



How efficiently educational programs prepare professionals to meet current and future challenges of transport interchanges

Eftihia Nathanail¹, Giannis Adamos^{1*}, Lambros Mitropoulos¹, Ioannis Karakikes¹, Irina Yatskiv (Jackiva)²

¹Department of Civil Engineering, University of Thessaly

²Mathematical Methods and Modeling Department, Transport and Telecommunication Institute

Abstract

The objective of this paper is to identify relevance of the existing educational programs to the skills required on job, as perceived by the stakeholders involved, such as policy makers, transport operators and service providers, academia and research sector. The research was conducted based on a questionnaire survey retrieving the knowledge gained through educational and training programs, the importance of this knowledge and its relevance to the skills required for further career pursuance. In parallel, analysis was done of various curricula offered by prominent educational institutions throughout Europe, in the context of or associated with transport interchanges. Findings indicated that there is significant deficiency of knowledge in the European policy on intermodal transportation, business models building and interchange design. Also, it was observed that there is an increasing requirement for gaining skills on sustainable development and transportation planning, decision making methodologies, data collection methods and utilization of big data for policy-making.

Keywords: Life-long education, intermodal transportation, stakeholder analysis, planning and policy, smart solutions, decision making.

1. Introduction

The European Commission has defined intermodality as a policy under which “*different transportation modes are being combined in a trip, in order to achieve a seamless journey*”, with the aim of providing the means for better mobility and impact minimization (European Commission, 2007).

Transport interchanges are the network components, which enable intermodal operations. From the view of passengers, transport interchanges can be defined as “transportation nodal points that enable seamless mobility, increase travelling efficiency, achieve user satisfaction and ensure system performance for door-to-door journey by making optimal use of combinations of modes in a sustainable way” (Adamos et al., 2015). Adjusting this definition to freight transport, freight interchanges can be

*Corresponding author: Giannis Adamos (giadamos@civ.uth.gr)

introduced as network nodes, which are required for the transshipment of goods along a corridor and enable logistics operations, considering sustainability of the operations and the environment where they occur.

In physical terms, transport interchanges constitute the field of intermodal activities. This includes interconnection of a long and a short distance trip, transferring from interurban network to urban distribution and “last mile” delivery through change of transportation modes and/or vehicles. Sustainable operation of transport interchanges requires acquisition of knowledge, skills and competence on a wide range of topics: planning models and policy formulation, smart solutions to facilitate operations, assessment methodologies and decision-making techniques.

According to a recent study by the U.S. (United States of America) Departments of Transportation, Education and Labor, transport industry is projected to experience steady growth in employment by 1.3 percent annually between 2013 and 2023 (US Departments of Education, Transportation and Labor, 2015). A strong understanding of demand and supply and a skills’ gap analysis will help plan for the changing workforce needs of the transport domain. The study highlighted a significant skills’ gap in the demand for and supply of high skilled workers and suggested as a solution to increase the Career and Technical Education programs.

At European level, attempts have been made during the last decade, towards creating a common understanding and common conditions, for carrying out the necessary education and training actions in the field of transport (DETRA project, MORE and MORE2 projects). Competence needs and gaps analysis have been conducted for European industries and educational institutions in rail, air and public transport (projects TUNRail - Tuning Transatlantic Cooperation in Rail Higher Education, European Commission, Atlantis Programme; EDUCAIR – Assessing the Educational Gaps in Aeronautics and Air Transport, European Commission, 7FP Programme; Bus Rapid Transit- Centre of Excellence on Bus Rapid Transit, Volvo Education and Research Foundations) (Macário and Reis, 2014).

To address the specificities and complexity of the domain of transport interchanges, Mitropoulos et al. (2017a) implemented gap analysis and studied the trends in transport interchanges and the available European educational programs. They identified the knowledge requirements for Latvia and the Baltic Region, as modest innovation performance states (European Commission, 2014a), with low expenditure in high education and business enterprise (European Commission, 2014b). Finally, they developed a complete curriculum addressing the above requirements for sustainable transport interchanges, adopting the outcomes specified by the European Network for Engineering Accreditation (ENAE, 2015), to assure the quality of engineering programs offered by European Higher Education Institutes (HEI).

Based on the topics identified in the latter study, as well as emerging trends in the domain of transport interchanges (HORIZON 2020, Transportation Research Board, 2016), the objective of this paper is to investigate relevance of existing knowledge, importance and requirements for skills and competence on job, as perceived by policy makers, industrial bodies, including transport planners, operators, and service providers, and stakeholders from the academia and research sectors. As research and innovation depend on the capacity of economies to become even more knowledge-oriented and innovation-driven through public expenditure on research and development (European Commission, 2014a), this work focused also on identifying specificities of countries of modest and moderate innovation performance, low public expenditure on Research and

Development (R&D) (as proportion of Gross Domestic Product) and low BERD intensity (business enterprise expenditure on R&D). The components of transport interchanges are analysed through the sustainability dimensions. Accomplished and current activities in the domain of interconnecting academic policies and industrial practices are documented and commented. The design of a survey addressed to the three groups of actors is explained and the results are analysed in detail and discussed so that to provide the grounds for further elaboration.

2. Background

In the recent years, European research addressed the topics of intermodality and sustainable transport with emphasis on transport interchanges, both for passengers and freight. Organizational and institutional structures, infrastructural and technological solutions and decision-making schemes were identified as the main sustainability dimensions of the transport interchanges (Adamos et al., 2012).

