has resulted in the material in this volume providing many excellent new insights into a wide range of strategic and operational issues. In tandem with this, there are illustrations of innovative practices from a range of different geographical settings. This is very welcome in the context of the increasingly international complexion of transportation and logistics systems and the attendant aspiration to develop world-class levels of performance.

As I noted in my Foreword to Volumes 3 and 4, rich tomes of this kind require immense dedication and commitment on the part of a range of individuals—authors, editors, publishers and others. In this context, I would again like to commend my former Aston University colleague, Dr. Marin Marinov, for his energy and enthusiasm in bringing this work to fruition. Marin is Passionate Advocate of rail research and its critical role in developing a sustainable future for this strategically critical industry. Thanks to his work, as well as that of his collaborators, Sustainable Rail Transport Volume 5 will play an important role in our ongoing discourse and debate in this field.

Prof. Ed Sweeney
Professor of Logistics & Supply Chain
Management at Edinburgh Business
School and Deputy Executive
Dean (Staffing) of the
School of Social Sciences and
Edinburgh Business School
Heriot-Watt University
Edinburgh, Scotland, UK

Communication Note from Ludolf Kerkeling

Vorstand Havelländische Eisenbahn AG Vorstandsvorsitzender Netzwerk Europäischer Eisenbahnen e.V.

Ludolf Kerkeling

Jahrgang 1962. 1983–1989 Studium Bauingenieurwesen (Vertiefung Verkehrswesen und Raumplanung) an der RWTH Aachen, 1990–2000 Eisenbahn und Häfen GmbH, Duisburg. 2000–2011 Geschäftsführer Dortmunder Eisenbahn GmbH, 2008–2010 Vorstand Rail4Chem transalpin AG, 2008–2014 Geschäftsführer Rail4Chem Eisenbahnbetriebsgesellschaft mbH, 2012–2014 Mitglied der Geschäftsleitung Captrain Deutschland GmbH, seit 2014 Vorstand Havelländische Eisenbahn AG.

Contact details: Havelländische Eisenbahn AG Schönwalder Allee 51 13587 Berlin Telefon +49 30 37 59 81 43

Email: ludolf.kerkeling@hvle.de

Homepage: www.hvle.de

In Germany (and to varying degrees throughout Europe), the shortage of skilled workers has worsened in recent years. This endangers Germany as a business location, and the local companies have to face this challenge.

From the company's point of view, the following approaches exist to meet this challenge:

1. Reduce demand,
2. Tapping into new sources,
3. Increase the attractiveness of the own company compared to the competitors.

1. Reduce demand

In a functioning market, competition ensures that all companies must constantly work on optimizing processes and increasing effectiveness. In this respect, this is not a task that has only arisen due to the shortage of skilled workers, and I do not want to go into this aspect further here.

2. Tapping into new sources

A company also has to deal with this. In our experience (i.e. from the point of view of a railway company in Germany), the challenges are that the language barrier is difficult to overcome and immigration from non-European countries is difficult. A significant improvement could therefore be achieved by lowering the barriers to immigration and (analogous to air traffic) a uniform language in European rail transport. However, both can only be tackled politically and can hardly be influenced from the company's point of view.

3. Increase the attractiveness of the own company compared to the competitors

From the company's point of view, it is therefore important, taking into account the points listed, that both existing and potential new employees perceive the company as more attractive as alternative employers.

So what are we doing as an employer to achieve this?

In the case of young academics, we try to introduce students with a part-time job or a bachelor's or master's thesis to our company at a very early stage through contacts with the universities. We have also already carried out a dual-study programme. We have conducted a trainee programme for the young academics already present in the company in order to improve internal cooperation, provide additional skills and create further loyalty to our company.

In the training professions (in our case almost exclusively train drivers), we have had our own highly qualified and well-equipped (e.g. driving simulator) training department for years. Trainees (if they do not live at our location) are provided with apartments. In order to strengthen cohesion, excursions are carried out during the training and a project abroad in the 2nd year of apprenticeship (which is funded by the EU). With our training programme, we have won various awards and, in particular, have achieved that hardly any employee leaves during or after their training.

And last but not least, it is very important to us to create a pleasant working atmosphere so that existing employees do not leave us and are happy to recommend us as an employer. The fact that we are basically on the right track is also shown by the reviews, e.g. on kununu, a portal where employees can rate their employer.

Contents

Existing Studies and Information Sources on Rail High Education and Skills Development

Arbra Bardhi, Francesco Martini, Stefano Ricci, and Carlos Casanueva Perez

Abstract This paper provides with a panorama of the review conducted on existing studies and structured information from various sources related to rail education and skills development. The purpose of this review was to gather insights from previous EU projects, research papers, web portals, and reports to better understand the current landscape and teaching approaches in rail higher education. To give a comprehensible visualization, preferably in a website format, a simple but tangible concept has been developed, facilitating a smooth connection between the concrete real-world application and more abstract fields of developments within the scope of study.

Keywords Rail transport · Rail education · Teaching methods · Datasets · Reviews

1 Review of Existing Studies and Sources

ASTONRail is an ERASMUS + funded project (2023a), whose top horizontal and sectorial priority is to close gaps and mismatches between industry requirements, expectations and current higher education offerings for rail knowledge and skills development. Over the coming years, the transportation industry will undergo significant change because of population age patterns and other demographic shifts, particularly because huge numbers of experts will retire and hopefully be replaced by younger professionals. Another issue is whether the workforce in the transportation

A. Bardhi (✉) · F. Martini · S. Ricci
Università Di Roma "La Sapienza", Rome, Italy
e-mail: arbra.bardhi@uniroma1.it

S. Ricci
e-mail: stefano.ricci@uniroma1.it

C. C. Perez
KTH Royal Institute of Technology, Stockholm, Sweden
e-mail: carlosc@kth.se

sector might attract enough experts with the necessary abilities. The demand on a workforce that is older than normal for the economy and where female employees make up a small minority will also likely increase because of this development and expansion (SKILLFUL, 2017). To conduct this study, the data collection started from extensive surveys carried out as part of past EU funded projects, such as EURNEX (2023), TUNRAIL (2011), SKILLRAIL (2012) and RIFLE (2013), which comprehensively covered over 70 Higher Education Institutions (HEI) throughout Europe and beyond. Important potential benefits emerged in past studies from the interaction of universities and industries, where United States showed a better interaction with industry than EU, as presented in Beckman et al. (1997). On the other side, some problems may arise and create difficulties in the alignment of curricula to industry's needs, as exposed in Zaky and Faham (1998). The major goal of ASTONRail is to create a portfolio of innovative approaches for rail skills developments and implement new methodologies and professional practices to improve and modernize Europe's current rail higher education system. As an example, in Fraszczyk and Piip (2018) the authors investigated the barriers to e-learning in the rail field, by investigating the challenges in developing an e-learning portfolio, from types of technologies to cost/benefits, as perceived by training providers.

To create a database for the ASTONRail project, the information from the EU initiatives was gathered and examined. Partners, target audiences, best practices, and industry-specific abilities were all included in the database. The evaluation emphasized the value of internships, curriculum congruence with business demands, university-industry partnership. It also identified challenges, such as lack of university-industry interaction in promotion and rewarding schemes, heavy teaching loads and timing misalignment between research and industry.

The review examined key competences and skills identified in projects, such as TUNRAIL, RIFLE, and SKILLRAIL. These competences were grouped into core competence areas and subdomains. The review emphasized the multidisciplinary nature of railway education and the need for practical skills, including environment-related competences.

The general working method for the preliminary analysis in ASTONRail, described in the present paper, includes the steps below:

1) Current teaching practices and methods of rail higher education in Europe: review of existing studies and structured information from various sources; Europe wide stepwise survey; organization and homogenization of survey results.
2) Matching with industry expectations and requirements: mapping out gaps and mismatches against industry expectations and requirements; systems perspective; railway sector needs and expectations; parallel experiences; mapping out gaps and mismatches between industry expectations and university provision.

The review examined innovative instructional strategies in higher education, including field trips, virtual labs, virtual laboratories, global education initiatives. It emphasized the significance of combining various engineering disciplines and giving students hands-on training. The examination covered activities promoting

gender equality in the rail industry as well as the creation of online learning opportunities and virtual colleges. The analysis of prior research and organized data gave important insights into rail education and skill development. It emphasized the value of university-industry partnerships, the requirement for practical skills, and the application of cutting-edge instructional strategies. The review's conclusions can help the ASTONRail project and advance the field of rail education and skill development. Future efforts should focus on addressing challenges and fostering closer collaboration between academia and industry to meet the evolving needs of the rail sector.

2 Europe Wide Survey

With the purposes to update, extend and detail the knowledge on the rail high education panorama, the ASTONRail project designed and carried out a Europe-wide stepwise survey. The first step was to consolidate the data collected. The data was gathered from various sources, including past projects, ASTONRail partners, other academic partnerships, and websites. Since there was no existing full database of courses, the information from these sources was aggregated to create a list of universities that are supplying relevant courses.

The following stage involved browsing the websites of the universities to learn more details about each programme. The beneficial information was gathered for each applicable course and kept in a preliminary database. The initial database contained details about the university or organization, department or institute, course name, provider, nation, city, state, region, activity status, European Qualifications Framework (EQF) level, language of instruction, European Credit Transfer System (ECTS) on rail, email requests and websites consultation.

The quality of the data in the preliminary database varied as the information gathered from websites was sometimes partial or not up to date. Inconsistencies were noted due to the inclusion of extra-European universities and short courses that did not fit the traditional classification. A No Data (ND) field was introduced as an alert for data validation when information was not available.

The preliminary database included over 380 courses from 190 different institutions. To assess the data and gather further information, a *Google Form*s questionnaire was created for distributing the questionnaire. The questionnaire was divided into three sections: (1) confirmation of data in the preliminary database, (2) basic course information, (3) further information needed. University's courses were grouped in separate tables, sent individually to the corresponding contact addresses along with the survey link. Information was gathered for about 49 courses from 16 countries (Fig. 1), with a coverage of about 13% of the entire database.

About the data obtained, a first insight can be offered by EQF levels (from 5 to 8) of the courses, a short description of which can be found in Table 1 (European Union, n.d) and Fig. 2.
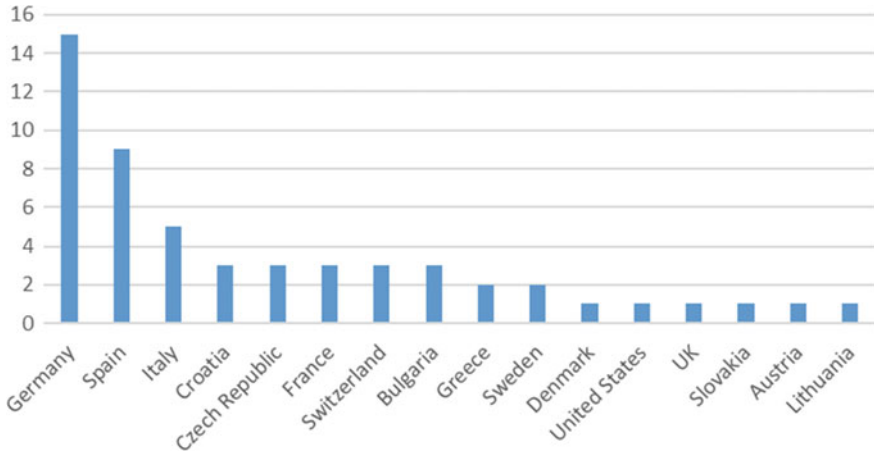
Fig. 1 Number of answers to the survey from different countries

The survey results provided insights into the courses based on EQF levels, language of instruction, presence of internships and technical visits, participation in student interchange programs, availability of employment data, distribution of training programs within different management levels, distribution of job groups in the rail career matrix described in Cannon et al. (2019) and further discussed in Abramovic et al. (2023) (Fig. 3).

Most courses corresponded to EQF level 7 (master's degree level) with 51% of the answers. EQF level 8 courses (PhDs, etc.) accounted for only 6% of the total. Moreover, most courses were taught in the country's native language, with 19% only taught in English.

Around 25 courses mentioned the presence of mandatory or eligible internships, primarily with railway and transportation companies. About one third of the organizations offered technical visits, with a prevalence of involvement of students in interchange programs.

Regarding employment data after graduation, only 39% of the organizations manage a systematic database. The distribution of training programs within different management levels was evenly spread, with a slight prevalence of tactical level over operational and strategic levels.

There was high variability of job groups. In Academia, the strategic level was just over 10%, while the strategic and tactical levels combined were under 50%. The strategic level was more prominent in the Economics and Vehicles groups, while the tactical level ranked higher in other groups like Administration, Signalling, Operations, and Infrastructure.

Further analysis was conducted on the distribution of careers within each level and job group. The database also provided information on the credits of single modules and the skillset for each course. The skill set would be cross-checked.

Table 1 EQF levels with description and examples

Level	Knowledge	Skills	Responsibility and autonomy	Example
5	Comprehensive, specialised, factual and theoretical knowledge within a field of work or study and an awareness of the boundaries of that knowledge	A comprehensive range of cognitive and practical skills required to develop creative solutions to abstract problems	Exercise management and supervision in contexts of work or study activities where there is unpredictable change; review and develop performance of self and others	(UK) HNC, HND, Foundation Degree, RQF levels 4 & 5, Certificate of Higher Education, Diploma of Higher Education, Scotish Advanced Higher, HTL
6	Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles	Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study	Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development od individuals and groups	(UK) Bachelor's degree with honours, Bachelor's Degree without honours, RQF level 6, Graduate Certificate, Graduate Diploma;
				(Germany) Vocational university German State-certified Engineer, Business Manager and Designer (Fachhochschule) Bachelor, German Fachwirt/ Fachkaufmann, German Operative Professional, German Meister; (Spain) Diplomado or Grado; (Greece) NT UA Laurea

Table 1 (continued)

Level	Knowledge	Skills	Responsibility and autonomy	Example
7	Highly specialised knowledge, some of which is at the forefront of knowledge in a field of work or study, as the basis for original thinking and/or research	Specialised problem-solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields	Manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches; take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams	(UK) Master's degree, Postgraduate Certificate, Postgraduate Diploma, RQF level 7;
	Critical awreness of knowledge issues in a field and at the interface between different fields			(Germany) Vocational university (Fachhochschule) Master', Geprüfter Betriebswirt (IHK) (Certified Business Administrator); (Italy) Laurea Magistrate, Master universitario di primo livello; (Spain) Licenciado or Máster, (Portugal) Mestrado; (Greece) NT UA Diploma
8	Knowledge at the most advanced frontier of a field of work or study and at the interface between fields	The most advanced and specialised skills and techniques, including synthesis and evaluation, required to solve critical problems in research and/or innovation and to extend and redefine existing knowledge or professional practice	Demonstrate substantial authority, innovation, autonomy, scholarly and professional integrity and sustained commitment to the development of new ideas or processes at the forefront of work or study contexts including research	Doctorate, PhD, Professional Doctorate, RQF level 8; (Italy) Dottorato di ricerca, Master universitario di secondo livello

Source (European Union, n.d)

Fig. 2 EQF levels from the answers

Fig. 3 Rail Career Matrix (*Source* Cannon et al., [2019])

3   Organization and Homogenization of Survey Results: A Handbook for Data Management

The successful completion of a survey often leads to a large amount of data that requires organization and homogenization to extract meaningful insights. Therefore, it was developed a detailed handbook dedicated to the organization and homogenization of the survey results, focusing on a specific case study, involving the integration of data acquired from the survey and the reference database, built form the previous projects concerning high education courses and modules, with rail-related contents. The resulting database is designed to serves as a valuable resource for researchers, educators, professionals involved in the field. The ASTONRail handbook is conceived as a living collection of useful links and information on rail higher education, living thanks to contributions of all stakeholders of the railway sector. However, it will live from public participation to update and enlarge it (ASTONRAIL, 2023b).

From a practical viewpoint, the handbook serves as a standalone file accompanying the integrated database. It provides a comprehensive description of its structure (columns, data sources, etc.). This detailed guide ensures clarity and ease of use for individuals accessing and analysing the database.

The database is built on Excel and comprises two complementary sections: data obtained from the web research and data obtained from the survey.

Data Obtained from the web Research. This section of the database consists of over 380 courses. Color-coding is used to indicate organizations' responses to the survey and the completeness of the provided information.

Data Obtained from Survey. This section of the database incorporates data obtained from the survey questionnaire. It includes columns for course duration, year of first launch, last year of activation, ECTS credits for individual disciplines, keywords related to vehicles, infrastructures, systems and operations, innovation, digital competencies. Additional columns cover internships and technical visits, student interchange programs, rail career matrix classification, employment data availability.

Filtering and validating. Various columns in the database can be filtered for easier analysis and validation. Validated columns include country, course activity status, EQF level, language, student interchange and more. However, caution in filtering columns related to course names and locations is suggested due to frequent misspelling or duplications.

Data manipulation and visualization. A separate electronic sheet is created to extract and analyse survey-specific data. This sheet includes several pages, such as raw data, credits analysis, keyword analysis for vehicles, infrastructures, systems and operations, innovation and digital competencies, rail career matrix analysis and more. These pages provide valuable insights into the distribution of skills, rail career groups and other relevant information.

4 Enhancing Access to Rail Education: Key Information for Prospective Students

As the demand for skilled professionals in the rail sector continues to grow, it becomes crucial to provide comprehensive and accessible information to prospective students. The goal is to provide prospective students with a visual guide to educational opportunities in the railway sector, ensuring standardized data and simplification for easy understanding. It means to achieve two targets: (a) standardization and consolidation of the educational database, with collected data refined and organized for further use; (b) simplification into a visual guide, where the educational programs in the rail sector are presented in a user-friendly manner, primarily targeting prospective students. The guide incorporates program-level information, general course contents, educational levels, degree of rail specialization.

Data Standardization: to fulfil the defined goals, the existing database is assessed and modified to ensure consistency and clarity. Several steps are undertaken to achieve this:

a) *database modifications*: the initial database is refined by replacing Course column with Program column, revising, adjusting accordingly the entries,

b) *categorization*: categories are established, such as Mechanical Engineering, Railway Engineering, Environmental/Energy Engineering, Civil Engineering, Electrical Engineering, Logistics, Vehicle Engineering, Transport Engineering; programs are assigned to these categories based on program names, curriculum analysis, responsible faculty/department,

c) *qualification framework and duration*: programs are classified according to the Bologna process qualification framework (Bachelor's, Master's, Doctorate) and their respective durations; Additional categories are introduced for programs that do not fit into this framework, e.g., the one described in Malavasi et al. (2017),

d) *rail specialization*: a four-level scale is implemented to categorize programs based on the extent of railway-specific courses; programs are classified as *Program*, *Module*, *Course*, *none*, depending on the percentage of rail-specific content in their curriculum,

e) *implementation and workflow: the modified database is organized into various columns,* including university/organization, program, country, EQF level, language, program type, railway specialization, tuition fees, website URL; this structured format ensures ease of comprehension and accessibility for prospective students; the prioritization of data filling involves sorting based on the ECTS on rail column, analysing the most significant programs, resolving duplicities between courses and programs,

f) *visualization*: to present the educational opportunities effectively, a user-friendly website format is employed; an overview picture depicting the railway sector's applications and associated disciplines is utilized; prospective students can have information on specific program categories to access a list of applicable programs; further filtering options, such as educational level, language, location,

enable students to refine their search based on their preferences (ASTONRAIL, 2023b).

Visualization plays a crucial role in processing and presenting key outputs from the rail education database. By standardizing and consolidating the data and providing a visual guide through an interactive website, prospective students can easily explore educational possibilities in the rail sector. The initiative aims to bridge the information gap and empower students to make informed decisions about their educational paths in this thriving industry.

5   Results

The final output is a thorough excel-based database, which includes a visualization concept and study programs in Europe related to rail. These findings have been added to a website for prospective students to help them with information and orientation for their study choice (ASTONRAIL, 2023b).

The traditional understanding of railways that still exists today was clearly shown by the current dataset research. While there was only one Environmental Engineering program included in the study, Civil and Transport Engineering together account for more than half of the programs looked at (Fig. 4).
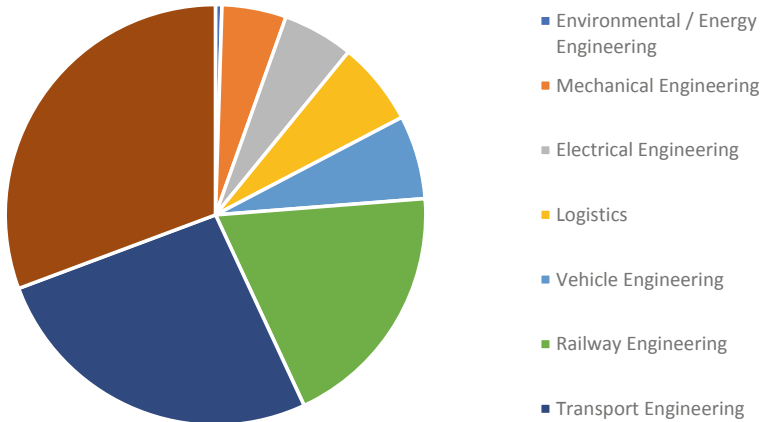
Fig. 4 Distribution of primary program categories

6   Conclusions

To enhance and modernize Europe's current rail higher education system, the ASTONRail project aimed to produce a portfolio of cutting-edge rail skills development methodologies, approaches, professional practices.

The options under investigation are designed to deliver an optimized result to future students drawn to the rail industry. Civil engineering, Transport engineering, and Railway engineering make up more than 75% of the programs examined globally, according to the data search described in the paper on current educational and training initiatives in the rail systems field.

The organized database hereby described demonstrates itself as a key tool for any future analysis of the present and the future in this area that will be produced as part of future rail education focused projects and incentives.

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Rail Sector Expectation and Requirements for Higher Education and Students' Expectations from Rail Companies in Slovakia and Czech Republic

Anna Dolinayova and Eva Nedeliakova

Abstract The rail sector needs employees equipped with new skills, competences and advanced knowledge of new technologies. Higher education institutions specializing in rail-related subjects must respond appropriately to these needs. The paper deals with the expectations and requirements of railway companies in Slovakia and the Czech Republic, which are a partial result of research carried out within the international project Erasmus + KA203 ASTONRail. The paper describes the expectations and requirements of the railway companies involved for the knowledge and skills of graduates based on both a questionnaire survey and a job survey. These requirements are divided into three levels of management: strategic, tactical and operational. In addition to the companies' requirements for students, the satisfaction level of the railway companies with regards to the knowledge and skills of the graduates was also investigated. Using the Focus Group method, students' expectations from their future employers in the railway transport sector were determined, which were then confronted with employers' requirements for graduates.

Keywords Rail transport · Surveys · Rail companies · Satisfaction level · Expectations

1 Introduction

Currently, the issue of education in the field of railway transport is very topical. In Europe as well as in other parts of the world, one can observe a lack of graduates for the needs of the railway sector, not only in the engineering or construction railway industry, but also in operation. Likewise, in the Slovakia and the Czech Republic, on

A. Dolinayova (✉) · E. Nedeliakova
University of Žilina, Žilina, Slovakia
e-mail: anna.dolinayova@uniza.sk

E. Nedeliakova
e-mail: eva.nedeliakova@uniza.sk

the one hand, a long-term demand for students in this field can be observed, on the other hand, a gradually decreasing number of graduates of study fields focused on railway transport. For universities that provide education in the field of rail transport, there is an opportunity to use this phenomenon in terms of marketing to attract new students, but at the same time consider the requirements of the railway sector for the knowledge and skills of graduates.

In both Slovakia and the Czech Republic, the problem is the lack of interest of society as such in supporting rail transport, which manifests itself as a lack of attractiveness for both young people and their parents. In the last ten years, according to documents from universities in Slovakia and the Czech Republic, dealing with the teaching of transport disciplines, the number of applicants has decreased by two thirds (University of Žilina, 2021; University of Pardubice, 2021). It is constantly necessary to work on educating people about sustainable transport. Then the understanding can be achieved, how necessary is the study of rail transport. That is why we strive to combine education with practice and show the public the importance of rail transport. This also motivated us to conduct research, the results of which we are presenting.

We dealt with this issue as part of the studies included in the Erasmus + project ASTONRail (Advanced approacheS and practices for rail training and education TO inNovate Rail study programs & Improve rail higher education provision). In this paper, we selected from our research the expectation and requirements of railway companies operating in Slovakia and the Czech Republic and compared them with the requirements of graduates for their future employers in the rail industry. The purpose of this research is to help align education in rail transport with the demands of practice and young people and as a result make both the learning environment and future work more attractive.

2   Literature Review

When examining the scientific literature dealing with the issue of education in railway trades, we found out that this issue is intensively dealt with by Lautala in the USA, and in Europe one can find mainly works by Prof. Ricci and Dr. Marinov.

Already in 2009, Lautala and Sproule described the problem of demand for railway engineers with study programs focused on railway transport. Their surveys of industry executives and recently hired engineering graduates, and university professors were used to define demand and supply for university engineering graduates and to determine the impact on students' career choices from undergraduate exposure to railway topics. The results indicated a high demand for railway engineers over the next 5 to 10 years, but few opportunities for students to be exposed to railway topics before graduation (Lautala & Sproule, 2009).

Lautala et al. compared rail education at the universities in Europe and the United States. They made the survey that concentrated on quantitative and qualita-tive demands, such as more detailed questions of core competences and preferred educa-tional backgrounds of graduates. Over 80 percent of the respondents stated that the

number of employees involved in rail activities in their company had increased or stayed the same during the past five years (Lautala et al., 2010).

In paper at the ASME Joint Rail conference 2012, Ma and Lautala pointed out the issue of education in rail transportation related to globalization. Globalization and changes in the political landscape have contributed to the growing pressure to expand the use of rail transportation across national boundaries. All the development is accelerating the need for international cooperation in railway design, construction and operation and the educational framework should shift accordingly to consider rail transportation beyond national boundaries (Ma & Lautala, 2011).

Lautala et al. in 2013 describes the problems that arose due to the neglect of education in railway transport at universities. The vitality of the private sector freight railroads, along with a growing interest in rail passenger transportation is creating a strong demand for graduates with rail expertise (Lautala et al., 2013). The link between the railway industry and university education has had many positive effects, among others several challenges have arisen about what the rail industry needs and wants from graduates and universities (Lautala et al., 2013).

In 2017, Lautala and Dick published a paper where they again pointed out the disproportions between university education and the need of the railway industry. North American railways have experienced a decades-long period of growth in freight ton-miles and in the number of commuter and intercity passenger rail trips. This growth, combined with the aging railway workforce, has triggered renewed demand for university graduates to enter railway careers. However, after decades of neglect, only a few North American academic programs are engaged in rail-related research and education (Lautala & Dick, 2017). Despite various activities American Railway Engineering and Maintenance-of-way Association and rail-focused University Transportation Centers slowly re-established a railway engineering academic community. To raise student interest in rail courses and satisfy industry demands for internships, students must be introduced to railway concepts before they decide on the direction of their studies (Dick et al., 2019).

Marinov and Ricci presented an intensive programme in rail logistics. Major aim of the programme was to arm the undergraduate students enrolled on the programme with the skills necessary to pursue employment in the railway and logistics sector after their graduation (Marinov & Ricci, 2012). Marinov and Fraszczyk dealt with rail freight and logistics programme curricula which have to be therefore flexible and efficient to be able to adequately respond to any changes. In their paper they discussed concepts, standards and designs for innovative curricula for an MSc in Rail Freight and Logistics which employs a flexible mobility-based hybrid model integrating subjects, teaching and learning methods from four European Universities (Marinov & Fraszczyk, 2014).

Tsykhmistro, Cheptsov and Cheklov and Marinov dealt with the differences between European and Asian rail education and research and the co-operation. After this study, the main problem in rail education is currently that the future rail professionals who serve in the rail industry must be able to master increasing levels of new information technologies and system complexities which differ from the historical concepts (Tsykhmistro et al., 2014).

Rizetto et al. introduced their postgraduate course in "Railway Infrastructure and Systems Engineering" at the University of Rome "La Sapienza", funded by rail companies operating in Italy, which represents a successful example of cooperation between academia and industry in the field of railway transport (Rizzetto et al., 2015).

Malavasi et al. described three different examples of cooperation between academia and industry in the field of railway transport that have been successfully carried out at the University of Rome "La Sapienza". They described three different levels of collaboration between academia and companies: the first level concerns the recruitment and the basic training of young engineers to be employed in companies; the second the specialist training of engineers already employed in companies; the third a training activity for third parties useful to export Italian railway know-how and technology in the world (Malavasi et al., 2019).

Dhondt et al. defined in their study Employment and skills in the rail sector: Impact analysis of Shift2Rail's innovation programmes the required knowledge areas for rail professionals, focusing in particular on new knowledge taking into account constantly advancing development of technologies in the rail sector and new scientific and research findings in the field (Dhondt et al., 2019). Fraszczyk and Piip focused on Barriers to eLearning in rail. This study also included a survey about the eLearning as a way of educating the employees in the rail industry, made on a sample of 31 respondents. They assume, that development of new eLearning modules in rail would encourage academia-industry collaboration settings (Fraszczyk & Piip, 2020).

In addition to technical knowledge and hard skills, soft skills are also important for employees in the railway sector. Madigan, Golightly and Madders (2015) dealt with this issue. Based on their survey, authors defined 7 areas of required non-technical skills by the railway industry: self-management, workload management, cooperation, decision making and action, communication, conscientiousness and situational awareness (Madigan et al., 2015).

As it can be seen from many studies, cooperation between the rail industry and university education is one of the ways to improve the development of the demand and supply of engineering graduates.

3 Survey with Rail Companies

A survey was realized for EU countries. For this paper, we have selected answers for Slovakia and the Czech Republic from questionnaires. The objectives and research questions, we aimed to answer with the work presented, included a demand and supply for skilled workforce, skills which rail companies required and assessment of the level of graduates in different skills by rail companies. We chose a mixed approach combining quantitative and qualitative research techniques in order to make the research outputs transparent and point out the objectivity of the results. The survey was mainly attended by freight carriers and regulatory/transport authorities from railway companies whose headquarters are in the Slovak Republic or the Czech Republic. In total, 17 companies participated in the questionnaire survey, which is
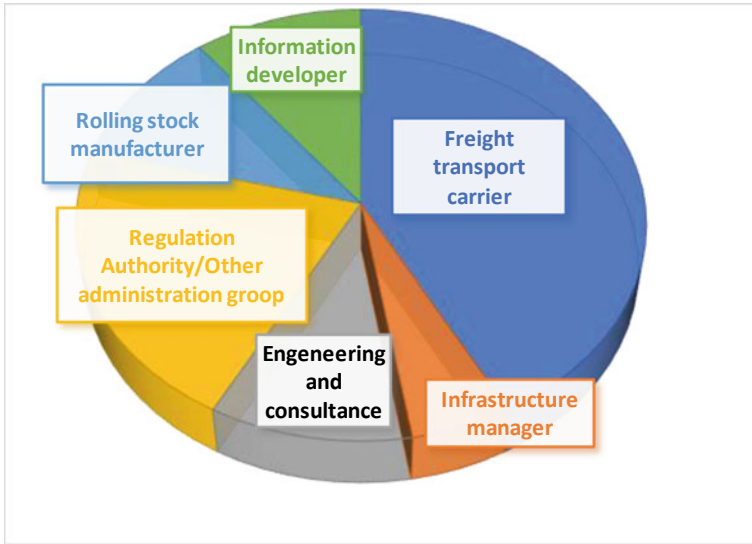
Fig. 1 Category of rail companies participating in the survey—Slovakia, the Czech Republic

not a lot, but it is a sufficient sample for comparison with job offers. The Fig. 1 shows the percentage of rail company type.

Questionnaire was divided into 3 parts, the first part dealt with demand and supply for skilled workforce, the second part dealt with skills which rail companies require and the third part dealt with graduates and their soft abilities, skillsets to work teams.

3.1 Demand and Supply for Skilled Workforce

The first question was about skilled workforce, more than 82% of rail companies from the Czech and Slovak Republics stated that demand for skilled workforce exceed supply. For a better understanding of the reality of the issue under study, it is essential to explain that the stated percentage is the result of inquiries from companies that have long suffered from a lack of qualified graduates of railway study programs, because there is not adequate interest in this study.

The structure of employees according to the level of education is closely related to the main activity of the railway company. Infrastructure manager and rail freight carriers have the most employees with high school, while the engineering and consulting type of rail companies and regulatory authorities require mainly graduates with master´s degree. The preferred kind of new employee education is technical—rail transport, railway engineering or vehicle engineering.

The results of the survey showed that rail companies will look for new employees already during their studies. Almost half of the rail companies said that provide

professional internships for university students during their studies. As it can be seen in Table 1 many of the rail companies accept recent graduates without previous practical experience and without being previously in a similar position.

Many of the rail companies (more than 82%) stated that the intensive training is required after graduates start working in their company.

In our research, we were interested in how many employees work at the three levels according to the rail career matrix (operational, tactical, strategic). Globally, in each category the most common percentage was 25–50%, the only exception is the operational level, where it was in the interval 75–100%. However, this is mainly due to the fact, that up to 42% of the companies were railway freight carriers, which corresponds to the structure of railway companies in Slovakia and the Czech Republic.

We also examined the approximated percentage of rail company's employees for each of the different levels according to the type of company. The results are shown in Table 2.

As it can be seen in Table 2, rail companies that are not directly involved in transport or railway infrastructure management have a more even percentage distribution of employees for each of the different levels portrayed by the rail career matrix.

Table 1 Accepting graduates without previous experience

Company accepts recent graduates without previous practical experience		Requirements for previous practical experience of newly hired employees	
	(%)		(%)
Always	17,65	Previous experience is not required	47,06
Frequently	41,18	Previous experience in a similar position for more than 1 year	47,06
Rarely	41,18	Completion of an internship	5,88

Table 2 Approximated percentage of rail company's employees for each of the different levels portrayed by the rail career matrix

Type of rail company	Approximated percentage according to the level of rail career matrix		
	Strategic	Tactical	Operational
Infrastructure manager	25–50	25–50	75–100
Freight carrier	0–25	0–25	75–100
Regulation Authority/ Other administration group	25–50	25–50	25–50
Rolling stock manufacturer	25–50	25–50	25–50

3.2 Skills Which Rail Companies Require

We researched which skills are important for the rail companies in the strategic, tactical and operations point of view. Table 3 shows the results by type of rail company.

The most required skills cannot be generalized. Other skills at the individual levels of the matrix are required by companies that deal directly with the operation of rail transport, other companies that provide advisory and consulting services and other companies that manufacture railway vehicles. However, it can be noticed that some skills are repeated in individual levels. In this case, different knowledge of skills (detailed or less detailed) is required in individual levels.

3.3 Assessment of the Level of Graduates in Different Skills by Rail Companies

Railway companies require soft skills from graduates. Table 4 shows the satisfaction levels of rail companies with the soft skills of graduates. Due to the fact that we did not take into account the size of the company in our survey, we evaluated these skills using the median.

By rail companies the soft skills of graduates are very good. For almost all skills, the median is greater than 70%, meaning that their level is very well rated by rail companies.

The results of other graduates' skills mentioned by rail companies are shown in Fig. 2.

As it can be seen in the Fig. 2, the rail companies mentioned almost all skills to be sufficient or better level. No graduate skills were rated as very poor.

When it comes to further skills, on the one hand, the rail companies rated the skills as sufficient for working in international contexts, because theoretical knowledge, and knowledge about new trends in transport were very good, on the other hand, they pointed out that graduates lack practical experiences. They emphasized the need for practical skills, training and analytical thinking.

4 Students' Expectations from Rail Companies

In the context of developments influenced by digitalization, as well as the crisis caused by the Covid-19 pandemic, and changes in employee demands on the working environment across all generations, new tools and concepts are being developed in the field of people management to sustain employee's satisfaction from work. Young people of generation "Z" have different job preferences compared to older generations. They require greater emphasis on workplace relations and more financial

Table 3 Skills which rail companies require by the rail careers matrix

Type of rail company	Rail career matrix	Required skills
Infrastructure manager	Strategic	Active steering, Air pollution, Noise pollution, Interlocking, Government regulation, LCC, Railway costing, Security, Safety
	Tactical	ERTMS, ECTM
	Operational	Security, Safety, Route based signalling, Maintenance, Level crossing
Freight carriers	Strategic	Active steering, Air pollution, Noise pollution, Interlocking, ERTMS, ECTM, Government regulation, LCC, Railway costing, Security, Safety
	Tactical	Interlocking, Government regulation, Interoperability, Intelligent transport system (ITS), Maintenance, Railway costing, Security, Safety, Logistic technology and transport chain management, Transport legal framework, Automatic train control, Energy consumption, Track capacity management,
	Operational	Active steering, Interlocking, ERTMS, ETCS, Maintenance, Security, Safety, Automatic train control, Availability, Route based signalling, Speed based signalling, Traction Drives
Regulation/Transport Authority	Strategic	Safety regulation, Sustainability, Infrastructure costs modelling, Transport modelling and simulation, Government regulation,
	Tactical	Air pollution, Noise pollution, Transport externalities, Government regulation, Interoperability, ITS, LCC, Security, Safety regulation, Sustainability, Data analysis, Transport legal framework, Demand forecasting
	Operational	Active steering, Interlocking, ERTMS, ETCS, Interoperability, ITS, Maintenance, Railway costing, Security, Logistic technologies and transport chain management, Timetable management,
Other administration group	Strategic	Active steering, Programing and software development, LCC,
	Tactical	Active steering, Interoperability, ITS, Railway costing, Safety, Security, Data analysis, Body construction,
	Operational	ERTMS, ETCS, Maintenance
Rolling stock manufacturer	Strategic	Government regulation, Interoperability, Programing and software development, LCC, Data analysis,
	Tactical	Active steering, Interlocking, ERTMS, ITS, Maintenance, Railway costing, Security, Safety,
	Operational	Body construction, Braking, Distributed power, Electric, Electromagnetic compatibility, Gas turbine, Wheel-rail interface

Table 4 Soft skills required from graduates

Soft skills	Median
Communication and presentation skills	65,5
Teamwork	83
Time management	75
Responsibility	75
Work ethic	75
Positive thinking and attitude	83
Flexibility and proactivity	70,5
Creative thinking	83
Assertiveness	70,5
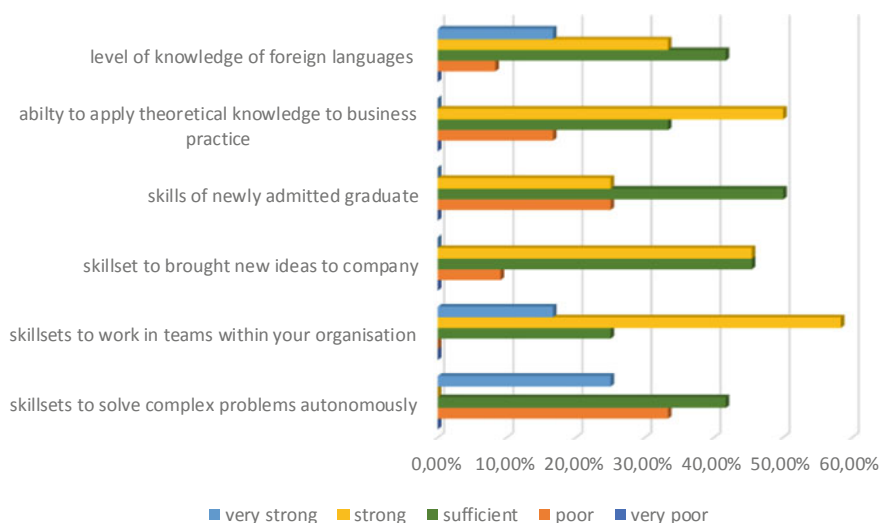
Fig. 2 Graduates' skills valued by rail companies

compensation from rail companies. This phenomenon is based on surveys carried out during the study period (Stacho et al., 2022).

A focus group was held at the University of Žilina. The participants were selected from the students of all three degrees of study, i.e., bachelor's, engineer and doctoral (considering age between 19–27, gender, Slovak and Czech nationality). Young people from Slovakia and the Czech Republic were present in the focus group. They were students, two-thirds of whom already work for or have part-time jobs in transport companies in Slovakia and the Czech Republic. When conducting a focus group of students, the importance of internal and external motivation was considered. The following facts should be noted. Intrinsic motivation is a completely autonomous type of motivation for students of transport programmes. Young people are motivated by the task itself rather than interest and pleasure. Individuals are intrinsically motivated

when they derive benefits directly from the activity itself without receiving external benefits. Intrinsically motivated employees show persistence and show higher work performance and emotional commitment (Delaney & Royal, 2017).

The external motivation of students is influenced by the organization and work environment (Mendoza-Ocasal et al., 2022). Behavior is controlled by the influence of external sources, such as social norms, mutual influence, authority or promises of reward (Vrabcová & Urbancová, 2022). It focuses more on the usefulness of the activity than on the activity itself (Assiri, 2016). Motivated employees are strategically important for the competitiveness of railway companies. They are efficient in the long term and thus are a source of competitiveness for the company (Ganta, 2014). According to the conducted focus group, external and internal motivators are the goals of motivation. Therefore, an individual's goals are often a decisive factor in determining the level of motivation.

The results of the focus group conducted at the University of Žilina showed that the problem of the declining motivation of the workforce, according to the students, was the problem of the internal organizational factors of the rail companies. At the same time, several of the students in question are currently employees of railway companies, both in Slovakia and in the Czech Republic. They perceive an inconsistent organizational culture in the rail companies and personnel policies. Procedures and external factors such as economic uncertainty in countries and budgetary measures adopted as a result of austerity measures during the crisis also affect their motivation to start a job and subsequently work in a railway company.

Students have high expectations and idealized views that the rail companies will fulfill their expectations not only in terms of financial satisfaction, but also in terms of motivational satisfaction of good relations in the workplace. If these two facts are not met, they have no problem looking for opportunities elsewhere and changing jobs. There is a more frequent fluctuation of young people, which is also perceived by our respondents.

Students have a different perception of work in state-owned rail companies and different opinions about private carriers. Externally, for students, rail companies in the state sector seem ideal for more permanent employment. However, over time they discover, according to their own experience, that companies did not meet their expectations, the work is monotonous, and the working conditions are not favorable. These facts also disrupt correct relationships at the workplace and demotivation arises. According to them, the rail companies are composed of heterogeneous individuals of different origins, classes and dispositions. Work processes are not as fluid and efficient as we might hope or assume from textbooks on organizational management and leadership.

Students consider private carriers to be more flexible. They know better how to adapt work to individuals. However, over time, also according to the students' experience, they have too high demands for performance at work. According to the statements of the students, they expect in the future that railway companies should focus more on a well-developed system of motivating young people. And not only from a short-term point of view when recruiting employees, but especially considering the permanent maintenance of their motivation at work.

Furthermore, students perceive major changes in the digitalization of the workplaces of railway companies. They take a critical approach to the fact that they are not trained to work with all the software tools that are used in the practice of rail companies. At the same time, they recognize that it is impossible to cover all of this within the study. They expect more space for training in the field of software solutions from practice and from rail companies.

Other problems that students perceive in rail companies are related to procedural complications, bureaucracy, unexpected way of working or organizational culture, especially in the public sector. It can lead to disillusionment and demotivation of public sector employees as they progress slowly and achieve only lackluster results, which is often attributed to the organizational culture of the public sector. Therefore, students expect an increase in the innovative approach to organizational culture changes. Students have higher expectations from the private sector. They perceive rail companies that are privately run as smarter and quicker to respond to changes.

The Covid-19 pandemic has caused not only changes in the behavior of employers, but also caused changes in the expectations of employees. Students who experienced this situation with their own experience in railway operation express many negatives, but also positives. The negatives, which according to them have not yet been resolved, relate to the loss of good communication between employees and between employees and employers. Home office was a positive thing during the pandemic. That is why they expect employers, both now and in the future, to allow them to use the home office as much as possible. The digital age makes this more and more possible.

Students of programmes focused on rail transport expect new enriching knowledge and possibilities of self-study at home from their future career. School should help to better adapt to practice in the field. In the future, they expect to focus more on passenger transport, plan effective public transport and work on projects on ecological transport. They need the possibility of working in a management and current executive position, e. g. conductor and train conductor.

And what are the key factors to work in the railway sector for the focus group students? The most important factors are good working environment, excellent working conditions, relations between colleagues, possibility of creative work, mutual help, passion for work in the railway sector. No less important is the financial evaluation of employees.

If we were to look at the results of the focus group from the point of view of gender, it might appear that larger differences would emerge. It is generally assumed that there are women and men with different preferences or goals about the workplaces offered by the rail companies, therefore their motivation is different. However, the students did not express that satisfying stereotypical male needs were more important for boys than economic profit, independence, and success. Performance incentives such as financial income, promotion, challenge, and the possibility of self-realization are important to them, but not more than the joy of work and good relationships. At the same time, interpersonal relationships, a sense of security, social benefits, environment, etc. are important for girls.

