Universities in Europe and the United States Collaborate to Develop Future Railway Engineers

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ABSTRACT
The rail industry is facing unprecedented levels of retirement and potential growth over the next five to ten years and it is becoming more globally oriented where major players function and operate in multiple nations and continents. With growing demands, it will be a challenge to find new rail professionals for the industry’s workforce, as the universities have abandoned or reduced rail programs over the past several decades. In addition, future rail professionals must understand the system complexities, new information technologies, and the global aspects of today’s rail industry that have traditionally not been required.

TUNRail is an on-going two-year project funded under the EU-US Atlantis Program that has brought together faculty from several universities in Europe and the United States to examine railway higher education programs, explore opportunities for knowledge exchange and collaboration, and develop materials for new railroad education and research programs. It is the first known effort to bridge the knowledge in rail higher education and the initial step toward continuous collaboration to strengthen the role of railway education and research in academia.

The first tasks of the project are an inventory of current rail university programs on both sides of the Atlantic and an industry survey to define the qualitative and quantitative demand for rail higher education and for educated professionals in the rail industry. Based on the outcomes the research team is assessing how well current university curriculum meets the demands and addresses the key aspects of modern rail systems. The research also highlights the similarities and differences between programs in the US and EU and the level of involvement between academic programs and the rail industry. One of the primary outcomes of the project is a Handbook for Rail Higher Education which will be an invaluable resource for the future development of existing and new railway education programs.

This paper/presentation introduces the TUNRail project and the Electronic Handbook. It summarizes the research outcomes to date, including the inventory of university rail programs in Europe and the United States and the initial results of the industry survey. Finally, the paper provides a brief overview to techniques and methodologies developed to make education more global and teaching strategies more suitable for today’s student body.
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**Keywords:** Higher education, Transatlantic collaboration, Workforce demand and supply, University-industry cooperation

1- Background

The world is changing fast and rail transportation is no exception. More skills are needed from rail industry professionals than ever before which necessitates higher level and continuous development of skills and qualifications. Future rail professionals who serve in the diverse rail industry must be able to master increasing levels of new information technologies and system complexities which differ from the historical concepts that concentrated more on local issues. The changes in the rail systems and industry provide a promising setting for increased transatlantic cooperation in education and research where institutions of higher education in the United States, Europe and beyond can work collaboratively with their industry partners to enhance two-way knowledge transfer and to benefit from the lessons learned on both sides of Atlantic. During past several decades, railway higher education programs were scaled down or discontinued due to low demand, but the growing interest and increasing complexity of railway systems warrants a re-evaluation of the programs necessary to adequately address the emerging challenges. These programs are also key components in securing the future professional workforce to the industry that is facing unprecedented level of retirements within next five to ten years [1] and a transition to a more global rail education and training warranted by the changes in the industry [2, 3].

2- Introduction to TUNRail

TUNRail is a policy oriented project funded in collaboration between European Union (EU) and United States (US) Department of Education and intended to “tune” and intensify the railway higher education knowledge exchange and collaboration between the EU and the US [4]. More specifically, this two-year long project uses benchmarking and comparisons analyses to investigate the current rail education programs, and to identify how well they address the key aspects of modern railway systems. The TUNRail project increases transparency, identifies similarities and differences between railway systems and educational programs, and provides a solid foundation for more extensive cooperation and for the establishment of new programs on both sides of the Atlantic. The work also compares and evaluates and current teaching and learning practices of the railway systems in European and US institutions of higher education, and defines the level of collaboration between the academic programs and the railway industry.