Organizational and institutional structures include the definition of roles and responsibilities among the involved stakeholders and regard issues such as regulations, financing, ownership and jurisdiction on infrastructure and operational procedures. It is expected that policy objectives and measures on intermodality, also affect the sustainability of the transport system (Banister and Berechman, 2001).

The infrastructural dimension comprises the supply side performance and the interchange physical properties are related to design, location, accessibility, space, capacity and equipment.

Smart solutions include technological tools and other innovative measures, regarding information, services and physical properties, which enable the efficient operation of intermodal interchanges and provide services of high quality, environmental protection, energy conservation and sustainability.

Decision making highly relies on data availability and prominent assessment methodologies. Data on intermodal mobility are generally nonexistent or insufficient and there is poor knowledge on the market segments for intermodal transport. Insights for modal split and market potential for intermodal mobility are usually addressed in terms of national travel surveys, but these are not sufficiently focused on intermodal mobility (Collet and Kuhnimhof, 2008). Scientific profound assessment methodologies are considered as essential components for establishing a coherent decision making framework and the structure under which discussions among involved stakeholders take place (Adamos et al., 2012).

3. State of the art

The generation of new knowledge through academic research and its transition to new services, products and patents is essential for the development of industry, technology, economy and competitiveness. Traditionally, universities and academia concentrate on pure research, while industry mainly focuses on applied systematic investigation of materials, sources and processes.

Considering the nine Technology Readiness Levels (TRL) of the European Commission (European Commission 2014-2015), which are used to determine the status of Research and Development (R&D) activities and enable the transitioning of technology, it seems that academic and industrial research address different TRLs. The ideal situation would be that academic research moves efficiently to industrial development and consequently to commercialization. Still, there are issues that create

difficulties in this “transition”, among which is the limited use of publicly funded R&D. For example, the average European universities demonstrate much fewer inventions and patents than the North American. Factors that impede this progress are: inadequate management of knowledge and intellectual properties by universities, cultural differences between the science and business communities, legal barriers, lack of incentives, etc. (Communication from the Commission, 2007).

Acknowledging the importance of university-industry collaboration and knowledge transfer for the enhancement of competitiveness and exploitation of public research, the Member States of the European Union have made efforts to reform National Programmes under the Lisbon strategy. Towards this direction, a large number of initiatives have been taken already, aiming at establishing linkages between academic research and the business sector, including commercialization, which is considered as an objective indicator of measuring the outcomes of the research conducted in universities (Communication from the Commission, 2007, Markman et al., 2008). In order to support commercialization, a lot of universities have developed specialized mechanisms, as for example, technology transfer offices, science parks, etc. (Siegel et al., 2003).

Apart from commercialization, there are multiple other alternatives for university research to be successfully transferred, and contribute to economy, industry and society. Such an alternative is “academic engagement”, defined by Perkmann et al. (2013), as “*knowledge-related collaboration by academic researchers with non-academic organizations*”. In fact, some enterprises prefer this way of knowledge transfer compared to licensing university patents (Cohen et al., 2002). Complementary to academic progress, studies on the consequences of scientists’ engagement have indicated that this collaboration can result to a positive and healthy working environment for a company, enhancement of creativity and overall increase of productivity (Kahn, 1990).

Historically, research institutions are considered as sources of generating new ideas, whereas industry provides the required means for the optimization of the use of these ideas. Significant enablers of knowledge transfer between industry and academia are the adequate autonomy of institutions to recruit experienced personnel on a competitive basis and the active pooling of resources among the research institutions (Communication from the Commission, 2007). For the wider possible level of the pooling of resources, i.e. transnational, the European Commission has created the Innovation Relay Centres network, which facilitates the transfer of innovative technologies to and from European companies or research departments. Such Centres are established in 33 countries and offer personalized assistance for universities and industry, with main focus on Small-Medium Sized companies (SMEs) (CORDIS, European Commission). Another initiative of the European Union (EU) is the establishment of the European Institute of Innovation and Technology, which is an independent EU body, aiming at promoting the interactions and knowledge transfer between research institutions and industry (European Institute of Innovation and Technology).

The European Commission (EC) has always supported transnational knowledge transfer and the involvement of SMEs in academic research, through its funding mechanisms, i.e. Research and Technological Development Framework Programmes (FP), which promote the collaboration between public and private sectors from several countries. The most recent initiative of EC is the European Union Horizon Program: Horizon 2020, which is the largest research and innovation program that has ever been funded (HORIZON 2020). Focusing on transportation, the main priorities set in this program, include: a) making transport more sustainable, b) making transport and transport

systems seamless, c) promoting European transport industry as an international leader, and d) conducting socio-economic research and forward-looking activities for policy-making (HORIZON 2020).