5   Review of Job Offers

The offers were collected from those railway companies that published a job offer in the period of 2022 and 2023. The source of information was the job offers published by individual companies on their portals as well as in cooperation with universities. Universities actively communicate with the human resources departments of individual companies. Offers were analyzed with respect to professional requirements regarding education in transport as well as soft skills. At the same time, an analysis was carried out, which points to the efforts of companies to create a favorable working environment for employees. Companies are thus trying to motivate young people. At the same time, they create a brand that wants to be attractive and offer interesting employment on the labor market in the future. The companies try to offer better working conditions, declare a friendly working atmosphere in the business, increase comfort for employees in the workplace and the recruitment often shows elements of a marketing campaign. Rail companies are therefore beginning to consciously use so-called employee branding, trying to be an interesting employer from the perspective of their own and potential employees. This approach includes progressive human resources activities so that the employer differentiates proactively from its competitors and retains and attracts as many new valuable employees as possible (Lizbetinova et al., 2020).

According to the research, employers in Slovakia and the Czech Republic offer job positions related to railway transport in the following areas, which include requirements within matrix level and matrix sector mainly in operational and infrastructure field. Positions offered by companies are:

- in the Infrastructure Matrix Sector: train dispatchers, inspection technician, system administrator, designer (railway superstructure, railway undercarriage),
- in the Operations Matrix Sector: traction energy manager, rolling stock electronics, electromechanics, customer service operator, locomotive manager,
- in the Vehicle Matrix Section: designer, business manager,
- in the Other field: general counselor.

It can be stated that the largest offer concerns the operation of railway transport and infrastructure, than rolling stock.

Both in Slovakia and the Czech Republic, manager positions are offered in various areas, from the preparation of projects, through their management, to process managers and administrative employees.

Technical skills are required, requiring knowledge of railway operations. Railway companies in these countries still do not have high demands on language skills. This fact applies especially to state-owned enterprises operating transport in one country. Although almost half of the companies intend for job seekers to be able to work in an international environment, knowledge of the national language is sufficient. No more than 5 years of experience is required, but it is important that applicants meet the education requirements, especially in transportation, electrical engineering, and engineering. mechanical engineering, economics, computer science. The tactical and

operational levels are more represented. Jobs at the strategic level of management are offered sporadically, they are more related to work in the state sector, for example at the Ministry of Transport.

6 Conclusion

The results of the questionnaire survey and job offers in Slovakia and Czech Republic are very similar. Rail companies offer jobs primarily at operational and tactical management levels, requiring knowledge and skills that correspond to the results of the notebook survey shown in Table 3.

The rail companies require primarily technical knowledge and skills, less emphasis is placed on soft skills and language skills, especially for incumbents. Smaller private railway companies also require language and soft skills, but at the same time allow graduates to acquire this knowledge in working time.

The results of our research showed that, on the one hand, railway companies require rather general knowledge and skills from students, as they have no problem with training students, but on the other hand, according to the students, there is a lack of a sophisticated system of motivating young people, especially with regard to their more permanent impact at work. Graduates are willing to learn new things (practical experience), but it is necessary that the railway companies provide them with very good working conditions, that they have the possibility of creative working and that they are adequately compensated financially.

The current job market in the rail sector can be compared to the job market in the IT sector a few years ago. Rail companies will have to give new young employees good financial remuneration hand in hand with other social benefits. At the same time, top managers must realize that young people are not willing to devote all their time to work, but demand stable working hours without overtime. This will require more effective HR planning in the future. This planning is fully influenced by the cooperation of companies in practice and educational institutions. Together, they must create a long-term perspective offer for young people that will influence their decisions in the future.

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Current Gaps and Mismatches Between Rail Higher Education Provision and Industry Expectations

Check for updates

Carlos Casanueva Perez , **Christian Matz, Borna Abramović** ,
Denis Šipuš , **David Calonge** , **and Kristina Svensson**

Abstract The expectations of railway companies are not always aligned with the skills and abilities that university graduates bring when finishing their studies. This work firstly analyses the higher education study paths related to railways and their flexibility; then surveys the expectations of a set of European railway stakeholders in order to get the most looked after skills and abilities; next it analyses sectors other than the railways looking for academic best practices; and in the end it matches the most sought after skills within the Rail Careers Matrix for determining the relative importance of these skills in the operational, tactical, and strategic levels. The final result is a visual representation of the skills gaps and mismatches that European railway companies need to cover in the context of the actual Higher Education in the European landscape.

C. C. Perez (✉) · C. Matz
KTH Royal Institute of Technology, Stockholm, Sweden
e-mail: carlosc@kth.se

C. Matz
e-mail: christian.matz@alstomgroup.com

B. Abramović · D. Šipuš
University of Zagreb, Zagreb, Croatia
e-mail: babramovic@fpz.unizg.hr

D. Šipuš
e-mail: dsipus@fpz.unizg.hr

D. Calonge · K. Svensson
EURNEX, Southampton, UK
e-mail: david@eurnex.eu

K. Svensson
e-mail: kristina@eurnex.eu

1   Introduction

Experienced recruiters in the rail industry face challenges when finding talent and personnel, as the skills and abilities that young graduates bring with them are most of the time not aligned with what these stakeholders need. Examples of this effect are specially visible in countries such as the UK (ARM, 2023) or Australia (Shepherd, 2022), but can be found all around the world (Smith, 2018). A study has been conducted to develop a better understanding of areas which are ill equipped with the necessary skills to find out current gaps and mismatches between rail industry expectations and higher education offerings. The work takes the educational benchmarking for railway studies and the industry requirements and expectations surveys and confronts them in order to understand the educational-job market pipeline and find out a common strategy towards developing and improving rail related education towards covering the existing perceived needs in the railway industry.

Additionally, other sectors might have already done similar studies, so educational setups from other specialities have been studied, including what implementations were done to improve the current subject-specific higher education teaching and learning practices.

1.1   Representation of Academic and Industrial Skills in the Railway Sector

In order to allow comparability with previous studies, a similar approach to SKILLFUL (2018) has been chosen, evaluating potential strengths and shortcomings of the used methodology and adapting the methods were necessary. The discussion about industrial skills is necessarily linked to the Rail Careers Matrix (Railway Talents, 2018) (Fig. 1), a visualization of the career opportunities in the railway industry. The application of the matrix in the context of the academic career paths is not direct though, as these are focused on thematic areas within the railway sector and not classic educational silos.

In SKILLLFUL (Ahern, 2017), new and emerging training tools, methodologies and schemes were identified and categorized in "Tools and technologies", "Settings" and "Pedagogical model". New innovative training scenarios had to be blended (using different tools and methodologies in the same course module) and learner centred (a more individually tailored learning opportunity for each trainee/learner). As these methods are rarely implemented nowadays, they complement traditional forms of teaching/training, instead of changing the training experience.

The COVID19 crisis in 2020 and 2021 boosted the implementation of distance/ ubiquitous or asynchronous learning methods enormously. Although it's difficult to support with empirical evidence, both teachers and students agree in claiming that a fully remote education is neither successful nor does it fulfil the participants needs
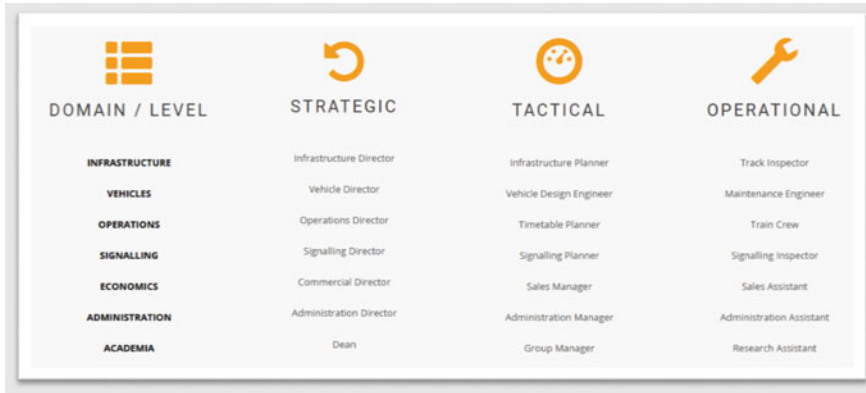
Fig. 1 Rail Careers Matrix (Railway Talents, 2018)

in other regards (Nikou & Maslov, 2021) further supporting the blended learning approach.

Regarding gaps in training for transportation careers, they used interviews and workshops to acquire knowledge about the industry's future needs and the current educational opportunities. "A training need is the gap between current and future knowledge and skills that can be bridged by training or learning activities" (Ahern, 2017). The results were presented in a table that displayed a short description of the gaps for different transport modes, and possible training methods to close these gaps. A summary of the rail sector is included in Table 1:

The rail career matrix (RCM) is represented in Fig. 1. UIC provides a thorough description for each matrix entry on its website (Railway Talents, 2018). The respective descriptions can be broadly summed up as listed in Table 2.

The use of the RCM (and derivative matrixes for the other modes of transport) in the SKILLFULL project seems to have led to rather broader outcomes. Other than expected, the gaps found were not specifically located in the matrix, but were listed in a broader way. Considering the small number of experts interviewed in the rail

Table 1 Gaps in the railway sector

Gap	Training tools/technologies/methodologies Nthat might be used to bridge this gap
New technologies and IT skills	Smart Learning Technologies Virtual Learning Environment (VLE) Heutagogy
Autonomous vehicles, connected vehicles	Virtual Learning Environment (VLE) Virtual/Augmented Reality Learning tools
Increased used of Augmented Reality in the workplace	Virtual/Augmented Reality Learning tools

Source SKILLFUL (Ahern, 2017)

Table 2 Description of matrix levels based on the Rail Talents description (Railway Talents, 2018)

Strategic	Tactical	Operational
• Representation and management duties, • Strong team-leading skills required, • Board member and decision maker • University degree and high level of experience required	• Liaison between operational and strategic • High levels of specific knowledge required • University degree not necessary • Team-leading skills required	• Mostly at-site and hands-on work • High level of practical, rail-specific skills required

sector and the overall (broad) scope of SKILLFUL, the results seem too broad and with a lack of specificity.

For the present work, using the RCM as a base seems natural. However, the current matrix certainly has its weaknesses when addressing educational programmes. In particular:

- Is a Traditionally biased matrix—the current matrix covers the traditional railway-related job fields. In present day, mostly through contemporary global challenges such as global warming and digitalization, new, emerging job groups might be necessary to complement the matrix.
- Is a career, not education matrix—the career focus of the RCM is evident. Required experiences in railways or other sectors are mentioned, whereas required educational backgrounds are rarely listed (almost exclusively for the tactical level). This way the RCM does not aim at freshly graduated students that don't have experience in applying their degrees in a specific sector.
- University education does not necessarily cover all levels of the matrix—the operational level is also served by other kinds of training or education, and there is arguably no direct access from university to a Strategic level position; for all Strategic and some Tactical positions, experience is required according to the matrix description.
- A specific university degree does not link to a specific area in the RCM—but opens a broad variety of different jobs. It is thus difficult to exactly assign programs to a certain matrix entry.
- Most positions do not require railway-specific education—non-railway-specific candidates may need longer initial internal training but can still staff the same position as a railway specialist.

Considering all mentioned shortcomings, there definitely is a need to review and adopt the matrix for the purposes of the present research program. There are two main aspects that should be addressed:

- Are the gaps in the industry needs visible and evident in the current Rail Careers Matrix, and does this need to be updated because of it?

- Is there a set of specific Study Paths that lead to specific RCM Careers? Can a more graduate-focused visualisation be implemented so that educational packages targeted are coupled with the actual needs of industry?

Still, the RCM is a tool that many stakeholders in the rail sector use, so if a review is performed the suggestion is to maintain the main configuration as much as possible to avoid the disruption of existing activities. The clearest objective is that the description of each level and area should be reviewed and rewritten considering the gaps and mismatches that appear between the descriptions and the industry needs.

2 Railway Education as a Preparation for a Job

When looking for the university-job market pipeline, the way higher education is organised in paths where students can take broad or more specialised courses and study programs. The first task is then to understand the possible study paths in different higher education institutions in Europe, if possible, splitting the railway systems knowledge into different thematic subsystems and how they eventually link to the different professional levels. This allows a sensible approach to understanding the position and perspective of different stakeholders when it comes to graduates as employees.

Additionally, and building over the training gaps and educational techniques in Table 1, other pedagogical techniques that can be applied to the railway education will also be explored, specially in how they link to an adequate transition to a railway job after graduation.

2.1 Educational Study Paths

In general, a bachelor program can be either used as a preparation for a master's or as direct access to the industry. To represent the available study paths in an academic institution, a matrix type of visualization is created (see Fig. 2). It consists of the available bachelor programmes (columns) and the available master programmes (rows) with '1' markers indicating that that specific bachelor program allows for unrestricted access to the respective master's program. If there is no direct access from bachelor's to master's the cell is left blank. The study paths are then grouped and highlighted in accordance with railway subsystems to give a more comprehensible visualisation.

The schemes produced this way are a more synthetic representation of the various study paths at different universities, which enables further discussions about the link between the study possibilities and the Rail Careers Matrix. The RCF is not directly an output of the railway study paths but guides the discussion by coupling educational paths and job experience via the grouping in subsystem thematic areas.
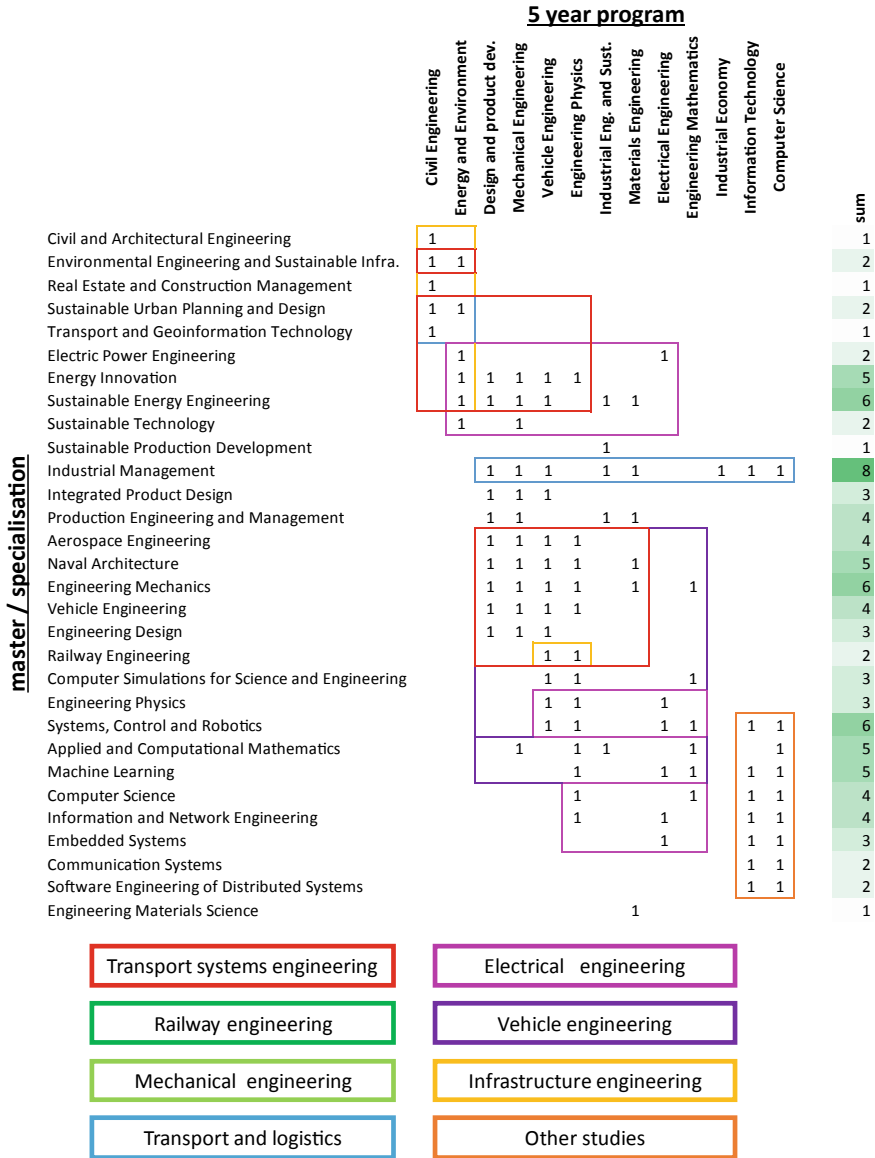
Fig. 2 KTH Matrix Study Path. The matrix suggests a high correlation between bachelors (or the first 3 years of a 5-year program) and master's, meaning only certain bachelor programmes allow to access a certain master's program

If the student decided to pursue a master's this allows them to either continue their studies with postgraduate courses and PhDs respectively, or to enter the industry directly. Due to their country-wise peculiarities, these are not considered in the study.

The matrixes and schemas of seven universities with railway-specific educational programmes or research units have been studied, and they reveal rather substantial differences among the available study paths at the different institutions. These differences concern the number and spectrum of programmes, the accessibility of master programmes, the availability of postmaster and PhD programmes, as well as the resulting job opportunities.

This variety of paths, with their different possibilities to reorientate during the studies, makes it challenging to draw a complete picture of all the railway-related study paths. What can be said though is that when starting in one of the generic fields of study from the railway subsystem classification, it is always possible to continue studying in this field up to the highest level (PhD).

Taking a closer look at what characterises a study path, we can conclude that it is arguably defined by its end. For students who end their studies after a bachelor's degree, a simple look at a university's list of bachelor programs gives the answer to the available study paths. For master studies, it is not only the area of the master program itself but also its accessibility from the bachelor's level. Or in other words, how easy is it to enter a certain master's program with a different bachelor's degree. We call this criterion "permeability".

We defined an integer scale from 0 to 3 to assess the permeability of the various master programs:

0   Master program(s) of this path not available.
1   Master program(s) of this path is only accessible with a bachelor from the same path.
2   Master program(s) of this path allow some permeability / are accessible with Bachelor's degrees from certain other paths.
3   Master program(s) of this path are accessible with bachelor's from nearly all other paths offered by the university.

Using this scale, we were able to draw a more complete picture of the actual availability of study paths at the institutions investigated (Fig. 3). Some study paths are rather narrow, meaning that it is not possible to end one's studies in this path when not already starting one's bachelors in the respective field. These are Mechanical Engineering, Infrastructure Engineering as well as Material Science. Others are highly permeable, given they are available. These are Transport and Logistics, Energy & Environmental Studies and to a certain degree also Transport Systems Engineering. The permeability of the remaining paths mostly depends on each institution. University of Zagreb stands out in this study, as all paths are highly permeable, allowing almost any bachelor student to continue in almost all master programs.

This raises the question of the definitions and limits of the different subfields from the railway's overview picture themselves. At various points in time during this study we were confronted with our own traditional perception of the railway industry. The fields apart from "other" indicate this. There are no fields called "Data Science",

		Areas / Paths										
		Traditional Rail related Paths							Other Paths			
		Transport and logistics	Transport Systems Engineering	Railway Engineering	Vehicle Engineering	Insfrastructure Engineering	Mechanical Engineering	Electrical Engineering	Computer Science	Management & Economics	Material Science	Energy & Environmental Studies
Institutions	La Sapienza (Rome, Italy)	2	3	0	2	1	1	3	2	1	1	2
	KTH (Stockholm, Sweden)	3	2	2	2	1	0	2	2	2	1	3
	Aston University (Birmingham, UK)	2	0	0	0	1	0	0	0	0	0	0
	TH Wildau (Wildau, Germany)*	2	0	0	0	0	2	0	1	2	0	0
	University of Ziline (Ziline, Slovakia)	1	2	2	1	1	1	1	1	1	0	0
	University of Malaga (Malaga, Spain)	3	2	0	2	0	0	0	1	1	1	3
	University of Zagreb (Zagreb, Serbia)	3	3	3	3	3	3	3	3	3	3	3

*does not offer PhD programs

Fig. 3 Study paths at the different universities including the permeability criterion

"IT", "Environmental Studies", "Project & Quality Management", "Security & Risk Management" and many others remain unnamed parts of "others". These are however important skills for the railway industry. We must thus admit that we did not capture all relevant rail-related fields in the railway overview picture and thus in the present study paths. We did however try to include some "others" when building this table.

Nevertheless, the railway overview picture and the present research remain important and useful as in many cases the missing fields listed above are considered necessary additions to more traditional studies. Engineers and logisticians are expected to not only fulfil the traditional requirements but to have versatile complementary knowledge beyond.

2.2 Teaching Methods for Future Professionals

The training gaps highlighted in previous projects showcase the most visible shortages, with possibilities for training these with pedagogical techniques. There are other underused techniques that could also be applied to the railway education, such as:

- Remote learning—this is useful in a sector where many practising professionals decide to study higher-level education while working, allowing for life-long learning.
- Flipped/inverted Classroom, where the reading/listening is done before the lecture and the time with the teacher can be used for practical discussions or more

advanced teaching, which can be further combined with many other techniques. Students usually think it is more work and less learning, but research has demonstrated increased deep-level learning for the same amount of time-on-task (McLean et al., 2016). From a job perspective, it enables a mentality of productive work meetings where the time dedicated to meeting other people is used in an active way, instead of just listening to others.

- Collaborative/team-based learning (Terenzini et al., 2001), encouraging the learner to contribute to the learning of others and to learn from others, is essential in a multidisciplinary sector like Railways where the interaction and overlap between disciplinary areas are inevitable.
- Informal learning, the spontaneous and non-structured learning that occurs in our daily life in different contexts, is very important in a system like Railways where many interactions occur between subsystems that are best exemplified by immersing in the topic in real life.

All of these can be used in the development of courses and modules for modernising railway education and adapting it to current practices.

3 Railway Sector Needs and Expectations

This section analyses the needs and expectations of the railway industry regarding the skills and education of the future workforce. The objective is to find out a number of groups of skills or knowledge that require special attention from higher education institutions.

In the industry surveys companies from the railway sector were asked to state particular skills future employees are supposed to have. This data serves as the basis for the present analysis where we try to confirm the 'stated preferences' from the industry surveys, it is compared to the 'revealed preferences' from the investigated job offers. Since the data from the job offers is way less specific than in the surveys, we grouped the single skills in "skill groups" to facilitate the comparison.

Finally, for each Rail Careers Matrix (RCM) level (European surveys) and for the German survey the five most demanded skills are selected.

3.1 Stated Preferences: Survey Data

The survey consisted on general questions, questions about the skills which rail companies required from the strategic, tactical and operational point of view (see the RCM); and about recently hired graduates and their abilities.

An online survey was carried out between April and September 2021. A database of railway companies was created that included operators, infrastructure managers, transport authorities, international rail companies and more from 25 European

countries. The answer frequency was quite low, 54 companies completed the questionnaire.

A German language survey was also created with questions less specific about the strategic, tactical and operational levels. A database of companies was created, and transport associations were also used to disseminate the questions among their associates. The anonymous online survey was conducted from April to May 2021, receiving 41 complete responses.

The data from the surveys has been split into four parts. There is one part for each of the three Rail Careers Matrix (RCM) levels operational, tactical, and strategic from the Europe-wide survey. The fourth part contains information from the German survey, here no distinction by RCM level has been made. As part of the evaluation of these four different data sets, a score from 1 to 4 (low to high demand) was associated with all different types of companies and all skills. Table 3 shows an example of these scores.

Note that all categories are directly related to a certain area of the rail system, so very general categories such as "Project management" are not present in the survey.

3.2   Revealed Preferences: Data from Job Offers

The data from the surveys is to be compared with data drawn from the investigation of job offers. This is to confirm the validity of the data obtained from the surveys. For gathering the data, 232 job offers from European countries have been gathered and analysed, obtaining data on the stakeholder sector, skills required, specific needs in the form of educational level or area of expertise, etc.

Since the data from the job offers are not as detailed it does not allow for a "skill by skill" comparison. Thus, we introduced skill groups as demonstrated in Table 4. As shown in Table 3, the different skills have been grouped into these, to facilitate the comparison with the data from the investigated job offers.

To determine the most demanded skills among the investigated job offers, each job offer was manually assigned one of the skill groups. In some cases, it was not possible to assign individual offers to a skill group. This was either due to a lack of information in the present data or to the fact that the offers required skills that were not among those investigated in the surveys. Unfortunately, the original information was not accessible anymore, as the job offers had been collected several months prior to the time of the present analysis.

3.3   Comparison Between Stated and Revealed Preferences

In the "European job offers" (all job offers except GER and AUT) (n = 172) 37% of job offers could not be assigned to one of the skill groups above (Table 4). This 37% consisted of 15% requiring Management related skills, 3% requiring System

Table 3 Example for survey evaluation results (Strategic - Europe-wide survey)

Strategic (Europe-wide survey)		Infrastructure manager	Freight transport operator	regulation authority	rolling stock manufacturer	information developer	other administration group	other manufacturing company	Engineering and consultancy company
Railway dynamics	Active steering	2.40	2.71	3.00	2.67	3.00	2.14	1.00	2.58
	Wheel set	1.00	1.00	1.00	2.17	1.00	1.00	1.00	1.00
	Suspension	1.00	1.00	1.00	2.33	1.00	1.00	1.00	1.00
	Wheel-rail interface	1.00	1.00	1.00	2.33	1.00	1.00	1.00	1.00
Traction and braking	Diesel	1.00	1.00	1.00	2.00	1.00	1.00	1.00	1.00
	Electric	1.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00
	Energy consumption	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Fuel cells	1.00	1.00	1.00	2.17	1.00	1.00	1.00	1.00
	Gas turbine	1.00	1.00	1.00	1.50	1.00	1.00	1.00	1.00
	Magnetic levitation	1.20	1.29	1.25	1.83	1.00	1.00	1.00	1.79
	Traction drives	1.00	1.00	1.00	2.67	1.00	1.00	1.00	1.00
	Braking	1.00	1.00	1.00	2.67	1.00	1.00	1.00	1.00
Signalling	ERTMS	1.80	2.29	2.50	1.67	1.00	2.14	1.50	2.26
	ETCS	1.80	2.43	2.50	2.00	1.00	2.14	1.50	2.63
	Route based signalling	2.20	2.00	1.00	1.00	1.00	1.00	1.00	1.00
	Speed based signalling	1.00	2.14	1.00	1.00	1.00	1.00	1.00	1.00
	Automatic train control	1.00	1.71	1.00	1.00	1.00	1.00	1.00	1.00
	Electromagnetic compatibility	1.00	1.00	1.00	3.00	1.00	1.00	2.50	1.00
	Lighting	1.00	1.00	1.00	1.67	1.00	1.00	1.00	1.00
	Interlocking	2.00	1.71	2.50	1.67	1.00	2.43	1.00	2.16
Externalities	Air pollution	2.00	1.71	2.00	2.17	1.00	1.43	1.00	2.37
	Noise pollution	2.00	2.00	2.00	2.50	1.00	1.43	1.00	2.32
	Other knowledge of transport externalities	2.60	2.00	2.75	2.17	1.00	2.29	1.50	2.58
	Sustainability	2.20	2.43	3.00	1.50	1.00	2.71	2.00	2.74
Costing	CBA (Cost Benefit Analysis)	2.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Infrastructure cost modelling	2.60	1.00	1.00	1.00	1.00	1.00	1.00	2.79
	LCC (Life Cycle Cost)	2.80	2.57	2.50	3.17	1.00	2.00	1.00	2.53
	Railway costing	2.60	3.57	3.00	3.17	2.00	2.29	1.00	2.63
Operation	Distributed power	1.00	1.00	1.00	2.83	1.00	1.00	1.00	1.00
	Freight management	1.00	3.57	1.00	1.00	1.00	1.29	1.00	1.00
	Interoperability	2.60	2.86	2.75	3.00	1.00	3.14	1.00	2.47
	Passenger management	1.00	1.00	2.00	1.00	2.00	1.43	1.00	2.16
	Timetable management	2.40	2.43	2.75	1.00	1.00	1.43	1.00	1.00
Legal	Government regulation	2.80	2.71	3.50	3.00	1.00	3.43	1.50	2.79
	Safety regulations	3.00	3.29	3.75	3.17	1.00	2.71	2.00	2.79
	Transport legal framework	2.40	2.86	3.25	2.33	2.00	2.71	1.50	2.47
Planning	Route assignmnent	2.20	2.43	1.00	1.00	1.00	1.00	1.00	1.00
Car body	Body construction	1.00	1.00	1.00	3.17	1.00	1.00	1.00	1.00
Modelling and data	Demand forecasting	2.20	3.00	2.75	1.00	1.00	2.43	1.00	1.00
	Programming and software development	2.40	1.86	2.50	2.67	4.00	1.71	1.00	2.68
	Transport modelling and simulations	2.40	1.86	1.00	1.00	4.00	1.00	1.00	2.63
	Data analysis	2.60	2.57	2.75	3.17	4.00	2.14	2.50	3.05
Logistics	Logistic technologies and transport chain management	2.40	2.71	2.25	2.17	3.00	2.00	1.00	2.11
	ITS (Intelligent Transport System)	2.20	2.29	2.50	3.00	1.00	2.29	1.00	2.74
Track	Track capacity management	2.60	2.14	1.00	1.00	1.00	1.00	1.00	1.00
	Level crossings	2.20	1.00	1.00	1.00	1.00	1.00	1.50	1.00
Safety and security	Security	2.60	2.43	4.00	3.17	2.00	2.14	1.00	2.47
	Safety	2.80	3.29	3.00	3.33	2.00	2.57	1.50	2.79
Reliability and asset control	Availability	1.00	2.29	1.00	1.00	1.00	1.00	1.00	1.00
	Maintenance	1.00	1.00	3.25	3.17	1.00	1.00	2.50	2.37
	Reliability	2.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Remote monitoring	2.40	2.86	1.00	1.00	4.00	1.00	2.50	1.00
	Resource management	2.60	2.86	3.25	2.83	2.00	2.86	1.00	2.95
Auxiliary	Heating and ventilation	1.00	1.00	1.00	2.17	1.00	1.00	1.00	1.00

Table 4 Skill groups

Skill group	Keywords					
Auxiliary	Heating and ventilation					
Car body	Body construction					
Costing	CBA (Cost Benefit Analysis)	Infrastructure costs modelling	LCC (Life Cycle Cost)	Railway costing		
Externalities	Air pollution	Noise pollution	Other knowledge of transport externalities	Sustainability		
Legal	Government regulations	Safety regulation	Transport legal framework			
Logistics	Logistic technologies and transport chain management	ITS (Intelligent Transport System)				
Modelling & Data	Demand forecasting	Programming and software development	Transport modelling and simulations	Data analysis		
Operation	Distributed power	Freight management	Interoperability	Passenger management	Timetable management	Stations
Planning	Route assignment					
Railway dynamics	Active steering	Wheel set	Wheel-rail interface	Suspension		
Reliability and asset control	Availability	Maintenance	Reliability	Remote monitoring	Resource management	

Table 4 (continued)

Skill group	Keywords							
Safety & security	Safety	Security						
Signalling	ERTMS	ETCS	Route based signalling	Speed based signalling	Automatic train control	Interlocking	Electromagnetic compatibility	Lightning
Structures	Bridges	Drainage	Earthworks	Tunnel				
Track	Track	Track capacity management	Level crossing					
Traction & braking	Diesel	Electric	Energy consumption	Fuel cells	Gas turbine	Magnetic levitation	Traction drives	Braking

Engineering skills and 2% requiring Business skills. The remaining 18% simply did not offer enough information.

In the "German job offers" (job offers from GER and AUT) (n = 60) 25% of job offers could not be assigned to one of the skill groups. This 25% consisted of 8% requiring Management related skills, 3% requiring System Engineering skills and 5% requiring Business skills. The remaining 8% did not offer enough information.

The 63%/75% (Europe/GER + AUT) could be assigned one of the skill groups used for the comparison with the data from the survey. To facilitate this, the number of job offers from one company category requiring a certain skill group was divided by the total number of job offers from this company category, resulting in a score between zero and one. This was done for all the above-mentioned sub-datasets (operational, tactical, strategic, and German). Table 5 shows an example.

The skill specific data from the surveys had to be generalised per skill group. For this matter a mean value for each skill group was used. Table 6 shows an example.

The red borders in Table 5 and Table 6 signify the most demanded skills. In the subset strategy of the European survey, the most demanded skills according to the survey are car body, modelling and data, reliability & asset management, track and traction and braking. According to the investigated job offers the most demanded skills in the same subset are externalities, legal, modelling and data, logistics, and safety and security. Since the most demanded skills obtained from the survey overlap in just one case (modelling and data) with the ones obtained from the job offers, we must conclude that the revealed preference does not confirm the data gathered from the surveys. As Table 7 shows, this is also not the case for the other subsets (the overlaps are marked in blue).

The job market analysis has some limitations though. It does not necessarily include the bigger gaps or needs in the railway market, but the jobs that have a higher

Table 5 Example of skill group specific evaluation obtained from job offers

Strategic	Developer/manufacturer of control and safety technology in rail transport	Development/ supply of information in rail transport	Economics company	Engineering/ consulting company	Freight transport company	Infrastructure manager	Manufacturer of rail vehicles or rail vehicle equipment	Other manufacturing company of the railway industry	Passenger transport company	Regulation authority
Auxiliary	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Car body	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5000
Costing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Externalities	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0000	0.0000	0.1250	0.0000
Legal	0.0000	0.0000	0.0000	0.0000	0.0000	0.3333	0.0000	0.0000	0.0000	0.0000
Logistics	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1250	0.0000
Modelling & Data	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000
Operation	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0000	0.0000	0.1250	0.0000
Planning	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Railway dynamics	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Reliability & Asset management	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5000	0.0000	0.0000	0.0000
Safety & Security	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Signalling	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Structures	0.0000	0.0000	0.0000	0.0714	0.0000	0.0000	0.0000	0.0000	0.1250	0.0000
Track	0.0000	0.0000	0.0000	0.2857	0.0000	0.1667	0.0000	0.0000	0.2500	0.0000
Traction & Braking	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 6 Example of Skill group specific evaluation obtained from surveys

Strategic (Europe-wide survey)	Infrastructure manager	Freight transport operator	regulation authority	rolling stock manufacturer	information developer	other administration group	other manufacturing company	Engineering and consultancy company
Railway dynamics	1.35	1.43	1.50	2.38	1.50	1.29	1.00	1.40
Traction and braking	1.03	1.04	1.03	2.11	1.00	1.00	1.00	1.10
Signalling	1.48	1.79	1.56	1.63	1.00	1.46	1.31	1.51
Externalities	2.20	2.04	2.44	2.09	1.00	1.97	1.38	2.50
Costing	2.70	2.04	1.88	2.09	1.25	1.57	1.00	2.24
Operation	1.60	2.17	1.90	1.77	1.20	1.66	1.00	1.53
Legal	2.73	2.95	3.50	2.83	1.33	2.95	1.67	2.68
Planning	2.20	2.43	1.00	1.00	1.00	1.00	1.00	1.00
Car body	1.00	1.00	1.00	3.17	1.00	1.00	1.00	1.00
Modelling and data	2.40	2.32	2.25	1.96	3.25	1.82	1.38	2.34
Logistics	2.30	2.50	2.38	2.59	2.00	2.15	1.00	2.43
Track	2.40	1.57	1.00	1.00	1.00	1.00	1.25	1.00
Safety and security	2.70	2.86	3.50	3.25	2.00	2.36	1.25	2.63
Reliability and asset control	1.96	2.00	1.90	1.80	1.80	1.37	1.60	1.66
Auxiliary	1.00	1.00	1.00	2.17	1.00	1.00	1.00	1.00

Table 7 Overlap of top 5 skills between surveys and job offers

subset	survey					job offers				
						top five demanded skills				
European strategic	Externalities	Legal	Modelling and data	Logistics	Safety and security	Car body	Modelling & Data	Reliability & Asset management	Track	Traction & Braking
European tactical	Costing	Legal	Logistics	Safety and security	Reliability and asset management	Modelling & Data	Planning	Signalling	Track	Traction & Braking
European operational	Signalling	Legal	Modelling and data	Safety and security	Reliability and asset management	Operation	Planning	Reliability & Asset management	Track	Traction & Braking
Germany + Austria	Costing	Operation	Legal	Modelling and data	Safety and security	Car body	Operation	Planning	Signalling	Traction & Braking

density (i.e. there are lots of that specific category employed in the sector) or have bigger turnover (people change jobs more often in that sector). Additionally, the sampling has been done with a specific keyword in mind, "railway", which might also limit the results obtained from the job offers, e.g., won't cover consultant companies working in broader infrastructure-related projects, or component suppliers that provide specific components in the railway system. Furthermore, each job offer (n = 170 + 60) covers only one position, while for the surveys with a much smaller n, each one answers for all the possible job categories they have been asked for directly targeting skill and knowledge gaps.

Because of this, we believe that the data from the surveys are a more reliable source, as it is directly targeting the explicit gaps in the industry. The conclusion is that the relevant top-demanded skill groups can be obtained from the survey-based top 5 evaluation.

Table 8 Most demanded skill groups for each subset

subset	top five demanded skills				
European strategic	Externalities	Logistics	Modelling and data	Legal	Safety and security
European tactical	Reliability and asset management	Logistics	Costing	Legal	Safety and security
European operational	Reliability and asset management	Signalling	Modelling and data	Legal	Safety and security
Germany	Costing	Operation	Modelling and data	Legal	Safety and security

The relevant top five skill groups for each of the subsets can be found in Table 8. The colours signify how many times the particular skill is mentioned among the subsets. The data are essentially identical to the data presented on the left-hand side of Table 7.

Dealing with data from surveys always implies some uncertainty about whether the responses given are true and valid. To deal with the stated preferences, we tried to confirm the findings from the survey by using the job offers investigated. Unfortunately, this was not possible. The rather low number of job offers, the non-systematic approach in their acquirement as well as the manual classification into skill groups introduced a lot of uncertainty concerning the job offers.

4   Parallel Sectorial Experiences

The objective of this section is to see if there have been any similar activities performed in similar sectors like the aeronautical or vehicle engineering, and how the higher education institutions and industry stakeholders have collaborated in order to develop the higher education curricula in a way that meets the needs for a certain talent pool. In the end and due to the wide array of industries, programmes, etc. the work was concentrated on identifying best and worst practices in academia related to teaching skills.

4.1 Analysis

The main driver is a student standpoint for the effective and efficient learning process that is covered using advanced teaching methods. In the following tables is represented the proportion of pure lectures (Table 9) and exercise sessions (Table 10) in the university activities for the different studied universities.

The number of theoretical hours is particularly high at some of the universities, which hints to outdated teaching praxis of hearing and repeating. Traditionally, at engineering universities, students gain a wide ranged basis of different engineering pillars. Positive about that is that they can understand a wider range of problems. But a negative aspect is that the amount of needed knowledge increases. In conclusion, it seems necessary to weigh the amount of basic engineering knowledge and build up new emerging knowledge, introducing new teaching activities that focus on student learning and not necessarily in lecturing.

All studied universities are using, in some cases, advanced teaching activities but they are mostly on a voluntary basis and depend strongly on the personal engagement of university professors. This differs between the project partner countries. The analysis of parallel experiences shows that at some project partner universities, the proportion of exercises in the curriculum is more than 30%. Table 2 is a comparative analysis of exercise hours and percentages among partner universities which include exercises held in a lecture room or/and laboratory. In addition, some project partner

Table 9 Comparative analysis of theoretical teaching hours and percentage

Universities	Study program	Lecture (hours)	Lecture (%)
UNIZG	Railway study program	345	54
	Aeronautical study program	120	66
KTH	Railway Engineering		49
	Vehicle Engineering (Railway track)		46
	Aerospace Engineering		41
UNIZA	Railway transport	106.75	40.47
	Railway structures	129	44.29
	Forwarding and logistics	114.25	43.32
DICEA	Aeronautical and maritime	310	63
	Traffic and logistics	310	63
	Railway	310	63
UMA	Intelligent systems in Energy and Transportation	332	57
	Industrial Engineering	538.5	66
	Mechatronics	274.5	73
TH WILDAU	Transportation System Engineering	63	50.81
	Logistics	57	45.97

Table 10 Comparative analysis of exercises hours and percentage

Partner universities	Study program	Exercises (hours)	Exercises (%)
UNIZG	Railway study program	190	31
	Aeronautical study program	57	31
KTH	Railway Engineering		47
	Vehicle Engineering (Railway track)		53
	Aerospace Engineering		56
UNIZA	Railway transport	157	59.52
	Railway structures	162.25	55.71
	Forwarding and logistics	149.50	56.58
DICEA	Aeronautical and maritime	182	37
	Traffic and logistics	182	37
	Railway	182	37
UMA	Intelligent systems in Energy and Transportation	215	37
	Industrial Engineering	190.50	23
	Mechatronics	89.50	24
TH WILDAU	Transportation System Engineering	44	37.10
	Logistics	54	43.55

universities offer practice-oriented teaching approaches including e. g. the use of laboratories or the integration of internship semesters.

4.2 Highlights

Based on the thorough investigation of what the common approaches are in these parallel programmes, we can highlight the following activities that could be considered in the rail sector and education, differentiating between bachelor and master:

Bachelor level (3 years—180 ECTS)

1. Limit the obligatory basic engineering courses within the first year (two semesters). This way, basic engineering is taught in the first year of study only, and the next two years are reserved for more specific railway courses.
2. Introducing obligatory course about system engineering. At its root of existence, the railway is a system-oriented engineering study. So, system engineering is key and basic knowledge.
3. Introducing laboratories in the curriculum as standalone courses with close didactic integration into the curriculum. Different Higher Education Institutions (HEIs) introduce laboratories in their curriculum. According to positive parallel

experience, for example, UNIZA, laboratories as the standalone course offer students a better understanding and focus on learning topics.

4. Introducing practical skills seminar during the study period. In today's society, soft skills are crucial for understanding work and communication in the railway system. Therefore, these skills need to be implemented in various courses during the study period.

5. Teaching some courses in a foreign language (for example English language, German language, etc.) There is a big difference in foreign language knowledge between European countries. To increase foreign language knowledge, it will be wise that identical courses at different higher education institutions (HEIs), full or partial, be offered to students.

6. Establish elective modules that are focused on concrete knowledge (for example automotive industry, transport services, railway operation, and traffic planning) The railway system is a huge area of knowledge and expertise. In that sense, it will be feasible to offer students different modules. By choosing courses that fit their interests, the students are much more focused on their studies.

7. Invite external professors and professionals from the industry with a combination of lecture plus panel discussion. Students should be allowed to discuss similar or the same topics with external professors and/or practitioners. In this way, they gain experience in understanding the same or similar topics from different points of view.

8. Set up seminars in which students solve practical problems in groups (if possible, with industry partners that formulate the problem). To get better acquainted with the practice or the real state of the industry, various seminars with practice can be introduced that are concentrated on real problem-solving.

9. Include internships to enable the students to gain practical experience during their studies as the bachelor's degree is the first professional qualification and practical experience is therefore needed The internship should be able to be provided to students during their studies. In this way, they will personally experience what it means to work in practice.

10. Write Bachelor thesis with/at industry partners. This approach enables a detailed acquaintance with the detection of the problem and its solution in the real environment.

Master level (2 years – 120 ECTS)

1. Only the first semester with obligatory advanced engineering courses. This way, only advanced engineering courses are taught in the first semester of study, and the next semesters are reserved for advanced railway courses.

2. Introducing obligatory courses about system-specific useable, general scientific research methods that can be applied in railway engineering (for example operational research methods, game theory, e.g.) Today's engineering is based on different types of research methods e.g., in optimization. So that students can understand complex system relationships and system handling, e.g., in optimization it is recommended to introduce a specific optimization course.

3. Introducing laboratories in the curriculum as standalone courses with close didactic integration into the curriculum. Different HEIs introduce laboratories in their curriculum. According to positive parallel experience, for example, UNIZA, laboratories as the standalone course offer students a better understanding and focus on learning topics.

4. Introducing seminars in the curriculum as standalone courses (creating new products/services, benchmarking, debates)—strong connection with industry. Different HEIs introduce seminars in their curriculum very often as a part of the course. Seminars as the standalone course (with close didactic integration into the overall curriculum) offer students a better understanding and focus on learning topics. But also working in and team and communicating with the industry.

5. Introducing soft skills seminar during the study period. The future master engineer is expected to communicate well (in speech and writing), allocate resources and manage teams or projects. These skills are soft skills and their training during the study period is essential.

6. A significant part of courses, there is an emphasis on European or international topics, such as ECTS or INCOTERMS, to teach English. There is a big difference in English language knowledge between European countries. To increase English language knowledge, it will be wise that identical courses, full or partially, be offered to students at the master level of study. This also will increase student mobility opportunities and the exchange of knowledge.

7. Introducing elective courses for different specific research topics (for example intermodal transport, timetabling, fleet management, marketing of services, travel behaviour, …) Although students are concentrated on studying the railway system, each of them has some personal preferences or subjects where he sees himself in the work environment, so it is necessary to offer different elective courses dealing with specific areas of railway engineering.

8. Invite external professors from different Universities/Faculties. Students should be allowed to discuss similar or the same topics with external professors. In this way, they gain experience in understanding the same or similar topics from different points of view.

9. Invite professionals from the industry with a combination of lectures and panel discussions. Students should be allowed to discuss similar or the same topics with professionals. In this way, they gain experience in understanding the same or similar topics from different points of view.

10. Organize regular technical visits (2–3 days per semester). For students to gain practical insight into theoretical knowledge, technical visits are organized to various industrial partners.

11. Obligatory internship (at least 3 Months) during the study. The internship should be able to be provided to students during their studies. In this way, they will personally experience what it means to work in practice.

12. Connect study programs with similar European union universities/faculties for establishing mobility among partners (professors and students). This way,

students will be able to expand their knowledge beyond the context of their own country and certainly better understand the single railway area.