The final products of the project include an Electronic Handbook in Railway Higher Education and dissemination of research outcomes through a final newsletter and web conferences. The handbook includes a comprehensive inventory and analysis (comparison and benchmarking) of current railway higher education programs and practices in the EU and the US, examples of better practices and successful approaches in railway higher education and specific recommendations and strategies for enhanced transatlantic knowledge transfer and for the development of new programs, or improvement of current programs. The main research tasks and overall timeline of the project are presented in Figure 1, followed by discussion of research outcomes to date which will eventually be incorporated in the Electronic Handbook.
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Figure 1. TUNRail Project Tasks and Schedule

3- Inventory of Current University Rail Programs

One of the primary objectives of the ATLANTIS TUNRail study is to gather railroad transportation and engineering course and program data from universities in both the US and EU. These data were obtained from universities with formal railway educational and/or research programs, as well as from universities that offer classes in railway transportation and engineering. The data collection effort primarily focused on four-year programs. Therefore, data on two-year associate degrees, short courses, and educational opportunities offered primarily to industry professionals were not included in this study.

US railroad course and research data were collected by electronic survey during 2009 and 2010. The list of survey recipients was developed based on the TUNRail team's knowledge of existing programs and courses, as well as a list of professors that recently attended one of two Railroad Engineering Education Symposium (REES) training workshops aimed at encouraging processors to include railroad engineering content into their curricula. Courses with only a small percentage of railroad-related content (i.e., an introductory transportation course with 10% of the course content devoted to rail) were not included in the survey data, and these professors were not targeted in the data collection effort. The data from the EU were collected using survey templates that were distributed via email to department heads or full professors responsible for development and inclusion of railway engineering coursework in their curriculum. The course-level data were then compiled into sub-sheets for each country.

Even though the TUNRail research team made every attempt to develop a comprehensive inventory of US and EU programs and courses, it is recognized that some academic institutions engaged in railway transportation research and teaching activities are not included in the data. This is especially true in the EU, where current levels of railway education and research in academia are considerably more extensive than in the US, thus more challenging to quantify. Additionally, there may be weaknesses in the data set due to language barriers (mainly in EU) and other sources of potential inaccuracies (EU and US). In summary, these data were not verified after collection, and are presented on an “as-received” basis from the respondents.

Table 1 summarizes the railway education in the US and EU. The comparison of university program data between EU and US is challenging, due to different structure, extent and emphasis of the rail education programs on both sides of the Atlantic. In general, the US has a very limited number of academic programs and course offerings and most of the rail courses are at introductory level. In the US, there are also at least 10 universities with railway research activities that are not currently engaged in teaching rail related courses. In EU, there are a wide variety of railway transportation and engineering courses available. EU has dozens of railway programs dispersed between the EU nations, with a high percentage of the programs being located in the predominantly German-speaking regions. Even though a multitude of
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universities exist in the EU with rail education and research related activities, there is no a uniform system of railway higher education. Instead, there are still significant differences between countries. One of the primary differences between the US and the EU is that research and teaching of railways is almost always linked together at the same university in the EU. In other words, with rare exceptions, there are no universities with research and not teaching, and vice versa while in the US this is more common.

Table 1- Summary of US and EU Railway Transportation and Engineering Course Offerings

<table>
<thead>
<tr>
<th>Description</th>
<th>US Railway Education</th>
<th>EU Railway Education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example course topics</td>
<td>Railroad Track Engineering and Design</td>
<td>Railway Operations Management</td>
</tr>
<tr>
<td></td>
<td>Railroad Operations and Management</td>
<td>Railway Signalling</td>
</tr>
<tr>
<td></td>
<td>Railroad Planning and Design</td>
<td>Transportation Economics</td>
</tr>
<tr>
<td></td>
<td>Intermodal Freight Transportation</td>
<td>Railroad Vehicle Engineering</td>
</tr>
<tr>
<td></td>
<td>Public Transit</td>
<td>Operation of Railroad Vehicles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Railway infrastructures</td>
</tr>
<tr>
<td>Number (range) of students enrolled in courses</td>
<td>10-40 (undergraduate) 3-15 (graduate)</td>
<td>20-200 (undergraduate) 10-20 (graduate)</td>
</tr>
<tr>
<td>Average number of railway courses offered per year (total for US)</td>
<td>10</td>
<td>260</td>
</tr>
<tr>
<td>Examples of collaboration with the railway industry</td>
<td>Railway industry funding</td>
<td>Railway industry funding</td>
</tr>
<tr>
<td></td>
<td>Sponsored research projects</td>
<td>Sponsored research projects</td>
</tr>
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<td></td>
<td>Official partnerships with financial support</td>
<td>Official partnerships with financial support</td>
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<td></td>
<td>Internships</td>
<td>Internships</td>
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<td></td>
<td>Field trips for classes or railroad student chapters</td>
<td>Field trips for classes</td>
</tr>
<tr>
<td></td>
<td>Development of course material</td>
<td>Guest speakers / professors from industry</td>
</tr>
<tr>
<td></td>
<td>Guest speakers</td>
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</tr>
</tbody>
</table>