The fact that transport sector is rapidly developing and changing in order to meet new technological accomplishments, increased environmental, societal, mobility, traffic and economical concerns and challenges and drove to the need of innovative and up-to-date approaches in the education and training of current and future practitioners. This need has been recognized by a number of EC Horizon 2020 projects, which focus on the development of the appropriate skills and competences of transportation professionals. For example, SKILLFUL project aimed at reviewing the existing, emerging and future knowledge and skills requirements of workers in transportation and structured the appropriate components of the curricula and training courses that can cover these competence requirements (SKILLFUL project). The goal of CAPITAL project was to build a collaborative capacity community and deployment program, in order to support private and public stakeholders in the application of Intelligent Transportation Systems (ITS), with training and educational resources that enable knowledge transfer (CAPITAL project). The ALLIANCE project's objectives were to enable the stimulating and strengthening of scientific and technological capacity of Latvia and to raise the profile of the research personnel and their institution, by providing knowledge in the field of smart interconnecting sustainable transport networks (ALLIANCE project).

Co-funded by the Erasmus+ Programme of the European Union, S.T.R.E.E.T. project (2015-2018) aimed at determining a new professional profile for experts in sustainable mobility and tourism, addressing two main sectors: alternative mobility and sustainable tourism. The project developed an open platform including a basic course on mobility management, a training section and material, best practices section, tourism information section, etc. (S.T.R.E.E.T project). A current Erasmus+ project is SKILLSEA (2019-2022), which focuses on identifying the skills that future maritime sector needs and delivering a roadmap towards a sustainable skills strategy (SKILLSEA project).

4. Methodology

The aim of this study is to identify the relevance of knowledge, importance and requirements for skills and competence on job, as perceived by the stakeholders in the domain of transport interchanges. To achieve its goal, an on-line questionnaire survey was conducted by the Traffic, Transportation and Logistics Laboratory of University of Thessaly (Greece) and the Transport and Telecommunication Institute (Latvia), investigating the level of knowledge on transport interchanges and its importance. The survey was structured based on the 12 topics that resulted as educational requirements for sustainable transport interchanges, as they have been identified by Mitropoulos et al. (2017a) and the 15 emerging trends identified by the collaboration of the EU and the US as regards the intermodal transportation (HORIZON 2020, Transportation Research Board, 2016).

4.1 Curriculum topics on sustainable transport interchanges

The 12 topics were formulated after an analysis which focused on the identification of the existing status and gaps between 1) The transportation industry, and 2) The research, education and training programs in Europe regarding sustainable transport interchanges (Mitropoulos et al., 2017a).

The considered education and training programs were selected from a list of postgraduate curricula offered by prominent educational institutions throughout Europe in the wider context of intermodal transport.

The selection process was based on a set of pre-specified qualitative criteria and resulted in the identification of 18 postgraduate programs and 114 courses. Furthermore, courses were allocated to eight categories, as follows (% = percentage of each category's courses over the total number of courses):

- Transportation planning (12.3%)
- Transportation economics (10.5%)
- Transportation policy (12.3%)
- Transportation environment (7.0%)
- Transportation modelling and technology (7.9%)
- Transportation logistics and business (20.2%)
- Transportation operations (21.9%)
- Transportation engineering (7.9%).

Educational programs were compared with transportation industry requirements, based on which 20 educational areas were specified, finally formulated into a 12-topic educational program entitled “Sustainable Transport Interchanges Program – STIP” (Mitropoulos et al., 2017b). Implementing the three sustainability dimensions of transport interchanges (Adamos et al., 2012), the 12 STIP topics were grouped in three categories, as follows:

- (1) Planning and policy: The European policy on intermodal transportation, Building business models for intermodal transport interchanges, Transportation planning and sustainable development, Operation and management of intermodal transport systems, Optimization of intermodal transport systems
- (2) Smart solutions: Intelligent services for passenger transportation, Information systems of intermodal freight transportation, Design of passenger transport interchanges, Design of freight transport interchanges, Smart technologies for efficient transport logistics
- (3) Decision-making: Decision making methodologies, Data collection methods.

4.2 Emerging trends on sustainable intermodal transportation

The 15 emerging trends in the domain of sustainable transport interchanges (HORIZON 2020, Transportation Research Board 2016), also grouped under the three categories, are:

- (1) Planning and policy: Utilization of big data for policy-making, Innovative organizational and governance concepts for mobility solutions at neighborhood and district level, Public procurement of innovative sustainable transport and mobility solutions in urban areas, Optimization methods improving resilience of interchanges (i.e. under unexpected events), Incorporation of Vehicle-to-Infrastructure (V2I) and Infrastructure-to-Vehicle (I2V) systems and information-sharing in efficient operation and management of interchanges, Benefits of connected-automated vehicles in the operation and management of interchanges, Shared-use services and solutions promoting interchange sustainability, Unmanned aerial systems in logistics
- (2) Smart solutions: Innovative design methods and green buildings at interchanges, Incorporation of alternative fuel vehicles in smart transshipment, Promoting accessibility, inclusive mobility and equity in interchange design, Physical and

cybersecurity at transport interchanges, Information Communication Technologies and cooperative Intelligent Transportation Systems for smart, safe, accurate and reliable interchange operations, 3D printing in supply chain.

- (3) Decision-making: Collection, storage, processing and visualization of big data to support decision making in transportation.

4.3 Formulation of research questions

The survey tool was a questionnaire composed of two parts. Part A aimed to assess the relevance of the 12 topics with the skills required on job and Part B aimed to assess the importance of the 15 emerging trends in the profession. Four different stakeholder groups were considered, based on their particular role and involvement in the design and operation of transport interchanges: 1) Policy makers, 2) Industry (including engineers/planners, operators and providers), 3) Academia/Research, and 4) Students.