13. Organize once per whole study program student competition (Hackathons or similar events). Today's industry is a highly competitive area, so the introduction of competitions allows students to cope in such an environment.

14. Master thesis fully connects with industry partners. Preparation, research, and presentation of master's theses should be fully related to the industry. This creates a win–win situation for all stakeholders involved.

All these points are either current practices in European universities, or suggestions raised during the discussions, and they create a critical size of experiential learning and industrial collaboration to promote the engagement of stakeholders with future employees earlier in the process.

5 Mapping Out Gaps Between Stakeholder Expectations and University Provision

This section will gather all the information in the previous sections and propose a good representation and visualisation of the correlation between the existing education and the industry needs, tailored for the prospective public (universities and companies). Cross-analysing the demands of the railway industry with those of the universities will help find development needs, but also generate material that can be used for project outreach with high visual impact.

5.1 Finding Gaps and Mismatches in the RCM

The gaps found in the industry analysis (Table 8) are not necessarily explicitly related to the RCM Levels and Domains. To understand where the needs are coming from, each RCM category description has been analysed, searching for references to the actual needs in Table 8. The result is depicted in Fig. 4, Fig. 5, and Fig. 6, where the explicit mention of the gap is marked with "Yes" and an implicit or more vague mention is marked with "not always".

For the industry needs coming from the German speaking survey, there is no possibility of performing this analysis because of the lack of differentiation in the Levels; from the overlap in these results, it is already evident that there are different needs in different levels, which won't be showcased for these survey results.

A more detailed analysis shows that:

- Reliability and asset management is a need that appears over all the different job domains, making it a low hanging fruit for a cross-disciplinary improvement.
- Modelling and data are not mentioned in many places in the RCM but is considered a big need from industry. This should be reviewed.
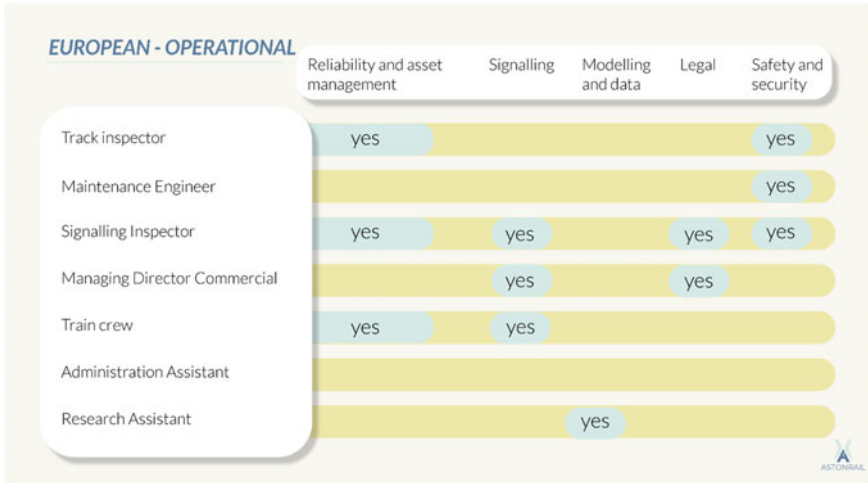
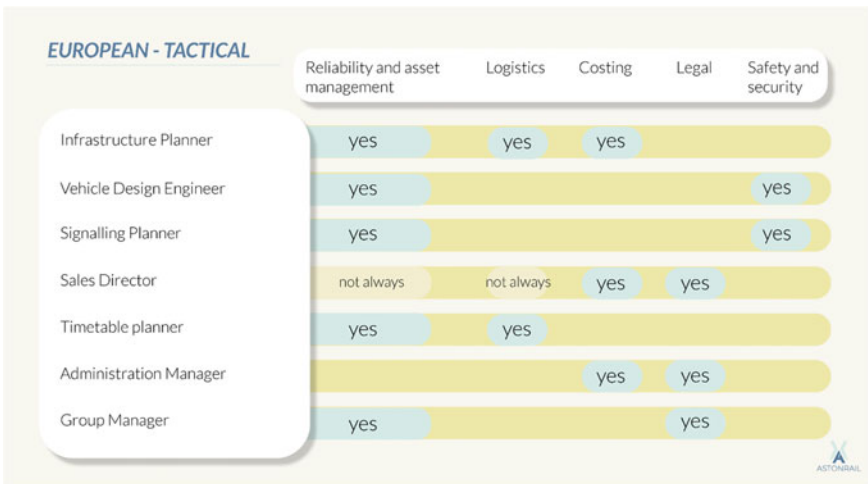**Fig. 4** Mentions of Industry needs in the RCM Operational level

The figure shows a table titled "EUROPEAN - OPERATIONAL" with columns: Reliability and asset management, Signalling, Modelling and data, Legal, Safety and security.

EUROPEAN - OPERATIONAL	Reliability and asset management	Signalling	Modelling and data	Legal	Safety and security
Track inspector	yes				yes
Maintenance Engineer					yes
Signalling Inspector	yes	yes		yes	yes
Managing Director Commercial		yes		yes	
Train crew	yes	yes			
Administration Assistant					
Research Assistant			yes		

Fig. 5 Mentions of Industry needs in the RCM Tactical level

EUROPEAN - TACTICAL	Reliability and asset management	Logistics	Costing	Legal	Safety and security
Infrastructure Planner	yes	yes	yes		
Vehicle Design Engineer	yes				yes
Signalling Planner	yes				yes
Sales Director	not always	not always	yes	yes	
Timetable planner	yes	yes			
Administration Manager			yes	yes	
Group Manager	yes			yes	

- Safety and security are mentioned in different job descriptions in the different level categories, so its consistency should be reviewed—having gaps at different category levels for different job descriptions should be double-checked.
- Legal is a category that covers Government regulations, Safety regulations and Transport legal framework, so the needs have a higher level but are system specific, cascading into every subsystem and applicable to every level of the RCM. A more specific analysis is needed so that the actual specific needs are understood and addressed in educational programs.
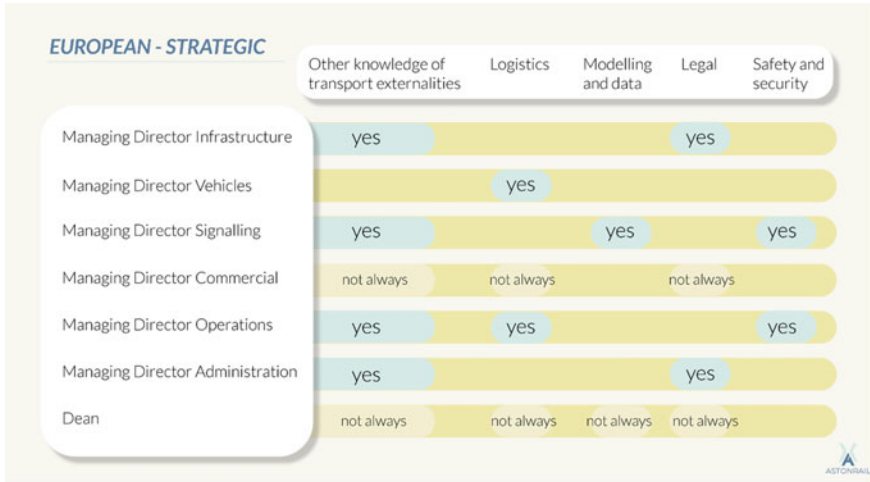
Fig. 6 Mentions of Industry needs in the RCM Strategic level

For a better coupling of the results from different work packages, a more systematic cross-disciplinary surveying should be defined. A single survey with a unique categorisation of paths (both study and career paths) that addresses both the Domain, and the Level in the RCM should be developed.

6 Conclusions

The main output of this work is a depiction of the gaps existing in the university provision, the expectations and desires of industrial partners, and an analysis of the suitability of the Rail Careers Matrix for highlighting the needs and expectations of the industry while coupling it to the educational provisions. Putting all this information together has showcased the possibilities and limitations of linking higher education paths and outcomes with specific job offers or needs, and in doing so, study path and permeability have been defined.

- Study path is defined by its endpoint, the final academic title, and covers the yearly academic components from the first bachelor course until that end. Even if defined by the result, an individual study path is already defined from start to end, so different study paths can lead to the same job position.
- Permeability defines how many different study paths reach a certain outcome, i.e., how easy it is for students of different backgrounds to arrive at that academic title.

Defining a systematic scale, a more thorough picture has been depicted, showing some study paths that are narrow (Mechanical Engineering, Infrastructure Engineering as well as Material Science) and others that are broader (Transport and Logistics, Energy & Environmental Studies and Transport Systems Engineering).

From the job market and stakeholder analyses, a thorough consolidation job has been carried out to highlight the top five skill groups that are needed in the railway industry. There is inherent uncertainty when dealing with data from surveys, so the stated preferences were compared with the revealed preferences from the job offers, with lukewarm results.

A systematic study of different sectors has also been performed, with a substantial amount of information coming from different university environments. A complete list of best practices for addressing student deep learning and engagement has been assembled, which is useful information for upcoming work packages. There is sadly no validation of these proposals when it comes to their positive or negative outcomes in coupling education provision and the jobs market in their respective sectors. The output of this study is still a very powerful analysis of academic practices in Europe and the final discussion will enable proposals in continuation work.

Finally, all the previous work has been crystallised in a visual representation of the Gaps and Mismatches both from the RCM and Career Paths point of view, highlighting those skills and educational areas that need an increased amount of talent in the railway sector. Some of the main conclusions are the need to strengthen Reliability and asset management and integrate Modelling and data in the study paths, as they are considered a big need from the industry. Additionally, Safety and security and Legal should be reviewed, as their high-level needs have subsystem-specific applications. A more specific analysis is needed so that the actual specific needs are understood and addressed in educational programs.

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A Reflection on Higher Education and Rethinking Teaching Practices and Approaches for Rail

Marin Marinov , Reem Hadeed, Constant Iannacci, and Prachiti Shinde

Abstract This contribution offers a reflection on higher education and encourages innovation in the current rail-focused teaching practices and learning approaches. A study of present teaching methods, programme delivery, and student performance assessments was carried out in seven European universities. The collected data were provided by senior lecturers and teaching fellows. As a result, improvements in 'Classroom Assessment Techniques,' course-related, and teacher-related student feedback practices were identified. New policies and practices for innovating rail skills development in academia that could be audited, shared, and improved in order to strengthen both the delivery of rail higher education provision and the development of rail skills in various universities across Europe were suggested and verified.

1   Introduction

The Higher Education Sector is facing a number of major challenges in the near future. Those challenges share the same characteristics, they are all of a lasting nature. They range from rapid increase in the number of students in UK (Bolton, 2023), via the search for education excellence, to the societal issues linked with professionalisation of studies.

The quality of teaching in the higher education sector is a sensitive topic for a number of reasons: employers' demands for higher skill levels coupled with increased

M. Marinov (✉) · R. Hadeed · C. Iannacci · P. Shinde
Aston University, Birmingham, UK
e-mail: m.marinov@aston.ac.uk

R. Hadeed
e-mail: r.hadeed@aston.ac.uk

C. Iannacci
e-mail: c.iannacci@aston.ac.uk

P. Shinde
e-mail: p.shinde@aston.ac.uk

diversity, additional social pressure due to student fees increases, and accentuated international competition between universities in the recruitment of specific academics.

Improving the quality of teaching in universities or making the teaching more relevant is regularly met with obstacles. School teachers are trained to teach and regularly assessed, this is much less the case for Higher Education (HE) academics. Recognition is often related to the level of publications or research involvement. Also due to the high number of students in the first year, there are little opportunities for innovative pedagogies to be put in place. The implementation of the Standards and guidelines for quality assurance in the European Higher Education Area (ESG, 2015), have improved both internal and external quality processes, however internal review, peer observations and students' feedback have their own limitations.

Currently, HE institutions are expected to provide students with a relevant range of knowledge but also with professional and transferable skills. On the one hand, Universities are producing graduates who are able to be operationally quicker, but on the other hand the traditional roles of universities (to transmit and develop new knowledge alongside developing responsible individuals and citizens) are more difficult to fulfil.

The sociologist Bourdieu, P. in 1964 wrote in an ambiguous way that it is "by its absence of pedagogy that pedagogy at the university is characterized". Without attempting a review of progress made since then, it is admitted that University pedagogy is only sixty years old (Loisy & Lameul, 2017).

In his "interactionalist theory 2012", Vincent Tinto promotes the idea that student motivation is driven primarily by their relationship with the teacher. Also, the variety of educational activities contributes to student engagement. This has been demonstrated over the past decade by Roland Viau (2006). Other studies focusing on learning methods such as problem-based learning (PBL) and competency-based-approach (CBA) also highlight the importance of interactions between students and academics. The "flipped classroom" developed by Eric Mazur (Harvard University) is another method relying on meaningful interactions.

A critical decision in implementing a pedagogy strategy in universities is to develop a coherent evaluation method. Its objective is to assess learning outcomes to be evaluated. Some essential steps must be taken in order to create a valid and reliable evaluation strategy.

One of them is the Identification of the specific learning objectives to be assessed. Some will be assessed with only one method, only once (examination for example), while others are assessed by more than one method, and possibly several times (assignments and online forums for example). As a principle, an appropriate evaluation method should align with the ways knowledge is acquired by students.

Another critical and important step is providing adequate supervision for students, to be included in all methods of course evaluation. This supervision has an impact on learning quality as well as, student motivation. Supervision promotes winning conditions for all parties involved in assessing course objectives.

The ASTONRail project targeted rail higher education across Europe. As a result of well aligned education-focused research activities, the project suggested

a better way of seeing rail higher education in future. The project results considered several improvements in three main areas: teaching methods, programme delivery, and student performance assessments. The collected data was gathered primerily by the project partners and scholars from seven European universities.

2 Reflection

Today's Higher Education Institutions (HEIs) are required to strive for high quality, not only due to society's growing demands, but also because they are one of the major drivers of society's competitiveness as a whole (Fernandes, 2017). The knowledge society is becoming increasingly demanding, and as a result, it is necessary to measure it, assess it and then improve it. The ASTONRail project targeted rail education at HEIs across Europe. As a result, a framework was suggested which considered several improvements in three main areas: teaching methods, delivery, and assessments. The collected data were gathered by conducting interviews with senior lectures from seven European universities.

3 Teaching Methods

In order to improve rail education, teaching should include a combination of methods (Burroughs et al., 2019). The findings from thorough research work conducted by the ASTONRail project team show that the fundamental goal is to employ an innovative multi-disciplinary approach. All the participants involved put an emphasis on the importance of keeping lectures sessions. Lectures help to introduce key concepts and approaches and to explain specific points on the course objectives. Additional activities in class and laboratories with specific tasks and challenges were suggested. That helps to create direct contact with practice. Learning from practice can also happen through specific tasks, frequent/internal problems and case study to be distributed between students to solve. In addition, it is beneficial to invite professionals with railway background from railway companies, infrastructure managers, safety agencies, transport and regulatory authority. It can help in promoting an 'intimate' contact between students and distinguished professionals. Students are also encouraged to practice Peer-teaching, stimulating interaction within groups and group-to-group discussions before asking the teacher any general questions.

Improving the classical skills development approach can have a positive impact on developing learning skills. Findings demonstrated the vital role of implementing a number of actions through in-teaching sessions. For example, students will be encouraged to: present, ask, discuss, challenge, reflect, collect, evaluate /interpret, critical thinking, collaborating, inspirate, emulate, and assess. Therefore, it is crucial to identify the role of the teacher. McWilliam (2009a, 2009b) illustrated that teacher can be acting as Director, as Leading Learner, as Nurturer and as Facilitator.

Our fieldwork found that the teacher can be a Director when delivering Lectures to introduce key concepts and approaches and a Meddler when students are asked to complete specific tasks and challenges. The teacher can also be a Meddler in motivating and attracting students' attention to relevant and complementary topics. Facilitator role can be practiced when teacher prepares and uses supporting teaching materials, when frequent problems are given for students to solve and when gradually guides the student's stepwise activities and/or organizes work in groups. Lastly the teacher can be a Nurturer when he/she is challenging the students with a specific problem to solve, during the practices in labs and when organizing activities so that each student is involved creatively and effectively in the learning process.

In the dynamic and multi-disciplinary skills development approach, the teacher will experience all four educator's roles, which can help in the shift from descriptive to critical analysis. Demonstrating a deep understanding of the informed practice and critical reflection can be brought by considering diverse perspectives: from the teacher's, the stakeholder's and the student's perspectives. In this approach, the stakeholder will observe, contribute, and benefit as appropriate. While the student will actively learn from a combination of teaching and learning activities.

As a result, engagement and positive learning outcome will be ensured where students receive input from the academics, experts, rail professionals, other students, and researchers. Therefore, they should have the attitude to act in a multifaceted professional environment and the awareness that the differences in viewpoints themselves are always bringing cultural richness. In this approach, the course teaching staff is focused on creating a learning atmosphere appropriate to the objectives of the modules. The competences gained from the course are crucial along with the student experience, focused on contents, theoretical issues, practical training, professional experience and research. However, the main challenge of this dynamic approach is the ability to help the student to transit from descriptive thinking to critical thinking in class, during the seminars and expositions. Active learning is still a challenge that needs to be favored with new engaging, exciting and innovative approaches.

4 Assessments Techniques

In HE, most assessment strategies, such as course assignments, serve both a formative (assessment for learning) and a summative (assessment of learning) function (Hernández, 2012). Rawlusyk (2018) addressed ongoing academic concerns about whether assessment practices in HE support student learning.

The findings suggested that the only one form of assessment should be avoided (examples, as follows):

1. The 2-h closed book exam on campus to be replaced by a 24-h 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.
4. Examinations through several tests during the semester with student-centered assignments and a final exam at the end of the semester (more teacher-centered, at least one individual non-group examination)

Following on that, the research undertaken within the ASTONRail project reveals that, all participants highlighted the importance of assessing the outcome of each learning activity. They also encouraged a shift from exam-based assessments (e.g., written and open-question exams) towards more project/course work-based assessment (e.g., the completion of a project based on applying the courses' contents).

5 Teaching Delivery Mode

The ASTONRail project findings further suggested to identify and establish the right balance between:

1. Information acquisition vs knowledge construction;
2. Teacher-centered learning vs student-centered learning;
3. Lectures in classrooms (theory) vs practical sessions in laboratories;
4. Distance learning vs self-studies;
5. Student mobility vs distance learning.

Figure 1 presents the distribution between teaching delivery methods that are suggested by the participants involved.

Based on the data presented in Fig. 1, lectures are still the prominent method to deliver knowledge to students.

Figure 1 reflects on the changes which are recommended to adopt and implement in the teaching delivery modes in rail higher education. Lectures mode remain the main mode to deliver the theoretical knowledge, however, we can see the decline of the percentage of the sessions that relay on delivering lectures to 50% only. The increase of self-studies sessions percentage is noticeable and reach at some institution to 30% of the total delivery modes. The interesting attention has been paid to increase the percentage of seminars, lab visits and challenging students by specific tasks to be completed throughout the sessions. The range of these specific sessions is between 10 to 25% of the new delivery modes to the rail modules in higher education. Based on Fig. 1, the future recommendation for teaching rail modules in higher education is to engage students by dropping the theory-based knowledge sessions (lectures) and increasing the practise and real-life problem-solving sessions (such as seminars).
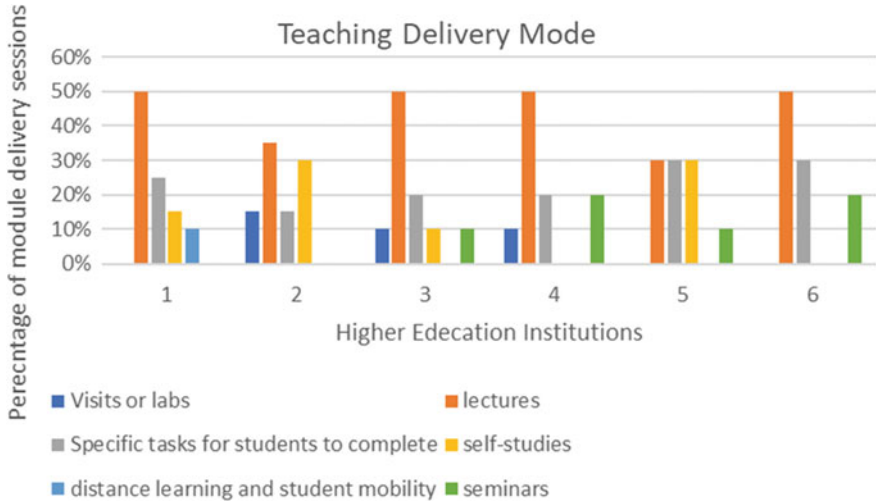
Fig. 1 Teaching delivery mode

Most importantly, encourage students to adopt self-learning approaches (self-studies) while freeing modules sessions to tackle more practical rail related issues.

The major focus of the participants was on linking teaching and research (i.e. Research-based teaching and learning). Such as bringing the research to the class: by searching for recent papers in the field and opening discussions on key concepts and subject specific challenges; or by introducing related projects conducted by the academic staff members to the students themselves; or by inviting experts in the field from industry to the university seminars. Furthermore, when possible, it is crucial to engage students with little tasks in ongoing research projects. Frequent contacts with PhD students is helpful for Post-Graduate and Master students to better focus research topics and approaches of their in interest. Sometimes, online conferences are an opportunity for students to participate in and be exposed to academic discussions.

In class, students can 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. Also, involving students in analytical surveys, in research directly undertaken by transport companies, information gathering, for example, for regions, municipalities, etc to enhance student training for specific conditions in particular practice can be an opportunity for proactive learning to be integrated in the research-based knowledge acqusition field.

6 Teaching Practices and Approaches for Rail Education by Subject Area

6.1 Rail Safety and Security

6.1.1 Current Delivery

Rail safety and security are two different subject areas although in many cases they are taught together, assuming there are overlaps. The current form of delivery includes in-class teaching. Learning activities are dominated by lectures. In addition to lectures, some courses also include short seminars and tutorials. To assess both the skills acquired and the knowledge gained, students have to pass a closed book exam on campus.

The current delivery practice suggests that the student–teacher contact hours are adequate and that in-class teaching using well-structured lectures to introduce theoretical aspects, key standards and operational rules to ensure safe and secure rail system performance are effective and beneficial.

In addition to in-class teaching, students benefit from lectures delivered remotely through online platforms.

In some cases when the form of delivery is linear, in particular, meaning students attend a learning activity timetabled every week at the same time slot for the whole term of studies, students can be given a specific task to complete on their own and be asked to present the outcome in class. Summative feedback is provided by a tutor. Such tasks normally are not marked, however they are helpful as they prepare students for their closed book exams.

6.1.2 Future Delivery

In addition to the current practice, it is suggested (Marinov et al., 2022) that this subject area could benefit more from including Task-based learning and Problem solving whilst teaching rail safety and security-related subjects. Specifically, common problems related to violation of traffic rules and level crossing misuses can be set up and offered to students to analyse and solve. During a module students could be tasked to develop projects, both individual and group projects, to design rail vehicles when considering safety interior and crashworthiness requirements.

Any 2-h closed book exam on campus in the end of a module/course could be replaced by a 24-h our open book online exam, during which e.g. students will be asked to answer 4 detailed questions out 6. Exam submissions should be online via a suitable platform.

A coursework based on a case study (group work) covering more professional learning outcomes (up to 2000 words) is also suggested. 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 number of credits of the module in question (e.g. 15 credits: 2000 words).

6.2 Rail Vehicles

6.2.1 Current Delivery

Rail Vehicles Dynamics, Technology and Maintenance are mainly taught MSc programmes (Level 7 in the UK). The current form of deliver includes small group teaching activities, regular lectures, a course-long project task in parallel to lectures and study (technical) visits/field trips. These modules/courses are complemented by invited/guest lecturers. Learning activities are centred on examining vehicle performance. Students benefit from:

1) working in small groups which creates positive atmosphere for interactive learning,
2) field trips to relevant railway companies and the maintenance headquarters, and
3) professional talks by specialists in the field in seminars focused on key points on vehicle dynamics, pantograph-catenary interaction and superstructure maintenance.

Active learning is employed when:

1) each student is tasked to review a paper about a recent research topic on railway technology and vehicle dynamics and discuss the key aspects learnt in class, and
2) students are invited to participate in a rail vehicles related event attended by professionals.

Learning outcome is assessed through a combination of methods including a closed books exam (normally 90 min), oral presentations (paper discussion) and project related/problem solving tasks. It appears that student participation in rail events with professionals, although highly beneficial, is not included in the assessment.

6.2.2 Future Delivery

It is suggested that for future deliver a better synchronisation between lectures and project tasks to be envisaged. This can be achieved by spreading the work more evenly throughout the term and/or by having Q&A sessions earlier on or more often. A requirement will be for lectures, exercises and individual tasks to be more aligned.

The time dedicated to lectures can be reduced. More time should be made for practical exercises, Q&A sessions, discussions on advanced topics. This can be achieved

by implementing a flipped classroom. Students should be equipped with basic knowledge that can be acquired through learning from pre-recorded sessions available prior to the related activity.

Short, pre-recorded videos on key concepts, about 10–15 min long should be offered to students prior to any learning sessions and actual lectures. It is essential for the students to come prepared. This makes it possible for the activities to start straight away with discussion on more advanced topics, ensuring more time for exercises and/or discussions, depending on the matter being studied. For preparation, informal learning using relevant YouTube channels is suggested for students to gather and analyse additional information on vehicle dynamics, hence start acquiring specific knowledge of the subject.

In addition to enhance the student experience hands-on mock-up models for studying different concepts are suggested. The design and creation of small physical setups that demonstrate key concepts such as equivalent conicity, guidance mechanisms, geometrical profile matching, stiff/flexible bogies, etc. are highly recommended.

Students, as part of their studies, should be included in the delivery of a railway-based research project. This learning method should be complemented by more student-led/focused workshops/brainstorming sessions/flash hackathons in which the involvement of senior lecturers and professionals is crucial.

Active learning as a "guide on the side" approach is proposed where all individual student tasks should be organised in groups for students to improve their communication, collaboration, cooperation and discussion skills.

Activities in subject-specific research laboratories are of interest for students to learn how to apply theoretical concepts and to acquire vehicle dynamics measurements. Research labs are expensive to set up and maintain, as a result simulation modelling computer-based programmes might be of interest as a substitute. However, it should be noted that not every aspect of rail vehicle dynamics can be replicated by simulation. Hence, the importance of hands-on mock-up models for studying different concepts should not be neglected.

Due to the nature of the subject area, when assessing students' knowledge, project-related tasks should be given more importance and greater weight. For some specific aspects within the subject an oral exam could still be introduced to replace a written exam and vice versa. An effort should be made to promoting self-learning by favouring student's natural curiosity to face and overcome technical and design-orientated challenges. This is proved useful and quite effective for subjects of this sort.

6.3 Rail Infrastructure and the Environment

6.3.1 Current Delivery

Lectures are delivered to introduce key theoretical aspects (e.g. geometrical alignment, superstructure performances by typologies, constraints on operation, maintenance management, passengers' stations functions and layout, marshalling yards and other freight terminals operation, etc.) to students. To enhance the student experience, practical knowledge from the field is offered in the classroom. It was found that about 50% of rail infrastructure related modules/courses is delivered by professionals and guest speakers from industry.

In-classroom teaching and learning activities include the application of concepts in wheel-rail contact, design and rail operations, rehabilitation of an existing line and constraints for operation joined with parallel approach to vehicles with final targets on capacity assessment and timetabling. The delivery is complemented by both seminars on ongoing research topics (by PhD students and/or teachers from other universities) and technical visits in groups to rail passenger stations with a focus on superstructure, layout, signalling, operation and accessibility. with students-to-students final presentation.

Environmental impact assessment and related subjects are taught at Post-MSc as part of Rail Infrastructures and Systems Engineering programmes.

Lectures, in-classroom learning, are delivered to present students with key theoretical aspects that include interaction between the rail system and the environment, externalities and carbon footprint concepts, assessment of impacts during construction and operation, energy management by eco-driving and timetabling optimisation. A specific learning practice includes an interactive assessment of carbon footprint by simulators.

A common assessment method includes a student-to-student presentation and an oral/or written exam. For re-sits and clarification, an oral exam including presentation of practices is organised individually for every student.

6.3.2 Future Delivery

The delivery of rail infrastructure related subjects should be enriched by introducing a meddler in the middle teacher role (McWilliam, 2009a, 2009b; The Schoolworks Lab, n.a.), namely a dedicated technical visit with task assignment to groups and a final 'students to students' presentation can be organised and included to enhance the student experience. Lectures can be delivered, not on campus, but during technical visits using a 1:1 physical example. To bring and introduce different perspectives and concepts from other regions and countries it is suggested for teachers and guest speakers from other universities and institutions to be systematically involved in a more osmotic multi-voice teaching.

6.4 Rail Operations

6.4.1 Current Delivery

It is a common practice for rail operations-related subjects, encompassing rail timetabling, planning, operations, slot allocation, signalling etc., to be included in modules/courses being part of both BSc degree programmes and MSc studies of railway engineering. In some Eastern European HE institutions, e.g. UNIZA, such subjects form a complete module.

Current form of delivery includes a set of in-class lectures, auditory exercises and seminars as well as lab-practice lessons. The lectures are normally complemented by real-world examples to demonstrate the role, functionality and impact of different systems and methods of rail operations, signalling and control and to introduce key principles and processes for a safe rail operation encompassing all responsibilities and duties of signalmen, train crews and dispatchers.

Individual lessons offered by professionals and guest speakers from the railway industry that bring practical experiences from the field are included. Students gain skills from practical exercises in a rail operations laboratory equipped with original interlocking systems from different eras. Students also learn how to use IT applications to locate public transport vehicles as part of an Intermodal/Integrated Transport Control System (ITCS).

In addition to on-campus learning activities, technical visits to different rail companies with focus on train management and operations control facilities are organised.

Existing static online platforms (e.g. Moodle) are used for sharing learning material. There are possibilities for students to attend lectures remotely through dynamic online platforms.

Systematic student feedback is collected throughout the module/course delivery and used for continuous evaluation.

Learning outcome is assessed either by:

1) two "open book" homework pieces (mini thesis) followed by a 1,5 h written (closed book) exam on campus, or by
2) a 30-min oral exam plus a case study on a specific topic, e.g. public tender, a short presentation of a "timely topic", and successful practical performance in a rail operations laboratory.

6.4.2 Future Delivery

In the future delivery of such subjects, it would be of interest to consider:

1) including problem solving challenges in the module learning activities,
2) adding video materials that explains the theoretical and practical side of rail operations, planning, slot allocation, etc.

3) introducing railway simulation models in rail physical and virtual laboratories (that can be connected online) for illustrating practices in different countries.

Due to the nature of the subject area, interdisciplinary group work with students from other programmes (e.g. economics) should be envisaged to promote the development of team working skills. The outcome from group work should be presented in student seminars, where the lecturers act as a guide on the side (McWilliam, 2009a, 2009b; The Schoolworks Lab, n.a.).

To illustrate different philosophies for managing rail operations safely and securely on an international level, guest lecturers from other universities and professionals with slot allocation background working in other countries should be involved to deliver some subject specific lectures/modules.

In addition, it was suggested that rail operations module/course content should be more selective and elective giving students the opportunity to design their own curriculum. This should enhance the student learning experience offering more opportunities for students to pursue subject-specific knowledge of their interest.

To enhance the overall student experience and confidence, self-assessment mock-up exams through online learning platforms should be implemented. It is suggested that self- assessments of student knowledge and skills development is voluntary to some extent, as there is no need for mock-up exams' submissions to be marked by the tutor/module leader. Instead, such submissions could be marked by other students being enrolled in the same modules/courses.

6.5   Rail Economics

6.5.1   Current Delivery

The subject of rail transport economics is currently delivered in both BSc (Economics of railway transport 1, Economics of railway transport 2) and MSc (Economics of railway transport 3) programmes.

Our analysis suggests that a typical module/course structure includes a set of lectures (26 + 39 h), practices (26 + 26 h) Lectures provide 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 and example of rail investment projects.

Selective/optional lectures with experts from industry (e.g. railway passenger and freight operators, rail infrastructure managers) are also included together with professional talks by specialists in the field focusing on key aspects of rail transport investment projects, in particular.

Within the subject, students learn how to conduct comparative analyses of national and EU documents, directives, regulation, feasibility study and critical analyses of rail transport investment projects through desk top studies and PC work—search and information processing, calculation of economic indicators. Learning activities such

as in-class discussions, brainstorming and brain-writing are organised in addition to student paper presentation on a predetermined theme.

Assessment of learning outcomes is done through work on individual assignments, written and oral exams, problem solving challenges, and oral presentation on a predefined theme.

6.5.2 Future Delivery

Informal learning via online channels using YouTube and podcasts is recommended to improve future delivery. Student attendance in a scientific conference and guided activities to stimulate the students' interest in scientific information/results from available scientific databases are encouraged leading to publishable outcome individually and collectively as a result of proactive team working.

As for assessing student's knowledge, instead of written exams, the knowledge acquired should be assessed through oral Q&A sessions during which students are asked to answer subject specific questions by a tutor. Tutor then evaluates the ability of each student to question and answer using a set of preestablished assessment criteria.

6.6 Rail Pricing, Ticketing and Access Charges

6.6.1 Current Delivery

As part of the Railway Transport Management theme, Rail Pricing, Ticketing and Access Charges are subjects that are taught primarily in modules/courses included in MSc programmes. Current form of delivery encompasses a set of lectures, auditory exercises and seminars. For Ticketing e.g. a typical module/course would include 10 h lectures, 8 h auditory exercises and 4 h seminars. Learning activities are delivered on campus using traditional means such as in-class learning during which key theoretical aspects supported by real world examples are presented and discussed. Students are encouraged to use existing online educational platforms (e.g. Moodle) to share information and teaching material. Under specific circumstances, COVID 19 e.g., it was possible for students to attend lectures remotely through common online platforms, suchlike Teams, Zoom and Google rooms.

6.6.2 Future Delivery

We found that lectures can be enriched by inviting and involving guest speakers from the industry and other universities. To enrich teaching material and to provide a better illustration of different practices adopted by different countries and rail administrations, the inclusion of short videos should be used by lecturers.

The seminars should encourage students to work in small groups and engage in provocative discussions leading to new approaches for pricing, ticketing and setting up access charges. Preferably these seminars should be student-led, meaning tutor's role should either be guide on the side or meddler in the middle (McWilliam, 2009a, 2009b; The Schoolworks Lab, n.a.).

In addition to on-campus learning activities, technical visits to the relevant departments of rail companies should be organised for students to familiarise themselves with the actual practice in the real world, feel the vibe of the professional environment and create a real sense of how it is done.

6.7 Rail (Passenger) Service Quality

6.7.1   Current Delivery

The topic of rail passenger transport service quality is included in both BSc and MSc rail transport quality management programmes. Programmes of this sort are quite specialised and more common in Central and Easter European Countries.

Current learning activities comprise a combination of methods. Specifically:

1) Lectures introduce key concepts and theoretical frameworks;
2) Conceptual maps, Discussions, Brainstorming sessions and Global 8D Method;
3) Practical exercises 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;
4) Individual work done in a laboratory;
5) Student group projects.

The module/course delivery is usually complemented by professional talks during which specialists in the field elaborate on the practical aspects of service quality in railway transport, legislative background of quality approaches, methods of quality management used in practice.

Informal learning is also employed using online channels with short videos to introduce practical examples and technical aspects relating to the quality of passenger services.

The student's knowledge is assessed through a closed book written exam centred on the methods of quality management in passenger transport service (written exam duration is either 90 min or 120 min), oral presentations (paper discussion, where each student selects and presents in-class a paper about a recent research topic on passenger service quality, and additional problem-solving tasks**.**

6.7.2 Future Delivery

As a result of the studies conducted it is suggested that the delivery form of rail passenger transport service quality subjects should be enriched and improved by:

1) Promoting self-learning by favouring student's natural curiosity with innovative/attractive challenges;
2) Encouraging students to engage in mystery-shopping when using a railway passenger service;
3) Involving more practitioners to bring valuable experience from the field;
4) Encouraging students' self-learning from foreign literature, and
5) Organising systematic involvement of researchers from other universities/research centres to share knowledge and experience.

6.8 Intermodal, with a Focus on Rail Freight

6.8.1 Current Delivery

An example includeds a twelve-hour MSc course being delivered as a 'pilot inter-disciplinary university thematic module/course' of a pan-European programme on Intermodal Transport.

This module/course comprises a set of lectures, in-class teaching with no compulsory assessment of student knowledge. The teaching content is rather limited focussing on intermodal aspects linked to logistics, but not connected to economic/legal aspects (e.g., market characteristics, demand, supply, regulation, etc.) of the subject in question.

6.8.2 Future Delivery

The course should be delivered at least as a 6-credit full university module, and differentiated from traditional railway transport-related university programmes. It should be made compulsory for Freight Transport-related university programmes.

It is essential that students understand how to 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.

The module/course content should be ameliorated to further cover:

a) the different stakeholders within the Intermodal Transport production chain (e.g., shippers, forwarders, logistic providers, etc.),
b) homologation and certification processes needed to overcome interoperability problems (e.g., standards definition), and

c) different types of legal documents required.

Any module/course on Intermodal Transport should include field visits to different intermodal nodes.

The assessment of student's knowledge should consist in preparing and presenting a practical case study as opposed to any conventional written and/or oral exam.

7 Analysis of the Current Methods and Development of New Methods for Skills Development

In order to develop skills in rail higher education, the project conducted a study of present techniques and developed new approaches in the focus areas by using the three key components of the improvement cycle: revise, reflect and innovate. The following outcomes were achieved in the respective areas:

7.1 Skills Development Approach in Rail Higher Education

In reviewing rail higher education skill development approaches, it was revealed that the current practice includes lecture, practice sessions, seminars, laboratories, and technical visits followed by a two-hour closed-book test. After careful reflection it was found that as opposed to being limited to a specific subject area, creative activities are constrained by the availability of resources, staff, and time. The innovative idea suggest that the practice should incorporate a combination of teaching and learning methods. An extension of technical visits with task assignments to groups and final presentations by students (meddler in the middle teacher). The involvement of extra-academic teachers with field experience, the involvement of teachers from other universities, as well as practical activities related to emerging technologies in the railway industry, linked to research whenever possible. Digital platforms such as YouTube channels, podcasts, and streaming can be used to facilitate informal learning in a creative way. It is observed that the use and attraction of these new approaches is growing among students. Teaching methods based on peer interaction Student-led workshops Online connections with diverse laboratories are some of the ways to improve lectures to introduce key concepts and approaches like assigning specific tasks, frequent problem-solving sessions, team activities, frequent practical sessions, implementation of digital platform and giving assess to recording of the lectures can impact the learning outcome greatly.

7.2 Teaching and Learning Environment

Currently, teaching and learning take place only in the classroom. However, this could be changed by including activities at round tables, in libraries, and even online. Shifting the focus from possible theoretical lectures to various industrial visits followed by report writing or feedback will lead to an increase in the active role of students. Also, promoting online learning on carefully selected concepts using fun and effective platforms like VR may greatly enhance the teaching and learning environment.

7.3 The Role of the Teacher in Rail Higher Education

According to the study, the role of the teacher in rail higher education is to be the sage on the stage, as well as a meddler during student-to-student presentations. In order to improve it, more roles could be envisaged when new methods of teaching and learning are introduced, such as extending the role of meddler in the middle, enhancing the role of the teacher based on the context of the class, or adding the role of a guide on the side in case of problem based-learning methods.

7.4 The Classroom Assessment Techniques

In the current practice student-to-student feedback is less or not used as part of the evaluation of student performance, and all work produced by the students is evaluated and taken into account as part of the final assessment (exam + practice + exhibit). According to the study, the reflections of students on the class work must be included as part of the assessment process and the Assessment Techniques should be extended to include a systematic method of using student-to-student feedback to enhance student performance, in addition to using online assessment. This will improve not only final assessment based on exams and reports but also include student participation in class using tasks with open questions.

7.5 Course Related and Teacher Related Student Feedback

In terms of course-related and teacher-related student feedback, the study concludes that the mid-term student survey should be revised, the final course survey should include feedback from students on the whole course, the topic-specific mid-term student survey should be improved, and the final survey should comprise student feedback on the whole course.

7.6 Assessment Method for Every Rail Subject-Specific Module

The current assessment procedure involves a two-hour on-campus closed-book written exam and/or an oral exam that is favorably taken into account for a systemic evaluation. To balance the test pressure at the end of the semester, use of a number of brief assessments throughout the semester can be included. The revision of crucial outcomes from course-related feedback is necessary for improvement (course survey and reflective task). Both questioning and answering are subject to evaluation by the teacher.

7.7 Research-Based Teaching and Learning for Rail Skills Development

In light of the revisions made to the research-based teaching and learning technique for rail skills development, it has been observed that seminars by Ph.D. students as well as presentations of ongoing research papers and lectures based on the results of rail focused research projects are occurring (Marinov, 2013). It is found that by assigning tasks in researching and designing new rail systems that are more secure and safer, as well as by focusing the paper discussion and laboratory activities on current rail-specific research projects, the entire programme is enhanced (Marinov, 2014; Marinov and Ricci, 2012).

7.8 Career Prospect for Every Graduate in Any European Country

In considering career prospects for graduates in any European country, we discovered that information about rail specific events and networking opportunities are rather limited locally, with no additional support for graduates outside the region. Internationalization of the learning process is not encouraged enough by teachers. It appears that there is a limited amount of time, resources, and training available. The use of digital technologies can contribute to the creation of new teaching and learning experiences outside the classroom, strengthening of ties between students with similar interest across Europe.

Amongst the innovations suggested are: a more flexible module specification and access to European networking events, a greater number of international internship opportunities, and more programs (BA and MSc) utilizing new technologies to support content and teaching practice that can overcome current obstacles. New technologies in particular contribute to inspiring and motivating teachers as well as students. A recommendation for improvement would be to include students in

module-specific revisions and encourage them to participate in networking events. It is imperative to encourage institutions to invest more time and resources in enhancing online learning through curated content. There are few tools available for teachers to promote international experiences. Using the Erasmus + programme to study abroad is a great way to encourage students to do so.

8 Conclusion

In conclusion, the study outcomes presented in this paper have brought to light some pertinent questions regarding the traditional approach to developing skills and competences in higher education. The approach, which involves listening, stopping, reflecting, writing, giving feedback, has been reviewed and scrutinised. Proposals for improvements in specific subject areas within the field of key rail-related disciplines have been put forward.

In order to achieve the stipulated learning outcomes, it is imperative that rail degree programmes are taught and delivered in an environment that fosters a sense of joy and pride in students' skills and knowledge. As the degree programme draws to a close, the graduates should have gained the necessary skills to pursue a career in the railway sector across the whole of Europe. They ought to be well-equipped with the necessary skills and competences to take on the challenges and opportunities that come with this exciting industry. To ensure success in education, it is imperative to always keep in mind the interests, knowledge, and satisfaction of the students. Through a thorough examination of various learning theories, we have been able to gain insight into the crucial role that teachers play in providing higher education in the field of rail. The role of the teacher for various rail-specific subjects and methods of teaching and learning activities was thoroughly examined, defined, and confirmed.

With an emphasis on when and where the teacher should be working as Director, Leading Learner, Nurturer, and Facilitator, new methods to evaluate the calibre of a learning result have been proposed. We identified improvements in 'Classroom Assessment Techniques,' course-related, and teacher-related student feedback.

Proposals have been put forward to aid in the identification and establishment of the ideal balance between various learning methods. These include finding the right equilibrium between information acquisition and knowledge construction, as well as between teacher-centered and student-centered learning. Additionally, new proposals suggest better balancing lectures in the classroom with practical experience in laboratories, and finding the right balance between distance learning and self-studying. Furthermore, concepts suggest better balancing exam-based assessments with project/coursework-based assessments, and finding the right balance between student mobility and distance learning. These proposals have been tailored to specific rail courses in each partner institution invloved in the ASTONRail partnership.

We also explored the significance of research-based teaching and learning in higher education in the rail industry and examined the possibility for supporting "fresh" initiatives and frameworks to further connect research and teaching. The

process of learning through research has been found to have a significant positive impact on the intellectual development of students. As a result, new policies and practices for research-based teaching and learning to strengthen both the rail higher education provision and the development of rail skills and competences in the universities of the ASTONRail partner organisations and departments have been worked out.

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Young People's Reflections on the Railway Sector: A European Perspective

Isabel Ruiz-Mora, Sergio Postigo-Pozo, Juan J. Castillo-Aguilar, Pablo-Javier Salas, and Marin Marinov

Abstract The aim of the Erasmus+ funded project ASTONRail (Advanced approaches and practices for rail training and education TO inNovate Rail study programmes and improve rail higher education provision) is to generate awareness and encourage young people, particularly those facing career path decisions, to consider the rail industry as an interesting and fascinating alternative to develop their working career. One of the project tasks is to create impactful initiatives, promotional events, and outreach activities to attract and inspire a greater number of aspiring railway talents and young professionals. To this end, focus groups have been used in this paper to explore the perceptions young people hold about this sector and the employment opportunities it can offer. Thus, by resorting to discussion groups, it has been possible to identify key aspects of the young generation's perception and demands on public transport in general and on the rail mode of transport in particular. As a result, it was found that the way young individuals perceive the railway sector is influenced by their personal experiences and preferences, environment and cultural context. Furthermore, the analysis of the findings indicates that environmental concerns hold considerable importance for the younger generations. In addition, the main expectations of future talents regarding the railway industry have been detected, with the aim of improving its attractiveness to them. In this regard, it became evident that a satisfactory salary alone is not sufficient. Equally vital are factors like a positive work atmosphere, ongoing training opportunities, and a healthy balance between personal and professional life.