4- Industry survey

A targeted (ad hoc) industry survey was conducted online by TUNRail team to define the quantitative and qualitative need for higher educated professionals by the railway industry in the US and EU. The industry survey consisted of two separate parts. The first (shorter) part was targeted to all rail industry professionals and concentrated on learning more about them as individuals, their background and paths to the industry and their opinions on the importance of university participation. The second (more comprehensive) part was mainly targeted for managers of young professionals and those involved in recruitment and training. The structure of each part of the industry survey is presented in Figure 2.
Part I of the industry survey was completed by almost 600 respondents throughout the world. The majority of respondents were males (88 percent). Almost 60 percent of the respondents were from the US, 25 percent from EU and the remainder from other parts of the world. The educational background of respondents is provided in Figures 3 and 4. The respondents from US had somewhat lower level educational degrees than their European counterparts and they came more heavily from engineering background, especially from civil engineering.
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The majority of respondents didn’t have exposure to rail topics either prior to or at the university (Figure 5). Respondents from US had slightly more exposure prior to university, while respondents from EU had somewhat more exposure to rail at the university. When asked about the importance of this exposure to career decision, approximately 90 percent and 70 percent claimed either major or minor importance in US and EU, respectively.

Figure 3. Educational level of respondents

Figure 4. Respondents’ majors
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Figure 5 - Exposure to rail prior to, or during university

Over 50 percent of the respondent claimed that their organization was collaborating with university and almost all respondents were unanimous on the benefits of Trans-Atlantic collaboration (Figure 6). There was much higher level of collaboration in research and project type of activities between academia and industry in the EU, while US had slightly more internship / co-op arrangements (Figure 7).

Figure 6 - Industry collaboration with universities
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Part II of the survey that concentrated on quantitative and qualitative demands, such as more detailed questions of core competences and preferred educational backgrounds of graduates, and on the importance of university relations was completed by approximately 150 respondents. Detailed analyses are still under way, but some of the initial observations include the following:

- 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 (50 percent and 30 percent respectively). 80 percent expected the number to continue to increase over the next five years. Respondents from US had the most optimistic view of the future employment levels.

- There were significant differences in the rankings of core competencies, preferred background and desired skills by the graduates between US and EU. For example, engineering majors were ranked higher in the US while business related majors, such as economics or law were ranked higher in EU. It is believed that part of the reason for differences was the background of respondents. US pool was very engineering oriented, while EU respondents came from wider variety of backgrounds.

- The greatest barrier for engaging in university-industry collaboration (mentioned by over 50 percent of the respondents) was the perception that time commitment for such agreements is too high.

- Higher percentage of respondents from EU (50 percent versus just over 20 percent) believed that the current courses (curricula) by universities are adequate in addressing the key competences required from graduates.

The complete outcomes of the industry survey will be incorporated in the Electronic Handbook and posted at the project web site [4].

5- Approaches to Increase the Global Education and Innovative Teaching Strategies

As rail transportation industry becomes more globally oriented, it must be considered whether the educational offerings should undertake similar transition. One of the first steps in the process is to understand what is meant by global education, what methodologies can be used and what tools are needed to achieve the desired outcomes. According to Alan Parkinson [5], the engineering students with
global competence should be equipped with a wide set of abilities. The most important abilities include: 1) appreciation to other cultures, 2) proficiency in working in or in directing a team of ethnic and cultural diversity, 3) ability to communicate across cultures, 4) effective dealing with ethical issues arising from cultural or national differences, and 5) engineering practice in a global context, whether through an international internship, a service-learning opportunity, a virtual global engineering project or some other form of experience.