For each topic, Part A asked:

- (1) How important is to have knowledge
- (2) How familiar are you with methods/techniques
- (3) During your university studies, at what level have you developed skills
- (4) How important would it be for your career development to gain skills

For each trend, Part B investigated:

- (1) The level that it has been introduced in the profession
- (2) The level of importance in the career development

The answers were given on a scale from 1 (Not important at all/Not at all/Very poor) to 5 (Absolutely essential/Extremely/Very high). Responders had also to state their:

- Stakeholder category
- Gender and age
- Level of completed studies
- Ongoing studies (if any)
- Source other than regular university studies that led to knowledge on transport interchange design and operation.

5. Analysis and results

The results of the analysis and the main findings are presented in the following paragraphs.

5.1 Data analysis

For the data analysis, both descriptive and inferential statistics were applied. In the first case, the sample characteristics, such as size, age, gender, stakeholder category, education, role and geographic location were analysed.

In the case of inferential statistics, the statistical analysis of the responses was carried out using non-parametric tests. Initially, bivariate correlations were conducted to investigate the relationships among the six main variables (research questions).

Then, hypothesis testing was used to estimate whether there were any differences in the average rating of respondents between different topics or topic groups. The null hypothesis H_0 was that there is no difference in the rating, and the alternative hypothesis

H_1 was that the ratings differ. Wilcoxon Signed-Rank Test was performed to assess differences between the paired responses (Park, 2009), and alpha test was used to build combinations of the variables (Cronbach, 1951), at a confidence level of 95% and confidence interval of 5%.

5.2 Sample characteristics

In total, 145 stakeholders participated in the questionnaire survey, where 66.2% are men and 33.8% women. The majority of the respondents (47.6%) are between 26-40 years old, 33.8% of them between 41-65, 17.2% between 18-25 and the remaining 1.4% over 66 years old. The 43.5% of the stakeholders are coming from academia and research, the group of industry is represented by 22.75%, students are also 22.75% and the remaining 11% of the sample are policy makers.

Regarding the education level of the respondents, it is indicated that the majority of them (41.4%) holds a master degree diploma, 31.7% hold a PhD diploma or have advanced graduate work experience, 19.3% own a bachelor's degree diploma and 7.6% are high school graduates. The countries of residence of participants were grouped in three clusters and the analysis showed that the majority of them (50.7%) live in the Mediterranean region (i.e. Greece, Malta, Spain, France and Israel), 33.3% in the Baltic region, and the remaining 16% in other countries, such as Belgium, Portugal, United Kingdom, the Netherlands, Slovakia, Czech Republic and the United States of America. Owing to this distribution, specific analysis on the educational attributes in countries with low expenditure in R&D was feasible.

5.3 Results

Figure 1 presents the Spearman bivariate correlation between the importance of knowledge and the current level of knowledge on STIP topics, where a significant neutral positive relationship is indicated ($\beta=0.257$, $p\text{-value}=0$). Similar results are met when correlating the level of knowledge of respondents on STIP topics and the importance of this knowledge for career development (Figure 2). It is observed that there is a significant neutral positive relationship between these two variables ($\beta=0.353$, $p\text{-value}=0$), meaning that respondents consider that high knowledge on STIP topics can contribute to their career development. Focusing on the degree that respondents are exposed to emerging trends in relation to the importance they consider that the knowledge on these topics has for their career development, a significant strong positive relationship was observed ($\beta=0.448$, $p\text{-value}=0$) (Figure 3).

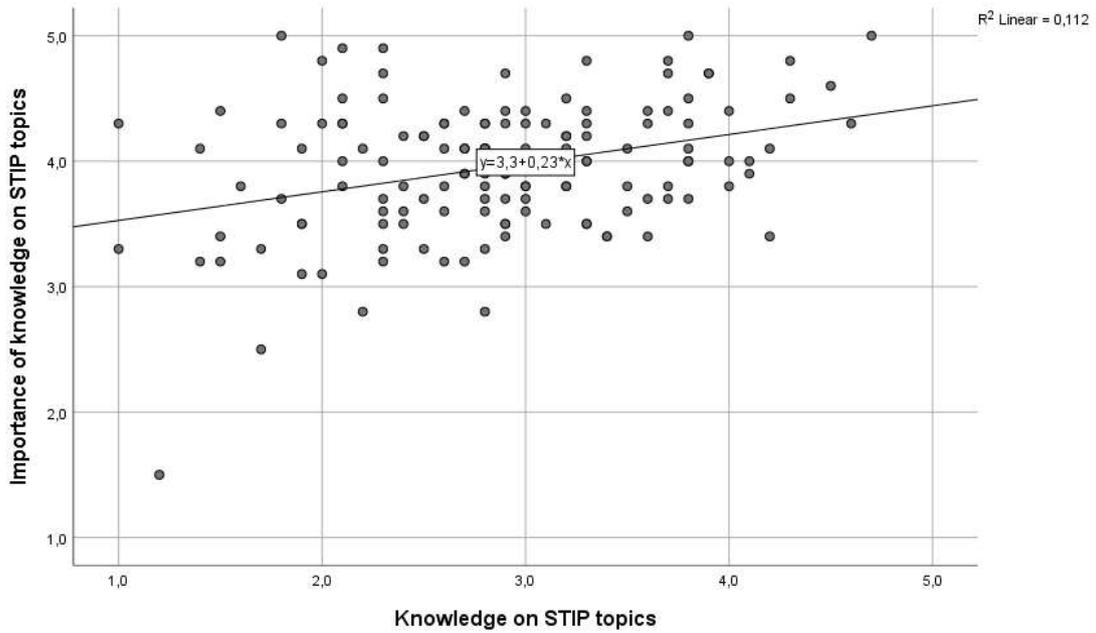


Figure 1. Bivariate correlations: knowledge on STIP topics versus importance of knowledge on STIP topics.