Keywords Rail transport · Young professionals · Focus Groups · Training opportunities · Career prespectives

I. Ruiz-Mora (✉) · P.-J. Salas · M. Marinov
Faculty of Communication, University of Malaga, Campus de Teatinos s/n, 29071 Malaga, Spain
e-mail: isabelruiz@uma.es

S. Postigo-Pozo · J. J. Castillo-Aguilar
Department of Mechanical Engineering, University of Malaga, Malaga, Spain

M. Marinov
Engineering Systems and Supply Chain Management (ESSCM), Engineering and Physical Sciencies, Aston University, Birmingham, UK

1 Introduction

We are currently witnessing an explosion in the railway sector due to its link with more sustainable and efficient forms of transport. Thus, this sector is increasingly attracting the attention of both the media and experts, as well as society in general. Its penetration and development over the years has been boosted by European policies that seek to promote sectors and forms of transport that contribute to mitigating the effects of climate change. Railway industry also represents opportunities for European society through innovation (like the Europe's Rail Joint Undertaking initiative[1]) and its commitment to youth employment to renew and modernise this sector. In Europe, the railway sector is extensive and interconnected, providing a vital mode of transportation for both passengers and freight across the continent. It's important to note that the railway sector in Europe is complex and varies from country to country. Each country has its own national railway company or companies responsible for operations, maintenance, and infrastructure management. European Union initiatives, regulations, and cross-border cooperation aim to improve connectivity and efficiency throughout the continent.

In the last report of the expert group on *Competitiveness of the European Rail Supply Industry* (European Commission, 2019), the role that technology and digitalisation will play in the sector is evident. The same report describes the skill needs of employees in the sector (European Commission, 2019, pp. 22–23). It is suggested that a good number of employees will retire in the coming years and that there is a mismatch between the skills of these employees and the skills that will be in demand as a result of this digitalisation. Some companies point to difficulties in filling railway engineers' positions. These difficulties also appear "to be linked to low public awareness about the high-tech job opportunities that are offered by the sector in connection with deployment of increasingly sophisticated railway technologies" (European Commission, 2019, p. 23).

Other issues covered in this report include diversity and gender balance (European Commission, 2019, p. 23). Transport is an ageing, male-dominated industry affected by negative stereotypes and often poor working conditions such as mobile workplace, irregular working hours, violence and harassment. As a result, the sector is unattractive to young women and men and is increasingly at risk of labour shortages. Only 22% of those working in the transport sector are women. Furthermore, the majority are in administrative positions. Women are also underrepresented in the rail industry (representing 21% of the workforce in 2016 and only 2.2% of train drivers are women). With one-third of the workforce retiring and major changes due to automation looming, young women should strengthen the future of rail. Having more women in positions that shape policy and drive change will better meet the demand. As the report states, by removing the glass ceiling, the invisible barriers

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[1] It can be consulted in this link: https://european-union.europa.eu/institutions-law-budget/instituti ons-and-bodies/search-all-eu-institutions-and-bodies/europes-rail-joint-undertaking_en#:~:text= EU%2DRail%20is%20the%20European,innovative%20technologies%20and%20operational% 20solutions.

that prevent women from entering the top positions, will lead to greater equality and increased efficiency.

Finally, the experts' report includes several recommendations to be considered in the sector, among them: improving public communication to increase the sector's attractiveness to young talent and increase female employment, focusing on the role of RSI (Rail Supply Industry) to address societal issues such as global warming, an ageing population and increasing urbanisation (European Commission, 2019, p. 23).

European citizens have diverse transport habits (Eurostat, 2022a) that vary based on factors such as geographical location, cultural preferences, infrastructure availability, and personal circumstances. Pedestrian-friendly infrastructure dedicated cycling lanes, and bike-sharing schemes encourage active modes of transport for short-distance trips, especially in urban environments. This is especially prevalent in countries like the Netherlands, Denmark, and Germany, where cycling is deeply ingrained in the culture. In addition, public transportation is widely used in many European countries, particularly in urban areas. Efficient and well-connected systems of buses, trams, trains, and metros contribute to people using them to commute and to travel between different cities and regions. Europe also has a well-developed high-speed rail network, allowing fast and comfortable travel over longer distances. Countries such as France, Germany, Spain, and Italy have extensive networks of high-speed trains offering a most sustainable alternative to short-haul flights. While public transportation and active modes of transport are popular, car usage is still common in Europe, especially in suburban and rural areas where public transport options might be limited. Many European countries have implemented sustainable transport initiatives to reduce carbon emissions and promote eco-friendly modes of travel. This includes incentives for electric vehicle adoption, car-sharing services, and the development of charging infrastructure. Additionally, some cities have also implemented low-emission zones to restrict access for high-polluting vehicles.

The study *Key figures on European Transportation* (Eurostat, 2022a) collects relevant indicators on transport within the European Union. Regarding inland passenger transport, the most commonly used mode of transport was passenger cars, followed by coaches, buses and trolley-buses. Trains share had been experiencing a continuous increase up to the COVID-19 crisis, which reduced the use of this mode of transport. Around 5.4% of the total of passenger-kilometres in 2020 in the European Union were carried out by train. In 2021, a positive trend was registered again (Eurostat, 2022b). Regarding employability, it is interesting to note that, on average, 12.1% of the jobs were done by people aged between 15 and 29. Moreover, only 17.1% of the workforce in all EU Member States was female.

This work is dedicated to obtaining adequate and updated knowledge of the perception of the young generations about the railway sector in Europe. The results will be used to determine the most appropriate strategies to promote and raise awareness about the railway industry among young talents, specifically those who are facing decisions related to their professional future. We seek to delve into the perceptions that young people have of the sector, as well as the job opportunities that they believe it can offer them. This chapter presents the usefulness of the focus group tool to deepen the perception that the new generations have of the railway sector

and its job opportunities, as well as to identify the main demands that future talents make on the sector to make it more attractive for them. A series of focus groups was conducted in Germany, Italy, Slovakia, Spain and the UK. The findings are useful in identifying areas for improvement in the sector, promotional strategies aimed at potential workers and the development of key messages to bring the sector closer to society in general and to future generations in particular.

This paper is structured into seven main sections. The first one consists of an introduction to provide a background and details about the research problem. The next section is devoted to presenting the context of the research. It is followed by a section that includes a literature review. These two sections contribute to describing the framework around which the research is constructed and developed. In the fourth section, the methodological development of the experience analysed, using the focus group technique, is described, detailing the design and implementation process. The fifth and sixth sections include the results achieved and a discussion respectively. The conclusions of this work are drawn in the last section.

2 Context

This work is part of the Erasmus+ funded project ASTONRail (Advanced approaches and practices for rail training and education TO inNovate Rail study programmes & Improve rail higher education provision) which aims to develop a set of innovative tools, methods, approaches and professional practices for rail skills development and, as a result, to improve and modernise the current rail higher education provision in Europe. The project partners include researchers from different European universities and institutions: University of Zagreb (Croatia), University of Sapienza (Italy), TH Wildau University (Germany), Zilina University (Slovakia), KTH University (Sweden), University of Malaga (Spain), Eurnex (European Railway Research Network of Excellence) and Aston University (UK), who leads the project. The research team is multidisciplinary, including teachers and researchers from the fields of mechanical engineering and communication sciences.

The University of Malaga team is in charge of developing effective initiatives, promotional events and outreach activities to encourage more potential railway talents and young professionals to join the railway sector within the AstonRail project. All project partners have contributed to the achievement of this goal. All efforts have been focused on making the rail sector more attractive to early career professionals and enthusiasts. For this, an evaluation has been carried out on the basis of current awareness about rail-orientated careers opportunities amongst European students and young rail professionals, for two main purposes:

- Creation of key messages to lead to a better understanding of the key opportunities the railway sector provides to young professionals.
- Development of strategies for better communication and understanding of the key opportunities that the rail sector can provide to them.
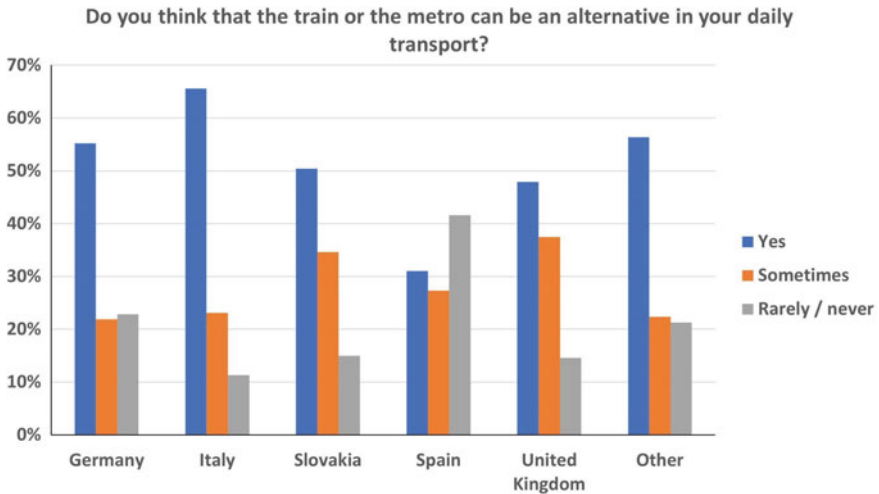
Do you think that the train or the metro can be an alternative in your daily transport?

Fig. 1 Train and metro as a daily way of transport. *Source* Own elaboration

The initial assessment was developed using the survey technique through a self-administered online questionnaire. Over 1000 responses were collected during the years 2022 and 2023, mainly from 5 European countries. Of these, 38% were responses from women, 61% from men and 1% others. By age, the distribution was 22% under 18, 57% between 18 and 25, 17% between 25 and 35, and the remaining 4% over 35. Most of the responses were obtained from university students (73%). To a lesser extent, the questionnaire was also answered by high school students (23%) and other educational levels (4%). The results of this initial assessment have yielded data related to transport habits (Fig. 1), their conception of the sustainability of rail transport (Figs. 2 and 3) and, finally, the possibility of choosing the professional sector in which to develop their career (Fig. 4).

On this question, most responses show how the train or metro could become an alternative mean of transport in young people's daily lives (Fig. 1). In the UK (38%) and Slovakia (35%) the possibility "sometimes" also stands out. In contrast, the result in Spain is remarkable, with 42% answering negatively to this question.

The results of the survey show that the majority of the new generations perceive rail transport to be a green and clean means of transport (Fig. 2). In all countries, rail transport is considered a sustainable way of transport and to have a reduced environmental impact. However, the importance of sustainability is not reflected in the level of choice of this mode of transport when there is a choice. Figure 3 shows that in countries such as the United Kingdom, Spain and Slovakia, rail is not always the preferred option.

The questionnaire included a question to assess whether students have considered the railway sector as a potential career path (Fig. 4). The results show clear differences between countries. For example, in countries such as Italy and the United Kingdom,
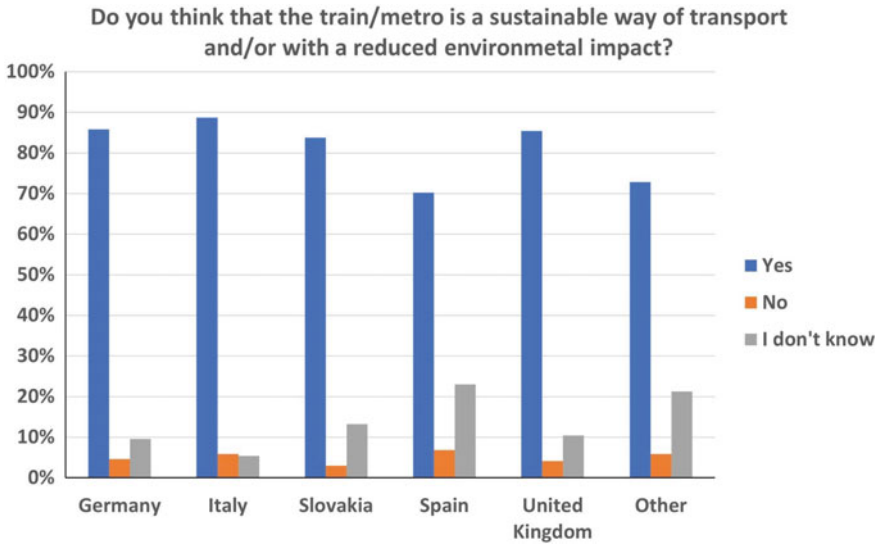
Fig. 2 Train and metro as a sustainable way of transport. *Source* Own elaboration
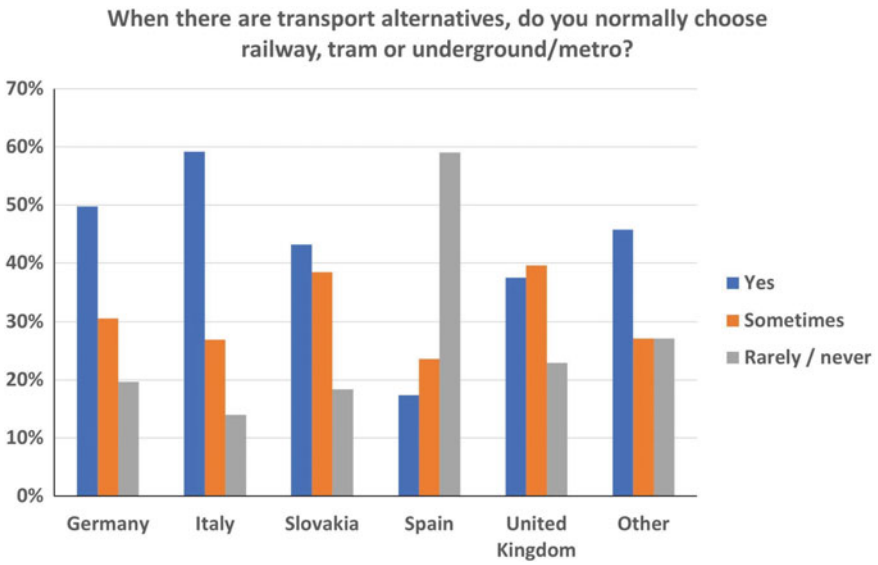

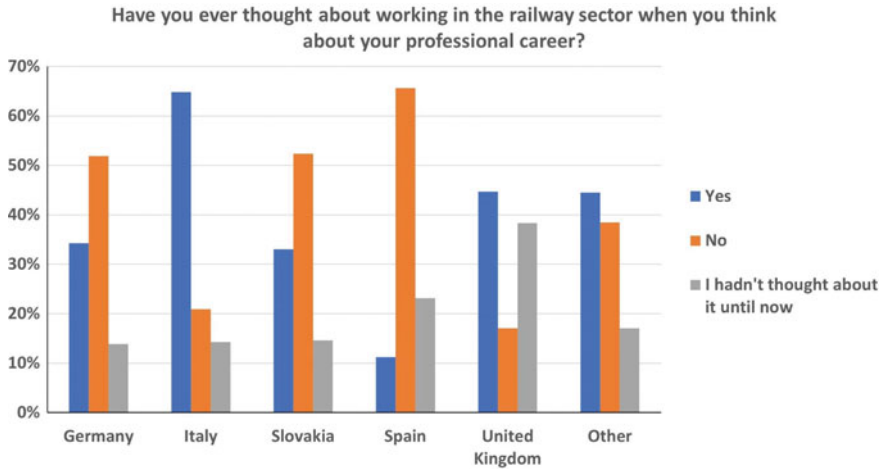**Fig. 3** Transport alternatives. *Source* Own elaboration

Fig. 4 Working in the railway sector. *Source* Own elaboration

the railway sector is widely considered as a career option. In contrast, in Germany, Slovakia and Spain this option is not considered as a preferred option.

After this initial consultation, it was considered necessary to further analyse the data from these questionnaire responses. To this end, by organising five discussion groups, we aimed to understand the different situations identified in the analysis from the point of view of young people in Germany, Italy, Slovakia, Spain and the UK. At this stage of the research, these focus groups will be useful to discuss the results (Albanesi, 2014) with key players in the rail industry. This combination of methods, between quantitative and qualitative approaches, known as methodological triangulation (Morse, 1991), is based on the assumption that different methods give access to different data and can provide new perspectives on the issue studied.

3 Literature Review

3.1 Youth and the Rail Sector

One of the aims of this study is to find out how European young people perceive the railway sector, not only as users but also as a possibility for developing their professional career. In this section, an approach is made to the most relevant opinions and habits of the new generations related to mobility and passenger transport, but also about their job demands and preferences when looking for a job or planning their professional career.

Rail is one of the greenest forms of transport and it's getting even more sustainable with the innovative solutions emerging from Europe's rail supply industry, but

this sector and all its possibilities must also become a pole of attraction for talent and opportunities for the new generations, especially for the so-called Generation Z. In the coming decades, individuals belonging to Generation Z will increasingly assume influential roles in various industries on a global scale. According to the study conducted in the context of the *HOP ON FOR OUR PLANET* campaign, particularly those individuals belonging to generation Z would work in the railway sector for the good of our planet. It will therefore be necessary to know what this population group expects from the industry, what motivates them to use this mean of transport and what opportunities they identify in it.

According to Meola (2023), Generation Z is composed of all people who were born between 1997 and 2012. The generation that precedes them are the Millennials (1980–1996). Generation Z is a very well-educated and prepared group, as they have a more liberal mindset and is open to emerging social trends (Meola, 2023); one of their top priorities is their professional careers and their fields of interest are focused on science, technology, and mathematics; however, many of them might prefer a stable job and a position that gives them security. They prefer to work as a team, leaving competitiveness aside and focusing on collaboration (Benitez, n.d.). They want to hop on to careers and studies for the benefit of our planet (ThinkYoung, 2020). This generation is described as persistent, realistic, innovative, and self-aware; they use social media to keep up with what's happening in the world, and they care about their health and well-being (Meola, 2023).

The European Travel Commission (2020) in its study *Generation Z Travel Habits* stated that the people of this generation look for the following aspects in their travels: return and add more value to destinations over time, discover new destinations, incorporate technology into their travels and gain personal cultural benefits and contribute to the places that they visit. According to the research carried out for the World Tourism Organization (UNWTO), young people have increasingly perceived travel as an essential element of their life and not just a brief escape from reality. Regarding this matter, in recent years, the sale of rail passes allowing travel through multiple European countries (InterRail) has seen a strong resurgence, and rail companies are revamping long-distance night trains to capitalise on the new demand too (European Travel Commission, 2020).

The study conducted in 2020 (the collection data was pre-Covid) by the international think tank, ThinkYoung (2020), including country-specific results for Germany, France, Italy, Spain, Poland and The Netherlands, provides exclusive insights into the views of European Generation Z on the issues raised. Results show that the majority of Generation Z are willing to hop on to greener transport for our planet and urge public authorities to invest in sustainable rail transport. Generation Z believes zero-emission technology is the future of innovation for rail transport and about half of Generation Z wants to hop on to careers and studies for our planet. Female Generation Z currently in STEM careers value sustainable employers even more than males.

Members of Gen Z have grown up in a world shaped by rapid technological advancements, the rise of social media, continuous online communication, climate change and, more recently, the irruption of the COVID-19 pandemic. Consequently,

their expectations and attitudes toward jobs and careers have been influenced by these unique circumstances. As a result, the main key aspects of Generation Z's job expectations include (Mărginean, 2021):

- Technological proficiency: Generation Z has an innate fluency with technology, having been raised in an era of smartphones, social media platforms, and constant connectivity. They expect to work with advanced technology and are trained to take advantage of it for various purposes, such as communication, collaboration, and problem-solving tasks.
- Workplace flexibility: Gen Z values work-life balance and prioritises flexibility in their jobs. Consequently, opportunities that allow for remote work options, flexible hours, and better integration of personal and professional life are more relevant for them.
- Entrepreneurial mindset: following a strong desire for autonomy, control, independence and self-expression, members of Gen Z are willing to take risks and explore their own ventures rather than following traditional career paths.
- Purpose-driven work: Social, cultural, and environmental awareness are essential elements for Gen Z. Thus, companies and organisations that demonstrate a commitment to sustainability and social responsibility, thus making a positive impact on society, are preferred.
- Continuous learning: Generation Z prioritises job offers that ensure advanced learning and growth. Therefore, they expect to have access to ongoing training and development opportunities to enhance their professional skills and stay relevant in an ever-changing job market.
- Values driven: Diversity, equity and inclusion are closely linked values held by Gen Z. Consequently, they prefer workplaces that foster a sense of belonging and respect for individual differences, not only in terms of race, ethnicity, and gender but also in terms of perspectives, experiences, and ideas.

3.2 The Focus Group Technique in Rail and Related Sectors

This research advocates for a qualitative approach that helps us to gain an in-depth understanding of social issues (Ochieng et al., 2018), such is the case of the perception of the railway sector among young citizens. Under this approach, the focus group as a study technique is one of the most widely used. According to Lezaun (2007), the focus group "is today a pervasive technology of social investigation, a versatile experimental setting where a multitude of ostensibly heterogeneous issues, from politics to economics, from voting to spending, can be productively addressed" (Lezaun, 2007). As Lefèvre et al. (2020) states, the focus group technique is based on the concepts of social group and group dynamics. It allows the production of a large amount of relevant qualitative information in a relatively short period of time and with few financial resources, as a result of the conversation and interaction that takes place between a group of people, guided by one or more moderators. For that reason, there is a consensus that focus groups could be used as a participative method

(Zani & Cicognani, 2010). We can define a focus group as a research method that brings together a small group of people to answer questions in a moderate setting (George, 2021). The group is chosen due to predefined demographic traits, and the questions are designed to shed light on a topic of interest (George, 2021). After a long trajectory of application of the technique, some aspects related to its usefulness include (Gibbs, 1997):

- To gain information about the selected group of individuals' views and experiences on a specific topic.
- To obtain several perspectives about the same topic.
- To gain insights into people's shared understandings of everyday life and the ways in which individuals are influenced by others in a group situation.

As pointed out by Ochieng et al. (2018), there are several types of focus groups, depending on how the discussion is organised, the interaction between participants and the role and number of moderators. Some of them are (Ochieng et al. 2018):

- Single focus groups: This is the most common type, involving a team of moderators who facilitate a discussion among a small group of participants (typically 6–10 people). It is widely used in market research, social sciences, and other fields.
- Two-Way Focus Group: two groups, each one with its own moderator. In this case, one group discusses the topic while the other listens and observes them. The second group discusses the subject by observing the thoughts of the first group.
- Dual-Moderator Focus Group: in this type, two moderators with different roles lead the discussion simultaneously. This approach allows for a more dynamic and interactive conversation by sharing the facilitation responsibilities and perspectives.
- Duelling Moderator Focus Group: it also involves two moderators but, on the contrary of the previous type, both moderators take opposite opinions and position on the topic to explore both sides of an issue to generate new insights regarding the subject.
- Respondent Moderator Focus Group: in this type of focus group, researchers may enlist selected participants to temporarily assume the role of moderators. By allowing participants to take the lead impacts on the dynamic of the group, allowing a greater likelihood of obtaining diverse and more candid responses.
- Mini Focus Group: in many research scenarios, researchers encounter challenges when attempting to gather a sufficient number of participants due to difficult to reach or limited availability. However, when the research design necessitates a group discussion format, researchers may opt to convene a small group consisting of two to five participants who have a high level of expertise in the topic.
- Online Focus Group: while online focus groups are not inherently a distinct category of discussions, they have emerged as an adaptation of traditional methods with the advent of the Internet. Utilising online platforms such as conference calls, chat rooms, or similar online means, these focus groups are conducted within the virtual environment. They are often associated with qualities such as dynamism,

modernity, and competitiveness, surpassing some challenges faced in face-to-face discussions.

Researchers can use focus groups in different situations to gather feedback and opinions on products, services, or topics. For example, in the education field (Kaluza, 2023) focus groups can get insight into students' experiences and preferences to improve the quality of education and to enhance students' engagement. Focus groups can also collect feedback from teachers on issues such as teaching methods, parental involvement, and student performance. Decision-makers can use this feedback to improve curriculum development, teaching methodology strategies, school policies, and educational products to meet the needs of students and educators. Marketing is the field in which the focus group has acquired its most visible and standardised form, as an instrument to probe and foretell economic behaviour by anticipating the encounter of consumers and products in the marketplace (Lezaun, 2007). Other fields where focus groups can be used are:

- Market research: commonly used in marketing and advertising research to gather feedback from potential customers about new products, packaging designs, or marketing campaigns.
- Political research: used by political campaigns to understand the opinions and concerns of voters.
- Social research: focus groups can be used to gather data on a range of social issues, including health behaviours, attitudes towards education, or public policy opinions.
- Product design: can be used to gather feedback from potential users about product designs, functionality, and usability.
- Evaluation research: is often used in program evaluation to gather feedback from program participants or stakeholders.
- User experience research: focus groups can be used in user experience (UX) research to gather feedback on digital products, such as websites or mobile apps.

The best way to utilise a focus group is when their research purpose is aiming to explore, understand or generate insights into a topic that is complex, subjective, or sensitive, and can benefit from the interaction and diversity of a group. Their use is not recommended when the intention of the research is to measure, quantify, or test hypotheses about a theme that is simple, objective, or factual and that can be answered by individual responses. In such a case, other methods such as surveys, interviews or observations may be more appropriate and reliable.

This research technique has been extensively applied in the railway sector for different purposes, we present some remarkable cases useful to illustrate how this research technique has been implemented next.

The first case presented involves the importance of measuring environmental performance in a Swedish public sector organisation. This research had the purpose of developing a performance measurement based on strategy, context, and reality regarding the case organisation and with the consideration of both strategic and operational levels of the organisation. The researchers used three focus groups to

conduct the investigation. The first group took part with four environmental coordinators of the five SRA Railway Regions. The second focus group took part with eight workers, six environmental coordinators and administrators and two members of the Environmental Department at the Head Office. The third focus group took part with four members of the Head Office (Lundberg et al., 2009).

In this occasion, the case refers to the liberalisation of the Turkish rail market and how the rail operator TCDD needs to understand the perceptions of different stakeholders regarding their problem identification with rail freight services. This research had the purpose of evaluating the perception of a group of stakeholders and their problem regarding rail freight transport. The researchers used focus groups with participants belonging to the manufacturing and forwarded sectors (Zeybek, 2012).

The third case presents the development and operation of urban rail projects through public–private partnerships in China. The researchers propose that urban rail projects cannot rely only on the private sector alone. The researchers used one focus group with 18 participants that have been involved in the development and operation of urban rail projects (Ke et al, 2017).

Another study involves the decision-making of investment regarding the passengers' rail and the state and local fund allocation in an established passenger rail line in the state of Indiana in the United States. The purpose of this work was to deliver insights on the stakeholders' commitment in transportation decision-making pertaining to decisions of investment in passenger rail and state and local fund allocation. The researchers used two focus groups. In the first group, they included 11 participants and in the second 9. Among the participants, two were included in both groups (Dimitra Pyrialokus et al., 2018).

The fifth case is motivated by the need for more efficient ways of acquiring information regarding the rail assets condition and how the method of asset inspection can be improved. The objectives set by the researchers were to identify the priority areas for the implementation of the Internet of things in rail asset maintenance, and to formulate a strategy using enabling digital technologies for implementing IoT (Internet of Things) in rail assets maintenance. The researchers conducted two focus group workshops. Each workshop formed five focus groups. Each group was composed of four individuals with at least one rail asset operator, rail asset maintenance expert and a digital technologies expert (Gbadomosi et al., 2020).

Another study looks more deeply into the importance of the train as a sustainable way of mobility in Europe. The research was used to estimate future transport demand between 2030 and 2050 in three trip lengths: regional, urban, and long distance in two main aspects; work and leisure. The researchers used two focus groups. One with nine technicians and one with eight transporter users (Cordera et al., 2021).

Finally, the following case involves how the Latvian Charging Body (LRN) must develop a balanced financing model for railway infrastructure charging with the purpose of promoting the competitiveness of environmental advantages in domestic freight and passenger transport. One of the main purposes of the study was to design the ideal experience for railway stakeholders in the matter of developing sustainable strategies in transportation and to identify which state intervention activities in the railway sector can provide balanced conditions of competition with other means of

transport. The researchers conducted one focus group with three stakeholders groups representatives: Railway policymakers, railway professionals and implementers of railway policy. The focus group was led by a moderator and one observer (Hudenko et al., 2022).

To conclude this brief review, we look at the case of how the use of formal methods (the use of mathematical formalisms) helps to verify that the railway signalling systems operate safely and correctly. The researchers conducted one focus group with a team of specialised engineers in railway signalling systems (Lloyd-Roberts et al., 2023).

While focus group discussions can give rise to various cognitive and communicative mechanisms, some of which can be advantageous while others can be limiting. Interaction among participants enables them to clarify their individual opinions, compare their positions, and engage in a "sharing and comparing process" that fosters the development of inter-subjective representations. However, the speed of interaction, dominance of some participants, time limitation and coordination issues among participants may hinder the free expression of ideas. Additionally, the presence of others and the lack of anonymity can lead to inhibition and the tendency to provide socially desirable or stereotypical responses.

In addition, the focus group technique may not always enable in-depth exploration of a phenomenon or generate innovative answers. Successful implementation of focus groups requires careful preparation tailored to specific goals and desired cognitive outcomes and the selection of an appropriate group of participants in terms of sample size and background. In addition, ensuring reliability and objectivity in the analysis obtained from the focus group can be challenging, especially when dealing with subjective opinions and viewpoints (Acocella, 2012).

It's important to consider the focus group's disadvantages when deciding whether or not to use them, and to complement them with other research methods to gather a comprehensive understanding of a topic or target audience. Design aspects, advantages, disadvantages and limitations were taken into account during the preparation of the activities carried out throughout this work, as described below.

4 The Experience

Guided by the main objective of this research, the following specific objectives to evaluate current awareness about rail-oriented career opportunities among young people were set:

- To find out young people's expectations of public transport.
- To assess young people's perceptions of the sustainable dimension of rail transport.
- To identify the main requirements for making the railway sector attractive to future generations.

The specific objectives lead us to ask the following main research questions:

RQ1—what do young users expect from public transport?
RQ2—is the train/metro/tram a sustainable way of transport for young people?
RQ3—what does the railway sector need to become more attractive to early career professionals?

The research design is markedly qualitative. Thus, it follows the interpretative paradigm to delve into the reasons for the reality studied from the point of view of the protagonists: young Europeans (as early career professionals and users of the railway sector). According to Ricoy (2006), the interpretative paradigm allows the generation of methodological designs arising from scenarios focused on the people who are part of the process and reaffirms dialogue and productive discussion to generate knowledge and understand the various problem situations. The interpretative approach also involves "a twofold process of interpretation which, on the one hand, involves the way in which human subjects interpret the reality they socially construct. On the other hand, it refers to the way in which social scientists try to understand how human subjects socially construct those realities" (Vain, 2012, p. 39). According to Ricoy (2006), the interpretative paradigm allows the generation of methodological designs arising from scenarios focused on the people who are part of the process and also reaffirms dialogue and productive discussion to generate knowledge and understand the various problem situations.

Under the interpretative paradigm and using the ethnographic method, we will address the choice of technique and instrument for the collection of information. Wilcox (1993) states that the defining characteristic of ethnography is its descriptive nature regarding social discourse and human relations. In this research, we approach ethnography as a form of research characterised by (Cotán-Fernández, 2020, p. 88):

1. Interest in exploring the nature of the social phenomenon under study rather than testing hypotheses about it.
2. Tendency to work with unstructured data that has not been coded prior to collection.
3. Investigate a small number of cases in depth and in detail.
4. Analysing the information from the interpretation of the meanings of people's actions, presenting it through verbal descriptions and explanations. Sometimes, statistical analysis does not appear or takes second place.

In this context, we will work with what is known as micro ethnography (Goetz & LeCompte, 1988), which is characterised by the use of a single technique for collecting information, in our case young people's perception of the possibilities of the railway sector through focus groups.

Research Technique

In this research, we have opted for the focus group technique. This methodology enables group conversation, guided by a moderator, where the discussion generated provokes interactions and debates on the proposed topics, which leads to reaching consensus or agreements on them and to final conclusions (Castaño et al., 2017,

p. 15). This technique is useful to know the positioning of a certain social group in relation to a given topic (Pedraz Marcos et al., 2014). The method aims to obtain data from a purposely selected group of individuals rather than from a statistically representative sample of a broader population (Ochieng et al., 2018). We have used the dual-moderator focus group option.

It is recommended to complement the focus group with other qualitative techniques such as exploratory interviews and observation (García & Martínez, 2012). In this study, the focus group was complemented by participant observation of the researchers. The focus group organised at the University of Malaga was used as a pretest (Morgan, 1997) to evaluate and adjust organisational and discussion issues. Following Albanesi's (2014) recommendation to hold between 3 and 6 focus groups, 5 group meetings were organised always seeking to avoid the concept of 'saturation' in the discussion, that is, "when across different groups do not emerge further opinions or ideas on a topic because this suggests that further data will not produce new understanding nor address the topic further" (Albanesi, 2014).

Focus Group Design

In the context of the research, five focus groups were conducted in different European universities, members of the Erasmus+ AstonRail project. The participating universities were: TH Wildau University (Germany), Sapienza University (Italy), University of Zilina (Slovakia), University of Malaga (Spain) and Aston University (UK). The fieldwork was coordinated by the University of Malaga research group. In each participating university there was a local team in charge of selecting the participants, organising, collecting, and recording the data from the focus group. A non-probabilistic convenience sample of students from high school, bachelor's and master's degrees, and PhD was chosen for the selection of participants. At all times we ensured balanced participation in terms of gender, age, level of studies also, the participation of students from different areas or disciplines (technical, social, humanities… sciences).

This paper builds upon empirical material from 5 focus groups with students across Europe; 15 researchers (5 moderators and 10 assistants) and 48 students (56% men and 44% women) participated. By level of education, the students were studying high school (12.5%), BA/BSc (22.9%), MsC (41.7%), PhD students (12.5%). The age range was 15–38 years. Table 1 presents information from the 5 case studies that were conducted between 2022 and 2023.

The process of data collection, as well as its development and subsequent analysis and interpretation, is detailed next.

1. Environment. The discussion took place in a neutral environment (a university seminar) for all participants, as well as for the researchers. Drinks, snacks and fruit were available at each meeting to encourage all participants to express their opinions, ideas, comments and suggestions in an open and friendly space.
2. Roles. Three main roles were identified: facilitator, assistant and participant. Each focus group had at least 1 facilitator, 1 assistant and 4 participants. The facilitator ensured the smooth running of the session, addressing all the issues

Table 1 Participants distribution

University name	WILDAU University (Germany)	DICEA Sapienza University (Italy)	ZILINA University (Slovakia)	UMA University of Málaga (Spain)	ASTON University (UK)
Date	17/2/2023	10/3/2023	1/3/2023	2/11/2022	22/2/2023
Duration	90 min	2 h	90 min	90 min	90 min
Number of researchers	3 (1 facilitator and 2 assistants)	4 (1 facilitator and 3 assistants)	3 (1 facilitator and 2 assistants)	3 (1 facilitator and 2 assistants)	2 (1 facilitator and 1 assistant)
Number of participants	4	10	11	10	13
Male	3	4	6	6	8
Female	1	6	5	4	5
Other gender	–	–	–	–	–
Age range	17–23	17–29	21–25	15–32	12–38
Academic level					
High school	1	2	–	2	1
BA	3	1	5	5	–
MsC	–	4	4	2	10
PhD candidate	–	3	2	1	–

Source Own elaboration

    agreed with the research team and guaranteeing the balanced participation of all participants. The assistants oversaw collecting the notes (in the field diary) that will be considered in the subsequent analysis, and also acted as participant observers in the session.

3. Topics. The topics to be covered were previously agreed upon by the main research team. They were initially tested in the first session at the University of Malaga. The topics can be found in Table 2.

4. Data collection. Sessions were audio-recorded with the prior authorisation of the participants, and in the case of underage students, family authorisation was also requested. We avoided revealing the identities of the participants in the graphic recordings. The recording was complemented by the researchers' field diary, where notes were taken of the session.

5. Duration. An initial duration of 90 min was proposed.

Table 2 Discussion topics

Habits	How do you commute daily? Why? What is your favourite means of transportation? Why? What would you ask of a means of transportation to opt for it, to use it more, to be your first choice of transportation? Have you seen any series or other railway-themed audio-visual or entertainment material (podcasts, series, documentaries, books, videos, movies…)? Do you remember any? Do you know what Interrail is?
Sustainability	Maybe you will have to explain what sustainability is (be aware that some of them might not be accustomed to this term). It is advisable to start asking them about the concept of Sustainability and its meaning for them What means of transport do you consider less harmful to the environment? Why? Are you worried about the consequences of environmental pollution? Do you do anything to take care of the environment?
Studies and future	What are you currently studying and what do you plan to study in the future? What would you like your job to offer/provide? What do you see yourself working on? Do you think that what you are studying would allow you to work in the railway sector? Do you know someone who works in the railway sector? Do you know what kind of professions exist in the sector? Would you like to study to work in the railway sector? Do you think that the railway sector offers employment opportunities for young graduates? Would you like to dedicate yourself professionally to working in the railway sector? What would you ask of the railway sector to make it more attractive to you?
Closure	Open question to let them express any idea, comment, or suggestion… related to the discussion and not included previously: What would you ask to the railway sector to make it more attractive to you? In terms of use and as an option to develop your professional career

Source Own elaboration

5 Results

The results are structured in five blocks where a brief contextualisation of the railway sector in each participating country is given first (Germany, Italy, Slovakia, Spain, and the UK) followed by a presentation of the results achieved in each focus group. Our analysis is guided through three thematic areas: habits, sustainability, and future career; other themes emerged as a result of the conversation and interaction of the participants. In the next section, the results will be discussed.

5.1 Germany

National and Local Context

Germany has one of the most extensive and well-developed railway networks in Europe in terms of passenger and freight services. The country's national railway company Deutsche Bahn (DB) is the main operator. DB operates high-speed trains that connect major cities within Germany, also providing international connections. In recent years, the government has made significant investments in upgrading existing rail lines, constructing new lines, and modernising train stations. For instance, recently introduced InterCityExpress (ICE-4) trains featured modern amenities, such as Wi-Fi, power outlets, and improved comfort for passengers. Germany is also investing in the development of high-speed rail connections. Thus, the Stuttgart 21 project aims to create a new high-speed rail hub in Stuttgart, improving connections between major cities in the region and beyond. Additionally, the new Berlin-Brandenburg Airport, which opened in late 2020, includes a modern railway station that facilitates easy access to the airport by train. Four German cities have underground/metro lines: Berlin, Hamburg, Munich, and Nuremberg. In addition, light-rail and tram networks are in use in cities such as Cologne, Hanover and Stuttgart. Germany is actively working towards reducing emissions in the railway sector, improving its sustainability. The government has set ambitious targets for the expansion of renewable energy in the rail sector, with the goal of having a fully renewable-powered rail system by 2050. This includes transitioning to electric trains and utilising more renewable energy sources for train operations.

Wildau is a town located in the state of Brandenburg, Germany. It is situated about 20 km southeast of the capital city, Berlin, being easily reached by the S-Bahn light rail. The town of Wildau is also served by several bus lines, which provide additional transportation options within the town and to neighbouring areas.

The Activity at TH Wildau University

The focus group at TH Wildau University took place on 17 February 2023 and lasted 90 min. 4 students and 3 researchers took part in the discussion. The main results are discussed below.

About habits, first of all they differentiate between short and medium-long distance transport. Thus, for daily commutes (e.g. to get to university), participants prefer to walk (if everything is within walking distance) and to use the bike for short distances. To this end, participants claimed that bike transport infrastructure should be available (v.g. accessibility of train stations with bikes). In addition, bike transport in trains should be easier.

Key points to use a means of transport more often as first choice includes aspects such as: environmental friendliness, safety, cost, flexibility, and the possibility of combination with different transport means (e.g. bike transport in train or even in bus). Another suggestion is the possibility of sharing offers, such as bikesharing. Regarding the main aspects to select rail, these include environmental impact, time aspects, flexibility, safety, cost and travel time usability. When students were asked

about the European initiative Interrail, half of the participants confessed that they knew this programme and most of them are willing to make use of it in the future.

A lack of knowledge of the term sustainability was detected. Furthermore, participants did not answer train/rail when they were asked about which means of transport, they considered less harmful for the environment. However, participants were concerned about environmental issues. Thus, for instance, they are willing to become vegetarian, use means of transport not producing emissions, reduce energy consumption, avoid using cars and combine routes if a car is needed and buy less plastic packaging.

Regarding considering the railway sector as a place to develop their professional career, participants described some of the main requests they will make to the sector. These include: home-office opportunities, good salary, flexibility to bring in your own ideas and having the possibility of changing what is done in the job. Participants think that their study courses will enable them to work in the rail sector and that the rail sector offers employment opportunities for young graduates. However, it is claimed that little information on job offers in this sector is available. On one hand, participants also observe that the rail sector is needed and will be constantly existing due to the mobility demands of people. On the other hand, the railway sector seems to be profit-oriented and less focused on customer satisfaction.

5.2   Italy

National and Local Context

Italy has an extensive railway network that is mostly operated by the national railway company, Ferrovie dello Stato (FS). The railway system in Italy connects major cities, towns, and regions, providing both domestic and international services. High-speed trains are an important part of the Italian railway system. This way, major cities such as Rome, Milan, Florence, Naples, and Venice are connected by high-speed services. Various projects have been undertaken to improve existing lines, expand capacity, and reduce travel times in Italy. For example, the Milan-Turin high-speed rail link was completed, reducing travel times between the two cities. Other ongoing projects aim to enhance railway connections to important regions, such as the high-speed rail link between Naples and Bari in the south. Italy has also been focusing on sustainability in the railway sector. Efforts have been made to increase the electrification of railway lines, reducing reliance on diesel trains. Regarding other rail-related services, it is worth mentioning that seven cities in Italy have metro systems and another 15 cities have commuter rail systems.

Rome has a metro system with three lines, which is one of the most efficient ways to get around the city, and an extensive bus network that covers the entire city, including the outskirts and nearby towns. Rome has a tram network that complements the metro and bus systems. They are particularly useful for reaching certain neighbourhoods or areas with limited metro or bus coverage.

The Activity at the University of Sapienza

The focus group took place on March 10, 2023. Four men and six women of ages between 17 and 29 participated in it. It lasted two hours. Within the focus group, several topics were discussed. A summary of the results is shown next.

In the first point, different aspects about their transport habits on a day-to-day basis were shown. With respect to how they get around daily, it was highlighted that they use public transport, such as the subway and in the first place and second respectively. In Rome city, the first option is the metro because of its low cost and high punctuality. Buses are not a preferred option due to traffic jams, delays, and the perception of poor security at night (specially perceived for female participants). In the case of the train, they would use it more often if the stations were closer to their final destination. Commuting by walking is opted if distances are not so long. Finally, private cars are not contemplated because of the lack of parking areas and heavy traffic at rush hour.

Participants considered micromobility as a minor option. Within it, they might consider the use of electric scooters and bicycles. Walking is another option widely used by the participants. An important aspect pointed out was having a convenient public transport timetable during the whole day. Security perception is very important since most participants expressed not feeling safe travelling late at night. It was also concluded that public transport in Rome was not expensive. However, price is an issue to consider. The metro presents a better scenario compared to other means of transport in Rome.

For long distances, participants expressed that travelling by train can be more expensive than by plane. Buses and cars are not options for long distances in most cases. However, private cars were mostly preferred when they carry out long-distance trips with relatives due to overall low cost and flexibility, when they travel abroad.

The reasons for choosing a means of transport are distance, price, time, comfort and the environment. Most of them also pointed out the relevance of schedules and punctuality. In addition, participants expressed that protecting health is important after COVID-19 crisis. Thus, many people have avoided using the subway and prefer micro mobility if possible.

The Interrail program was known by most participants. In fact, some of them have already used it. Interestingly, it was also proposed that if a train campaign were to be developed, the metaphor of the train can be used as a way to illustrate life and career development for young professionals.

The second part of the activity was devoted to sustainability. Participants were asked which means of transport cause the least damage to the environment in their opinion. The following order was proposed: bicycles, train/metro, boats, cars and planes. On a scale from 1 to 10, sustainability was rated 8 in terms of importance and relevance. To go deeper into this matter, they were also asked if they did something for the environment. The main environmental sustainability activities mentioned were planting trees, collecting garbage, reuse plastic and be aware of zero waste, as well as use less water, buy second-hand and recycling. Participants consider that as a society not enough is being done. In general terms, they consider themselves sustainable,

first because they should do it (they assume responsibility) and then because they want to do it (they believe in it).

The final section was focused on studies and the future. As expected, those who are studying some course related to transport are more willing to dedicate professionally to the railway sector. Half of those who are not involved in a transport-related course would also consider the railway sector to develop their professional career. The other half do not consider this possibility.

The most valued aspects regarding job positions are salary (including extra-bonus for food, transportation, and childcare), and working conditions that enable them to maintain a good balance between work and personal life with aspects such as maternity leave and kindergarten benefits. Other mentioned aspects were good working environment courses to improve skills, creativity, flexible working hours (four-day weeks), career projection at an international level and working close to home.