To prepare the students with these abilities, emphasis should be placed on three areas of education: 1) foreign culture appreciation and understanding, 2) communicating in foreign language, and 3) real-world practice in a global context. Based on Parkinson, an individual program that only focuses on one of these aspects, such as on campus foreign language training class, is not sufficient. A complete program should combine the three aspects. If this is not possible, a program system constituting different levels of activities should be established, and the activities should involve training or education that can compensate for missing elements.

In the past several decades, many innovative approaches toward global education in the engineering field have been developed and experimented. These approaches can be grouped into several categories and some of the features and existing program formats were introduced by Alan Parkinson [6], James L. Melsa [7] and other literature. Lautala and Ma compiled these approaches to a comparative Table (Table 2) [8]. Although the table is not all inclusive, it provides a basic introduction to the most common approaches currently used to global education.

<table>
<thead>
<tr>
<th>Program Formats</th>
<th>Description</th>
<th>Summary</th>
</tr>
</thead>
</table>
| Traditional international activities | Visiting lectures by foreign visitors, international conference, visiting scholars, foreign culture course, foreign language training, enrolling international students, bilingual teaching. | • The most extensively used methods.  
• Easy to organize and easier to recruit students.  
• Have an introduction to foreign culture and meet the local students |
| E-learning & E-teaching          | Teaching by foreign universities lecturers through internet-based tools                                                                                                                                       | • Economic way for the students learn foreign technologies  
• Limited exposure to foreign culture |
| Virtual global I-class           | Students from different universities study together by using internet-based tools in a virtual global classroom.                                                                                           | • Good opportunity for students to learn about global issues.  
• Exposure to foreign culture is limited. |
| Short-term study-abroad programs | Extended field trip, summer program or mentored travel: Students travel to one or several countries and visit companies and/or universities for a tour and/or lectures between one to several weeks under the guidance of a faculty member.  
Internship or Co-op: students work abroad for a company or at an international branch of a U.S. company.  
Research abroad: students travel to an foreign laboratory and conducts research under the guidance of a faculty member, etc.  
Project-based learning: students travel abroad and are immersed in another culture via a                                                                 | • Brief exposure, but an efficient way to attract the students to participate in more extensive programs  
• A good approach for the real-world practice and brief exposure to industry issues.  
• Good approaches for real-world problem solving.  
• Team work typically included.  
• Deeper exposure to foreign culture. |
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<table>
<thead>
<tr>
<th>Long-term study-abroad programs</th>
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<th>Long-term on campus programs</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Exchange: students from the two universities involved are exchanged for a period and take regular courses in the host university. Degree awarded by their home university.</td>
<td>• A popular study abroad program format. • Credits, reorganization and exchange as well as a parity exchange must be coordinated. • An in-depth exposure to living abroad on campus.</td>
<td>Dual degree: the students obtain one degree from the home university and another one from the foreign university during a period of study abroad.</td>
<td>• Most difficult one for the students to fulfill. • Mostly for graduate-level programs. • An in-depth exposure to living abroad</td>
</tr>
<tr>
<td>Partner sub-contract: the home university cooperates with a foreign university and contracts for courses to be taught to students of the home university.</td>
<td>On-campus foreign course study rather than studying abroad. • The students always are taught in English. • The exposure to foreign environment is eliminated. • Varieties of international programs can be organized easily.</td>
<td>Extension: the home university operates a pseudo-extension campus in the other country at a permanent facility.</td>
<td>• More global experience opportunities are offered for the students from both campuses or universities</td>
</tr>
<tr>
<td>Branch campus: the home campus works together with a branch campus in foreign country.</td>
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</tbody>
</table>

Others

Combination of the previous formats

The second key component of a successful global education is to understand the learning styles, so a proper set of tools and activities can be used by the programs. “How People Learn” (HPL) was founded on a review of recent research in cognitive science and it describes the four principles that should be included in the design of learning environments. The principles include:

- **Learner Centered**: takes into account the learning styles, attitudes and unique characteristics of users; recognizes the prior knowledge and skills that users bring to the learning environment.
- **Knowledge Centered**: provides opportunity for hands-on, learner-driven, interactive learning that leads to students learning with understanding, rather than acquiring disconnected sets of facts and skills. The goal is a mastery of concepts and “transfer of learning” that can then be applied elsewhere.
- **Assessment Centered**: finds ways to monitor progress; not just a test at the end; allows for feedback along the way.
- **Community Centered**: considers the context in which learning takes place; promotes a sense of community through shared goals and values [9].