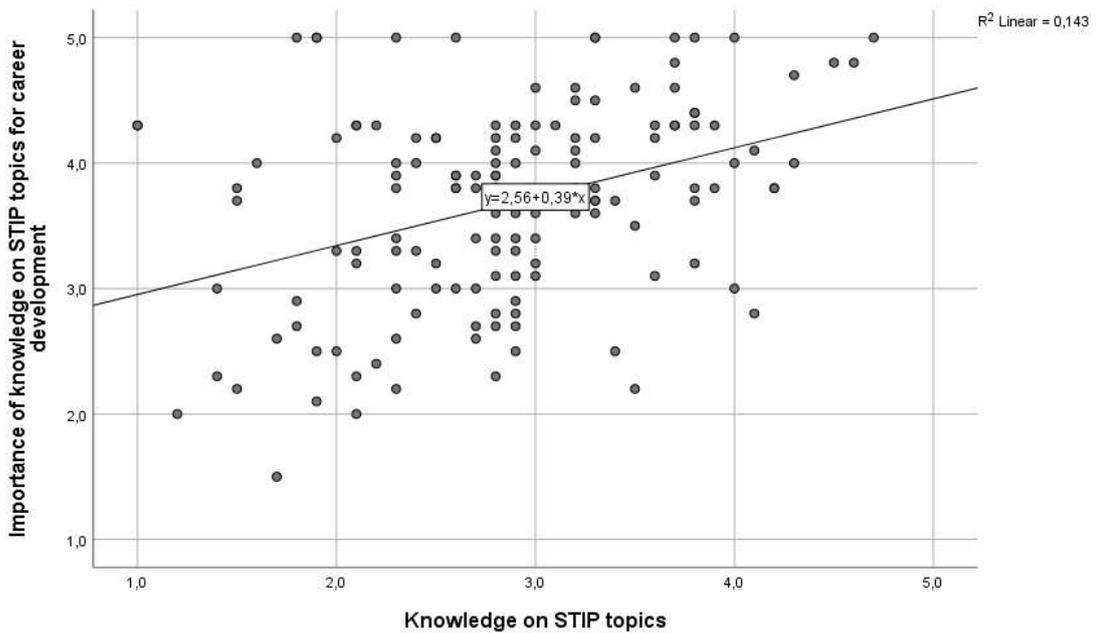


Figure 2. Bivariate correlations: knowledge on STIP topics versus importance of knowledge on STIP topics for career development.

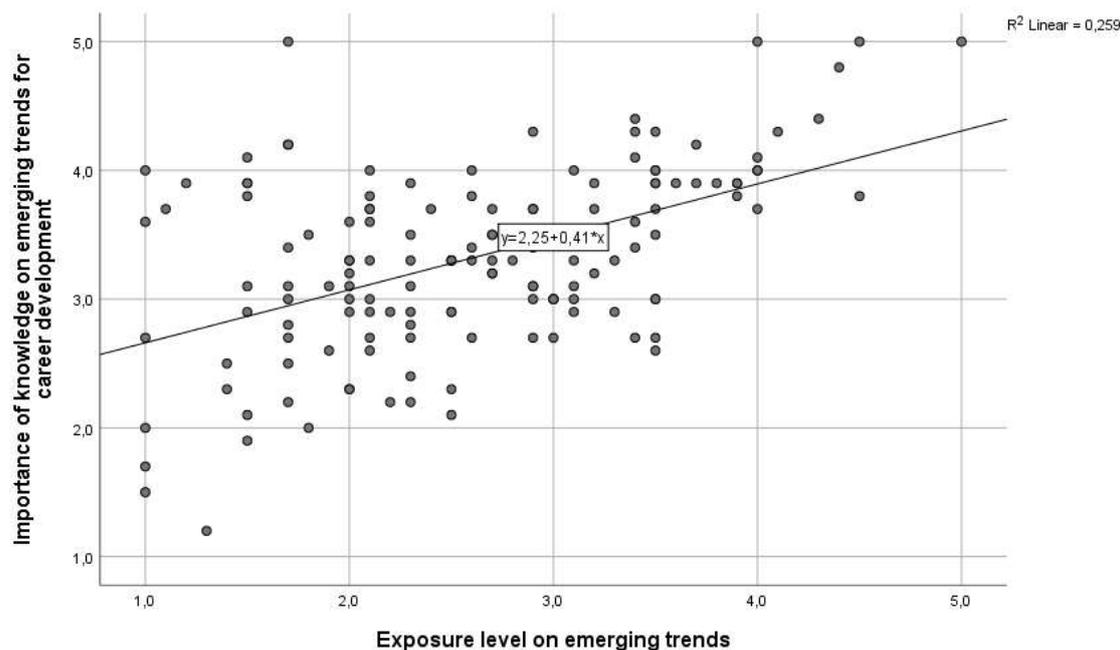


Figure 3. Bivariate correlations: exposure level on emerging trends versus importance of knowledge on emerging trends for career development.