Participants see themselves working in large companies in any sector, in the public sector in the European Union or in Non-Governmental Organisations. Most of them think that, according to their studies, they would work in the railway sector. In addition, when asked about their knowledge of what kind of professions can be found in the railway sector, most of them mention maintenance and train manager. Most participants consider that the railway sector offers job opportunities for young people.

With respect to what could make the railway sector more attractive to young people, participants responded that it should offer a greater offer of entertainment, that it should have a more connected infrastructure (more places to travel), lower fares and that it should be better connected with other means of transport (that could be included in the same ticket, that is, a mobility ticket).

Finally, other issues raised during the conversation were:

1. Everyone agreed that the sector offers diverse positions, as well as possibilities for all professions with the proper training. However, many of them think that the railway sector is not diverse. Job positions in the railway sector are not commonly chosen by women. Interestingly, participants point out that railway companies make advertisements about female drivers, but most of the time you only see them at the station in positions like ticket control.
2. Most participants had the perception that the railway sector was only for experts in rail transport. However, after the discussion, everyone agreed that the sector offers diverse positions, as well as possibilities for all professions with the proper training.
3. Micromobility is recognized as a mean of transport.
4. Price is an important issue for them. If the price is low, the quality of the service may be secondary.

5.3 Slovakia

National and Local Context

Slovakia has a railway network that connects various cities and regions within the country. The national railway company is Železnice Slovenskej Republiky (ŽSR), which operates the majority of passenger and freight rail services. Slovakia has rail links with neighbouring countries such as the Czech Republic, Hungary, Austria, Poland, and Ukraine. The Slovakian railway network has undergone various improvements and modernizations in recent years. Some of the key projects include the modernization of existing lines, upgrading infrastructure, and the introduction of new rolling stock. Slovakia does not currently have dedicated high-speed rail lines. Slovakia, like many other countries, has been working towards more sustainable, greener, and more efficient rail operations. Efforts have been made to reduce emissions, improve energy efficiency, and explore alternative energy sources for train operations. Slovakia does not have a subway or metro system in any of its cities. The country's major cities, such as Bratislava, Košice, and Žilina, rely on other modes of public transportation, such as buses and trams, to serve the urban population's transit needs.

Zilina is a city located in northern Slovakia. Zilina is home to several universities, and the public transport system provides special student fares for eligible students. The primary mode of public transportation in Zilina is the bus network which covers various routes within the city, connecting residential areas, business districts, and important landmarks. In addition to buses, Zilina also has a limited network of trolleybuses, which are electric buses powered by overhead wires. Trolleybuses primarily operate within the city center and connect key locations.

The Activity at Zilina University

The focus group took place on March 1st, 2023. Six men and five women between the ages of 21–25 participated in it. It lasted ninety minutes and had one moderator and two assistants. Main results are presented in the next paragraphs.

In the first place, participants talked about their transport habits where different aspects of their use on a day-to-day basis were shown. To begin with, they prefer public transport, as well as the train in combination with urban public transport. In the same way, it was commented that the bicycle is the best means of shared transportation in summer. Train is used for leisure activities, thus avoiding road transport due to congestion and damage to the environment. Travelling by train has economic advantages for them as students, even though it is a more time-consuming alternative. The recalculation of costs for travel in a passenger car is significantly higher, therefore many do not take this option into account. When going to school participants prefer a combination between walking and public transport. Likewise, bus transport is used due to time benefits. Another important aspect is the size of the luggage, which will influence the means of transport chosen. Interrail is very well known, and it is used by many people such as family and friends.

Regarding sustainability, participants considered that the train should serve the entire country. Likewise, in the train stations there should be bus stops with time continuity or with the park and ride system with unified fares. Another important point is to educate people, as well as keep them informed regarding the possibilities of public transport. People must also be taught a new standard of travel regarding ecology. Ecology is another important aspect that must be considered. In the same way, rail companies must include environmental taxes and foster circular economy. It is also important to offer concessions from the state to families if they behave in an environmentally friendly way, as well as if they cycle or walk to school or work.

Regarding future careers, the sentence "We learn all our lives, because we have to" emerged. The perception that people have about new enriching knowledge, as well as self-learning, helps them to adapt to practise in the field. About the future, participants think that they should focus on passenger transportation, effective public transportation plans, as well as work on green transportation projects. Participants also contemplate the possibility of working in management positions as well as executives such as conductor and train conductor.

It was concluded that the use of the train represents safety, comfort, cost, and leisure. The key factors of working in the railway sector include good working environment, creativity, as well as passion and helping others.

At the end of the meeting, the students appreciated the opportunity to share their points of view with the other members of the group. They agreed that an approach to ecology is needed as well as the motivation to change the country's public transport system. They also want to help educate society about these ideas.

5.4 Spain

National and Local Context

Spain has a well-developed railway network that spans across the country, connecting major cities and regions. The main railway company is Renfe, which operates both passenger and freight services. Spain was one of the pioneers in Europe in developing high-speed rail infrastructure. Thus, high-speed trains connect major cities such as Madrid, Barcelona, Valencia, Seville, and Malaga. In recent years, Spain has continued expanding and improving its railway infrastructure. The government has focused on enhancing connectivity and reducing travel times between cities. This includes ongoing projects such as the extension of high-speed lines to additional regions and the development of new railway connections. International rail services connect Spain with neighbouring countries such as France and Portugal. Additionally, Spain has been exploring the potential of high-speed rail projects beyond its borders. For example, the proposed high-speed rail link known as the Mediterranean Corridor aims to connect Spain with other European countries along the Mediterranean coast, enhancing international connectivity and promoting economic integration. In addition, Spain has several cities with subway or metro systems, such as

Madrid, Barcelona, Bilbao, Valencia and Malaga. In terms of sustainability, Spain has been working toward greener and more energy-efficient rail operations. This includes the introduction of eco-friendly technologies, such as the use of electric trains, as well as efforts to reduce emissions and improve energy efficiency across the railway sector.

Malaga is located in the southern region of Andalusia, Spain. Los principales medios de transporte en la ciudad de Málaga son bus. Buses cover various routes within the city, connecting different neighbourhoods, residential areas, and key attractions. Although it is not as extensive as the bus network, the metro provides a fast and efficient way to travel within the city. It currently has two lines. There are also suburban train connections to nearby towns and cities around Malaga. It also offers connections to the Malaga Airport. In addition to buses, the metro, and suburban trains, Malaga offers other public transport options such as taxis and ride-sharing services for point-to-point travel. The city also has a bike-sharing program called "Malagabici", which provides bicycles for short-term rentals and a dedicated cycling infrastructure.

The Activity at the University of Malaga

The focus group held at the University of Malaga took place on 2 November 2022 and lasted 90 min, with the participation of 10 students (6 male, 4 female, aged between 15 and 32) and 3 researchers. The main results addressed the three main themes of the research (habits, sustainability, and future career) and other topics of interest were identified as a result of the interaction between the participants.

Firstly, in terms of the habits described by the participants, they prefer private transport to public transport, especially when they own one (preferably a car or motorbike, although some also say that they use bicycles or micro-mobility). When it comes to choosing a means of public transport, the bus is preferred to the metro, mainly because the metro does not reach all areas of the city, although they confess that it depends on the destination and the time of day, especially if it coincides with peak hours. The reasons for choosing the metro/train are low fares, speed, connectivity with other means of transport, comfort, timetable. When asked about the Interrail European initiative, this is mostly unknown among participants. Those who have used it, reported that it was expensive, and the booking process was somehow complex and slow, but recommend the experience of travelling and getting to know European cities. In general, rail (train/metro) is associated with leisure rather than a commuting method.

When discussing the link between the sector and sustainability, we found that the concept of sustainability is somewhat confusing for the participants, especially among the younger ones (like the German case). The group homogeneously states that environmental issues are important to them but, in general, they do not take big measures to protect the environment. Train is considered a sustainable mode of transport, but a lack of knowledge is detected, they do not have a clear idea about the reasons. Among the measures they have adopted to take care of the planet are walking, cycling, recycling, reducing energy and plastic consumption and using the second-hand market.

Regarding the possibilities that the sector can offer to young people (future career), most of them had never considered working in the sector, although they are clear about what they want from an organisation to work with. They say it is important to have a mindful job, where they can help others, that is stimulating and offers them financial and job stability. They express the importance of being able to reconcile work and personal life. In this sense, they state that they prefer to work fewer hours if the salary allows them to live, travel and have experiences. They attach importance to mobility and flexibility at work, as well as working in a friendly work environment that fosters creativity (linked to personal passion for their speciality) and career development (promotion).

They admit that they thought that they could not work in the railway sector, especially those who are not linked to technical studies, but they affirm that they would consider working in the sector if they could get a job related to their current studies. They also comment that information on job offers in the sector is generally not received. To the question, what would you ask of the railway sector to make it more attractive to you? The participants answered in order of preference and unanimously: low fares, speed, and comfort. Other topics or ideas that appeared in the discussion and which the sector should improve or consider, according to the students, are: higher frequencies, improvement of communication channels (especially those to connect companies with users), and new "types" of items of luggage allowed (bikes, motorbikes, electric scooters, mopeds, …).

Other issues identified in the dissolution were related to the influence of politics and what stereotype the sector is associated with. Students, mainly older ones, state that the penetration (knowledge and use) of rail/metro in Spanish society as a means of transport is strongly influenced by political decisions taken over the years, which have limited or reduced its reach and use among the population. In some cases, rail is associated with the idea of "old fashioned" (stations, coaches, …) but at the same time it can be an "experience", they have a romantic view of the experience of travelling by train.

5.5   The United Kingdom

National and Local Context

The railway sector in the UK is overseen by the Department for Transport and operated by several different entities. Network Rail is responsible for managing and maintaining the national rail infrastructure, while passenger train and freight services are operated by various train operating companies. One significant development in the UK railway sector is the implementation of new ticketing initiatives aimed to simplify ticketing options, introduce mobile and smart ticketing solutions, and make the ticket-buying process more user-friendly for passengers. The UK has also been investing in upgrading its rail infrastructure. This includes major projects like the High Speed 2 (HS2) rail line, which aims to provide high-speed rail services between

London and the West Midlands with a further phase extending to cities in the North. Regarding sustainability, the UK government has committed to achieving net-zero carbon emissions by 2050, and the railway sector is playing a role in this effort. Electrification of rail lines and the use of more energy-efficient trains are part of the sustainability agenda. The government has set targets for the decarbonization of the rail network and has been exploring hydrogen and battery-powered trains as alternative solutions. The UK was the first country to build an underground system in the world. That was in London. Nowadays, Newcastle, Liverpool and Glasgow also have underground metro systems. In addition, light rail is also in use in 9 cities across the UK.

Birmingham, often referred to as the "Second City" of the United Kingdom, has a comprehensive public transport system. The primary mode of public transportation in Birmingham is the bus network that covers a wide range of routes, connecting various neighbourhoods, residential areas, and major landmarks across the city. Birmingham also has an extensive rail network that connects the city with other major cities and towns across the country. Birmingham is also served by the West Midlands Metro, a light rail system that operates primarily in the West Midlands region. In addition to buses, trains, and the metro. Birmingham offers other public transport options, including cycling infrastructure with dedicated lanes and bike-sharing schemes.

The Activity at Aston University

The focus group took place on 22 February 2023. Eight men and five women between the ages of 12 and 38 participated in it. It lasted ninety minutes and had one moderator and one assistant.

Regarding transportation habits, participants prefer to walk or use the bus due to the short commute distance on a daily basis. Furthermore, in general terms, buses are preferred to the metro. However, selection depends on the destination, the duration of the trip and the price. Referring to the key points to selecting the train as a means of transport, aspects such as fares, discounts, journey time, connectivity, comfort, safety and good schedules were mentioned.

Regarding sustainability, it was admitted that environmental issues are significantly important, and some take small actions to protect the environment. One example would be to use the train at night instead of flying from one country to another when the distances are relatively short. Others consider taking some actions in the future, like riding the electric bus. Likewise, the train is considered a sustainable mode of transport because it is more energy efficient and less polluting than the car or the bus.

Regarding the railway sector as a possible career, they would consider it if their studies were related to the train. Good pay is also an important factor to choose the rail sector to develop their professional career.

Other aspects that were discussed during the conversation refer to the fact that most participants were unaware of career opportunities in the railway sector, probably due to lack of advertisement, that only offered certain types of positions such as drivers are the only ones advertised and that job offers do not attract students other than engineering studies. They also mentioned that women are unaware of job

opportunities and that they rarely found any opportunity that could develop their interest.

One idea that came out was that students never came across any idealistic company (for engineers, Apple, Microsoft and others are some of the idealistic companies) in the rail industry that could motivate them to work in the rail industry. In some cases, rail is not considered prestigious to be a part of as compared to aviation and to some extent automobile industry.

In conclusion, we can find that the use of the train goes according to the cost, the duration of the trip, the comfort, the security, and the connectivity. Key factors for working in the railway sector include good pay, growth in skills development and a good working environment.

Assistants Overview

Participants were provided with valuable information and resources to help them better understand the railway industry, such as links to specialised sites, advice on the development of the railway industry, as well as job opportunities in the sector.

The different events were very successful. It was very enjoyable to see how everyone came together to participate in the activity. Likewise, the organisers were delighted to see the enthusiasm and understand their perspectives in the railway sector. It was a unique and memorable experience.

6   Discussion

An analysis of the main findings of the focus groups is included next. In the first place, Spaniards, Germans, and Italian students consider private transport as an option, with different nuances. In the Spanish case, it is seen as an alternative for daily transport, while Germans only consider it when public transport requires a greater investment of time and price depending on the destination. For Italian students, it is only an option when there is no public transport alternative, mainly the metro or train. Therefore, it is identified that the variables distance-price and availability of the public transport service (frequency and destination) influence the choice of private transport over public transport. Sustainability is not considered an issue in this group. On the other hand, British and Slovak students do not see private transport as an alternative. Among the reasons identified (congestion/traffic, environmental damage, student fares, car prices not affordable) three main themes emerge: prices, time and environmental damage.

As we have mentioned in Sect. 4, Slovakia does not currently have dedicated high-speed rail lines. However, the country has invested in more sustainable, greener and efficient rail operations. Similarly, in the UK, public administrations have a strong commitment to achieving net-zero carbon emissions and the use of more efficient trains are part of the sustainability agenda. These decisions probably have a more obvious and direct impact on young people's daily lives than those that have been

made in other countries. For this reason, rail as a means of public transport is a priority and a more sustainable option.

In Spain, the government decided to work on enhancing connectivity and reducing travel times between cities and neighbouring countries. On the contrary, only a few cities have subways. A similar situation occurs in Italy, where the railway system connects major cities, towns and regions, but only seven cities have metro systems, and another 15 cities have commuter rail systems. Although in this country, the use of rail is much more accepted.

Perhaps the answers from the German student group were the most surprising, given the reputation of the rail sector in this country that has one of the most extensive and well-developed railway networks in Europe. In addition, Germany is actively working towards reducing emissions in the railway sector, improving its sustainability.

In a sentence, we could say that when we talk about public transport (and in our case we are referring to train, metro, tram), the responses have shown that the young people we have talked to prefer a cheap means of transport that is well connected to other means of transport, including public services and private options like bikes, micro-mobility and motorbikes. The environment is a variable that would appear on a second level of importance, but important enough not to be forgotten when constructing messages dedicated to young people, since, as we have explained throughout this work, future generations will be influenced in their decision-making by the sustainability variable in their relationship with organisations and transport.

Security (considering physical safety and health, following the Covid19 pandemic) has appeared as a minority issue for students, in general terms; but, as a topic that has emerged in conversations, it deserves attention from the sector, as it alludes to issues that affect or may again affect the European population; as shown by the study of Coppola and Silvestri (2020)*, assessing travellers' safety and security perception in railway stations, shows that "security issues are perceived as more threatening than safety ones, (…) people travelling in train stations feel usually more unsafe for crime, violence and strangers than for accidents. Moreover, the fear of criminal acts has the most significant impact (..)" (Coppola & Silvestri, 2020, p. 1135).

The sustainability dimension, although important for all participants, is not equally consolidated in all groups. In general, there is a lack of knowledge of the concept when we ask the students. As we have observed, the reduced environmental impact of the train is not a priority criterion for choosing it as a means of transport, except for students from Slovakia and the UK. All students report taking measures to reduce their environmental impact (reduce energy consumption and plastic use, among others) some of which are related to choosing public transport (train and buses) and reduced or zero impact modes of transport (bikes and micro-mobility). The industry can make a commitment to improve communication on the environmental dimension of train use. As we have observed, for Generation Z it will be a priority and may in the future become a determining variable when choosing where to work or how to travel.

Finally, considering the railway sector as the place to develop a professional career, we observe that the lack of knowledge is generalised in all groups and traditional stereotypes continue to appear. It is considered that the sector only offers possibilities for students of technical careers (mainly engineering studies) and women are relegated to the ticket office and administrative tasks. For all, they will consider rail if it is related to their studies and work conditions are fair and good (considering salaries, professional development, working environment and professional and personal life balance).

They all feel that more advertising is needed to promote jobs in the railway sector and make it look as prestigious as in the aeronautical and automobile industry. They mention important aspects such as a good salary and the importance of making the railway sector more diverse and inclusive.

Another issue that arises in the analysis is gender and diversity representation in the sector and how this lack of DEI (diversity, equity, and inclusion) criteria in employers' representation is affecting youth's expectations and opinions. As Zoe Hudson states in the last issues from Global Railway Review, enhancing DEI criteria within the public transport industry, "serves to make workforces stronger—increasing productivity, creativity and improving cultural awareness" (Hudson, 2023). The railway sector must improve its commitment with this dimension as a key element to ensure that the sector is attractive to all young professionals and is recruiting from underrepresented groups (women, ethnic minorities, LGTBQ+ community or disabled groups, among others) to face employment ageing and the new digital skills demands from the supply industry.

The results presented in this paper should be interpreted as the opinions, positions and ideas that a sample of young Europeans have about the railway sector from a double vision, as users of a service and as candidates to be future professionals in this sector. Therefore, we think that this evidence can serve as a starting point for companies, educational institutions and public bodies in the redesign of policies that seek new strategies focused on renewing the talent of the sector, making it more accessible to the youth and transforming it into a sustainable alternative to other means of transport.

7 Conclusions

In this section, we present the main conclusions of this paper. This research was initiated with an online questionnaire carried out between 2022 and 2023. After interpreting the main data obtained, five focus groups were carried out in Germany, Italy, Slovakia, Spain and the UK to understand the different situations identified in the analysis from the point of view of young people. Concerning the research questions that have guided this study, we proceed to present the conclusions of this work considering each one of them.

Referring to RQ1: what do young users expect from public transport? Perceptions of the railway sector among young people vary depending on individual experiences,

environment, cultural context, and personal preferences. Additionally, the availability and quality of railway services differ between countries and appear to influence perceptions on a regional or national level. However, some general trends and factors on how young people perceive the railway have been detected. For instance, regarding the use of trains, low fares and the possibility of combining rail transport with other methods seems to be factors of relevance to promoting rail transport.

For RQ2: Is the train/metro/tram a sustainable way of transport for young people? It was detected that many of the focus group attendees were not familiar with the term "sustainability" and its implications. Despite this fact, it was found that environmental issues are fairly significant. The train was considered the most sustainable mode of transport and young generations are willing to use the train for commuting purposes but also for medium-long distances, preferably if night trains are available. We can conclude that, although the sector is generally identified as a sustainable means of transport, it is still necessary to reinforce among the population the meaning of the concept of sustainability and its implications, so that the sector can make this dimension profitable in its relationship with stakeholders.

Considering RQ3: what does the railway sector need to become more attractive to early career professionals? Not only a good salary is valued when young generations examine job opportunities within the railway sector. Aspects such as a good working environment, continuous training and a good balance between personal and professional lives are crucial. In addition, it is necessary for companies to make the sector visible as a professional area with job opportunities for all academic disciplines (not only technical) and thus be seen as a sector capable of attracting multidisciplinary and more diverse talent. In addition to improving communication channels. This would favour the inclusion of DEI criteria and allow it to face employment ageing and the new digital demands. Finally, these changes would help to improve the image of the sector among this public, which is somewhat romantic and stereotypical (associated with steam trains), to link it with a technologically advanced, sustainable sector with future job opportunities for all.

Finally, despite all participants complying with the established criteria for participation, a possible limitation of this study might be that the University of Malaga defined the structure of the focus groups, but it was not responsible for the sampling process. Since no feasible strategy to assess potential participants in other countries was available, the local organizers were the ones who selected the participants. Future works will be devoted to conducting new activities to confirm the main results presented in this paper.

To conclude, this work has highlighted the value of utilising focus groups as a tool to gain deeper insights into the perceptions of the railway sector and its job prospects among the younger generation. The results of this research will be useful both for the objectives of this project, as well as for companies and organisations in the railway industry that aim to improve their relations and perception among future generations.

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ASTONRail Handbook—Supporting Tool for Attracting Students and Young Professionals to the Railway Sector and Modernizing Rail Higher Education

Anne-Katrin Osdoba and Martin Lehnert

Abstract The rail sector is facing a shortage of skilled workers and needs more professionals who are able to respond to the sector's future needs. This work presents the ASTONRail handbook developed in the ERASMUS+ funded project ASTON-Rail. The ASTONRail handbook should function as a supporting tool for the modernization of rail higher education and as a result recruitment of more students into rail-related study courses. The work describes the implementation and functions of the handbook and what it offers for its user groups to support the modernization of rail higher education and the recruitment of more young professionals to the rail sector.

1 Introduction

A key output of the ASTONRail project (http://astonrail.eu) is the ASTONRail handbook (http://astonrail.eu/dokuwiki). It is a web-based, interactive supporting tool meant to help modernizing rail higher education, and attracting and recruiting young professionals to the rail sector. Presently, the need for getting more skilled workers into the railways is very high (Cannon et al., 2019). For the UK, a large retirement rate is expected by 2030, while the available workforce of younger people below 25 is with five percent lower (Robertson, 2022). In addition, as stated in Robertson (2022), "modernising work practices and the use of digital technologies requires widespread upskilling of rail staff". In Germany, the shortage of skilled workers is also a big issue in the rail sector (Hartmann et al., 2022a; Weber & Mühl, 2022). Among other reasons, the rail sector needs a lot more skilled workers in future due to the current

A.-K. Osdoba (✉) · M. Lehnert
Technische Hochschule Wildau, Hochschulring 1, 15745 Wildau, Germany
e-mail: anne-katrin.osdoba@th-wildau.de

M. Lehnert
e-mail: martin.lehnert@th-wildau.de

automation and digitalization trends (Weber & Mühl, 2022). A job offers' analysis study in Germany in 2021 suggested that for most job offers, especially for those in infrastructure/track construction and in IT/administration and purchase a study degree is required (Hartmann et al., 2022a, 2022b). The shortage of skilled workers who are able to respond to the future needs of the railway industry is a key driver for modernizing and improving rail higher education in Europe. The ASTONRail handbook targets especially (future) students on their way to becoming young rail industry professionals and teachers in rail higher education to support students on this way. It should e.g. facilitate the search for suitable study opportunities and offer suggestions for more modern higher education in the rail sector. The ASTONRail handbook presents a large part of the project results in a user group-oriented and up-to-date online format, making them easily usable for the rail sector and especially for young people who are looking for a career in rail and want to be part of the rail sector in future. It is expandable with additional functions. The ASTONRail handbook was presented at the ASTONRail final conference in Stockholm in June 2023. The industry representatives and other attendees agreed that the handbook is very valuable for the whole railway industry.

2 Development and Design of an Interactive and User-Oriented Handbook

2.1 Development Path and Requirements for an Interactive Handbook

To develop an interactive and user oriented handbook, as the ASTONRail handbook, the requirements had to be stated first. Then came the selection of an appropriate platform for its development, the identification of user groups and the development of the handbook structure.

To achieve the greatest possible benefit for the railway sector, requirements for a modern, interactive, sustainable and always up-to-date handbook were defined within the ASTONRail project:

1. It must be designed in an innovative format that is interactive and easy to use. Different user groups should be addressed by function, scope and presentation.
2. It must be dynamic and flexible to integrate new and revise existing content. This is the only way to ensure that information can be kept up to date with little effort.
3. It must have an open design so that other topics can be included with little effort and that the handbook can be easily developed further.
4. It must be available public and easily accessible for all user groups in order to enable high acceptance and use by the user groups.
5. It must be sustainable. Therefore, it has to be available and continue to exist after the end of the ASTONRail project and it has to be updatable and thus be usable

in the long term. The platform used must only incur low running costs and must offer the possibility of integrating the handbook into other contexts.

6. It must be easy to update on the IT side by handbook users without much IT knowledge.

Taking into account the project budget and the technical and organizational possibilities of the project partners, the evaluation of the requirements resulted in an implementation of the handbook on the basis of a wiki software. DokuWiki (Gohr, 2023) was selected as the open source wiki software for implementing the handbook. The online implemented ASTONRail handbook is integrated into the ASTONRail project website (http://astonrail.eu). The handbook is hosted by the project partner EURNEX e.V.

The implementation of the handbook included a pre-test of the DokuWiki software on a test installation at servers of the Technical University of Applied Sciences Wildau (TH Wildau). Further implementation steps were the installation and final setup of the DokuWiki software, the development and integration of content and the overall review and formatting of the handbook. The handbook, like all other wikis, will live by the contribution of the users, in this case the railway sector stakeholders, and remains only in this way up-to-date and attractive. Every handbook user can easily get a login and can contribute with his/her experience to the further refinement of the handbook to keep it up to date and sustainable.

2.2   User Groups and Structure of the ASTONRail Handbook

The results of the ASTONRail project are of special interest for different user groups. The handbook is designed to make information quickly and easily available to users. The handbook has been structured according to the following user groups:

1. **Future students** who want to start a career in rail and therefor are looking for suitable study courses.
2. **Students and graduates** who are looking for a job in the railway sector.
3. **People in higher education institutions (HEI) and teachers** who want to implement approaches and learning methods in their railway course and programmes and/or who want to build up new rail-focused study courses and programmes
4. **Career changers** who want to enter the railway sector are also welcome to inform themselves about study and job opportunities in the sections for future students and students and graduates.

Each user group (except career changers) forms a pillar in the handbook in which the project results most interesting for the user group are presented. Each pillar is, of course, as well accessible for all users. Figure 1 gives an overview about the handbook structure with three pillars developed for special user groups and two general pillars. One general pillar contains general ASTONRail project information, such as a description about the project, information about partners and results of
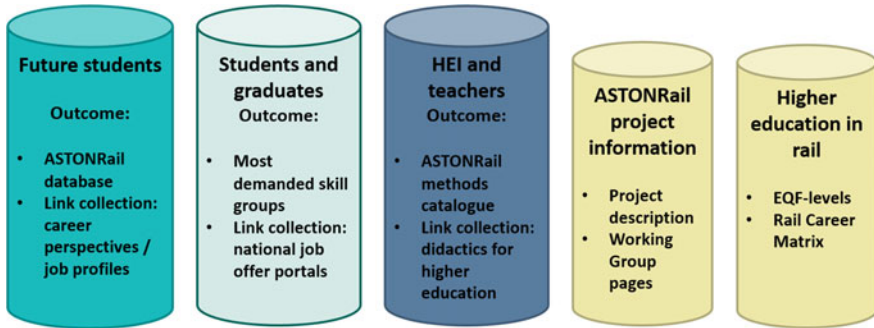
Fig. 1 Handbook structure and pillars

the working groups. The other general pillar of the handbook offers information for all interested users about levels of the European Qualifications Framework (EQF) (Europass, 2023) and the Rail Career Matrix (RCM) (Cannon et al., 2019; Railway Talents, 2018). The focus of this paper lies on the first three pillars.

3 Supporting the Recruitment of Students and Young Professionals

3.1 Aim of the ASTONRail Handbook with Focus on (Future) Students

The ASTONRail handbook is intended to be an information tool for future students, providing an up to date and easy to read overview on existing and active rail related study courses in several countries with the aim to get more students into rail-related study courses and to attract more young people to the railway sector.

Beside the study course database (see Sect. 3.2), future students can find out more about their career opportunities and the attractiveness of the railway industry in the ASTONRail handbook, as it offers a link collection to websites with career prospects and job profiles in the railway sector. Handbook users can contribute to the study course database and to the link collection.

Additionally, the handbook helps students and graduates to get information where to find a job in the railway industry (see Sect. 3.3).

3.2 ASTONRail Study Course Database for Future Students

The ASTONRail database on rail-related study courses has been developed after intensive research and a survey at course providers. Future students can find her/his future study course in the database and additionally can get information about career perspectives and job profiles in a link collection in the handbook. The ASTONRail database is a publicly available extensive collection of information about railway degree programs or degree programmes with rail-related content. For the future, the ASTONRail database in the handbook should help to build up more young and skilled professionals for the railway industry.

The database itself was developed in two stages. First, existing results of previous research projects related to railway education were evaluated under the responsibility of the University of Rome La Sapienza. This was expanded by extensive internet research by the project partners on existing courses and course modules in European and non-European countries. The research was related to courses that are classified at levels 5 to 8 according to the European Qualifications Framework (EQF) (Europass, 2023). In the second stage of development, the results were completed and verified by carrying out a survey among the pre-listed universities and other course providers. As a result, 54 course entries from 16 countries were verified and could be added to the online database in the handbook at the day of implementation. They now form the basis for a centralized overview of existing rail-related study courses. Figure 2 shows the distribution of the available entries across the countries included so far.

The handbook offers a flexible presentation of the database entries as a table (Fig. 3). The course entries can be sorted and filtered. Users can as well search for
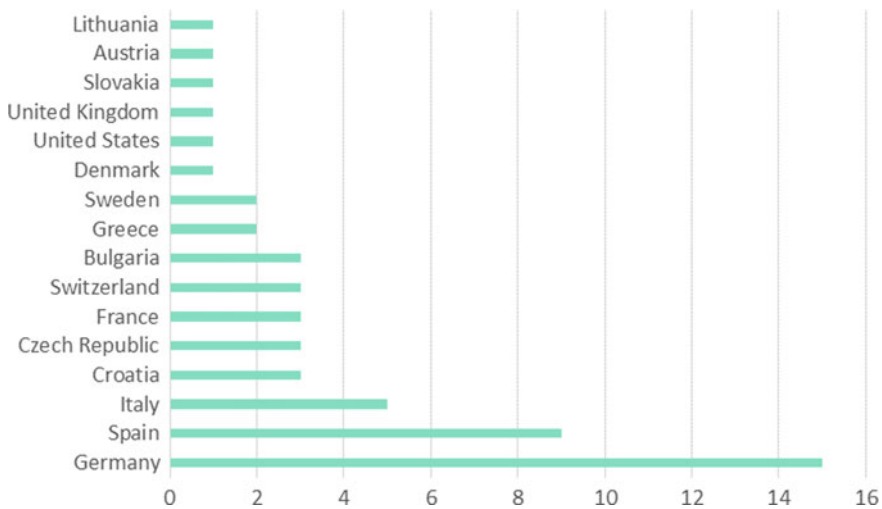

Fig. 2 Number of database entries for rail-related study courses per country at the time of implementation

keywords. For each study course a fact sheet is available with information to the study course, e.g. name of the university, website of the study course, EQF-level, language and course duration (Fig. 4).

To get new talents to the railway sector it is necessary to keep the information in the handbook up to date and reliable. To reach this aim the help of all handbook users is essential. Therefore, all handbook users, especially from universities or other higher education institutions, can add new study courses to the database or revise existing courses (after registration). This is crucial for a sustainable usability.

Page	University or Organisation	Name of Study Course	Country	Teaching Language	Duration in Month	EQF level	Year when course was launched	Level in Rail Career Matrix
🔍	🔍	🔍	🔍	🔍	🔍	🔍	🔍	🔍
course_001	Technical University of Denmark DTU	Railway Design and maintenance, 11404	Denmark	English	4	7	2010	strategic, tactical, operational
course_002	Michigan Tech	Railroad Engineering	United States	English	3		2006	tactical, operational
course_003	University of Rome La Sapienza	Railway infrastructures (within Civil Eng. transport infrastructures)	Italy	Italian	3	7		strategic, tactical, operational
course_004	University of Rome La Sapienza	Master's degree in transport systems engineering	Italy	English	3	7		strategic, tactical, operational
course_005	University of Rome La Sapienza	Ingegneria sistemi ferroviari	Italy	Italian	9	8		strategic, tactical, operational

Fig. 3 Table view of the ASTONRail database of rail-related study courses

StudyCourseData	
University or Organisation:	Technical University of Applied Sciences Wildau
Institute or Department:	Engineering and Natural Sciences
Name of Study Course:	Transportation System Engineering (B. Eng.)
Country:	Germany
City or Region:	Wildau
EQF level:	6
Teaching Language:	German
ECTS in Rail:	25
Website:	🌐 th-wildau.de/...
Duration in Month:	42 https://www.th-wildau.de/studieren-weiterbilden/studiengaenge/verkehrssystemtechnik-b-eng/
Year when course was launched:	2014
Internship Comments:	Three obligatory internships (8 weeks plus 20 weeks) in (transportation) companies and/or administrations, depending on the individual interest & competences of the student, no fixed assignments – plus 12 weeks Bachelor thesis occasionally in company
Level in Rail Career Matrix:	tactical, operational
Notes:	The course is offered full-time, part-time and dual. Course duration (in months): full-time 42, part-time 72, dual 48.
Last Data Update:	2023/04/04 23:33

Fig. 4 Example for a fact sheet in the ASTONRail database (study course Transportation System Engineering at TH Wildau)

3.3 Career Portals for Students and Graduates

To support the recruitment of young professionals it needs to be easy for students and graduates to find available jobs in the sector. Therefor the ASTONRail handbook provides a collection of links to national job and career portals that contain job offers from the railway industry. In this way, relevant information and search platforms for a career in the railway industry are bundled in one place. This is intended to pave the career path in the railway industry and to make the transition into the profession easier. This collection of links can also be updated by registered handbook users. The goal for this part of the handbook is that this page establishes itself as the first point of entry into the job search in the railway sector. In the future, it may be considered to build a dynamic page that directly displays job offers from career portals instead of the current links to the job portals. For this step more resources will be needed then were available in the ASTONRail project.

4 Contribution to Modernizing Rail Higher Education

4.1 Aim of the ASTONRail Handbook with Focus on Teachers

Study courses need to be modern and attractive for young people to motivate them to a rail-related career. But in many countries the higher education in rail has not changed much over decades and looks in some context "old fashioned". Therefor the modernization of rail higher education might be a chance to attract more students. As part of the modernization process the handbook offers for teachers and HEI information about how to innovate or improve rail teaching in theory and in practice. The ASTONRail handbook contains the ASTONRail methods catalogue providing an easy to read overview of teaching, learning and assessment methods. To support the integration of new teaching, learning and assessment methods into existing or new study courses it is important to show the user how those methods can be used in rail higher education. Therefor the handbook offers best practice examples.

In addition, a collection of websites offering information about didactics in higher education in the partner countries in general is included in the handbook. Registered handbook users can update the method catalogue and the didactics link collection.

4.2 ASTONRail's Methods Catalogue for Teachers and HEI

The handbook offers the ASTONRail methods catalogue developed in the ASTONRail project. The method catalogue consists of teaching and learning types, teaching and learning methods and assessment methods applicable in railway teaching and

Types and Methodes by Classification

For an easy orientation all teaching and learning types and methods as well as the assessment methods from the database are listed by this classification on this page. In the tables some essential information is given only. The individual whole information about the types and methods you can reach by the highlighted page names in the first column of the table.

Teaching and learning types

Page	name of type or methode	short description	best practice examples
type-method_001	In-class teaching/lectures	Well-structured lectures executed in the classroom for introduction, presentation and discussion of key theoretical aspects, standards, operational rules, and similar for medium size and big size groups	bp_1_type_in-class_teaching_or_lectures_1.pdf, bp_2_type_in-class_teaching_or_lectures_2.pdf, bp_3_type_in-class_teaching_or_lectures_3.pdf
type-method_005	Invitation of guest lecturers/experts	Delivering the teaching content by university non-academic experts and professionals, coupling the course content to stakeholders and applications	bp_10_type_invitation_of_guest_lecturers_experts_1.pdf, bp_11_type_invitation_of_guest_lecturers_experts_2.pdf
type-method_004	Online teaching and learning	- Type where teaching process is delivered remotely through online platforms - Level of implementation is very different (starting from sharing learning material (produced in advance) via a static online platform up to interactive and synchronic virtual classrooms delivery)	bp_8_type_online_teaching_and_learning_1.pdf, bp_9_type_online_teaching_and_learning_2.pdf
type-method_006	Practical learning/internship	- Type of learning provided outside a university in a practical and real-live working context - Duration can be a few weeks or a whole semester - Can be an integrated part of the curriculum	bp_12_type_practical_learning_internship_1.pdf, bp_13_type_practical_learning_internship_2.pdf, bp_14_type_practical_learning_internship_3.pdf
type-method_007	Self-learning	Type of learning where students learn on their own without influence by teachers during that time	bp_15_type_self-learning_1.pdf, bp_16_type_self-learning_2.pdf
type-method_002	Seminars	- Type of small and medium sized group teaching (approx. 5 - 30 persons) with huge share of interaction between the students - Mostly in the classroom in an in-class teaching situation, but not necessarily - No front-of-class teaching instead of that tutor guide on the side or meddler in the middle, sometimes student-led - Research seminars: Can as well be a format to show students ongoing research activities of internal or external researchers or to let the students present research publications to each other	bp_4_type_seminars_1.pdf, bp_5_type_seminars_2.pdf

Fig. 5 ASTONRail methods catalogue sorted by classification (only first entries displayed)

learning. It is an interactive database offering the possibility to search for entries and to filter them (Fig. 5).

The ASTONRail methods catalogue consists of 41 entries (types and methods) at the time of implementation. A minimal set of description, namely the type/method name, a short description and the available best practice examples, are listed in the overview page. Filtering and sorting gives the chance for individual search and adaption of these overview. For each type or method a factsheet with further details is reachable by selecting the individual pages. There a short description about the type or method, possibilities how to use it, challenges and opportunities for the combination with other teaching, learning or assessment methods are shown in a well-structured way (Fig. 6).

With this information, teachers can quickly and easily assess whether the methods presented are applicable in their specific teaching context or in what context the method is applicable. At the same time, they will also be made aware of the challenges associated with the method and its application. In addition, for each method, information is included as to what other didactic means the method could or should be complemented with. This is particularly helpful for designing a balanced set of teaching and learning methods for the own lessons. In order to get suggestions for a concrete use of the method, a list of best practice examples is offered.

type-method_016

types_and_methods_list	
classification:	teaching and learning method
name of type or methode:	Laboratory exercise
short description:	Practical exercises in individual (or in small groups) done in a laboratory to deepen and to apply theoretical aspects
is applicable or could be used for:	- Gaining first practical experience related to the theory in an simplified, academic context - Practical verification/testing of theoretical knowledge
be aware of (challenges):	- Preparation is very time-consuming - In most cases, simplifications have to be made to the laboratory setup or test implementation so that implementation in the laboratory is possible - Very support-intensive - Previous work of the student about the topic covered in the lab - Generally, a high initial budget is required to acquire the resources for the laboratory
to be complemented by:	- Practice report, practical test - Teaching theory and showing and classifying it in larger contexts - Transfer methods to other framework conditions
short description of examples:	TH Wildau (27): use of railway operation laboratory UMA (28): Pracical exercise in laboratory
best practice examples:	bp_27_method_laboratory_exercise_1.pdf, bp_28_method_laboratory_exercise_2.pdf

Fig. 6 Factsheet for a method, as an example the factsheet for laboratory exercise

4.3 Best Practices for Implementing Teaching and Learning Methods in Rail Higher Education

Each type or method in the ASTONRail methods catalogue is equipped with at least one best practice example from the ASTONRail partners showing how to use the type or method in railway teaching, learning or assessment. It provides 65 best practice examples functioning as a guide for implementing the types and methods in rail higher education contributing to a modernization of railway teaching and learning.

Best practice descriptions for teaching and learning types or methods include beside the name a short description of the type/method and what it is applicable for. Further it is listed which challenges users should be aware of when using this method/type and what other methods can be complemented with. After these general aspects the best practice description gives specific information about the implementation at the specific university and course. It informs the reader at which university and in which study course it is currently used. Relevant technical information for a successful implementation are given, for example what the recommended group size is, what time is needed, which material is required and what the preparation effort for the teacher is. Additionally, the best practice case is described in detail. Further information is included about the role of the teacher and pros and cons regarding the teaching and learning perspective. The best practice description for an assessment

method is similar but includes, for example, the time required for preparing, carrying out and correcting the assessment.

5   Conclusions

To attract and employ young people to work in the rail sector is a crucial goal to keep the railways running in the future. A step in this overall goal is to find those (future) students who are interested in railway study courses. The study courses in railway context have to be modernized to reflect upon the current requirements for higher education. Both aspects are reflected in the ASTONRail handbook—a key output of the Erasmus+ funded project ASTONRail.

The handbook supports future students with the ASTONRail database in their search for rail-related study courses. Students and graduates obtain an overview of job and career portals related to the railway industry. Teachers have access to a catalog of methods with innovative teaching/learning methods and best practice examples.

For sustainable use, the developed ASTONRail handbook is a wiki handbook that can be used in the long term and that can be flexibly adapted to cover new findings. It offers the opportunity to be expanded and further developed e.g. through subsequent research projects and, very importantly, it can be kept up to date by handbook users. All users are requested to use their knowledge to keep the handbook up to date and thus contribute to the recruitment of skilled workers in the railway sector.

The format of the wiki makes it possible to integrate other topics into the handbook that are relevant to the railway industry in terms of both the modernization of rail education and the recruitment of young rail talents. The railway sector can use the handbook and further develop it to become an essential tool for attracting young people to a large variety of railway professions.

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Deployment of Autonomous Trains in Rail Transportation: Addressing the Needs for Higher Education and Leadership

Prashant Singh, Bokang Li, Zeinab Elmi, Yui-yip Lau, Qiong Chen, Marta Borowska-Stefańska, Szymon Wiśniewski, and Maxim A. Dulebenets

Abstract Nowadays, there are fully Autonomous Trains (ATs) that have been deployed for passenger and freight transportation. Automation is viewed as an effective alternative for addressing the issues surrounding rail transportation, including safety issues, increasing demand, human errors, excessive waiting time of passengers, and passenger comfort. ATs allow decreasing the total operational costs due to reduced train crew size and optimized operations. Furthermore, reliability of automated rail services is much higher when comparing to conventional rail services, as ATs can effectively respond to potential disruptions during the train journey. Nevertheless, there exist a number of challenges associated with the AT deployment,

P. Singh · B. Li · M. A. Dulebenets (✉)
Department of Civil and Environmental Engineering, Florida A&M University-Florida State University (FAMU-FSU) College of Engineering, 2035 E Paul Dirac Dr., Sliger Building, Suite 275, Tallahassee, FL 32310, USA
e-mail: mdulebenets@eng.famu.fsu.edu

P. Singh
e-mail: prashant1.singh@famu.edu

B. Li
e-mail: bl22a@fsu.edu

Z. Elmi
Department of Civil and Environmental Engineering, Florida A&M University-Florida State University (FAMU-FSU) College of Engineering, 2035 E Paul Dirac Dr., Sliger Building, Suite 206, Tallahassee, FL 32310, USA
e-mail: ze20a@fsu.edu

Y. Lau
Division of Business and Hospitality Management, College of Professional and Continuing Education, The Hong Kong Polytechnic University, 9 Hoi Ting Road, Yau Ma Tei, Kowloon, Hong Kong
e-mail: yuiyip.lau@cpce-polyu.edu.hk

Q. Chen
Navigation College, Jimei University, Xiamen 361021, China
e-mail: qchen@jmu.edu.cn

which include design challenges, operational challenges, technology-related challenges, and human aspect-related challenges. User perception may slow down the AT development and deployment, as many people still have doubts regarding the AT performance during emergency scenarios. Furthermore, the employment issues due to layoffs of train drivers and other employees after the AT deployment are considered as a significant barrier as well. Effective higher education and leadership programs are anticipated to overcome some of the challenges in the AT development and deployment. This study performs a comprehensive review of the existing initiatives for higher education and leadership that have been organized by different countries over the past years, aiming to determine whether sufficient efforts were dedicated towards the AT deployment. The outcomes from this research are expected to identify the key areas where more efforts should be concentrated to ensure successful AT development and deployment via efficient educational and leadership programs.

Keywords Rail automation · Autonomous trains · Automation benefits · Deployment challenges · Educational programs · Leadership programs

1 Background

Autonomous Trains (ATs), also known as driverless trains, are not only autonomous in their movement but can also take any decisions and react to a situation independently. Autonomous systems are, therefore, expected to provide safe and efficient travel under any circumstances (Towards Data Science, 2021). The trains with a full automation level have been operating for a significant amount of time (Allianz, 2021). The first AT was launched in Kobe (Japan) in 1981 as a part of their autonomous transit systems. Nowadays, ATs operate in more than 40 cities across the globe, including the major autonomous metro systems in Paris (France), Copenhagen (Denmark), Singapore, London (England), and Dubai (United Arab Emirates). The AT development for freight transportation took longer, and the first fully automated freight train was launched by Rio Tinto, one of the world's largest mining corporations, in 2018 (Allianz, 2021). As of March 2018, more than 1000 km of metro lines have been

M. Borowska-Stefańska
Faculty of Geography, Faculty of Geographical Sciences, University of Lodz, 90-142 Łódź, Poland
e-mail: marta.borowska@geo.uni.lodz.pl

S. Wiśniewski
Faculty of Geographical Sciences, Institute of the Built Environment and Spatial Policy, University of Lodz, Kopcinskiego St. 31, 90-142 Łódź, Poland

Research Center for European Spatial Policy and Local Development, University of Lodz, Kopcinskiego St. 31, 90-142 Łódź, Poland

S. Wiśniewski
e-mail: szymon.wisniewski@geo.uni.lodz.pl

fully automated (UITP, 2018). Among all the major cities worldwide, Singapore has the largest automated rail network, with a total length of 126 km. Kuala Lumpur (Malaysia) and Dubai (United Arab Emirates) also have extensive automated metro lines totaling 97 km and 80 km, respectively.