HPL transforms the teaching from traditional teacher-centered to learner-centered with more focus on self-learning and active-learning. Active learning can be defined as any instructional method that engages students in their own learning process by encouraging them to think about what they are learning and how well they are learning it [10].

While it is not the objective of this paper to develop a teaching strategy for rail higher education, it must be recognized that institutions should incorporate methodologies and tools that provide a close alignment with today’s learning styles. Some of the innovative methodologies include problem, project and challenge-based learning and collaboration, and context based learning styles. Specific tools and technologies that have played a major part in the expansion of new learning styles include simulators, virtual environment based games and on-line courses.
The learning style is dependent on the teaching and training policy and practice of the Higher Education Institutions (HEI). The organization and development of the courses specify to a certain extent the method of teaching which suggests the learning style. Recently, universities have been promoting innovative teaching and learning through multidisciplinary approaches. An example of such an initiative in the rail higher education is the RIFLE project funded by the ERASMUS programme of the European Commission [11]. RIFLE stands for Rail Freight and Logistics Curriculum Development and combines two different sectors – railways and logistics. Specifically, the aim of this project is to develop and run a joint MSc programme that teaches how rail freight services could benefit from lean logistics principles and how logistics chains could benefit from the railways as an environmentally friendly transport mode. The programme will be run in parallel in four European HEIs and include compatible modules to allow for students to do some of their modules at one of the other universities of the participating HEIs. To ensure best results from the EU sustainability agenda the programme will partner with rail-/and logistics-focused companies and institutions. This way, students will be moved away from specialized academic training towards new computer systems, research-driven solutions and real-life problems, which has a positive effect on driving economic progress in society at large.

6- Summary and Conclusions

This paper has provided introduction to TUNRail which is an on-going two-year project funded under the EU-US Atlantis Program. The project has bought together faculty from several universities in Europe and the United States to examine railway higher education programs, to explore opportunities for knowledge exchange and collaboration, and to develop materials for new railroad education and research programs. The final outcomes of the project will be included in an Electronic Handbook in Railway Higher Education posted to the project web site.

University data analyses have revealed that US has a very limited number of academic programs and course offerings and most of the rail courses are at introductory level. EU has dozens of railway programs dispersed between the EU nations, with a high percentage of the programs being located in the predominantly German-speaking regions. However, there is no a uniform system or approach to railway higher education in the Union. In addition to the vast difference the scale of activities, one of the primary differences between the US and the EU is that research and teaching in railways is almost always linked together at the EU universities while in the US this is not the case.

Over 600 industry professionals from US, EU and beyond responded to the on-line survey conducted by the research team to define the quantitative and qualitative needs for professionals. The survey analysis is still in progress, but the preliminary results have revealed that limited number of professionals had exposure to rail topics either before or at the university. There was a high level of agreement that transatlantic collaboration would be beneficial to the industry. It was also interesting to see that there were clear differences between the US and EU respondents in many categories, such as their background, and their rankings of core competences and skills required from the new graduates.

As rail industry continues to become more globally oriented, it should be considered whether the educational offerings should undertake similar transition. The paper shortly reviewed some current approaches for global education and provided a discussion on learning styles that can be beneficial in the process. It also provided an introduction to RIFLE project which is an example of a modern educational program in EU to advance the education of rail transportation and logistics.

7- References

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[3] FUTURAIL, "Job Opportunities for the Railway Community of Tomorrow, on-going EU collaborative project funded by Seventh Framework Programme", Grant Agreement for: Coordination and Support Actions (supporting)