In all categories, planning and policy, smart solutions and decision making, results showed that there is a significant strong positive relationship between the knowledge level on STIP topics and the skills that respondents developed during their university studies, validating that the main source of this knowledge was obtained through their studies ($\beta=0.626$, $p\text{-value}=0$; $\beta=0.687$, $p\text{-value}=0$; $\beta=0.570$, $p\text{-value}=0$, respectively). Other sources of obtaining knowledge on interchange design and operation were vocational training (21%), on-job training (25%) and on-job experience (54%).

Table 1 presents an overview of the average rating and standard deviation of the six variables and the test results of the comparisons between the three topic categories, which are described through the z-statistic, the calculated effect size ($r=z/\sqrt{N}$, where N is the total number of observations) and p-value, indicating the strength of the respective evidence.

Regarding the importance of knowledge on STIP topics, results showed that respondents rated higher topics addressing decision making ($M=4.0$, $SD=0.84$) and planning and policy ($M=4.0$, $SD=0.58$) and then, smart solutions ($M=3.9$, $SD=0.61$), with the difference between smart solutions and decision making being statistically significant ($r=-0.15$, $p\text{-value}<0.05$). When respondents were asked how familiar they are with methods and techniques relative to the three topic categories, results showed that they have higher knowledge on topics referring to planning and policy ($M=2.8$, $SD=0.83$) compared to smart solutions ($M=2.7$, $SD=0.88$) ($r=-0.15$, $p\text{-value}<0.05$), but they are more familiar with decision making ($M=3.4$, $SD=0.94$), when compared with planning and policy topics ($r=-0.43$, $p\text{-value}<0.05$) and smart solutions ($r=-0.43$, $p\text{-value}<0.05$).

Respondents were also asked about the level of the skills they developed during their university studies in relation to STIP topics. It was observed that they mainly developed skills on decision making ($M=3.3$, $SD=1.06$), then planning and policy ($M=2.7$, $SD=0.93$) and lastly smart solutions ($M=2.5$, $SD=0.94$). The differences in all three pairs of comparison were statistically significant ($p\text{-value}<0.05$). When respondents were asked

about the importance to have knowledge on STIP topics for the development of their career, they replied that knowledge on decision making topics (M=4.1, SD=0.91) would improve more their career compared to planning and policy (M=3.6, SD=0.88) or smart solutions (M=3.5, SD=0.93) topics.

The second part of this analysis refers to the emerging trends in transportation and the relevant feedback of the sample in terms of their exposure to these topics and also the importance of having such knowledge for the development of their career. The exposure of the respondents to the emerging trends can be considered as relatively low, since the average rating on planning and policy was 2.7 (SD=0.89), on smart solutions 2.5 (SD=0.94) and on decision making 3.0 (SD=1.15). The differences between planning and policy and decision making, and smart solutions and decision making were statistically significant (p-value<0.05). Similarly to the STIP topics, the respondents stated that they find more important for their career development to have knowledge on emerging trends addressing decision making (M=3.9, SD=1.03), then planning and policy (M=3.3, SD=0.79) and lastly, smart solutions (M=3.2, SD=0.8). Analysis showed that the differences between planning and policy and decision making, and smart solutions and decision making were statistically significant (p-value<0.05).

Combining findings of the comparison among the three topic clusters against all six considered variables, it is noted that decision making is similarly important, when considering both STIP and emerging topics. At the same time, it supports the necessity of incorporating such courses to expand skills in the professional domain of transportation engineers and planners.

Table 1. Average rating and summary of the test results for comparisons between the topic categories.

Variables	Topic clusters						P vs. S			P vs. DM			S vs. DM		
	Planning and policy (P)		Smart solutions (S)		Decision making (DM)		z-statistic	Effect size (r)	p-value	z-statistic	Effect size (r)	p-value	z-statistic	Effect size (r)	p-value
	M	SD	M	SD	M	SD									
Importance of knowledge on STIP topics	4.0	0.58	3.9	0.61	4.0	0.84	-1.5	-0.09	0.13	-1.85	-0.11	0.07	-2.58	-0.15	0.01*
Knowledge on STIP topics	2.8	0.83	2.7	0.88	3.4	0.94	-2.59	-0.15	0.01*	-7.25	-0.43	0*	-7.3	-0.43	0*
University skills development on STIP topics	2.7	0.93	2.5	0.94	3.3	1.06	-4.24	-0.25	0*	-6.77	-0.4	0*	-7.84	-0.46	0*
Importance of knowledge on STIP topics for career development	3.6	0.88	3.5	0.93	4.1	0.91	-1.92	-0.11	0.06	-6.08	-0.36	0*	-6.95	-0.41	0*
Exposure level on emerging topics	2.7	0.89	2.5	0.94	3.0	1.15	-1.01	-0.06	0.3	-2.16	-0.13	0.03*	-3.14	-0.18	0*
Importance of knowledge on emerging topics for career development	3.3	0.79	3.2	0.8	3.9	1.03	-1.21	-0.07	0.2	-5.58	-0.33	0*	-6.45	-0.38	0*

M: Average rating, SD: Standard Deviation
P: Planning and policy, S: Smart solutions, DM: Decision making
**statistically significant (p-value<0.05)*

In addition, sample was grouped according to parameters such as stakeholder categories, gender, age, countries of residence and education level and the six variables were statistically analyzed based on this grouping and also on the three topic categories (planning and policy, smart solutions, decision making). Two-way ANOVA was used to examine the impact on the six variables of the interaction between the topic categories and the groups of the rest parameters. The most representative results are presented in Figures 4 to 9 and discussed in the following paragraphs.