Figure 1 illustrates the top 10 automated metro lines with the largest growth globally in the last 10 years, where it can be observed that Dubai experienced the most rapid development in terms of automated metro lines, with a total of 53 km of new automated metro lines in the last 10 years. Singapore, on the other hand, invested substantial funds into extending the existing automated metro lines. Fully automated metro lines are expected to bring significant benefits to the communities, including safety, mobility, employment opportunities, enhanced customer service, energy efficiency, and affordability (UITP, 2018). Figure 2 shows the existing and projected growth in fully automated metro lines across different geographic locations for a time span between 2018 and 2028. The data show that the Asia–Pacific region will experience most of the growth when it comes to fully automated rail lines, which are expected to be tripled by the year of 2028 and reach 1489 km. Most likely, the growth in this region is expected to be attributed to the growth in the Chinese metro projects. The European countries are anticipated to see an increase in automated rail lines of more than 100% (i.e., from 303 km to 611 km). On the contrary, the North American countries are not expected to experience any major growth in terms of automated rail transportation within the next decade.

With the growth of new industrial hubs and creation of new economic power houses in different parts of the world, the economic activities caused some negative externalities, such as traffic congestion, pollution, noise, and climate change. Therefore, the movement of passenger and freight has become more challenging than ever before. The deployment of ATs is expected to overcome the aforementioned challenges, facilitate the development of truly smart cities, promote economic and social sustainability, and improve quality of life (Fraga-Lamas et al., 2017; Singh et al., 2021; Wang et al., 2016). It is estimated that the global market for ATs is likely to grow from $6.95 billion in 2020 to $10.8 billion in 2025 at a cumulative average
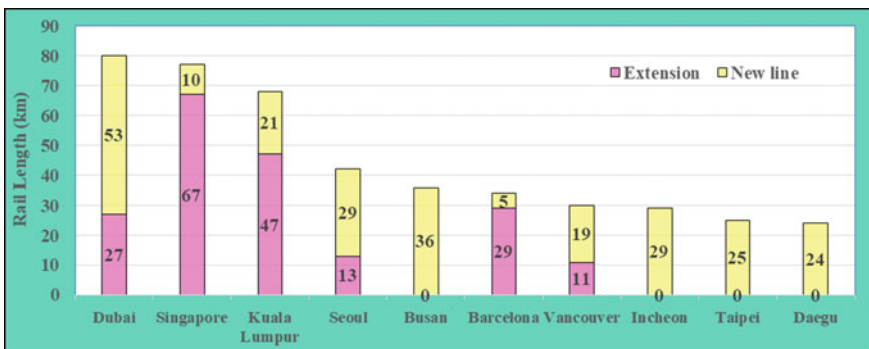

Fig. 1 Top 10 automated metro lines with the largest growth globally in the last 10 years
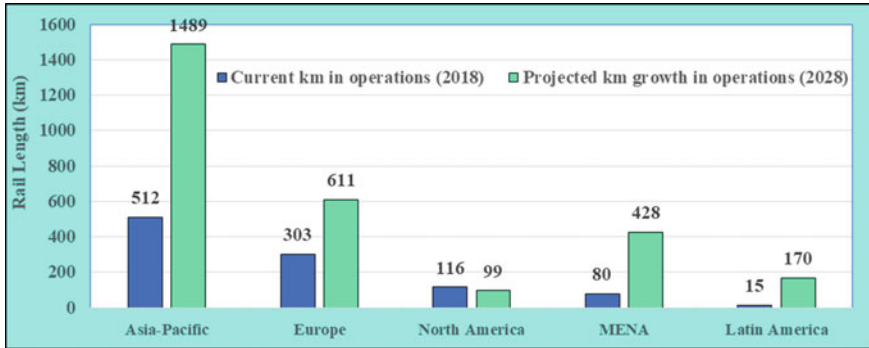
Fig. 2 Existing and projected growth of automated metro lines between 2018 and 2028. *Notes* MENA—Middle East/North Africa

growth rate of 9% (Cision, 2021). Such a rapid development can be justified by the fact that rail is considered as the safest transport mode and is typically more attractive to customers. In the meantime, rail lines provide a competitive transportation speed. In particular, high-speed lines are able to provide the average speeds of up to 300 km/ h (Cision, 2021). Furthermore, rail transportation allows an extended flexibility by its ability to adjust train frequencies in order to effectively meet the demand even during peak hours.

It is also important to mention that certain factors negatively impacted the development of ATs over the past years. The COVID-19 pandemic caused major disruptions in various sectors, including the rail transportation sector. Due to the restrictions imposed by the COVID-19 pandemic, the AT development and deployment efforts substantially slowed down (The Business Research Company, 2023). Despite the fact that the global AT market grew from $9.08 billion in 2022 to $9.79 billion in 2023, the negative effects from the Russian-Ukraine conflict are viewed as significant. This conflict disrupted the steady recovery of the global economy from the COVID-19 pandemic. As a result of the Russian-Ukraine war, economic sanctions were imposed on different countries, which caused substantial supply chain disruptions, rising prices on different types of commodities, and record-high inflation rates. Nevertheless, the AT market is still optimistically projected to grow and reach $13.00 billion by 2027 (The Business Research Company, 2023).

Along with numerous advantages that could be achieved with the introduction of fully automated rail lines, there exist a number of challenges associated with the AT deployment, which include design challenges, operational challenges, technology-related challenges, and human aspect-related challenges (Singh et al., 2021). ATs require substantial monetary investments. Moreover, the coordination of autonomous and human-driven trains at shared rail lines is viewed as one of major barriers as well. User perception may significantly slow down the AT development and deployment in many countries, as certain people still have doubts regarding the AT performance during emergency scenarios. Furthermore, the employment issues due to layoffs of train drivers and other employees after the AT deployment are viewed as a major

barrier as well. Effective higher education and leadership programs are anticipated to overcome some of the challenges in the AT development and deployment. Therefore, this chapter performs a comprehensive review of the existing initiatives for higher education and leadership that have been organized by different countries across the globe over the past years, aiming to determine whether sufficient efforts were dedicated towards the AT deployment. The remainder of this chapter is arranged as follows. In the second section, the AT deployment efforts in passenger and freight transportation are discussed in detail. The review of existing rail educational and leadership initiatives is presented in detail in the third section. The identified challenges in the educational and leadership initiatives are thoroughly discussed in the fourth section. The study concluding remarks and the potential future research needs are described in the fifth section.

2 Autonomous Train Deployment Efforts

The development and operation of autonomous rail systems go back to the era of the early seventies. Although the operation of driverless trains is considered as a recent development, the developments associated with the first ATs were initiated the 1960s with the start of an autonomous subway line between Grand Central to New Utrecht Avenue in New York, which was operationalized in 1962 (Rachel, 1962). Subsequently, an underground rail line "The London Victoria Line" was successfully started in 1968. Although the train could run in an autonomous mode, a driver still had to be present to control some of the train operations, such as train departure and door operations (i.e., door closure and opening). In 1983, a fully autonomous metro line opened for the first time in Lille (France), which served 60 stations on two lines for a length of 45 km (Nelson, 2013). In Vancouver (Canada), the first fully autonomous sky-train was launched in 1985, serving 47 stations on three lines (Wang et al., 2016). The total length of fully autonomous train lines reached 196 km by 1990, as three French and four Asian fully autonomous train lines became functional (Wang et al., 2016).

In 1998, the 14th additional fully autonomous metro line was started to celebrate the 100th anniversary of the Paris metro. Several advancements that followed the deployment of the first ATs led to a successful deployment of the metro system in 2011 in Paris, which used a communication-based train control system. By the end of 2016, there were a total of 53 fully automated metro lines in 36 cities with the total rail length of 789 km (Wang et al., 2016). More than 50% of these metro lines were developed in France, Singapore, Korea, and the United Arab Emirates, with France holding the first place and having approximately 16% of the automated metro lines. Based on the automation level, trains can be classified into different Grades of Automation (GoAs), which include the following four major groups (Fraszczyk et al., 2015; Powell et al., 2016; UITP, 2018) (see Fig. 3).

Fig. 3 Grades of automation for ATs

- **GoA-1**: All the trains are manually operated with automatic train protection (ATP), which provides protection from any hazard by deploying breaks, maintaining train spacing, and prevents the trains from moving against the authorized direction, speeding, and passing through red signals. The train driver performs all train-related functions, such as opening and closing doors, monitoring the condition of the train, and train acceleration and deceleration.
- **GoA-2**: This level of automation offers a semi-automatic level of operations where the system provides complete ATP and automatic train operations (ATO), with a train driver positioned at a control cab to oversee the track conditions ahead. Train starting and stopping motions are automated. However, door opening and closing operations along with the operations under disruptive conditions are performed by the train driver.
- **GoA-3**: Train starting and stopping motions, door opening operations, and door closing operations are fully automated. The presence of a train attendant is still required to handle the operations under disruptive conditions and handle passenger needs.
- **GoA-4**: At this level, neither a train driver nor an attendant is required to be present on board for train operations. The train runs in a fully autonomous mode. The International Electrotechnical Commission (IEC) provides a set of safety guidelines for Unattended Train Operation (UTO) rail systems (IEC, 2011).

The AT development is rapidly progressing in many countries across the world. Some of the major companies have successfully deployed ATs in their operations, including Alstom, Thales, Hitachi Rail STS (Ansaldo), Siemens AG, Kawasaki Heavy Industries, General Electric, Bombardier Transportation, CRRC Transportation, ABB, Mitsubishi Heavy Industries, and others (Allied Market Research, 2023). The following sections of the manuscript discuss some of the recent tendencies in the development of passenger and freight autonomous rail lines.

2.1 Recent Tendencies in the Development of Autonomous Trains for Passenger Transportation

In passenger transportation, China developed the fastest driverless long-distance train in the world that was deployed on the Beijing-Zhangjiakou Railway line in 2019 (Allianz, 2021). This line was able to connect two large cities and provide a fast service with up to 350 km/h. The Alstom company initiated a research project in 2021 aiming to start testing of daily automated train operations for regional passenger trains in Germany (Alstom, 2020). Alstom has been heavily involved in the AT deployment for metro systems, and the aforementioned research project is recognized as the world first one related to the AT testing for regional passenger trains. The trains with GoA-3 and GoA-4 automation levels were mainly considered by Alstom for testing purposes. In 2021, the German rail operator Deutsche Bahn, in collaboration with Siemens, launched a driverless train in Hamburg (Germany), which could carry approximately 30% more passengers and yield 30% savings in terms of its energy efficiency (Techtheday, 2023). The increased train efficiency was mostly attributed to the deployment of advanced artificial intelligence methods that allowed improving punctuality of train arrivals and better travel demand management, when comparing to human operators.

SBB, a public railway company in Switzerland, tested an AT for the first time on the Bern-Olten line in December 2017. The train could break and accelerate automatically without any input needed from the train driver. The driver was only responsible for overseeing the train operations (i.e., autopilot mode). The SBB's future plan is to operationalize fully autonomous rail transportation in Switzerland by 2025 (Mediarail, 2022). Austria, similar to its neighbors Germany and Switzerland, started a project called autoBAHN2020, which aims to develop a simulation environment for the AT deployment on secondary passenger rail lines (Mediarail, 2022). Different environmental factors are considered during the experiments to ensure that various situations ATs could potentially face are adequately tested. Austria also extensively deploys the latest technologies (i.e., laser scanners, radars, mono and stereo videos, sensor technologies, and artificial intelligence) to assist with an efficient detection of obstacles and automatic system control.

Along with the AT development and deployment, numerous countries are making significant investments into the development of high-speed rail services. There is

no particular standard for the minimum required speed at high-speed rail corridors. However, the new high-speed rail lines generally operate at the speeds above 250 km/h (which is 160 mph), whereas the existing lines typically operate at the speeds above 200 km/h (which is 120 mph) (Nunno, 2018). Japan is the first country that introduced a high-speed rail system (1964). Nowadays, the high-speed rail network connects 22 major cities in Japan, with some services carrying more than 420,000 passengers per weekday. Table 1 provides a comparison of various countries globally by their existing high-speed rail status, including the following information (Nunno, 2018): (1) length of lines in operation; (2) lines under construction; (3) approved but not started construction; and (4) maximum speed. It can be observed that China is leading in terms of the existing size of high-speed rail network and lines under construction. Furthermore, Chinese high-speed rail networks operate at the highest train speed with up to 350 km/h. Taking into account the growing length of high-speed rail lines, the future ATs should have the appropriate features that will enable operations at high speeds.

2.2 Recent Tendencies in the Development of Autonomous Trains for Freight Transportation

As indicated earlier, the development of autonomous rail freight transportation took longer, when comparing to rail passenger transportation. After the introduction of the first freight AT by Rio Tinto in Australia, significant efforts have been dedicated towards the deployment of freight ATs in France. The Société Nationale des Chemins de Fer Français (SCNF), the French national railway, announced the launch of two types of ATs that are expected to be fully operational in the year of 2023 (Allianz, 2021). The first one would be a freight automated train developed by Alstom, Hitachi, Altran, and Apsys. The second one would be a regional passenger automated train developed by Bombardier, SpirOps, Bosch, and Thales. Finland has also made a substantial progress toward the development and deployment of freight ATs. Proxion, the Finnish railway technology company, aims to develop an AT system for short-distance transport of goods in the forestry and steel industries, which is expected to be fully operational in 2023 (Allianz, 2021). Autonomous rail lines are expected to expand not only for long-distance passenger transport but also for intermodal freight as well due to rapid developments in disruptive technologies, which are expected to contribute to high safety standards and decrease the risk exposure along with major human errors.

Table 1 High-speed rail by country

Country	Length of lines in operation (km)	Lines under construction (km)	Approved but not started construction (km)	Max speed (km/h)
China	26,869	10,738	1268	350
Spain	3100	1800	0	310
Japan	3041	402	194	320
France	3220	125	0	320
Germany	3038	330	0	300
Sweden	1706	11	0	205
United Kingdom	1377	230	320	300
South Korea	1104	376	49	305
Italy	999	116	0	300
Turkey	802	1208	1127	300
Russia	845	0	770	205
Finland	609	0	0	220
Uzbekistan	600	0	0	250
Austria	352	208	0	250
Taiwan-China	354	0	0	300
Belgium	326	0	0	300
Poland	224	0	484	200
Netherlands	175	0	0	300
Switzerland	144	15	0	250
Luxembourg	142	0	0	320
Norway	64	54	0	210
U.S.A	54	192	1710	240
Saudi Arabia	0	453	0	300
Denmark	0	56	0	200
Thailand	0	0	615	300
Sweden	0	11	0	205
Russia	0	0	770	250
Iran	0	0	1351	300
Indonesia	0	0	712	250
India	0	0	508	250
Malaysia/ Singapore	0	0	350	250
Israel	0	0	85	250
Portugal	0	0	550	250
Czech Republic	0	0	660	250

Table 1 (continued)

Country	Length of lines in operation (km)	Lines under construction (km)	Approved but not started construction (km)	Max speed (km/h)
Greece	0	500	200	250
Hungary-Romania	0	0	460	250

3 Review of the Existing Educational and Leadership Initiatives

This section of the chapter provides a detailed review of the literature specifically focusing on the existing educational, training, and leadership-related initiatives being undertaken in various parts of the world, such as Europe, Asia, Australia, North America, South America, and Africa. Apart from the educational and leadership initiatives, the present study also focuses on various existing training modules related to the elements associated with rail transportation, rail-specific courses, rail safety and management programs, and initiatives for accepting new and emerging technologies. The findings from these studies can be used to understand the global practices and trends and determine whether sufficient efforts were dedicated towards the AT deployment. The existing gaps in the stat of the art are also highlighted in this section as well.

3.1 Educational and Leadership Initiatives in Europe

The International Union of Railways (UIC, 2015) proposed the concept of the "forever open railway", which aimed to create a pool of well-organized, efficient, reliable, and well-trained professionals who can contribute to the development of national strategies for the railway industry. The "forever open railway" mainly contains the following elements: (1) adaptability that promotes flexible ways in addressing operational constraints and changing user demand; (2) enhanced automation that facilitates a full integration of intelligent communication technology, user and vehicle applications, and traffic management services; and (3) resilience that ensures that the target service levels are met even under adverse operational conditions. The importance of training and education was underlined as well. It was pointed out that the railway industry must utilize the expertise of universities and educational organizations to provide the best training opportunities for railway professionals and increase their knowledge level. The educational goals can be effectively achieved with the development of an international platform that offers tailored programs for all workforce levels (e.g., experts, senior managers, and young professionals).

Bureika et al. (2016) underlined that the European railway industry mostly educates its personnel in-house. New employees learn many operational features

when they start their duties. Additional training sessions are generally administered only after certain basics are known and the preliminary practical experience is gained. Certain important courses (e.g., the courses related to safety issues) can be conducted by a separate educational institution. A maintenance-related training is typically extensive and may take up to 2 years. After completing the initial maintenance training, the employees are still required to take re-assessments every year to ensure compliance with the latest guidelines and the required skills are maintained. The study also highlighted the potential of e-learning, where employees can use web-based technologies, educational network channels, blogs, and forums to gain certain knowledge into different railway-related aspects.

Evtimova (2017) discussed the emerging technologies in rail transportation (e.g., electric trains, renewable energy sources) and highlighted the role of railway higher education in the rotating economy. The study pointed out the need for developing a global educational program in collaboration with the relevant organizations. Qualification, learning outcomes, knowledge, and skills were identified as the major competency elements in the European qualification framework. Cooperation between universities and industrial partners was recommended to improve the quality of rail education and reduce the competence gap. Fraszczyk and Piip (2018) pointed out that many institutions around the globe adopted the e-learning approach in their curricula. However, the railway industry was moving slower than other sectors towards the adoption of e-learning approaches. The study, which was supported by the International Union of Railways, aimed to investigate the existing barriers associated with digital learning, as perceived by railway education and training providers. A set of e-learning advantages were discussed, including the following: (1) flexible learning; (2) geographic independency; (3) ability to reach many participants at the same time; (4) communication with a more diverse rail workforce; (5) collaborative development and sharing of the course materials; and (6) increased affordability. A number of challenges were discovered as well: (1) e-learning may not be suitable to the individuals who are used to traditional learning; (2) skill challenges with new technologies; (3) technical complexity in design of course materials; and (4) advanced skills are required for the instructional design. The key characteristics of traditional and digital learning approaches are summarized in Table 2.

European Commission (2020) listed the top priority areas for European cooperation in training and education, which include the following: (1) pertinent superior skills and competence; (2) inclusive education, equality, fairness, and encouragement of urban competence; (3) innovative and open training and education; (4) potent support to educators; (5) acknowledging skills and qualifications in a transparent way; and (6) continuous investment in education and training to enhance performance and efficiency. Figure 4 illustrates the major topics covered by the EU railway-related courses, where it can be observed that the railway infrastructure and the railway operation are the two most common topics. Less attention is dedicated to IT, telematics, and human factors.

Lend and Segercrantz (2021) evaluated the existing conditions of railway educational initiatives in the Central Baltic region of Europe, including Finland, Estonia, and Latvia. The study also aimed to investigate the new ideas and designs for better

Table 2 Traditional and digital learning characteristics

| Item	Traditional learning	Digital learning
Timetable	Fixed	Fixed or flexible depending on whether synchronous or asynchronous
Learning order	Chronological	Flexible
Location	Classroom-based	Online-based
Tools	Lectures, seminars, workshops, assignments	Video, podcast, articles, discussions, tests, assignments
Learning theory	Social, experimental, and transformative	Behaviorism, constructivism, and cognitivism
Learning methodology or andragogy	Traditional	Flipped
Number of lecturers	1+	1+
Course preparation	1 + lecturers	1 + lecturers + media team
Certification	Exam	On request, often paid
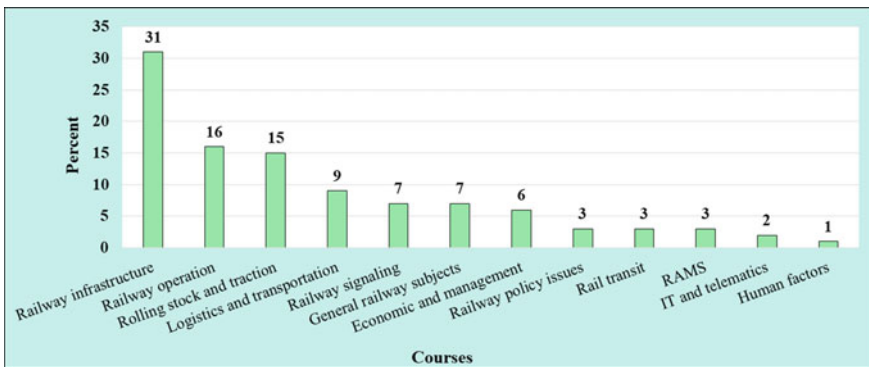
Fig. 4 Topics covered in the EU railway-related courses. *Notes* RAMS—reliability, availability, maintainability and safety; IT—information technology

balanced and less disintegrated railway educational curriculum. As a part of the conducted study, a qualitative research method was proposed for developing multi-disciplinary study modules that cover railway engineering topics (see Fig. 5). After conducting a set of national roundtable interviews, it was concluded that the railway study modules should provide more insights regarding the EU and national-level safety and operational regulations. Moreover, professional knowledge regarding rail transportation should contain the knowledge of key railway technologies along with the major elements of railway infrastructure. The authors underlined that the educational materials for safety-related rail professionals (e.g., train drivers, dispatchers, traffic controllers) should be updated on a regular basis, considering frequent changes
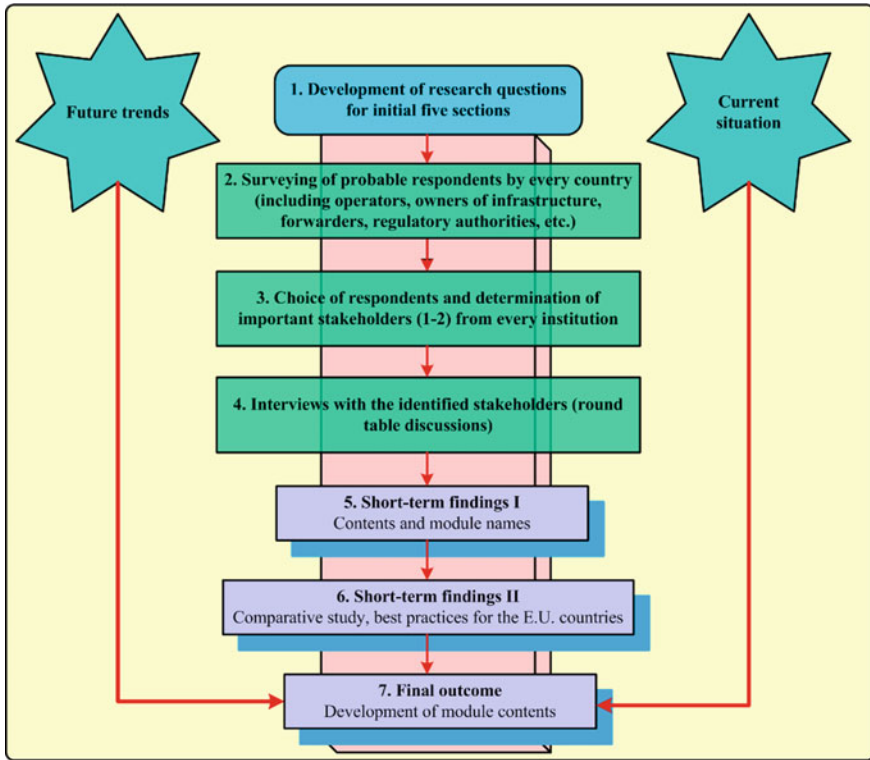
Fig. 5 Qualitative framework for developing multi-disciplinary study modules

in safety regulations. The language barrier was also found to be an important issue that has to be addressed to improve the educational level of rail employees.

Malavasi et al. (2019) described successful examples of cooperation between academia and industry on railway educational initiatives at the University of Rome "La Sapienza". As a part of this cooperation, three different courses were developed that allowed achieving the following objectives: (1) recruitment and basic training of developing professionals who would be later employed in railway companies; (2) specialized training sessions of railway engineers who have been already employed in different railway companies; and (3) specialized training sessions for third-party professionals to share Italian railway know-how with other countries. The modules of the courses were designed by the university faculty and the managers from the railway industry, which enabled an effective combination of the state of the art and the state of the practice. The study underlined the importance of collaboration between academia and industry, especially when it comes to training railway employees on critical topics (e.g., railway safety).

ASTONRAIL (2021a) conducted a comprehensive review of the EU educational and workforce development projects for the railway sector. In particular, the following

projects were discussed: EURNEX (2004), TUNRAIL (2010), SKILLRAIL (2011), RIFLE (2013), and SKILLFUL (2019). The study described various educational and training programs that were offered by different institutions to improve the knowledge and competency of railway employees. It was indicated that more attention should be dedicated to the new generation technologies (e.g., smart sensors, on-board testing systems, collaborative logistics ecosystems, multimodal management technologies, automatic train control, and communication networks). As a result of the conducted Europe-wide survey, the majority of railway educational courses, which are related to digital competencies, concentrate on computer-aided design and advanced modeling. Only ~ 6% of the courses cover the topics associated with artificial intelligence and automation. ASTONRAIL (2021b) specifically focused on the skill development and industry expectations in the railway sector. As a result of the performed survey, it was found that the rail companies generally expect their employees to have the skills and perform their work in an international context. Moreover, many rail companies require foreign language skills along with the basic technical skills.

Based on the outcomes of the research conducted by ASTONRAIL (2021a) and ASTONRAIL (2021b), ASTONRAIL (2021c) aimed to determine the existing gaps between the current education provision and railway industry expectations. Safety and security skills were found to be the most important ones required by the railway sector. The study also presented the list of best practices identified for the rail educational programs, including the following: (1) specialization on the main areas (i.e., transport modeling, commercial procedures, and economics and management); (2) connection with the industry (e.g., student internships); (3) utilization of railway labs; (4) site visits; and (5) high percentage of excises. ASTONRAIL (2022) presented a portfolio of new methods and teaching alternatives that could potentially benefit the railway sector and enhance the workforce knowledge. It was underlined that the railway degree programs should be delivered in a friendly environment where students can be satisfied with the skills and knowledge they gained. The study indicated the importance of integrating research with teaching, which will be critical for the student intellectual development.

ASTONRAIL (2023) aimed to assess the current situation of rail higher education in Europe. As a part of the study, the authors performed a survey across relevant academic institutions. The survey revealed a total of 311 confirmed courses offered by 190 different academic institutions. The courses were classified and analyzed based on different aspects (e.g., graduate courses vs. undergraduate courses, distribution of courses by different topics). The study also discussed the existing railway sector needs and expectations. It was found that the newly hired employees were often required to have previous experience in a similar position of at least one year and more. Moreover, completion of training programs and specific certificates were required for certain positions. Recruiting companies indicated that the courses related to transportation systems were more preferential for the positions they have when comparing to other disciplines (e.g., mechanical engineering, industrial engineering). Various study paths for railway-related educational plans offered by various European universities were discussed as well.

A number of studies focused on the educational and workforce development activities and discussed not only Europe but other countries as well. Lautala et al. (2010) underlined that the existing concerns associated with emissions, congestion, fuel costs, and rapidly growing demand increase the interest of communities for rail transportation. The study discussed an ongoing project, called TUNRail, which is a collaboration of different universities in the EU and the US aiming to promote the railway higher education. A number of important educational outcomes are expected by the end of the project, including the following: (a) comprehensive analysis of the existing rail educational programs in the EU and the US; (b) examples that can serve as the best practices for the railway higher education; and (c) specific strategies and recommendations that can be used for transatlantic knowledge transfer and development of innovative programs.

Tsykhmistro et al. (2014) focused on the existing policies, practices, approaches, and initiatives taken in research and rail education in the EU and Asia. The study performed a Strength Weaknesses Opportunities Threats (SWOT) analysis for the Euro-Asian cluster of educational and research initiatives in rail transport (see Table 3). It was indicated that the Euro-Asian cluster could provide a broad network of railway education and research for the EU countries and Asia and enable new opportunities for effective collaborations. However, the issues due to significant geographical distances and variations in the existing national standards associated with rail research and educational initiatives should be considered and addressed. The study also discussed EURNEX, TUNRail, and NEAR2, as the major rail educational initiatives undertaken by the Euro-Asian cluster. EURNEX is recognized as the first European cluster for excellence in rail research. On the other hand, NEAR2 aims to establish an effective collaborative rail research network among research centers in Europe and Asia.

Bureika et al. (2016) discussed the issues related to education, training, and future research needs in the areas of specialized training and staff development to strengthen the land bridge connecting Europe and Asia. As a part of the study, the authors investigated the educational models that were adopted in European and Asian countries. It was found that, based on the European educational model, the railway company typically chooses a group of employees to take the appropriate training sessions depending on the existing demand and technologies (see Fig. 6). Such an educational model can be very effective in training the employees of a given railway company in a short period of time to perform certain tasks. However, the employees may lack some fundamental knowledge and skills. On the other hand, the Asian educational model suggests that the railway companies employ individuals who have expertise in rail transportation (i.e., graduates from railway-specific universities) (see Fig. 6). Therefore, the employees will have deep theoretical knowledge. However, the main drawback of the Asian educational model consists in the fact that the employees may lack practical experience.

Table 3 The SWOT analysis of the Euro-Asian cluster for rail education and research

| Strengths	Weaknesses
• A broad network of railway education and research in institutions of CIS (Commonwealth of Independent States) and Asian countries • Rapid development of a new rail route via the Trans-Asian land bridge (i.e., Silk Road from Europe to China) that creates the demand for railway experts with international qualifications • Increasing demand for innovative concepts in the rail industry • Extended experience of the EU countries with collaborative projects	• Large geographical distances • Variations in the existing national standards that are associated with rail research and educational initiatives • Lack of a coordination mechanism/center
Opportunities	Threats
• Synergistic effects that could be achieved from integrating educational, scientific, and informational activities • New opportunities and contacts for collaboration • Integrated rail educational and scientific potentials • Transfer of knowledge and railway technologies • Enhance the mobility of staff • Harmonization of scientific and educational standards • Common international strategies that could facilitate innovation	• Excessive specialization of the cluster • A single organization can be more competitive than the other companies in the cluster
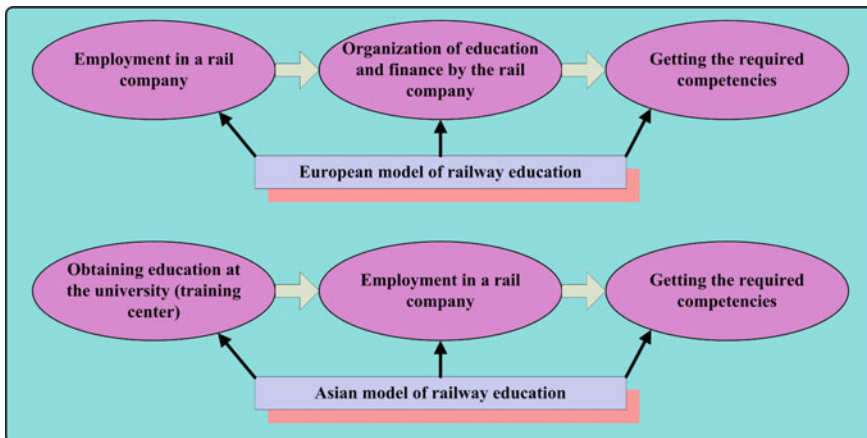
Fig. 6 Comparison of the rail educational models adopted in Europe and Asia

3.2　Educational and Leadership Initiatives in Asia

The international clustering processes for promoting railway research, education, and training have not been extensively developed in Asian countries, when comparing to the EU and CIS (Tsykhmistro et al., 2014). However, there are associations and clusters at the national level in Asia, such as the Railway Association of Korea and the Japan Railway Engineers Association, which could provide a platform for the development of international collaborations. The first step towards the development of an international cooperation was made by a group of Chinese and Russian transportation universities, which allowed forming the International Association of Transport Universities of the Asia–Pacific region (IASTU APC). The IASTU APC includes a total of 17 railway-specific universities from different countries, including China, Russia, Mongolia, Korea, Uzbekistan, and others. The overall objective of this association is to enhance the scientific potential of the railway industry in the Asia–Pacific region. The 6th International Symposium for Transportation Universities in Europe and Asia, which was conducted in Seoul (Korea) in 2013, demonstrated an increasing necessity for the new collaborations between the transportation-focused universities in Asia and Europe (Tsykhmistro et al., 2014).

The railway companies in Asia generally choose to hire experts who are qualified based on their rail education and have studied at specific railway institutes (Bureika et al., 2016). Regardless of this, the rail companies have to provide training to these experts again due to the existing gaps amongst the university education and the railway industry. The experts with solid theoretical knowledge often lack practical experience, which is viewed as critical in the railway profession. Liu and Qin (2021) underlined the need for the development of an ecosystem within Chinese higher educational institutions, which captures the "high-speed railway going global" strategy, mass entrepreneurship, innovation, theoretical guidance, and cultural connotation. The study proposed a three-dimensional integrated methodology for the educational ecosystem. The three dimensions included the following: (a) theoretical system (i.e., theoretical guidance, cultural outputs, top-level design, and integration of industry and education); (b) implementation strategy (teaching reformation, platform development, and mechanism innovation); and (c) service support (condition guarantee, leadership and organization, three-dimensional guidance, and brand promotion). Such a three-dimensional ecosystem would promote innovation, mass entrepreneurship, and internationalization.

Several studies discussed the existing railway educational initiatives in India. Bureika et al. (2016) highlighted that the training of future railway engineers is conducted by six institutions under the National Academy of the Ministry of Communication of India. However, the training is generally narrow-profiled. The duration of each training course may vary from one week up to 10 weeks. The training sessions could be developed for different categories of railway employees, ranging from low-level trainees to the highest management. The courses are generally compiled without

introducing any major research component. The main objective of railway educational initiatives in India is to prepare narrow-profiled professionals in a short span of time.

Pereira et al. (2018) studied the high-performance work practices (HPWP) and their potential for the Indian railways. The study objectives were accomplished by means of interviews with a total of 62 professionals from the human resources departments selected from six railway zones. It was found that most of the practices that are implemented by the Indian railways are in line with the HPWP concept, irrespectively of the existing context-specific practices that are unique in their nature. Moreover, the study underlined that the practices are substantially influenced by different stakeholders that include not only railway employees and managers but also political parties, governmental stakeholders, and customers themselves. The presence of different stakeholders explains a variety of financial and non-financial performance indicators for the Indian railway industry. Financial indicators include gross earnings and staff expenditures, whereas non-financial indicators include absences due to sickness, number of train accidents, number of casualties and injuries, among others. The study highlighted that the Indian Ministry of Railways plans to automate in-house operational procedures, personnel practices, and the entire railway system.

Bhati et al. (2019) indicated that the Indian railways have to accommodate many requests from their 23 million users every year. A social media-based engagement system was launched by the railway company in 2014 to improve passenger services and enable better interactions between the railway staff and its passengers. As a result of a multi-stage implementation process, the Indian railways were able to enhance work processes and even automate certain procedures. It was found that the public engagement could be an effective means of improving railway services and increasing the trust of customers. The entire project served as an educational initiative for the railway employees to better meet customer needs.

In case of the Korean railway education, the system is similar to the one used in Europe, where the education for their employees is arranged by the railway companies themselves (Bureika et al., 2016). The key educational objective is to prepare a specialist with the general technical knowledge (e.g., transportation, engineering). The training of employees is administered by the KORAIL, the Korean national railway company, in designated training centers. New employees typically start with the three-phase training program, which includes the following stages (see Fig. 7): (1) an introductory training; (2) on-the-job training; and (3) work-field training. The introductory training generally lasts for two weeks after joining the company, aiming to familiarize with the overall functioning of the system. The on-the-job training stage begins at the worksite right after the introductory training and may last between 1 and 3 months. The final stage of the training program is the work-field training. The six-phase training study model is used by KORAIL to provide hands-on training to their employees over a period of three months. The main steps of the KORAIL training study model are presented in Fig. 8, where it can be observed that the program contains a set of group and practical assignments. The program also arranges worker coaching, which provides a feeling of unity among workers that helps building a team competent of achieving the best results.
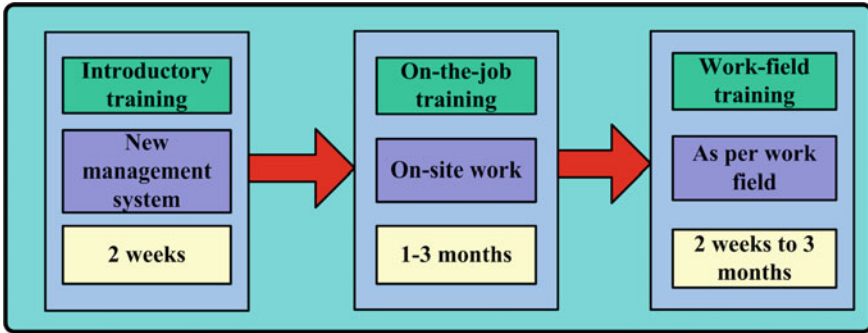
Fig. 7 Training system for new employees in Korea

Fig. 8 Six-phase study model of the KORAIL

Mysore et al. (2020) discussed the rail freight and logistics training course delivered in Thailand in 2017. The employees from the energy and petrochemical industry mostly participated in the course. The main objective of the course was to assist the staff with gaining the basic knowledge of managing rail freight and logistics systems. The course also highlighted the potential of Thailand to emerge as the railway-based logistic hub for the Association of Southeast Asian Nations (ASEAN) countries. The course participants did not have a deep prior knowledge regarding the topics covered in the course. The sessions of the course were completed in a 5-day time interval. The course participants mostly provided positive reviews and indicated that the course successfully met their expectations.

3.3 Educational and Leadership Initiatives in Australia

Mahendran et al. (2007) evaluated the development of skills and training initiatives in the Australian rail transport industry. It was pointed out that the microeconomic reforms along with industry privatization caused a significant downsizing of the

national railway workforce and extremely low levels of industry recruitment. Furthermore, a lack of individual expertise became an emerging issue as well. Considering the aforementioned changes in the railway industry, the operators have to administer more effective training initiatives to make sure that the existing employees will have adequate skills despite the workforce shortages. The study recommended the development of more cost-effective educational programs, increased employee awareness regarding training benefits, and workforce retention after the training completion. Lancaster et al. (2013) aimed to evaluate the behavior of supervisors that could be potentially unhelpful and helpful to their employees in terms of facilitating the training process. A total of 24 semi-structured interviews were performed as a part of the study. It was found that motivation, encouragement, and expectation setting by supervisors were very helpful before the training. Practical assistance during the course and meetings after the course played an important role as well. Policies, culture, and a lack of encouragement were identified as the main barriers in the training process.

Naweed and Ambrosetti (2015) aimed to assess the workspace learning with a specific emphasis on the railway industry and the training necessary to become a successful train driver. A total of 61 driver trainees and driver trainers from six Australian railway organizations participated in the study. The data were collected by means of cab-rides, interviews, and focus group discussions. The results showed that the current learning approaches are not effective, as they are generally conducted in a haphazard manner despite the desire of trainees to gain the experience. The study recommended the implementation of classroom curriculum and incorporation of the mentoring process. Fleming et al. (2017) investigated the various aspects that could affect the acceptance, future use, and satisfaction of e-learning, mainly focusing on age and other potential predictors. An online survey was conducted that involved employees from one Australian railway organization. Authenticity, low complexity, and technical support were determined to be the major factors that could influence the future use of e-learning in the railway industry. Age, on the other hand, did not have a significant impact the future use and satisfaction criteria. In order to successfully implement the e-learning programs, railway companies should focus on managing the factors that they can control.

The Australasian Railway Association (ARA) underlined that the COVID-19 pandemic negatively affected the rail skill supply in Australia (ARA, 2022). It is predicted that the workforce gaps would reach 70,000 skilled rail workers in 2023. Another challenge facing the Australian railway industry is inconsistency in terms of skill availability across the entire country. In particular, regional areas experience deep long-term skill shortages associated with technical and engineering-related roles. Skilled workforce is also needed for track maintenance, rail manufacturing, signaling, professional and train driver roles. It was also pointed out that Australia does not have any rail-related undergraduate courses, and the existing courses have a very limited focus on rail (ARA, 2022). A few universities offer rail infrastructure, rail operations, and rolling stock engineering courses mainly at the graduate level. In order to address the existing challenges, the following actions were suggested for strategic workforce planning: (1) develop a skill intelligence model that would be

able to assess the demand and supply of specific skill sets; (2) continue supporting the centralized rail skill competency management system; (3) establish collaborative partnerships with the government in order to increase the workforce capacity; and (4) utilize the existing stakeholder reference group to facilitate intergovernmental approaches for major workforce project planning.

3.4 Educational and Leadership Initiatives in North America

Haas et al. (2012) conducted an assessment to determine the needs for job creation, attendant education, and training development, considering the beginning of construction of the California high-speed rail network (US) in 2012. The analysis was performed focusing on the following aspects: (1) review of the existing challenges associated with 220-mph trains; (2) assessment of the education, labor, skills, and knowledge needs required to complete the project; and (3) evaluation of the current railway educational initiatives in California and the entire nation. The study underlined the major training needs for the construction workforce, especially the managerial workforce. Furthermore, the educational high-speed rail capacity was found to be limited in the entire country. It was further highlighted that universities should develop additional programs that could provide training sessions related to automatic train supervision, operations, communication, central and local controls, and communication system properties. Such educational programs would be essential for the workforce development.

Lautala et al. (2013) indicated that the growing demand for rail freight and passenger transportation in the US creates the need for graduates that have adequate rail expertise with an emphasis on engineering and technical fields. The American Railway Engineering and Maintenance of Way Association (AREMA) collaborated with the representatives from academia to develop an innovative program, called "Railway Engineering Education Symposium" (REES). As a part of this symposium, university professors are able to exchange their knowledge in the area of rail transportation and rail engineering, which could be further used in the development of rail-related courses. The REES is generally organized on a bi-annual basis starting 2008. The study highlighted that expansion of the REES program should be considered in the future along with the inclusion of additional engineering disciplines. AREMA mostly concentrates on railway civil engineering, and other professional organizations should be engaged to bring new knowledge. The rail engineering curricula should be based not only on civil but also on industrial, electrical, and mechanical engineering disciplines.

Dick et al. (2019) underlined the need for graduates that have railway-specific expertise across North America. Over the last decade, rail-focused University Transportation Centers and AREMA put a lot of efforts into the establishment of a railway academic community. As a result of these efforts, around two dozens of universities in the US are now offering railway-specific courses. Moreover, several institutions even offer railway engineering degrees. However, the student awareness regarding the rail

industry career paths still remains a significant challenge. The study pointed out that the outreach to K-12 students could be an effective approach to attract student attention to the railway profession. Several universities (e.g., Penn State, University of Illinois, and Michigan Technical University) implemented a set of initiatives to advance K-12 outreach activities. Nevertheless, more collaborative efforts between academia and industry are needed to create a higher level of exposure and satisfy future workforce requirements. Additional investments from public and private sectors would play an important role.

3.5 Educational and Leadership Initiatives in South America

Asaff et al. (2015) presented a historical outline of education in the Brazilian railways and metro engineering covering its inception, its peak, its near-disappearance, and it's come back at the start of twenty-first century. The Brazilian railway education started with the introduction of small railway workshops, which were outside of the regular educational program. The end of twentieth century observed an economic crisis that led to a drastic decrease in railway investments, eradication of the Brazilian railway network, and disappearance of the railway education. Nevertheless, the railway industry started receiving more stimuli in the twenty-first century, which prompted the development of new professional rail educational programs. The first educational project was undertaken at the Federal University of Santa Catarina, where the course on railway and metro engineering was proposed for the first time. That course covered some of the critical railway aspects, including operations, maintenance, vehicle design, and metro management. The study also reviewed the educational practices encouraged by the CFESP ("Centro Ferroviário de Ensino e Seleção Profissional"), an organization responsible for the administration of professional education (see Table 4).

Dias et al. (2015) investigated the key requirements for strengthening the railway industry in Santa Catarina (Brazil) by means of technology road mapping. The study

Table 4 Proposed curriculum for railway courses

Culture	Subject and learning workshops
General: in class; in charge by "normalistas" (women trained in middle school to teach in elementary schools); consonants to the program established by CFESP	1. Portuguese, geography, and Brazilian history
	2. Arithmetic, trigonometry, and algebra notions
	3. Geometry and technical drawing
	4. Elements of physics and mechanics
	5. Physical education
Technique: workshop learning guided by CFESP and delivered in the general railway workshops	1. Practical work covered in the general railway workshops
	2. Specialized technical classes

aimed to propose a set of guidelines for the Federation of the State of Santa Catarina Industry and assist with designing its strategic plan for the following 8 years. The technology road mapping was characterized in terms of purpose (e.g., product planning, knowledge asset planning, process planning) and format (e.g., single layer vs. multiple layers). The proposed railway industry roadmap, which was developed based on the feedback from the expert panel, put a strong emphasis on the educational initiatives. In particular, new postgraduate courses should be created in the railway field. Furthermore, the program of technical and higher education should be developed, taking into consideration the industry demands and input. It was also recommended to develop a technological center for the railway industry based on the knowledge gained from technology applications in the relevant domains.

Bastos et al. (2016) presented a methodology in order to develop a model consolidating the key knowledge and information for the Brazilian regulatory agency "Agência Nacional de Transportes Terrestres", which is responsible for terrestrial transport services. Moreover, the agency is responsible for monitoring the state of the roadway and railway infrastructure. The proposed management model was expected to address the issue of insufficient information integration amongst various organizational units. The developed model could also assist with a better guidance and training of employees, reinforcing the overall reputation of the organization, and providing a healthy environment for testing new ideas. The project was divided into four separate phases: (1) evaluation of the informational assets; (2) identification of methodologies that could assist with the modeling procedures; (3) determination of the processes for a complete information flow, knowledge tree structuring, and training program development; and (4) determination of the information architecture, consolidation of separate organizational units, and training program continuation. The proposed project is expected to automate decision making and assist with the regulation and monitoring of daily activities.

3.6 Educational and Leadership Initiatives in Africa

Mackona (2013) aimed to assess the role of on-the-job training on the performance of employees at the Tanzania-Zambia Railway Authority (TAZARA). The study objectives were achieved by means of conducting a questionnaire survey. A total of 50 TAZARA employees participated in the survey. A set of interviews were performed with the managerial staff as well. It was found that the training programs were mostly administered on the need basis. Furthermore, the on-the-job training substantially improved the performance of TAZARA employees. However, the training practices should be improved and be in line with the best educational practices. Nwokeiwu (2013) evaluated the effectiveness of training and development for the Nigerian railway companies. The main aim of the study was to assess the effects of training and development on the performance and worker attitude towards the effectiveness of the organization in supervising the elements that obstruct or encourage the training transfer. The study was conducted using 297 employees of the Nigerian Railway

Corporation based on a questionnaire survey. The results were evaluated using statistical models, such as Pearson correlation and Chi-Square multiple regression. The research outcomes showed the positive impacts of training and development on skills and expertise of employees regardless of their role and position.

Majavu (2016) studied how a knowledge management system could be used by the railway industry in South Africa for extracting the tacit knowledge. The main objective was to effectively implement the knowledge management system, facilitate the process of extracting the tacit knowledge from experienced railway employees, and making this knowledge explicit. The research was conducted at the metropolitan division of Passenger Rail Agency of South Africa (PRASA). The representatives from different departments participated in the study (i.e., signaling, human resources, information and communication technology). It was found that the proposed system is expected to improve the workforce knowledge management and yield monetary savings. Kamukwamba (2017) assessed the effects of organizational structure on human resource management for TAZARA. The required data were collected via structured interviews, group discussions, and questionnaires. It was found that the organizational structure could have its own advantages and disadvantages. Based on the governmental perspective, the structure allows maintaining ownership, equal commitment, and management. However, based on the business perspective, the organizational structure incurs additional costs and may cause slow decision making due to government bureaucracy.

Chen (2021) underlined that Chinese financial support was often used by certain African countries for railway construction. The study specifically focused on the Chinese-financed railway projects in Ethiopia. It was indicated that the projects brought some challenges along with the associated benefits. One of the major challenges was found to be a lack of experience and technical capacity of the railway institutions and the Ethiopia's government. Another challenge was associated with the development of a managerial infrastructure that could accommodate and integrate various types of technologies. The educational and training issues were discussed in the study as well. In particular, Chinese-financed projects often suffer from long-term sustainability issues due to a lack of the knowledge transfer. Furthermore, training of Ethiopian employees generally takes longer due to insufficient hands-on experience and lower standards of education. The language barrier was found to be one of the factors that slowed down the training process as well.

4 Discussion

A detailed review of the relevant literature indicates that the European countries are the most proactive in terms of the existing educational and workforce development projects for the railway sector. A large variety of different projects have been implemented in the EU over the past years, including EURNEX, TUNRAIL, SKILLRAIL, RIFLE, and SKILLFUL (ASTONRAIL, 2021a; Tsykhmistro et al., 2014). Based on the European educational model, new employees are generally

scheduled to complete necessary training sessions as needed once they are already onboard with the railway company (Bureika et al., 2016). Certain employees may be requested to take re-assessments every year on specific topics (e.g., safety, security, maintenance) to ensure compliance with the latest guidelines. The Asian educational model has distinct differences with the European educational model and requires the individuals who have expertise in rail transportation (i.e., graduates from railway-specific universities) before they could join the railway company (Bureika et al., 2016). Therefore, the employees are expected to have deep theoretical knowledge regarding the key railway concepts and operations. Furthermore, there are different initiatives supported by the Railway Association of Korea and the Japan Railway Engineers Association to promote the education and workforce development in the Asian railway sector and facilitate collaborations with the EU and CIS countries (Tsykhmistro et al., 2014).

Similar to Europe and Asia, many efforts were dedicated to collaborative initiatives between the railway institutions and academia in the US. For example, the American Railway Engineering and Maintenance of Way Association (AREMA) collaborates with the US institutions to conduct various educational activities and support the development of rail-related courses (Lautala et al., 2013). Some railway educational initiatives even involve K-12 students (Dick et al., 2019). Fewer developments were identified in Australia and South America. Microeconomic reforms and industry privatization resulted in a significant downsizing of the national Australia railway workforce and extremely low levels of industry recruitment (Mahendran et al., 2007). Therefore, the Australian railway companies have to administer more effective training initiatives to make sure that the existing employees will have adequate skills despite the workforce shortages. Furthermore, the current learning approaches have to be improved (Fleming et al., 2017; Naweed & Ambrosetti, 2015). Similar to Australia, the rail educational programs require substantial improvements in South America. Due to the economic crisis at the end of twentieth century, there was a drastic decrease in railway investments, which impacted not only the Brazilian railway network but the educational initiatives as well (Asaff et al., 2015). The program of technical and higher education should be developed, taking into consideration the Brazilian railway industry demands and input (Dias et al., 2015). Several studies were conducted aiming to improve the railway educational initiatives in Africa as well, focusing on the on-the-job training, knowledge management, and organizational structure (Kamukwamba, 2017; Mackona, 2013; Majavu, 2016).

More importantly, a detailed review of the existing educational and workforce development initiatives across the world shows that there is a lack of specific focus on the AT development and deployment. However, the reviewed studies do acknowledge the importance of automation for the railway sector and related educational programs. As an example, the International Union of Railways highlights that enhanced automation would facilitate a full integration of intelligent communication technology, user and vehicle applications, and traffic management services (UIC, 2015). ASTON-RAIL (2021a) indicates that the majority of railway educational courses, which are related to digital competencies, concentrate on computer-aided design and advanced modeling. There is a lack of courses that cover the topics associated with artificial

intelligence and automation, which are both critical for understanding the AT technologies. The universities should develop additional programs that could provide training sessions related to automatic train supervision and operations (Haas et al., 2012). Moreover, many railway companies across the globe acknowledge numerous benefits of rail automation and expect to transition towards autonomous operations and AT deployment (Allied Market Research, 2023; Bhati et al., 2019; Singh et al., 2021).

In order to support successful development and deployment of autonomous rail lines across the globe, the following recommendations should be considered for education and workforce development by higher education institutions, railway industry representatives, and other relevant stakeholders.

4.1   New Educational Activities Based on Lessons Learned

The development of new educational and workforce development programs associated with the AT deployment should be performed considering the existing practices and lessons learned. In particular, the EU had many successful initiatives (e.g., EURNEX, TUNRAIL, SKILLRAIL, RIFLE, and SKILLFUL), and the best practices from these well-established initiatives should be used when developing new educational programs. As an example, the 2010 TUNRAIL project allowed developing a comprehensive inventory of higher rail educational practices and programs that had been administered over the years in the EU and the US (ASTONRAIL, 2021a). The collected data can be used in developing the future educational programs associated with the AT deployment in order to effectively fill the existing educational gaps. Furthermore, the specific strategies and recommendations that were provided as a part of the TUNRAIL project for the transatlantic knowledge transfer can be assessed and evaluated for their suitability in terms of the AT context. The 2019 SKILLFUL project specifically highlighted the need to implement innovative technologies in order to ensure sustainability of rail transportation (ASTONRAIL, 2021a). The project also acknowledged the important role of artificial intelligence and machine learning, which are the integral components of ATs. However, some railway-related jobs may be affected by these disruptive technologies, and this issue should be effectively addressed by the relevant stakeholders.

4.2   Training Initiatives on Effective Communication, Artificial Intelligence, and Demand Planning

ATs are expected to efficiently communicate with the surrounding infrastructure and onboard passengers (Wang et al., 2016). As train attendants will not be present onboard the ATs, the appropriate railway employees will be required to transmit

the information to ATs from operational centers. Specific training sessions should be developed to ensure effective communication with the AT onboard passengers (especially, in case of emergency situations). Furthermore, artificial intelligence is an integral component of ATs. Artificial intelligence-based algorithms can assist with solving challenging decision problems (Dulebenets, 2019; Fathollahi-Fard et al., 2021; Pasha et al., 2020a). In case of ATs, artificial intelligence-based algorithms can assist with optimal selection of travel speed based on the existing timetable, effective energy consumption, delay minimization, object detection, big data processing, etc. Many railway employees may not be familiar with basic features of these algorithms. New educational programs should be developed in order to make railway employees aware of the role of artificial intelligence-based algorithms for ATs. Moreover, the demand for rail passenger and freight transportation has been showing a growing trend. New educational initiatives should be established for railway managers and planners that can facilitate the design of mid-term and long-term strategies, considering the potential advantages that could be achieved by the AT deployment. These strategies would assist with meeting the rail transport demand variations and market requirements.

4.3 Educational Initiatives for Highway-Rail Grade Crossings

Highway-rail grade crossings (or level crossings), where highway segments intersect railway tracks at the same elevation, pose a risk of collisions between trains and passing vehicles or pedestrians (Abioye et al., 2020; Kavoosi et al., 2020; Pasha et al., 2020b). A significant number of collisions between highway vehicles and trains at highway-rail grade crossing locations are reported every year in different countries across the globe. There are different alternatives that can be used to reduce the number of accidents and improve highway-rail grade crossing safety. Implementation of different types of countermeasures (e.g., flashing lights, gates, median barriers) can be viewed as a common alternative for safety improvements projects at highway-rail grade crossings (Kavoosi et al., 2020). However, implementation of countermeasures can be an expensive alternative. Normally, the funding available for safety improvements projects is limited, and it is not economically feasible to upgrade all the hazardous highway-rail grade crossings in a given geographical location. Therefore, some authorities also consider closures of highway-rail grade crossings (i.e., fully restrict the movements of highway vehicles and only allow train movements). Automation is expected to enhance interactions between trains and highway vehicles at highway-rail grade crossings. Therefore, additional educational programs should be administered for the railway employees to better understand interactions of trains, highway vehicles, and pedestrians at highway-rail grade crossings; so, they can be aware of potential safety issues. Automation of trains and highway vehicles is one of

the promising alternatives for improving user safety at highway-rail grade crossings, and relevant educational initiatives for railway employees would be essential.

4.4 Re-orientation and Re-training Programs

The deployment of ATs in rail passenger and freight transportation is expected to decrease the size of train crews. There exist job security issues associated with layoffs of employees due to the AT deployment (Cassauwers, 2020; Crains, 2017). The employment issues may result in labor strikes by rail unions that will slow down the AT development and deployment. Certain experts indicate that rail unions are not against the development of AT technologies, but there are certain sensitive issues associated with the job security of train drivers that should be addressed (Cassauwers, 2020). It would not be ethical to put technology first and disregard the existing concerns of railway employees. Re-orientation and re-training of the existing employees (e.g., transfer to other duties associated with non-automated rail lines or customer service) can effectively address the issue (Cassauwers, 2020). Therefore, the future efforts should be dedicated towards the development of effective re-orientation and re-training programs for the relevant railway employees. Continuing technological changes in rail transportation are expected in the following years. However, all the changes and transitions should be coordinated with the existing railway workers, as it will not be possible to support these changes and transitions without the human input.

4.5 Standardization of Courses on Rail Automation

A recent study conducted by ASTONRAIL (2023) discovered a large variety of rail-related educational programs. A total of 311 confirmed courses were identified, which are offered by 190 universities across Europe. These courses are related to railway infrastructure (e.g., building information modeling, rail-wheel contact, asset management, and predictive maintenance), operations management (e.g., train movements across the network, optimization of train timetables, and optimization of railway operations), rolling stock (e.g., traditional design of railway vehicles, innovative types of design for railway vehicles, and rail freight wagons), system safety and security (e.g., protection of railway infrastructure from malicious acts), and technology (e.g., new approaches for improving sustainability of railway operations, reduce energy consumption, and decarbonize the environment). The present study revealed significant variations in rail educational programs offered by various universities in different countries. The future efforts should focus on standardization of educational programs on the AT development and deployment; so, these programs could be offered at the international level and serve as the educational point of reference worldwide.

4.6 Innovative Learning Opportunities and Public Involvement

Some of the reviewed studies acknowledge the potential of e-learning for railway employees (Bureika et al., 2016; Fraszczyk & Piip, 2018). However, there may be some challenges associated with the e-learning approaches (i.e., skill challenges with new technologies; technical complexity in design of course materials; advanced skills are required for the instructional design). The future research should addresses the issues associated with the implementation of e-learning approaches, so these approaches could be effectively used for the delivery of courses on the AT development and deployment. Furthermore, many railway users are not familiar with certain important features of ATs (e.g., how ATs would respond to uncertain situations) (Fraszczyk & Mulley, 2017; Fraszczyk et al., 2015). Hence, specific educational initiatives should be implemented for the public to ensure that the future AT users will be aware of its features and important operational characteristics. This will help increasing the AT adoption raters worldwide. Moreover, public involvement at the AT development stages would be important as well, so the future AT users can start gaining the confidence in the AT technologies (Pakusch and Bossauer, 2017; Singh et al., 2021).

4.7 Funding Issues

Certain countries receive less funding allocated for rail educational programs, and railway employees have fewer opportunities to learn about new cutting edge technologies that are deployed at automated rail lines. New funding mechanisms should be developed to ensure that rail educational programs could be administered at the appropriate level. Based on the research project conducted by ASTONRAIL (2021a), it was found that industry is very open to fund university rail-related research if there is sufficient collaboration and interaction. Rail industry partners can benefit from new markets and products developed from the outcomes produced by academic research. The option of self-funded education is not considered as viable, as some students may not be able for afford the cost of various educational programs (especially, the ones that require traveling to study abroad). Therefore, a sufficient financial support should be provided by employers. Strong financial incentives for higher rail education should be developed not just by employers but also by relevant industry and government organizations.

5   Concluding Remarks and Future Research Needs

Automation has been receiving a lot of attention in the railway industry. Autonomous Trains (ATs) are expected to provide numerous benefits, including safety improvements, increasing capacity, lower operational costs, service reliability improvements, and more flexible train fleet management. The length of automated rail lines is expected to substantially increase in the following years. Along with numerous advantages that could be achieved with the introduction of fully automated rail lines, there exist a number of challenges associated with the AT deployment, which include design challenges, operational challenges, technology-related challenges, and human aspect-related challenges. This chapter performed a comprehensive review of the existing initiatives for higher education and leadership that have been organized by different countries across the globe over the past years, aiming to determine whether sufficient efforts were dedicated towards the AT deployment.

It was found that the European countries are the most proactive in terms of the existing educational and workforce development projects for the railway sector. A large variety of different projects have been implemented in the EU over the past years, including EURNEX, TUNRAIL, SKILLRAIL, RIFLE, and SKILLFUL. Asian institutions also administered different educational and workforce development activities for the railway sector. As an example, the Railway Association of Korea and the Japan Railway Engineers Association initiated a set of programs to promote the education and workforce development in the Asian railway sector and facilitate collaborations with the EU and CIS countries. Similar to Europe and Asia, many efforts were dedicated to collaborative initiatives between the railway institutions and academia in the US. Fewer developments were identified in Australia and South America. Microeconomic reforms and industry privatization resulted in a significant downsizing of the national Australia railway workforce and extremely low levels of industry recruitment. Due to the economic crisis at the end of twentieth century in Brazil, there was a drastic decrease in railway investments, which impacted not only the Brazilian railway network but the educational initiatives as well. Several studies were conducted aiming to improve the railway educational initiatives in Africa, mainly focusing on the on-the-job training, knowledge management, and organizational structure.

More importantly, a detailed review of the existing educational and workforce development initiatives across the world shows that there is a lack of specific focus on the AT development and deployment. However, the reviewed studies do acknowledge the importance of automation for the railway sector and related educational programs. Therefore, a set of recommendations were presented to assist with the education and workforce development in the railway industry, aiming to support successful development and deployment of autonomous rail lines across the globe. These recommendations cover a variety of different aspects, including new educational programs on advanced communication technologies and artificial intelligence, re-orientation and re-training programs to prevent employee layoffs, standardization of educational programs on the AT development and deployment, e-learning programs, and

others. The proposed recommendations would be valuable to higher education institutions, railway industry representatives, and other relevant stakeholders. The present research can be further extended in the following areas:

- More research is needed to determine policy-related challenges that slow down the development of educational and workforce development initiatives. Innovative alternatives should be designed to effectively address these policy-related challenges.
- The future efforts should concentrate on the development of comprehensive curricula for undergraduate and graduate rail educational programs.
- Practical exercises are essential after completing the initial theoretic educational materials. More research is needed to design integrated rail educational programs, which can effectively combine theoretical knowledge delivered in the university settings and practical experience delivered on-site at railway facilities. Such educational programs would require even more cohesive collaborative efforts between the railway industry and academia.
- The future research efforts should concentrate on the development of repositories, where the main rail educational materials can be stored and accessed by the appropriate personnel in a timely manner. Such repositories would facilitate the exchange of educational materials between educators and trainees.
- The existing studies show a lot of potential for e-learning programs in the railway sector. However, effective e-learning programs require advanced digital resources. The appropriate railway stakeholders should explore different alternatives to determine how the required digital resources could be provided to railway employees, so they can successfully complete e-learning training sessions in the future.

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Navigating Skills Gaps: Career Pathways for Migrant Engineers in Australia's Expanding Rail Sector

Janene Piip

Abstract A shortage of engineers for rail projects in Australia has been exacerbated recently by COVID-19 and other factors such as not enough graduates to fill vacancies and competition from other industries. Australia has successful immigration programs that allow skilled migrants to develop their career as an engineer in a new country. However, this untapped pool of talent is not being fully utilised and could assist with engineering workforce shortages.

Keywords Rail industry · Australia · Skill shortages · Electrical engineering · Migrant engineers · Career pathways

1 Introduction

As a response to the COVID-19 pandemic, Australia has fast-tracked rail construction projects that had previously been in the pipeline or moving slowly for several years. A projected investment of \$154 billion is scheduled for new construction ventures over the coming 15 years to transform the nation's transport and freight networks (Australasian Railway Association, 2023). Engineers will be crucial to the success of these projects, requiring specific expertise in rail engineering, project management, software skills, knowledge of both local regulations and international standards, and aptitude in communication or 'soft skills', amongst other abilities and talents (Crosthwaite, 2021). Additionally, engineers will need an insight into the local Australian rail context, encompassing vast geographic landscapes and unique cultures that blend Indigenous and migrant peoples. Knowledge of professional education, training, career, and skill development that align with the rail industry's workforce needs will assist engineers in finding appropriate employment in these new projects.

In 2007, the problem of finding appropriately tertiary qualified applicants with specialisations in civil, electrical, mechanical engineering, and signal maintenance engineering was reported by Mahendran et al., (2007, p. 15). Wallace et al (2011)

J. Piip (✉)
SkillSmart Careers, PO Box 2614, Port Lincoln, SA 5606, Australia
e-mail: janenepiip@gmail.com

concluded that the demand for engineers exceeds global and national supply, and employees can choose the employer who best meets their needs. Wallace et al (2014) conducted further comprehensive research on what rail engineers are looking for in a career and how the rail industry can reach this cohort to fulfil impending workforce shortages. They identified eight key expectations that engineers are seeking in a career including

1. Engaging work that combines engineering expertise with creativity to deliver high-quality, innovative products and services.
2. A workplace filled with enjoyment and fun and characterised by a strong team spirit.
3. Compensation that exceeds industry averages, coupled with job stability and opportunities for advancement.
4. Opportunities for professional growth through enriching experiences, employer recognition, and future prospects.
5. A work environment that recognises and leverages employees' unique skills, knowledge, and talents, enabling them to excel in their roles.
6. Opportunities to travel as part of the job.
7. A company culture marked by supportive management.
8. Employment with a prestigious company that instills a sense of pride and association in its employees.

At the same time in 2011, the Australian Government's Cooperative Research Centres Programme investigated skilled migration for the rail industry as a way to solve workforce challenges (Cameron et al., 2011). Key points from this report state that skilled migration does not 'fix' all workforce needs as 32% of employers who employed people on 482 Visas (for skilled workers) experienced a 'problem' with employment of migrant worker; 24.43% of employers and 53.16% of the workers colleagues reported English proficiency as the main barrier; and 89% of those who haven't employed a migrant worker were concerned about problems with English proficiency.

By 2021, the engineering supply problem was still ongoing, exacerbated by border closures during the COVID-19 pandemic when migration dropped by 85,000 people (Centre for Population, 2023).

Engineers Australia—the peak body for engineering professions in Australia—has around 100,000 active members (Engineers Australia, 2023a). They reported that 58% of engineers in Australia were born overseas and around 47% many of them have been unable to find long-term employment in Australia in their engineering field (Romanis, 2021). Some of the key reasons include—lack of experience; no local networks in Australia; no local references to use for recommendations; don't know where to get support or advice; qualifications not at the right standard; can't afford to pay for skills recognition and low English proficiency (Romanis, 2021, p. 15). The report concluded that the impending shortage and mismatch of talent for new projects in all engineering disciplines including those in the rail industry, could be filled using engineers who are not working or not working to their full capacity.

2 Objectives of the Study

Considering the overarching problem of finding the right engineering talent for new rail projects in Australia, the principal objective of this chapter is to examine what companies might do to facilitate the untapped labour pool of under employed migrant engineers, in particular electrical engineers. To add to the chapter, we include a supplement at the end of this chapter describing a case study that outlines steps a recent migrant engineer could undertake to facilitate recognition of their skills in Australia and associated career development actions that would lead to potential employment in the rail industry.

The exploration aims to facilitate the process of helping both industry and migrant engineers consider the challenges both are facing to secure skills and talent and employment in Australia's railway sector when the industry is developing new projects but is facing high levels of skill shortages.

To achieve these objectives, we posed three questions to guide the study

- What are the workforce challenges faced by the rail industry in Australia?
- What could the industry do to make employment more accessible to migrant engineers?
- How will engineering skill shortages impact the rail industry into the future?

This chapter, therefore, provides an opportunity to explore the background of the Australian rail industry, and educational and career development actions companies might consider assisting migrants to fulfil their career goals of becoming an electrical engineer in the rail industry in Australia.

3 Australian Rail Industry Workforce Challenges

3.1 Current Issues

Ageing Workforce

Australia's population increased exponentially post 1945 after the end of World War II, with almost one third of the current population now expected to be older than 60 years of age in 2028 (Andrei et al., 2019). Ageing workforces will impact all sectors including the rail industry which is ageing at 2.6 times the national rate with rail employees older than employees in other sectors. In 2028, more than 20% of the existing workforce will retire, leaving a large knowledge gap. Additionally, the Australian rail sector is represented by 77 per cent male and 23% female, with only 11% of females working in the freight sector (Australasian Railway Association, 2022b).

Low Diversity

Gender as well as cultural inclusion is a challenge for the rail industry workforce. Women, indigenous people, people from disadvantaged backgrounds, regional and remote people, youth and new mature aged workers, LGBTI+, people with a disability, and neurodiversity, are all under represented in the rail industry. Attracting females and other diverse groups into rail apprenticeships, and other roles within the sector is a start to increasing the diversity of the workforce (Australasian Railway Association, 2022c).

Attraction and retention

With a largely, male dominant workforce, the rail industry has not previously needed to consider strategies to attract and retain diverse candidates with flexible workplace arrangements. Widely promoting these types of arrangements along with full-time and part-time hours availability can make the industry more attractive to diverse groups and assist with filling workforce shortages (Australasian Railway Association, 2022c).

Tapping the migrant talent pool

The rail industry has not capitalised on the migrant talent pool to fulfil workforce shortages, especially in engineering. Considering 47% of migrant engineers are not working in their chosen career, the industry could benefit from targeted strategies to utilise this labour pool (Romanis, 2021).

   This opportunity has been available to the industry for many years as the migration program was developed in 1945 after World War II to counteract the impending ageing workforce of the future, at the same time of population growth through natural means. People were attracted from the United Kingdom to further increase the Australian population. Since 2010, the Australian migration program has changed focus from only increasing the population to meeting the labour market needs of the economy and is available to people from across the world who meet entry requirements (Engineers Australia, 2019; Parliament of Australia, 2023).

   Skilled migrants are now required to work in regional Australia as a condition of their visa, a change implemented from 2019, to assist with workforce shortages in all types of industries (Engineers Australia, 2019). While this concept has assisted many migrants to find suitable employment and settle in a new location, it is not without its challenges such as limited cultural networks and access to education and professional development.

   During COVID-19, Australian borders were closed and migration dropped by 85,000 people in the period 2020–2021 (Centre for Population, 2023).

3.2   Engineering Labour Force

Engineering vacancies in Australia are typically filled by graduates and migrant engineers (Infrastructure Australia, 2021b). As an example, 896 domestic students and 446 international students graduated in electrical engineering in 2019, prior to the COVID-19 pandemic (King, 2021). At the same time, there were around 2000 vacancies for electrical engineers in 2021 and 3000 vacancies in 2022 across all industries in Australia (Field, 2023), leaving a shortfall of many skilled electrical engineers to fill roles.

Some rail businesses sponsor individual migrants directly to work within their business but there are other migrants who have arrived in Australia independently and are now seeking work.

To supplement the required number of electrical engineers, skilled migration is important to the Australian engineering workforce. Between 2006 and 2011, 71.4% of the total engineering workforce across all disciplines grew from skilled migration, increasing to 76.5% to 2016 (Engineers Australia, 2019). However, many engineers are unable to find appropriate engineering roles and are likely to be working in retail trade, accommodation and food services (Infrastructure Australia, 2021b).

The Australasian Rail Industry reports that high levels of skill shortage are being experienced in roles requiring electrical engineers such as signalling, electrical and communications, and are more pronounced in remote areas of Australia (Australasian Railway Association, 2022a). As more projects are developed post-COVID 19, these skill shortages will increase. Electrical engineers are responsible for designing, maintaining and upgrading complex electrical systems that power trains, signalling systems and other critical infrastructure. The integration of advanced technologies like electrification and automation emphasises the need for appropriately skilled electrical engineers, especially with increasing complexity of technology, artificial intelligence and automation.

The Australian rail industry has undergone a structural shift in the past decades where non-core business is often contracted to other businesses that provide these non-core services instead undertaking all functions inhouse. These shifts have created changes in industries where engineers were traditionally employed such as in public sector rail companies and have created opportunities for engineers to specialise in niche markets. The rise of the 'gig economy' will allow engineers to utilise work platforms such as Airtasker and Upwork to offer niche skills—an advantage for the individual but difficult for the rail industry when trying find more permanent staff (Crosthwaite, 2019).

This further adds to skill shortages as niche skills may be specific to one company. Engineers working in consulting roles (a service based industry/approach) are now the second largest employer of engineers in Australia (Engineers Australia, 2019).

3.3   Education, Training and Specialised Skills

Rail engineering education plays a crucial role in Australia's transportation sector and has significant importance as the development of infrastructure in projects for new heavy haul, freight and passenger projects. Investment of around $13.3 billion in 2023–24 will increase over the next 3 years, driven by publicly funded projects on the Eastern coast of Australia making the years to 2031 record levels of construction (Australasian Railway Association & BIS Oxford Economics, 2022). Projects such as Inland Rail, Victoria to Queensland—a 1600 km line for rail freight; North South Corridor, SA; METRONET project, WA; Sydney Metro, New South Wales; Canberra Light Rail, ACT; (Australasian Railway Association, 2023) to name just a few projects. In September 2022, the Australian Government established the High Speed Rail Authority to develop a high speed rail network in Australia.

The rail industry requires unique skills for many specialised roles that take a long time to acquire. In Australia, privatisation of the rail industry followed by decentralisation of rail training and education are contributors to the current skill shortages (Infrastructure Australia, 2021b). Therefore, in regard to Railway Engineering specialisations, there are a limited number of universities spread across Australia that have unique railway focussed course offerings outlined here:

- University of Wollongong, New South Wales offers rail engineering specialisations as part of their engineering courses and hosts the Rail Cooperative Research Centre (CRC) (University of Wollongong, 2023)
- University of Queensland has a focus on railway engineering within their Civil Engineering courses, particularly at postgraduate level (University of Queensland, 2023)
- Queensland University of Technology (QUT), Queensland provides specific rail engineering courses and opportunities for research (Queensland University of Technology, 2023)
- Central Queensland University offers program focused on railway engineering, including courses customised for the rail industry's needs (Central Queensland University, 2023)
- RMIT University, Victoria offers course related to railway systems and transportation engineering [RMIT (Royal Melbourne Institute of Technology), 2023]
- University of South Australia offers transport engineering research and education (University of South Australia, 2023)
- Monash University offers various transportation engineering courses that investigate rail transportation systems and is home to the track and vehicle railway research centre (Monash University, 2023)

The significant challenge for the rail industry, graduates and migrant engineers is the limited provision of rail specific courses as evident in the above compilation, compounded by the extensive geographical distribution of rail companies across Australia. If courses are not offered in the location where engineers are working, they may be difficult to access as a significant number of courses are conducted

through traditional face to face learning with limited online learning alternatives. This presents a multifaceted dilemma in terms of accessibility to courses and tailored education for rail careers. The Australasian Railway Association further states that there is no specific training for people not already employed in the rail industry as a way for people wanting to change careers and enter the rail industry (Infrastructure Australia, 2021b). This is a significant barrier to filling skill shortages as there are no clear entry pathways to rail industry careers if one is working in another sector and has limited knowledge of the rail sector.

Further compounding the problem of acquiring rail specific skills, Australia is home to differing rail networks in each state. Australia is a vast country characterised by six states (New South Wales, Queensland, South Australia, Tasmania, Victoria and Western Australia) and three internal territories (the Australian Capital Territory, the Jervis Bay Territory and the Northen Territory) (Wikipedia contributors, 2023). Sizable geographical distances between capital cities with sparsely located populations across inland Australia, meant that the development of the rail industry occurred in a piecemeal approach.

Early rail lines developed in individual colonies in Australia with a localised approach that connected rural areas with cities and local ports (Commonwealth of Australia, 2023a, 2023b, 2023c). The vastness of the landscape meant that shaping the rail transportation system was difficult and lacked overarching standardisation and regulation, leading to each state developing its own rail networks. Consequently, variations in gauge sizes emerged across states, persisting until the Federation in 1901 and still in existence today. The vast distances at play in Australia means there has been no clear railway model of efficiency and competitiveness which meant operations and training and education models have changed frequently over time depending on various government strategy of the day (Abbott & Cohen, 2016).

3.4 Competition from Other Sectors

Competition for skilled engineers from other industries is apparent across the industry. As an example, electrical engineering is a specialisation important to the rail industry, playing a key role in advancing rail systems towards environmental sustainability. The rail industry faces challenges in acquiring professionals with the expertise to undertake these roles in signalling, data analytics, automation, and cybersecurity as the industry needs become increasingly complex and it embraces technological advancements. Additionally, new systems need to be interoperable across states and differing rail networks (Australasian Railway Association, 2022b).

Electrical engineers are in high demand from other industries such as other transport sectors, renewable energy, automation and power generation (Infrastructure Australia, 2021a). Finding electrical engineers with rail industry specialisations with knowledge of rail systems, safety standards and understanding of the sector's unique challenges can be difficult as engineers working in the sector must have extensive knowledge of and adhere to strict safety and regulatory standards.

Many high performing engineering students secure a non-engineering role and others who move into engineering roles face inexperience and inadequate industry knowledge on commencement. Mentoring and graduate programs can help new engineers by providing support and more positive experiences to help manage expectations on both the employer and employer's sides to retain graduates for the longer term (Engineers Australia, 2022b). Regarding migrant engineers, barriers to finding employment in Australia include:

1. A lack of local knowledge and experience
2. Perceived cultural differences in soft skills
3. Visa or sponsorship working rights issues
4. A lack of people who can 'vouch' for them locally and provide workplace references
5. Certification queries
6. 'Flight risk' concerns
7. Tendency for employers to hire from personal 'networks' for senior roles (Engineers Australia, 2022a)

3.5 Geographic Challenges

Vacancies exist for engineering roles across the Australian rail industry—in both metropolitan and regional and remote locations. For both new graduates and migrants, regional and remote roles may not be as attractive as other roles in metropolitan locations due to lack of family support, amenities (such as access to ongoing education and healthcare), isolation and cultural belonging and social factors.

Access to vocational and higher education in regional and remote areas is difficult due to large distances and prohibitive costs to provide training to 'thin' markets (low populations). For specialist courses, such as those required by the rail industry, there are few courses offered in regional locations (Infrastructure Australia, 2021b).

4 Making Australian Rail Industry Employment More Accessible to Migrant Engineers

To address the challenges faced by migrant engineers, in particular, in being able to access employment in the rail industry there are several strategies that could be utilised. Currently, migrant engineers reported that they sought to find out about opportunities from wider networks (33%), online jobs boards (37%) and recruitment agencies (11%). Clearly, these strategies are not working well as the could be as 47% of those seeking a job as an engineer are underemployed (Romanis, 2021).

4.1 Recognition of Overseas Qualifications and Experience

More could be done by both the rail industry and organisations to facilitate recognition of overseas qualifications and to help electrical engineers work through the recognition process. Five percent of migrants stated the cost of the recognition process was prohibitive which meant that they could not work as an engineer until their qualifications were recognised (Romanis, 2021). Helping migrants to understand the Australian Qualification Training Framework compared to their own education and qualification could be undertaken by the rail industry along with describing the entry points for differing career roles that would lead to becoming an electrical engineer (in our example).

The Australian Qualifications Framework

The Australian Qualifications Framework (AQF) is a national, Australia-wide system that provides a comprehensive framework for all qualifications. There are 10 levels of qualifications in the AQF, each representing a different level of complexity and depth of knowledge starting with Certificate I (entry-level) and culminating in a Doctoral Degree (the highest level of academic achievement). Each level is defined by a set of learning outcomes, including knowledge, skills, and application of those skills. These learning outcomes are used to define the complexity and depth of knowledge required to achieve a particular level of qualification (AQF, 2023).

The AQF provides a clear and objective way to assess local qualifications in Australia as well as those of individuals who migrant from other countries and seek recognition of overseas qualifications. It is an important tool for individuals who require knowledge about their education or career, providing a transparent way to identify existing skill levels and knowledge. By understanding the AQF and the levels of qualifications, individuals can make informed decisions about their education and career goals and take steps toward achieving them. In Australia, the AQF allows progression of careers from entry level qualifications through the AQF levels.

To ensure consistency across the country, the AQF is overseen by a national body called the Australian Qualifications Framework Council. The Council works with education providers, industry, and government to ensure that qualifications issued in Australia are of high quality and meet the needs of learners and employers.

Utilising the role of an electrical engineer, we outlined the AQF with typical job roles that could be found in the Australian rail industry at each AQF level. This provides an opportunity for the industry to commence migrants in roles at the differing AQF levels and provide support to upskill them once they have been employed (Table 1).

In this example, aspiring electrical engineers would require their overseas qualifications to be assessed by a state authority relevant to the electrical engineering field so they can gain recognition of the AQF level in Australia before finding an electrical engineering role in their new country.

Table 1 The Australian qualifications framework with example electrical engineering jobs

AQF Level	Qualification	Level of knowledge	Example electrical engineering Jobs
AQF—level 1 Equivalent to Yr 11 or stage 1 SACE	Certificate 1	This level represents basic knowledge and skills in a particular area	• Assistant in electrical work
AQF—level 2 Equivalent to Yr 11 or stage 1 SACE	Certificate II	This level represents a basic level of operational knowledge and skills in a specific area	• Entry-level electrical technician • Installation of basic electrical systems
AQF—level 3 Vocational education e.g. TAFE	Certificate III	This level represents a broad range of knowledge and skills, often requiring some degree of autonomy	• Entry level electrical assistant or trade worker
AQF—level 4 Vocational education e.g. TAFE	Certificate IV	This level represents a broad range of skills and knowledge, often requiring high levels of autonomy and responsibility	• Electrical technician or trade worker in signal maintenance or routine electrical tasks
AQF—Level 5 Vocational education or higher education	Diploma	This level represents a high level of specialised knowledge and skills, often requiring extensive theoretical and/or practical understanding	• Advanced technician or supervisor
AQF—Level 6 Vocational education or higher education Vocational education	Advanced diploma	This level represents a high level of specialised knowledge and skills in a particular area, requiring extensive theoretical and/or practical understanding	• Advanced technician involved in design and troubleshooting electrical systems • Management of small teams and projects
AQF—level 7 Higher education (University)	Bachelor Degree	This level represents a broad range of specialised knowledge and skills, often requiring a significant research component	• Entry level electrical engineers
AQF—level 8 Higher education (University)	Bachelor Honours degree	This level represents a high level of specialised knowledge and skills in a particular area, requiring a significant research component	• Specialised electrical engineer leading larger projects that may focus on innovation and integration of new technologies

Table 1 (continued)

AQF Level	Qualification	Level of knowledge	Example electrical engineering Jobs
AQF—Level 9 Higher education (University)	Masters degree	This level represents a high level of specialised knowledge and skills in a particular area, often requiring a significant research component	• Senior electrical engineer or Specialist • Research and Development roles
AQF—level 10 Higher education (University)	Doctoral degree	This level represents the highest level of academic achievement, requiring original research and/or scholarship	• Leadership and Management roles in the rail industry

Articulation of alternate pathways to engineering through lower level roles could help migrant engineers work towards professional recognition through Engineers Australia while gaining employment in roles where there are skill shortages.

4.2 Language Support

Engineers Australia is the approved accrediting body for engineering education. To become a member, candidates require their qualifications to be assessed and to prove that they have English language competency in written and spoken English at IELTS level 6 (Engineers Australia, 2021a, 2021b, 2021c). Companies and the rail industry could provide opportunities for English language training and support to help migrants improve their English proficiency, especially in technical and safety-related communication. Some of these actions may include providing financial support for tutoring, work shadowing other engineers at work to be immersed in differing workplace situations and certification programs to enhance English language ability.

4.3 Cultural Sensitivity, Mentoring and Workplace Adjustment Training

Engineers Australia (Romanis, 2021) states migrant engineers pose 'a risk to managing relationships within the team as well as with clients and suppliers' due to differing cultural soft skills and language. Rectifying these issues is seen as costly and time consuming. However, The Engineering Futures 2035 scoping study in Australia states that along with the high levels of technical engineering knowledge and skills, graduates and migrants seeking employment in Australia will need a range of 'soft

skills' including emotional intelligence and interpersonal skills to meet anticipated changes in the nature of engineering work (Crosthwaite, 2019).

Soft skills including communication skills, empathy, professional ethics and emotional judgment are likely to be increasingly valued by employers as projects develop and employers seek motivated and self-sufficient employees with the talent to solve new, unknown problems (Crosthwaite, 2019). Technical skills will form the base of engineering careers, but lifelong learning will enable engineers to be adaptable, flexible and resilient. Crosthwaite (2021) states theses talents will include working in diverse teams; self-management; professionalism; creativity/problem-solving; management/leadership; engineering business; practical engineering; innovation; contextual responsibilities; and applying technical theory.

To access the migrant engineering talent pool, it is of high imperative that employers assist new employees adjust to workplace norms by providing support to integrate into the company's culture, learn English and become part of the team. Strategies might include linking new employees with a mentor, establishing ways for employees to provide feedback about their needs and providing cross cultural training for teams that work together to help them understand and appreciate different perspectives at work.

4.4 Streamlining Immigration Processes for Migrants

Accessing the migrant engineering talent pool could be expedited by rail employers assisting potential employees to navigate the immigration processes and find the appropriate visa pathway (Romanis, 2021). Once in Australia, employers can support potential employees to overcome barriers they face in finding employment by matching them with employment opportunities that best suit their needs at the current time by using more proactive strategies such as peer support networks, industry specific short courses and assistance to translate documents (Engineers Australia & Consult Australia, 2023a, 2023b, 2023c).

Considering, around 47% of migrants who want to work in engineering are currently underemployed, working collectively across the industry to access this talent pool could be a positive strategy (Romanis, 2021).

5   Electrical Engineering Skill Shortages Will Impact Future Rail Industry Productivity

There is an urgent need for solutions to address skill shortages in the rail industry. These shortages are impacting industry wide productivity as large projects are planned but not able to be completed on time due to lack of qualified engineers in key areas. The solution to finding enough engineers with appropriate skills has

to be multisectoral with 'government, industry, the tertiary education sector, and professional associations' working together to devise innovative solutions to these challenges (Engineers Australia, 2022b).

A shortage of, for example, electrical engineers can have far reaching consequences on the rail industry impacting safety, innovation, and project efficiency. Electrical engineers play a crucial role in maintaining the electrical systems of railways, including signalling, power distribution and control systems. Skill shortages may lead to inadequate maintenance, result in safety concerns and operational disruptions.

The rail industry is evolving with technological advancements, such as electrification of rail networks and the implementation of smart systems. A shortage of electrical engineers can slow the adoption of these innovations, making the rail industry less competitive than other transport modes.

With numerous large projects planned in Australia, electrical engineers are crucial in providing complex electrical components and working across systems that are currently found in each state. Skill shortages in electrical engineering can lead to project delays and increased costs and decreased productivity. At the same time, sustainable solutions for the rail sector, such as energy efficient trains and renewable energy integration may be hindered by electrical engineering skills shortages.

6 Conclusion

Workforce challenges faced by the Australian rail industry include an ageing workforce, competition from other industries, low levels of diversity and the requirement for specialised skills that are difficult to access through a limited number of education and training providers. Traditionally, the rail industry has been a male dominated sector with its roots in the apprenticeship model of training, developed during the settlement of Australia and the establishment of the rail industry. Now, Australia is a multi-cultural society with a myriad of cultures and diverse cohorts who have much to offer rail companies, yet entry points to careers in the industry are not well described for outsiders.

Accessing skilled engineers to fulfill vacancies in the rail industry will involve multifaceted strategies at the industry, organisation and individual levels. Migrant engineers are seen as a potential talent pool to fill some of the industry's shortages, however, connection to the industry is lacking. Consideration of how the industry can provide fulfilling careers for graduates, migrants, career-changers and other diverse cohorts will require exploration of workplace and flexibility needs so that skill shortages can be filled.

Appendix

Case Study

As a workforce development strategist and educationalist who creates and manages training programs and projects, developing curricula tailored to industry needs, I am fortunate to work with diverse cohorts of people. Recently, I have assisted TS, aged 21 who is a 2022 graduate of the Master of Electrical Engineering Program from an international university. TS recently migrated to Australia in pursuit of his dream career in engineering as his academic transcript demonstrated his high levels of theoretical ability. He was eager to explore the potential opportunities in the Australian electrical engineering sector and establish his electrical engineering career. TS's mother has been residing in a rural area of South Australia for more than 10 years and recently became an Australian citizen, so he was able to seek her encouragement and support to navigate the visa process and secure a Child Visa (Subclass 101) (Department of Home Affairs, 2023). This visa category allows a child who lives outside Australia to move from where they currently live, to be with their parent, if the child is a dependent of the parent (who must be an Australian citizen or an Australian permanent visa holder).

Upon arrival in February 2023, TS has faced several challenges that he had not anticipated before migrating. While studying at university, he commenced learning English but lacked the opportunities to practice in conversational and workplace settings in his home country. On arrival in Australia, his limited English skills have restricted the type of jobs he can obtain. His inability to communicate in English has slowed his progress in integrating into the local community as he is not able to understand the local cultural norms and cultural practices as easily as if he were more fluent in English. By leveraging her local insights and connections, TS's mother has guided him to find local unskilled work where basic English could be learnt and practiced on the job.

While TS has fulfilled one of his career goals of migrating to Australia, he requires more support to identify how he could understand the specific requirements and standards for electrical engineers in Australia, how he can gain recognition of his engineering degree and what sectors of Australian industry he can consider enabling him to secure employment. TS has not accessed any further education or training since arriving in Australia as he fears he may not be able to understand the course material or the lecturer.

This case study provides an opportunity to explore the background of the Australian rail industry, and educational and career development actions TS might consider to fulfil his career goals of becoming an electrical engineer in the rail industry in Australia.