Results showed that there were significant differences in the average level of importance of knowledge on STIP topics between combinations of topic and country of residence ($p\text{-value}<0.05$), but not in average level of importance within topic categories ($p\text{-value}=0.862$) or country clusters ($p\text{-value}=0.998$) (Figure 4). It is realized that countries of the Mediterranean region attribute less importance to planning and policy, but higher to decision making than the other country clusters.

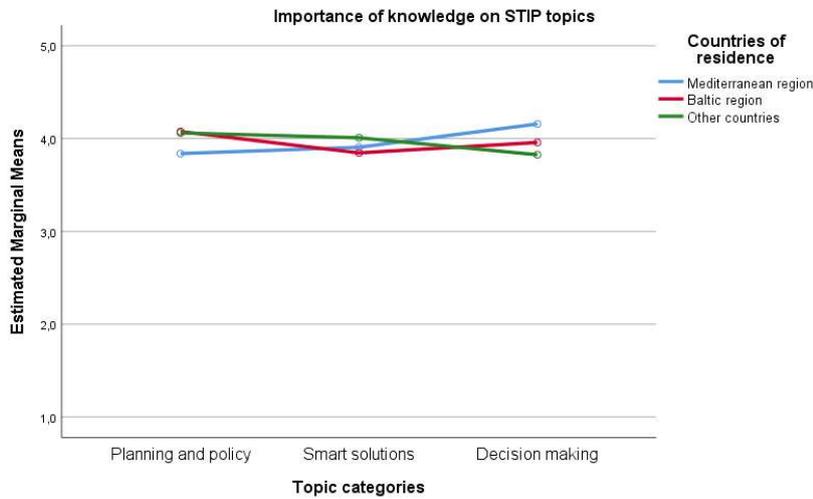


Figure 4. Estimated importance of knowledge on STIP topics.

Focusing on the level of knowledge on STIP topics, it was observed that there were significant differences in the average level of knowledge within topic categories ($p\text{-value}<0.05$) and stakeholder groups ($p\text{-value}<0.05$), but the interactions of these two parameters did not have a significant effect on knowledge ($p\text{-value}=0.604$) (Figure 5). Specifically, the representatives of industry, academia/research and policy making stated that they are more familiar with techniques/methods related to decision making, then planning and policy and lastly smart solutions. Academia/research stakeholders acquire higher knowledge than industry, then students and finally policy makers. Students also determined decision making as the topic they know better but seem to be more familiar with smart solutions compared to planning and policy aspects.

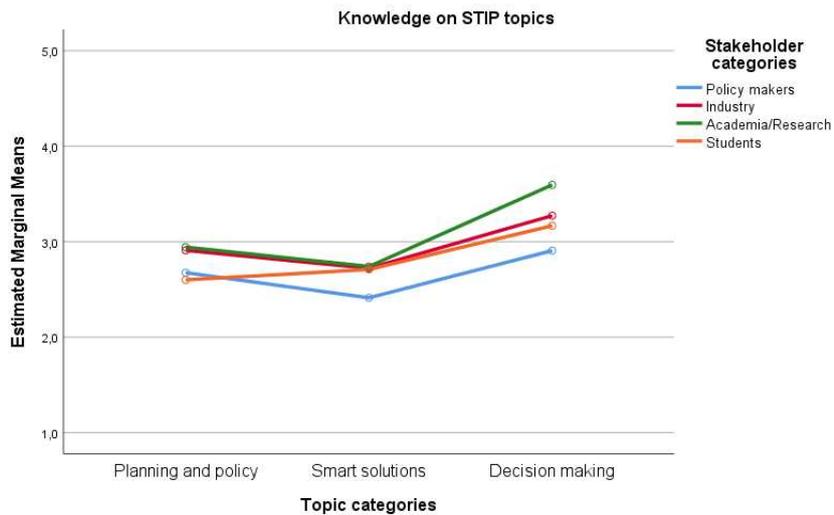


Figure 5. Estimated knowledge on STIP topics.

When testing university skills development on STIP topics, results showed that there were significant differences in the average skills development within topic categories (p -value=0) and stakeholder categories (p -value<0.05), but their interactions did not have a significant effect on skills (p -value=0.615) (Figure 6). It was observed that all stakeholders developed higher level skills during their university studies on decision making, below average on planning and policy and even lower on smart solutions. Again, academia/research, followed by industry and students seem to have higher skills than policy makers.