Ten steps to finding electrical engineering employment in Australia

To assist TS find employment in Australia, we considered rail industry electrical engineering requirements that are required to demonstrate the technical and educational requirements for electrical engineering registration. In addition, the candidate

will be required to demonstrate that he has the required soft skills to fit in well as an employee in the rail industry as an electrical engineer. Some of these soft skills might include communication, teamwork and collaboration, emotional intelligence, problem solving and critical thinking, organisation, professionalism and work ethic (Crosthwaite, 2019).

Learning English

For new migrants, one of the greatest challenges is to develop adequate English skills to meet the Australian standards required for the workplace. The Australian government recognises this challenge and provides English language training through the Adult Migrant English Program (AMEP), allowing permanent visa holders and eligible dependent family members to access unlimited hours of English classes until vocational English proficiency (at least a score of five for each of the four (International English Language Testing System) test components) is reached (Australian Government, 2023a). Classes are provided face to face and by distance learning for eligible migrants.

Furthermore, for membership of Engineers Australia candidates will require a higher level IELTS (International English Language Testing Score) score of six (Engineers Australia, 2021a, 2021b, 2021c). To transition from a proficiency level of 5–6 on the desired English language scale, the candidate will require a rigorous approach to enhancing his linguistic capabilities, requiring dedicated time, effort and support. Seeking the assistance of a specialised English language tutor can accelerate the acquisition of industry specific communication norms that will be required to rail industry workplaces. Engagement with a native English language mentor can provide other opportunities for experiential learning in the wider community that will develop the candidate's understanding of Australian culture and the development of his soft skills such as self-awareness, resilience and problem solving. This type of mentorship can offer real world application of language, the element that is often missing from learning in the classroom.

By reading technical literature written in English and viewing media such as electrical engineering specific YouTube, podcasts and webinar, TS can deepen his understanding of technical language. Using official IELTS practice materials to develop speed and accuracy in undertaking the test will help TS work on areas of weakness. Some Vocational Training Organisations and Universities offer English for Engineering courses which can be found by searching online and can be undertaken face-to-face or by distance education.

Skills Recognition

In order to identify the equivalency of his international master's degree with the Australian Qualifications Framework (AQF), TS must undergo an Overseas Qualification Recognition (OQR) assessment. The evaluation processes for OQR may differ slightly across Australian states, each of which has its own Skills Recognition Authority. For instance, the government of South Australia defines the specific procedures for the Skills Recognition Process, as outlined online (Migration, 2023). Post assessment, TS will be better positioned to determine his next steps—either in employment or further study in Vocational or Higher Education.

Should TS select employment, multiple career paths within the field of electrical engineering are available to him. Engineers Australia, the peak organisation for engineering professionals, offers various guidelines for entry-level positions. These include, but are not limited to, Engineering Associate (AQF6) or Engineering Technologist (Engineers Australia, 2023b). This career decision would offer TS the advantage of acquiring on-the-job experience along with skill development in engineering.

However, the critical prerequisite for embarking upon his engineering career in Australia is English language proficiency, measured by the International English Language Testing System (IELTS) at Level 6. The inability to reach IELTS Level 6 will preclude TS from professional registration. Additionally, certain Australian states mandate specific registration protocols for electrical engineers (Engineers Australia, 2023d). While membership in Engineers Australia is not obligatory, affiliation with the organisation could provide TS with networking prospects, opportunities for professional development, and industry recognition.

If TS's chosen career path requires work with electrical systems, he may be required to obtain an electrical worker's License. This license demonstrates compliance with Australian safety legislation, English language proficiency and cardiopulmonary resuscitation (CPR) skills (Electrical Regulatory Authorities Council, 2023).

Work Experience

Acquiring professional experience in the Australian context is crucial for TS to develop his confidence, enhance his proficiency in the English language, and acquire foundational knowledge relevant to starting a career in electrical engineering. Engineers Australia provides an accredited 44-week program, known as the Professional Year, which is officially recognised by the Australian government and designed to facilitate the vocational progression of recent graduates (Engineers Australia, 2023c).

The program aims to accustom graduates to engineering work environments within Australia, illuminate the specific skills and competencies valued by employers, and offer networking opportunities as well as mentorship support. However, it should

be noted that the program restricts admission to a limited number of candidates and necessitates the payment of substantial fees, in addition to satisfying other eligibility criteria.

Alternatively, internship programs present another viable pathway for career development in electrical engineering. Employers offering these internships typically seek candidates who have attained at least an IELTS level 6 in English proficiency. Should TS opt for an internship pathway, prioritising his English language development firstly is of vital importance.

Moreover, entry-level roles within companies or organisations may serve as another way for TS to acquire work experience and improve his English language skills. As illustrated by Cameron et al. (2011), the absence of local experience or specific workplace knowledge often poses a significant obstacle in securing employment within Australia. For TS, such entry-level positions offer the advantage of acquiring localised knowledge and nurturing professional networks. Local work experience is pivotal in contributing to a 'good fit' employee who will fit the culture of the organisation, as it attests to a graduate engineer's familiarity with Australian occupational culture and norms. In terms of securing more permanent positions, the aspect of 'cultural fit' gains more significance; organisations will prioritise candidates who can seamlessly integrate into existing teams, demonstrate proactive behaviour, and can adhere to local codes and regulations.

Vocational Qualifications

By undertaking further study in Australia at the vocational level (AQF 3–5), TS could develop workplace and employability skills such as communication skills, English language skills and further knowledge about Australian workplaces. As his Master's degree is in the field of electrical engineering he could pursue vocational studies in this area with a short course or full qualification. The benefits of vocational study will help TS to develop skills that meet the specific needs of the Australian rail workforce through aligning current skills with current industry needs. At the vocational level, students can apply for Recognition of Prior Learning so they can accelerate their pathway through study programs and into the Australian workplace as they may not have to study all competencies in the qualification.

Often overlooked as a viable education pathway within the Australian context, vocational education programs serve as a critical foundation for migrant engineers to acquire practical skills in engineering. Through these programs, participants gain familiarity with localised methods, regulations and technological systems—elements that are necessary within niche sectors such as rail electrical engineering. Vocational education providers maintain strong connections with local industry which facilitates networks for future employment opportunities. For individuals like TS, electing to pursue vocational studies as a beginning to a professional engineering role in Australia can provide a foundational framework for career development.

TS could enhance his skills within electrical engineering and the rail industry in Australia by considering the following vocational courses (Australian Government, 2023b):

Qualification	Purpose of this qualification	AQF level
Certificate III in electrical fitting	Provides competencies to manufacture, fit, assemble, erect, operate, test, fault find, alter and repair electrical equipment and includes electrical wiring work associated with assembling, maintaining, terminating or altering the wiring between electrical components within a plant or machinery	AQF 3
Certificate IV in electrical—rail signalling	Provides competencies to install, certify, fault find and maintain rail signalling equipment and systems. This includes ERAC requirements for an 'Electrician's licence', performing like for like replacement, performing authorised installations and alterations, and applying emergency operational restriction	AQF 4
Diploma in rail signalling systems	Provides a pathway for railway signalling technicians to upgrade to railway signalling technical officers, signalling managers and signalling supervisors. Course participants will gain the skills and knowledge to enable them as part of a team, to plan and implement railway signalling systems, coordinate fault diagnosis and rectification of systems, manage the implementation of maintenance plans and contribute to signalling incident investigations	AQF 8
Short courses in train control systems	Various institutions offer short courses that focus on specific aspects of train control systems, suitable for electrical engineers looking to expand their knowledge in areas such as automatic train protection and control systems	
Occupational health and safety for rail	Courses focusing on safety protocols and regulations specific to the rail industry would enable electrical engineers to learn more about compliance with Australian rail safety standards	

Part-Time or Casual Work in Other Industry Areas

Vocational courses often have experiential learning and work experience components integrated into the curriculum, accompanied by support to find a placement in industry. Alternative avenues for obtaining practical work experience encompass engaging in part-time and casual work in sectors that align with electrical engineering careers.

Such opportunities may encompass roles in the repair of electronic devices such as smartphones, computers and electrical appliances that would allow TS to gain

knowledge of different Australian customers and their needs. TS would not only accumulate valuable hands-on experience but also develop his English speaking skills, while gaining work experience and the ability to demonstrate his competencies in an Australian workplace. Other casual jobs may include working as a trade assistant with a qualified electrician in domestic or commercial settings as this role would provide practical experience with electrical installations, wiring and systems. Engaging in part-time or casual employment offers the twofold advantage of fostering skill development in English language communication, self-awareness and other essential workplace competencies while simultaneously identifying areas of weaknesses he needs to address.

Develop a Career Action Plan

In the context of career development within the rail industry, a Career Action Plan serves as a crucial instrument for aligning TS's occupational objectives, existing competencies, and interests with the industry's specific demands and opportunities. The absence of a systematically documented plan featuring SMART (Specific, Measurable, Actionable, Relevant, and Time-bound) goals could lead to TS drifting away from his aspirations and actual accomplishments. A Career Action Plan describes the required steps for goal attainment and guides TS in identifying potential barriers and constraints that may materialise during his professional journey. Seeking the support of an experienced coach or mentor, can ensure TS remains aligned with his career aspirations.

The Career Action Plan may typically consider the following components to facilitate TS's progression toward his professional journey within the Australian rail industry:

Career goals

- Short-term goals: e.g. engagement in relevant training modules
- Long-term goals: e.g. attainment of specific roles or positions within the rail industry

Skills Audit

- Current Competencies: e.g. document strengths and identify areas necessitating improvement
- Skills Prerequisite: e.g. outline the competencies required for the desired position within the rail sector

Educational pathway

- Vocational Training: outline specific vocational courses that are relevant to the desired role
- Higher Education: highlight the educational credentials required for Australian registration as an electrical engineer

Work and practical Experience

- Internships: explore avenues for gaining practical experience in electrical engineering specifically related to the rail industry
- Work Observation: facilitate opportunities for job shadowing to observe professionals within the desired role

Networking and Mentorship

- Professional Associations: work towards membership of professional organisations to enhance networking prospects
- Mentorship: engage a mentor from within the industry to provide guidance and insights

Job Procurement Strategy

- Curriculum Vitae: adapt resumes and cover letters to cater to diverse opportunities within the rail sector
- Interview Preparation: gain coaching and engage in simulated interviews to enhance interview competencies

Obstacles and Constraints

- Core Beliefs: recognise self-limiting beliefs and formulate strategies for their rectification

Monitoring and Accountability

- Progress Reviews: set regular evaluation of progress toward career objectives
- Plan Adaption: make adjustments to the Career Action Plan in response to shifts in the career trajectory or industry trends.

Resume

In the Australian employment landscape, employers exhibit a strong preference for candidates who not only possess substantial knowledge of Australian workplaces but can also adhere to conventional structures of Curriculum Vitae (CV) and Resumes. The distinction between these two documents is significant: a CV serves as a comprehensive account of one's academic and professional background, inclusive of employment history, notable achievements, and ongoing professional development. On the other hand, a Resume is a more condensed version, tailored specifically to each job application to feature only pertinent skills, experiences, and accomplishments. Mastery over the appropriate utilisation of these two formats is integral for career advancement in Australia. For each type of application, candidates should be able to succinctly describe why they are the best candidate for the role by outlining their technical and soft skills, achievements and aspirations for the role, considering the employer's context.

Standard categories often found in a Resume include the following:

- **Career Statement or Profile**: This introductory section summarises the candidate's qualifications and accomplishments relevant to the position in a concise paragraph of no more than five lines.
- **Technical Skills and Qualifications**: This segment outlines the candidate's alignment with Australian industry norms and standards.
- **Soft skills**: that align with the attributes determined by Engineers Australia such as collaboration, communication, teamwork, creativity, ethics, sustainability (Crosthwaite, 2021) and demonstrated through participation in workplace experience or other transferable skills. Other soft skills will be highly valued including problem solving and self-management, that could be demonstrated by work experience and having a career action plan to achieve identified goals and objectives.
- **Workplace Experience or Employment**: This section outlines work experience directly relevant to the position being sought.
- **Achievements**: Here, the candidate can list any pertinent accomplishments that demonstrate their suitability for the role.
- **Referees**: Preference is often given to local referees capable of providing comprehensive evaluations of the candidate's qualifications, skills, and workplace competencies.

Understanding the nuances of these various sections and adapting one's CV or Resume accordingly is critical for a successful job application process in Australia. Seeking the guidance and support of an external mentor or support person can provide valuable insights into resume development and future job applications.

Referees

In the Australian employment landscape, it is typical for candidates to identify suitable referees who can substantiate their qualifications, professional experience, and other personal attributes such as integrity. These referees usually have professional associations with the candidate, comprising former supervisors, colleagues, or clients. Referees may be requested to provide insights into the applicant's abilities, work ethics, and suitability for the role. Usually, the referee will be contacted by phone to provide a verbal reference and in some cases, a written report answering questions about the candidate.

Selecting appropriate referees and providing their contact details is usually part of the job application process. For electrical engineers like TS, finding local referees is difficult when there is no relevant work experience and one of the reasons migrant engineers find it difficult to secure employment in Australia. Part of the Career Action Plan could include strategies to build in opportunities to undertake volunteer activities and casual and part-time work, so a list of potential referees can be identified. Prior to utilising referees, and each time an application for employment is made, it is

incumbent upon TS to confirm with each prospective referee their willingness to offer a detailed assessment of his professional capabilities.

Volunteering

Development of new networks in Australia can be undertaken by considering volunteering as a way to meet new people, expand social networks and hone linguistic capabilities. While volunteering is an unpaid activity, for migrants like TS it offers an alternative way to understand Australian culture, especially if he selects activities that are congruent with his career goals for electrical engineering. Such an approach can facilitate connections with professionals who are potentially well positioned to act as a referee for job applications. In the electrical engineering profession, this will be important as TS's referees will have firsthand experience of his work ethic and skills. Volunteering activities may provide career opportunities TS had not previously contemplated.

Know What You Want

TS migrated to Australia with the professional aspiration of establishing a career in electrical engineering in the rail industry. The implementation of a thorough Career Action Plan will serve as a fundamental tool in determining the precise steps he envisions for himself within this sector.

The rail industry presents a multitude of specialised areas where an electrical engineer can develop a fulfilling career within a rail system as an electrical engineer including in traction systems; signalling and communication systems and train control systems to name just a few areas. The array of opportunities with this sector can be so extensive that TS could feel potentially feel overwhelmed by the options in front of him. By carefully documenting his preferred job role, TS can ascertain the competencies and actions that align closely with his identified career objectives. This focussed approach enables TS to pursue professional opportunities that are directly corresponding with his overarching career goal.

Summary

This section set out to identify how a potential rail engineer could ensure their qualifications meet Australian industry standards so they can find employment in their chosen career in their new country. In addition, ten career development actions outlined how formal processes can be enhanced by personal action that works toward engineering registration in Australia.

A central focus is the Career Action Plan, a strategic tool designed to align TS's occupational objectives, skills, and interests with industry needs. This plan details SMART objectives and covers several components such as career goals, skills audits,

educational pathways, work experiences, and opportunities to learn and practice English language skills. It serves as a roadmap for an engineer to navigate potential challenges, seek mentorship, and strategies for job applications in electrical engineering in the rail sector.

The value of vocational courses, volunteering and experiential learning, outlining specific avenues for hands-on experience in relevant sectors, cannot be understated. The study emphasises the twofold benefits of part-time work for both skill development and linguistic enhancement. These opportunities facilitate identification of potential referees for the job application process, particularly considering the challenges faced by migrant engineers like TS in securing employment.

This section highlights the need for focused career planning, especially given the multitude of specialised areas in the rail industry, and the importance of opportunities to develop English language skills to make a start in his career. Through a careful documentation of career objectives, the candidate can streamline his journey in a highly specialised and opportunity-rich sector to demonstrate that he is a suitable employee who integrates seamlessly into an organisation.

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Innovation, Communication, and Talent Attraction

Begoña Tiscar Vega

Abstract Why is the mobility sector not considered an attractive career option for students? Is it about technology and innovation, or are there more factors to contemplate? In recent years companies in the mobility sector have explored the challenges of attracting and retaining talent, trying to understand the career drivers for diverse cohorts. According to the IEA Future of Rail Report 2019, Global Rail Transportation Market Report 2022–2026, 70% of the world's population will live in cities by 2050; passenger movement is predicted to multiply by three by 2050; higher cargo volumes are predicted to increase by two within the next 30 years. It's important to consider the rail sector's contribution to a sustainable future, with approximately 75% of conventional passenger rail operations powered by electricity. Additionally, the rail sector accounts for about 2% of the total energy demand in transportation, while its carbon dioxide (CO_2) emissions make up roughly 0.3% of the overall 37% of CO_2 emissions in the transport sector. Furthermore, electric rail plays a significant role, accounting for approximately 50% of all freight rail operations. So, the challenge of attracting and retaining talent to the sector is here, and action is needed.

1 Current Paradigm—The Mobility Sector View

Today's world is changing permanently. It's essential to be agile and to provide solutions to the current challenges such as climate change and over population. Through increasing populations, one of the bigger challenges is mobility as people demand an efficient, reliable, and sustainable transport system. Railways are the backbone of mobility and mobility companies are key to provide solutions to all these challenges through innovation and digitalization.

B. T. Vega (✉)
Head of R&D for Main Line, Siemens, Madrid, Spain
e-mail: bego.tiscar@siemens.com

Mobility companies have the opportunity to positively impact society and to be part of the sustainable transport solution. At Siemens Mobility, sustainable mobility is underpinned by our push toward mobility digitalization and digital solutions through our motto 'Transform mobility for a better tomorrow'. Siemens has employed new technologies in the following areas:

- Simulation and Digital Twin technology to help simulate real situations and their outcomes,
- Sustainable energy and infrastructure,
- Software Systems and processes,
- Connectivity,
- Cybersecurity,
- Data Analytics and AI,
- Automation,
- Power electronics.

Siemens has met these new challenges and has digital solutions to offer intelligent trains and infrastructure and increased value through the lifecycle, improving passenger experience in a sustainable way.

2 Students View

What do students think about the mobility sector? Siemens has asked them; they have a different perception, and they don't see innovation.

Why do students think that the mobility sector is not innovative? Why do they prefer to work in companies like Google, Amazon, AI companies, and they do not see the mobility sector as innovative?

What can companies do? What does the mobility sector have to do?

In the case of Siemens Mobility, the company:

- gives talks about current issues and presentations at colleges and universities,
- offers employees' children the possibility to be close to the sector,
- organizes and participates in Hackathons, where we offer students the opportunity to devise solutions for the sector with innovative ideas.

Along with these initiatives, Siemens has created a dual Master program, which has had a high degree of success.

In this Master program, we teach students #Telecommunications; #Engineering; #Mechanics; #Robotics; #Industrial; #Technologies; or #IT #Technologies, and offer them specific training in signaling, safety, ERTMS, coding in a railway environment. The Master program is a collaboration between Siemens Mobility and Universidad Politécnica called "Master of Sciences Rail Mobility Technologies". Graduates dedicate one day to university education followed by four days in an office setting. During this time, they have the opportunity to start their career, expanding their knowledge in the railway industry, by being part of major signaling and rail electrification projects

both locally and internationally. The Master program takes 1 year to complete with graduates achieving 60 academic credits plus the practical phase in Siemens Mobility for four days each week, six hours a day.

Students become familiar with different roles, understand how the mobility sector impacts society and learn about the different possibilities for their careers. The advantages of the dual Master for Siemens Mobility are obvious:

- The company has created its own talent pool,
- Return on investment is achieved in a shorter period of time,
- Depending on the specific technical areas, Siemens Mobility could save around 25–50% of the time graduates require to become autonomous in the workplace,
- The dual Master has created a stronger bond between graduates and Siemens Mobility Spain (0% voluntary turnover),
- The qualification is aligned with the company equity strategy, starting talent at earlier career stages,
- Master graduates are prepared to move faster than others within the different technical areas in Siemens as they get a global vision of the business,
- Master students have a successful learning curve in short period of time in terms of technical knowledge and personal relationships,
- As company, we have achieved greater visibility in the university market, as well as more attraction for generation Z → Graduates of first promotion to become company promoters (active referrals for 2nd edition),
- Students apply reverse mentoring with managers and mentors.

After the Master program, Siemens Mobility sought student feedback about the mobility sector and their opinion of the sector was completely different from their initial perception. They proposed some actions to change this image:

- Enhance the student knowledge in this field, explain that they can be part of the solution, and that there are more challenges that are coming to this industry,
- Real degree will be the best, but what about some signatures and explain the real option?,
- Practical lessons and internships,
- Some in-depth knowledge related to trains.

Siemens Mobility found that the Master program has had a high degree of success but it's clear that the sector needs to continue working with all the stakeholders, universities, private and public companies to create a framework where we provide the visibility that the sector deserves, where communication is a key piece of this change.

3   Diversity in Mobility

What else can be done if the mobility sector wants to grow and attract more talent? What else can be done to improve our cities?

3.1 What About Diversity?

According to the World Economic Forum, mobility manufacturers, operators, innovators and regulators are addressing the underrepresentation of women across the mobility sector. Ensuring more female representation in the mobility sector will help to close employment demand gaps.

Women are underrepresented in the mobility sector with around 22%; while mobility systems are less accessible for women even though women use public transport more than men. Within the mobility sector, there is a considerable gender wage gap with women earning 21% less than men.

It's important to know that women move differently, and multiple studies have shown, women have different patterns, needs and behaviors:

- Women in general have a greater need for mobility flexibility.
- 75% of unpaid care work is done by women.
- Women comprise up to 66% of public transport users.
- Women also perform intermodal trips, combining several modes on one stretch.
- Women are more likely to schedule in a stopover (trip-chaining).
- Women more often travel with luggage and other people.
- Women often travel under more time pressure.
- The car is less often the default choice for women.
- Women also feel more vulnerable when out and about alone.

4 Sustainability in the Mobility Sector—Women's Impact

The rail sector's impact on a sustainable future with currently ~ **75%** of conventional passenger rail activity running on electricity, **2%** of the total transport energy demand comes from the rail sector, **0.3%** of the total **37%** of CO_2 emissions in the transport sector are caused by rail and ~ **50%** of all freight rail is electric.

The growing demand for usage must be planned, managed in a sustainable, reliable and safe way, through transport solutions that allow progress that is respectful of the planet, reducing greenhouse gas emissions to mitigate the effects of climate change and the depletion of natural resources. In this sense, it is essential that the adoption of sustainability measures make it possible in the medium and long term to impact decarbonization and dematerialization of the entire chain value in mobility.

Companies such as Siemens Mobility respond to this need, taking into account women's behavior and sustainable development, developing alternative mobility modes that are more reliable, efficient and elegant, enhancing the quality of life in our cities. To achieve this outcome, womens need to be part of the decision making processes, creating value related decarbonization and resource efficiency.

5   Diversity Makes the World Go Round

To increase the number of women in the sector is not a topic of diversity alone but also a business issue, as more talent is needed, and the sector strives to meet women's mobility needs. More women working in the mobility sector can bring their viewpoints to the table as they are using the transport system more than men.

What does the sector think?

> We live in a constantly changing world, in which it is essential to have talent that allows us to face current and future challenges. That is why we must promote and fight for organizations to be diverse. Organizations where men and women have the same opportunities. The railway sector is key in achieving the decarbonization objective. Therefore, we must promote the presence of women in this sector. Always aligned with the SDGs—MM CEO

> The lack of female engineers is a social challenge, despite the fact that the situation has evolved in recent years, women are a minority in technical careers in Spain, where only one in five engineering students is a woman. We believe in the importance of multidisciplinary teams and the added value that women bring to decision-making. In particular, it is necessary to promote their incorporation and promotion of women in the public transport sector where the number of users is significantly higher than that of men—Caminos School Dean

> Diversity means the talent pool increases which will drive a clear business opportunity and added value to the railway sector, a booming sector with a forecasted high demand. Are we sure we can afford not to increase female presence in the railway sector?—Marketing and Business Development Manager

What do we do in Spain to increase the number of women working in the Mobility sector?

Give women visibility by creating role models, like the events that UMA and ASTONRail organized "Women in the railway sector"—see Fig. 1.

Initiatives such as the "Equal miles" signature, promoted by the EJE&CON Association, where mobility stakeholders, private and public companies, schools, signed their promise to promote the best talent without gender and generation, following some principles and recommendations that the EJE&CON association, who are experts in that topic, prepared. The initiative was supported by the Spanish Transport Minister.

Initiave as the "FeMale Voice in Mobility" (see Fig. 2) where women and men promote the diversity through support and different activities. In this initiative we undertake internal networking events, external networking events, motivational events, support and guides and training.

The diversity challenge is here, and it's important to continue with these initiatives and continue working to improve the underrepresentation of women in the sector. By working together, collaboration and synergies are created.

Fig. 1 Women in rail event posters

Fig. 2 FeMale voice in
mobility logo

6 Communication, Innovation and Digitalization

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Talent Management in the European Rail Sector: Myths, Errors and Modest Advices

Miguel Faro Viana

Abstract Talent management has been an overrated concept in human resources management. The rail sector has difficult demographic and brand challenges to address but talent management is not the miraculous recipe which is being sold. The paper aims to put the concept in perspective under human resources management common practices within the sector and advance recommendations to foster organizational effectiveness.

1 Introduction

Talent Management is currently on the agenda of top management and human resources professionals in multinational corporations. It is generally accepted that a McKinsey article published back in 1998—"The war for talent" (Chambers et al., 1998) has coined the term Talent within the human resources management domain (Minbaeva & Collings, 2013). On the other hand, academics from the field of human resources management and organizational behaviour have only started studying the topic in a systematic way some 10 years ago and commonly agreed that its operationalization in the organizations is rather poor (see for instance Gallardo-Gallardo et al., 2020). The time gap between practitioners' and academics' efforts and initiatives on this front may explain why talent management looks to be an overrated concept in the human resources management practice.

M. F. Viana (✉)
Learning and Development, Infraestruturas de Portugal, Lisbon, Portugal
e-mail: miguel.viana@infraestruturasdeportugal.pt

Talent and Expertise Development Platform, International Union of Railways—UIC, Paris, France

Direção de Capital Humano, Infraestruturas de Portugal, Praça da Portagem, 2809-013 Almada, Portugal

The rail sector has serious demographic and brand challenges to address, particularly in the European countries, but talent management, as in other sectors, is probably not the miraculous recipe which is being sold to address these issues. It lacks clarity regarding its definition, scope and overall goals (Lewis & Heckman, 2006; Tansley et al., 2007). In addition, its intended results in organizational effectiveness indicators are rather weak (Skuza et al., 2022). As Minbaeva and Collings (2013) state the challenges associated with talent management are related to the fact that the concept and practice are poorly defined.

This paper aims to put the concepts of Talent and Talent Management in perspective under human resources management common practices trying to contribute to a better understanding of both the concept and the practice. It is also intended to advance some recommendations to foster organizational performance through Talent Management policies and practices within the rail sector. The recommendations are generic and apply specially to the European context.

2   The Concept of Talent

Academics and practitioners adopt different terms for talent, for example, "key employees," "high potentials", "excellent abilities", "highly committed and motivated" or "those individuals with high potential who are of particular value to an organization". However, according to Ashton and Morton (2005, p. 30) "there isn't a single consistent or concise definition" of talent. Other authors (e.g. Thunnissen et al., 2013; Wiblen, 2016) sustain that using different definitions and views about this concept in the literature is not contributing to build and advance scientific knowledge. Skuza et al. (2022) propose on their recent literature review several approaches usually used to define talent. In this paper we focus on three perspectives which may help to better understand the concept:

1. The first perspective is to consider talent as an innate (natural ability, also called a trait approach) or an acquired competency through education and practice. If it is innate, possessing some cognitive skills and/or personality traits, it is not subject to great change over time. If it is acquired, it requires to identify individuals with above average competencies who have the will to develop it further. The debate between nature versus nurture equals a long discussion in psychology about the genetics, individual development and education. If talent is mostly innate, it follows a normal distribution and is not available in the majority of the workforce, then it has to be found outside the firm. This requires sophisticated methods to spot relevant individual attributes in external candidates. This also limits progressively the ladder to climb to more senior positions. Inversely, it does not assure flexibility or adaptation capability for any work change due to social, technological or business reasons. As Davies and Davies (2010) conclude natural talent cannot really be managed and organizations should focus on the enablement of talent instead.

On the contrary, if talent is acquired is always a function of experience and effort (e.g. Pfeffer & Sutton, 2006). Talent as mastery has to be developed internally based in strong assessment procedures and effective planning for learning and development. Formal training, job rotation, job enrichment, special assignments, mentoring and coaching are the prime methods. Middle and top management have a special role and responsibility within this approach. Compared with the innate approach this perspective allows all people to participate and encourages initiatives for their development and career management.

2. The second perspective, as proposed by Skuza et al. (2022) is if talent should be expressed in terms of performance or potential. Does it relate to past performance or potential to perform effectively in the future in a different position? We will be back to this approach when talking about Talent Management later. Silzer and Church (2009) state that in work environments potential is typically used to suggest that an individual has the qualities to effectively perform and contribute in broader and different roles in the organization at some point in the future (p. 379). Nevertheless, the main issues relate to what means high performance or, even more complex than that, what really means high potential, what are the qualities and determinants that contribute to both, or if is it possible to identify both and measure them accurately? If employee performance evaluation by the manager is subject to common errors and bias (see, for example, Latham & Mann, 2006), then potential is not demonstrated in actions and behaviour, requiring additional challenges to overcome subjective judgements.

3. The third perspective is to consider if talent is a person (an employee or professional) or a specific set of individual attributes? Accordingly with Gallardo-Gallardo and Thunnissen (2015) the subject approach, the former one, means that the person is relevant for the organization, unique, rare, non-imitable, difficult to replace if leaves. This implies a solid employment and retention bundle of initiatives. The later approach, the object approach or talent as characteristics of people, means a different paradigm and implies a clear mapping of relevant business skills and a sound development emphasis on those skills.

Besides the three perspectives described above we can ask other interesting questions about talent, namely: Is talent portable? Talent is most of the time taken for granted and is subject to the halo effect bias. But research results do not support this claim. Expatriate policies are not bullet proof and performance success is not consistent across expatriates specially when they are forced to move (see, for example, Collings et al., 2007). Groysberg et al. (2006) also found that a performance decline when Wall Street top market analysts change jobs frequently. Job performance is the best predictor of future performance, but people change every day, and if you change the context, i.e., the job, the team, the organization, the country; then the probability of maintaining the same performance standards lowers.

Other question is what is more important for the organization? A very talented employee in a general position or an above average talented employee in a strategic role, job or function? Huselid et al. (2005) give the example of a commercial flight. Who is or has the most important talent, the pilot, or the cabin crew? Talent has to

have the context and opportunity to express itself and to imply variable contributions to business results. From the customer experience, the cabin crew may have a more important impact on the client retention than the pilot. On the other hand, the pilot performance is highly standardized and prescribed by training, operation norms, procedures and restrictions applied to their jobs. Besides individual talent and his/her capabilities, talent management strategy has to consider jobs, roles and responsibilities that are most relevant to strategy implementation, exhibit high variability in the quality of work that is done and require unique firm-specific know-how and work experience.

As Skusa et al. (2022, p. 120) conclude "there is no single best approach define talent and therefore, organizations may choose a definition that best suits their situation, hence context matters". Some talent it's innate and other acquired. It can be observed in job performance but it also means the capacity to deliver the same level of results in other circumstances because has a transferable nature. It's a person but also may share some common denominators in terms of personal attributes. For instance, Dries and Pepperman (2012) suggest that for Leadership Potential, Analytical Skills (intelligence), Motivation (drive), Learning agility (curiosity, speed, opening to experience) and Emergent Leadership are meta competencies or superior order soft skills. Finally, talent does not happen in a vacuum, it has to be expressed in a specific context, within the organization and the business, so it may be valued and gain any relevance.

Apart from issues regarding talent definition, we also need to look at the concept of Talent Management to understand more clearly what approaches and views organizations follow to manage it. What is really Talent Management? What are its practices and activities? What are its intended outcomes and effects?

3   The Concept and Practice of Talent Management

Talent Management is usually described as systematic attraction, identification, development, engagement/retention and deployment of talents (e.g. Scullion et al., 2010). Its activities may be classified in four categories: Recruiting, Staffing and succession planning, Training and development and Retention management.

Those are common practices in Human Resources Management (HRM). Likewise, talent management activities have typically three intended outcomes and effects. The first outcome is the HRM subsystem, that means the fulfilment of qualitative and quantitative needs of human capital, to narrow the supply demand gap of the organization. This is related to workforce planning, succession management and backups which are old and known HRM practices.

The second outcome is company performance which relates to short term profits, and long term competitiveness and sustainability.

And the third intended outcome is on the individual, motivation, engagement, commitment, and job performance.

As Minbaeva and Collings say (2013) in recent years contributors such as Boudreau, Cappelli and Fitz-Enz suggest several techniques to enable HR managers

to better articulate the contribution of talent management to organisational performance (p. 1770). Creating a line of sight between investments in talent management and organisational performance is the holy grail of the HR professionals permanent search and the most difficult endeavour of the profession. These two authors stress the importance of companies to combine quantitative and qualitative measures, subjective employee perceptions and objective indicators of talent performance to calculate the Return On Talent (ROT) rate (p. 1771).

But it looks we are quite far away from having strong evidence supporting Talent Management effectiveness. Pfeffer (2001) says that it is a mistake to assume that high levels of individual performance automatically aggregate to organisational performance.

Organizational surveys answered by HR professionals tend to be quite overrated and self-biased. We know that there are great discrepancies between intents and practices of Talent Management. Implementing Talent Management is not an easy task. Copying best practices from others usual does not work very well.

Regarding the third intended outcome cited above, paradoxically, it is the easiest result to demonstrate through climate surveys directed to talented employees but seldom they are asked about their experiences and opinions. Some authors state that the managerial and economy-oriented needs of the organization collide very often with the non-economic interests of the talents (Thunnissen et al., 2015).

Besides the issues about talent management effects and results, it is also important to consider how different or similar are its policies and practices when compared with the HRM traditional portfolio. To understand the boundaries between these two sets of activities here we will have a closer look at three strategic dilemmas on the design and implementation of policies and practices, which may influence dramatically the intended results:

1. The First dilemma, is Talent Management for all the workforce or just for a few? This has been called the Egalitarian versus Elite approach. The most common one, in small and large private multinational corporations across the globe is the Elite or exclusive approach (see Skuza review, 2022). A small sample of leaders and managers, a special group of employees with special skills, and on the like. It comes from the HR tradition of having backups and successors for critical positions. It is easier and less costly to implement, it is pragmatic and addresses' a clear business need. In accordance with this approach, talent is managed on the basis of performance. A good illustration of it is Jack Welch management philosophy where only 10% to 20% of the employees may be qualified as talents.

    Regardless the fact that the Elite approach may vary a great deal in a continuum from 1 to 99% of the talents in the headcount, it is not only individual talent that counts but also a talent being in a strategic role or position as we have seen before. Hence this approach raises serious questions of fairness, organizational justice, and business ethics (Gelens et al., 2013). That is why many organizations opt to invest in all employees to develop those talents (Leigh, 2009). Moreover, they apply the term Talent Management to standard HRM practices. Nevertheless, the

inclusive or egalitarian approach may be utopic, costly, and ineffective in large organizations (Gelens et al., 2013).

2. The second dilemma in Talent Management design and implementation relates to who effectively owns and controls the process? The top management, line managers, HR or the Talented Employee him-/her-self? The answer is related to the previous question. A very exclusive approach implies most of the time a centralized and strong involvement of the top management. As the number of talents increases, HR assumes responsibility. Then the line managers are critical to leverage the HR initiatives. What to do, how to do it, how many actors we need to involve?, are the main questions here. Furthermore, apparently the most important thing that research has alerted us recently is that the talent management initiatives usually assume a managerialist orientation (like a plumber that needs to fix a plumbing problem) and the talented person is merely an object of talent management activities and practices. Not considering the person, his/her short and long term social and materialistic needs, may be a serious problem (see Mortensen & Edmondson, 2023).

3. The third and last dilemma relates to talent management as just an employment practice, specifically, recruiting, selecting and integrating, or something a bit broader than that? Most of the research conducted in the last decade has a focus only on employment practices suchlike recruiting, onboarding, employment branding, succession and retention. Most of the organizations that present their talent management programs in popular media refer to the employment branding initiatives encompassing young talents, recruitment and retention. But this is only one face of the coin, or, to be more precise, one of the six faces of the cube.

First, even in a very elitist strategy, there are other talents inside the company that should be identified according their value to the organization, for instance, emergent leaders, technical specialists and/or senior talents. Moreover, to design and implement talent management programs we should also consider other matters like work design (for instance, teleworking policies), flexibility, job rotation, corporate culture of learning orientation, careers, communication and leadership styles. Organizational context matters (Thunnissen et al., 2013). It may hinder or enable the talent management initiatives effectiveness. How many companies have a true holistic and integrated view when designing talent management initiatives?

In summary, designing and implementing effective talent management activities as well as identifying the Talent within an organisation may be a complex endeavour. But, it is a fact that HR, middle and top management never used the words Talent and Talent Management so many times before. Is talent management a "new thing" with real added value compared to HRM or just a cosmetic rebrand for the same people management policies and practices? Assuming that talent management is distinct from HRM, although it pursues the same final organizational intents but has specificities and addresses different people, management problems and challenges, we have now come to a point where we should answer the following question: does the rail sector, in Europe in particular, need a special talent management strategy and

sophisticated initiatives distinct from other HRM practices and activities which are already in place?

The topic covered in the next section, focuses on positive and negative forces which may be part of the business case on talent management in the rail companies in Europe.

4 Does Rail Sector Need a Talent Management Approach?

What factors may promote the talent management movement? The macro social and economic conditions are currently favouring big investments in rail because of the Europe's integration needs and environmental challenges. Rail is becoming more fashionable compared to other transport modes. Technological change also needs new skills. Regarding the social challenges, the rail companies share serious demographic problems because of its ageing workforce. Also, the great resignation syndrome which occurred after the COVID19 pandemic is affecting the sector for the first time. Low unemployment augments against these challenges to find and retain the right talents in the sector.

Besides, for private companies the economic value of talent management is determined by business strategy and market forces. But for public sector companies, like in many rail organizations, institutional pressures are more important than market pressures (see Minbaeva & Collings, 2013). For instance, non-economic issues such-like employee wellbeing, public service mission or job security are probably more important than market ones which may be congruent with some new generation attitudes towards work.

Of course there will be different situations across countries and sub-sectors such as infrastructure, passengers and freight operators, rolling stock, industry and authorities. But this is precisely one of the big advantages of the sector offering a huge diversity of jobs and opportunities to support talent development. The rail companies are big organizations. Job for life may not be over yet. Long life careers may be quite diverse and appealing within the same organization for any talented employee.

But what other factors and sector specificities may hinder talent management initiatives?

Talent Management emerged 25 years ago in US based Multinational private Corporations, evolving as knowledge-based economies. Rail is still a commodity economy and most of the rail companies in Europe have a public nature. More than 50% of the workforce is working onsite in operative and not particular complex jobs. They are not considered "knowledge workers" in pure terms. The working conditions did not change much during the last decades. Moreover, does safety and security norms, which cause a high job standardization, leave space for the demonstration of special talents?

Another factor relates to the union influences and collective agreements which are common in the rail companies. Like safety and security norms, collective agreements do not leave much space for individual management policies and flexible norms.

Furthermore, new employees in operative jobs have fast and short learning curves when start working in a rail company. Continuous learning and knowledge scope are limited and tend to remain stable within the job. Additionally, seniority in rail jobs is typically very long and there is a minimum job change. These circumstances do not comply with the usual talent management demands.

Finally, it is worth noting that for the most of the workforce the rail companies do not have flexible and competitive compensations and benefits which should be applied frequently to attract and retain talented employees who stand above the norm.

5 Implications for Talent Management Programs in the Rail Sector

Considering the pros and cons presented above, *where do we stand regarding the strategic need to have a particular bundle of talent management practices in place within the sector*? The answer is not easy. The rail sector is quite diverse. The rail companies go through different maturity cycles, facing different challenges in the pursuit of different business strategies and goals.

First general conclusion and line of action should be clear. The rail companies need to modernize their people's management policies and align them with the world class best practices. There are no comparative studies to support this claim across Europe but it's not difficult to accept that the rail companies have to became more HRM strategic, agile, sophisticated and effective when compared to other sectors. They must excel in recruiting, by looking for the best in class supply chain processes to attract, select and integrate external candidates, filling vacancies on time because it improves quality, leadership, retention and climate. They must excel in training and skills development initiatives. Compared to other sectors, the railways have been always a centre of excellent for training and skills development. But due to new generations, learning modes and support needs are changing and have to be addressed. They must excel in performance management and people deployment. Talent management efforts within the company may work as a pulling force to promote high class policies and practices in people management.

A second line of action would be to align talent management strategy with business needs and the overall people management strategy. This should be an everyday issue to be discussed in top management meetings and to be scrutinized across the several functions and management layers of the organization. Talent management has to have a clear strategy and operating plans for talented people, with unique and rare skills for critical jobs and roles that maximize contribution. *How exclusive or inclusive should the talent pool be*? Giving the nature and dimension of the rail companies' human capital, a totally inclusive talent management strategy would fail because it is not feasible in large organizations. Young talents and managers are already being involved in special talent programs in several rail companies. But there are other potential talents that may deserve special attention. For example, senior

experts that have not pursued a management career may be crucial for preserving valuable knowledge, retaining and mentoring young people in the organisation. The more senior members of staff need to be helped and assisted whistle transitioning to retirement to free promotion positions to younger colleagues. These are often the forgotten talents. We need to have a leadership pipeline working properly to support talent management specific programs. To the best of my knowledge not a single European company is doing it in a structured and systematic way.

Moreover, the rail companies have to decide on *what do they mean by a real talent*? What are the specific talent attributes and/or competencies that are missing for effective strategy execution? Do we have to get them from outside or develop them internally? Social and technological changes in the rail sector are demanding new skills and several studies are currently going on (see the Staffer project). But we still have to work more seriously on what concerns critical competencies' mapping. If the company is having safety problems in the operations department, if it is a new technology for information management that is needed in construction or in train driving, or if it is a new sales and marketing strategy, the required skills should be mapped correctly and reflected in the workforce planning, training and development programs. If those skills have an innate nature, it is better to reflect it on external acquisition.

Finally, talent management strategy needs to consider the jobs and roles that may make the difference in terms of contribution. Deciding what are the critical jobs and roles which have a greater impact in the business helps to establish priorities and inclusive or exclusive criteria for including employees in talent management initiatives. HR should lead this process.

Beyond the generic recommendations covered up to now there are some other more specific for the rail sector.

There's a common mistake to think that the big rail companies are the incumbents and do not need to work hard in its image, reputation and employer branding. Several surveys in different countries, even those with advanced national rail systems, attest that the young generations do not know the economic structure of the sector, business strategy, organization of work, jobs and future opportunities (see for example, final results of the ASTONRail Project, led by Aston University, 2023). We have to communicate more effectively the employee value proposition of the sector in each company and create attractive and aggressive conditions to compete with industry, builders and contractors. Governments and rail authorities have great responsibilities in this regard as well.

Another common mistake from the rail companies is to give priority to external candidates in filling internal vacancies. Yes, the rail companies have an ageing workforce and getting new blood form outside the sector to renew the workforce is probably the easiest way. Human capital in the sector is characterized by high seniority and long monolithic careers. Career crystallization and no internal selection policies are quite pervasive across the sector. But for many positions, the best candidates for a vacancy may be internal ones. As state by Cowgill et al. (2023) the solution is faster, cheaper, assures a better placement within a large workforce, bring more opportunities to generalists and promotes a positive organizational climate.

In addition the authors say that we have to strive to create a real internal talent marketplace. To complement that we have to create talent marketplace for all the employees, talents and "non talents", from operator levels personnel to supervisors, for leadership positions and highly specialized analysts.

Another yet common mistake in talent management programs is to misjudge what really matters to employees, with special emphasis in young talents. As Mortensen and Edmondson (2023) point out it's not only about employment and training. We need constantly to look at the social needs of our talents and try to address them through coaching and mentoring programs, special assignments and intercompany mobility. This must be done with a focus on the talented individual and not on the company.

Finally, we have to retain the "real talents". Turnover is not a problem. If happens it should be managed as an opportunity (Minbaeva & Collings, 2013). Rail needs marathoners rather than 100 m runners. If they are coming for money they will leave for money (Pfeffer, 1999). Retain talent without selling the organization soul but still love your employees.

6   Conclusion

In this paper we tried to clarify the concepts of Talent and Talent Management under the human resources management domain. Talent management has to be seen as distinct and complementary to the standard human resources management. Otherwise, it would be only another fad and fashion in the field. We have to be more precise in using these terms.

Good talent management practices may help the organizations to improve its people management policies and practices. Additionally, it may help the rail organizations to address sustainability challenges they are facing. Talent management is not only an employment practice. Talent management practices should cover the whole employee experience from start to exit.

We have to be prepared to break some myths and work on employer's branding, creating a more dynamic internal talent marketplace, revitalizing and bringing to the front stage forgotten talents within the company, know better our talents to align with the company and employee preferences, and balance the 'retain/let go' decision because turnover maybe is not the end of business.

The rail sector has a bright future in creating a better world. Rail people are talents and the most relevant asset an organization needs. Better talent management policies and practices have a particular role in making this happen.

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