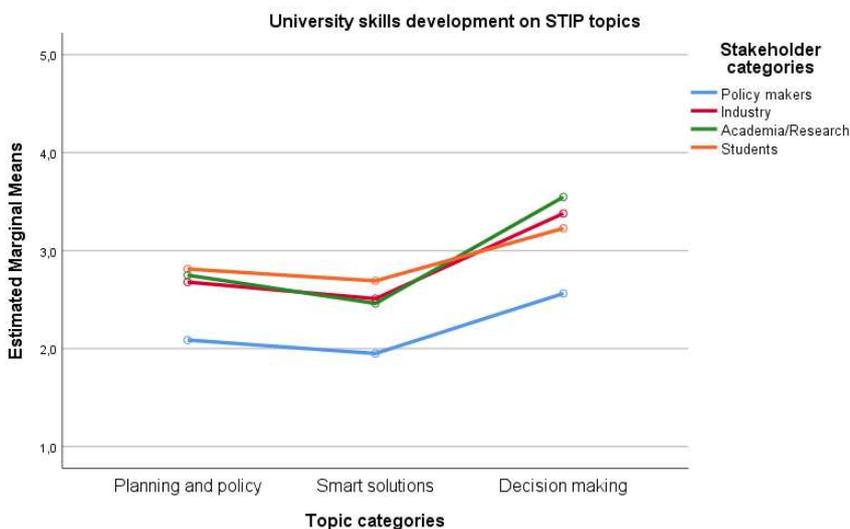


Figure 6. Estimated university skills development on STIP topics.

Importance of knowledge on STIP topics for career development differs significantly within topic categories (p -value<0.05), but not within age groups (p -value=0.076). The interactions between age group and topic category do not affect significantly this variable (p -value=0.932) (Figure 7). In this case, stakeholders rated higher the importance of knowledge on decision making for career development compared to smart solutions or planning and policy, regardless of their age.

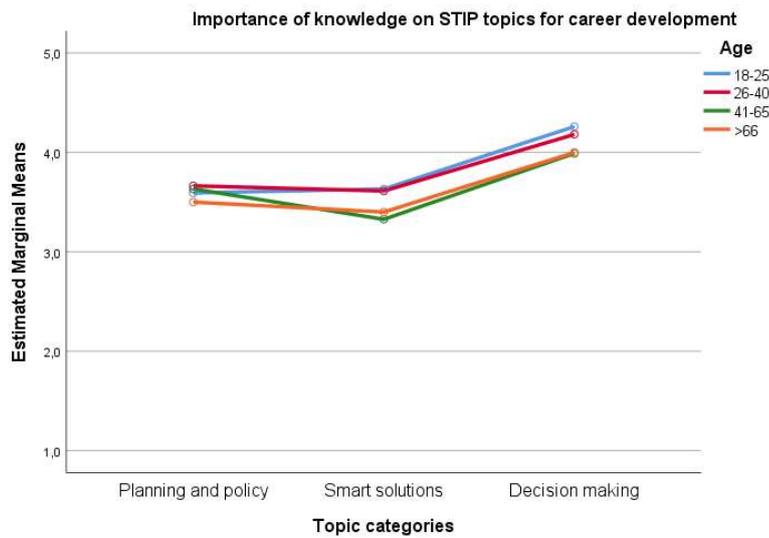


Figure 7. Estimated importance of knowledge on STIP topics for career development.

Regarding the emerging trends in transportation, it was observed that the interaction between topic categories and educational level does not affect significantly the exposure level (p -value=0.136) (Figure 8). Decision making is rated the highest in all educational levels.

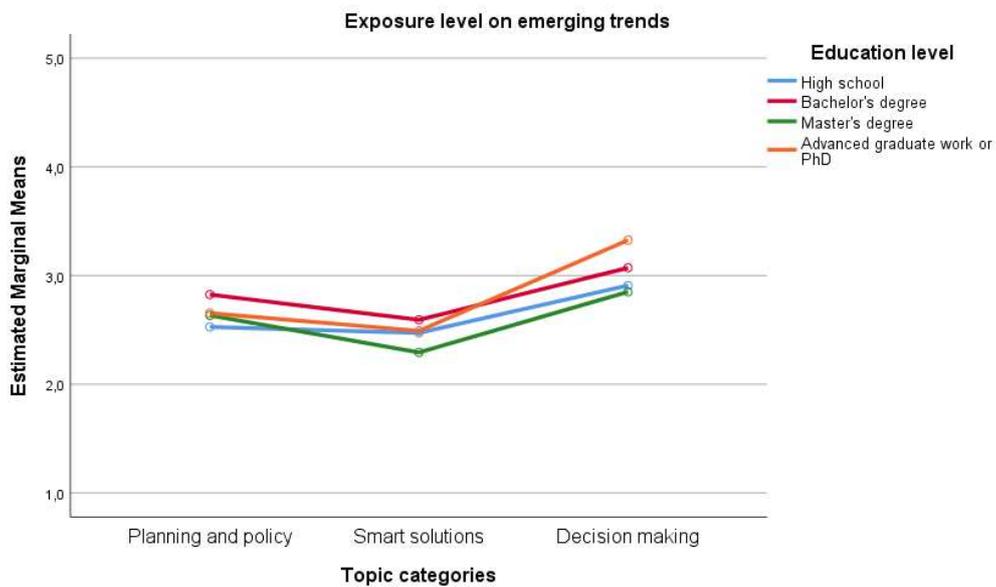


Figure 8. Estimated exposure level on emerging trends.

Finally, the level of importance of knowledge on the emerging trends for career development, varies significantly within topic categories (p -value<0.05) and age groups (p -value<0.05), but the interactions between these two parameters do not affect it significantly (p -value=0.841) (Figure 9). Figure 9 clearly reveals how important decision making is considered by all age groups of stakeholders.

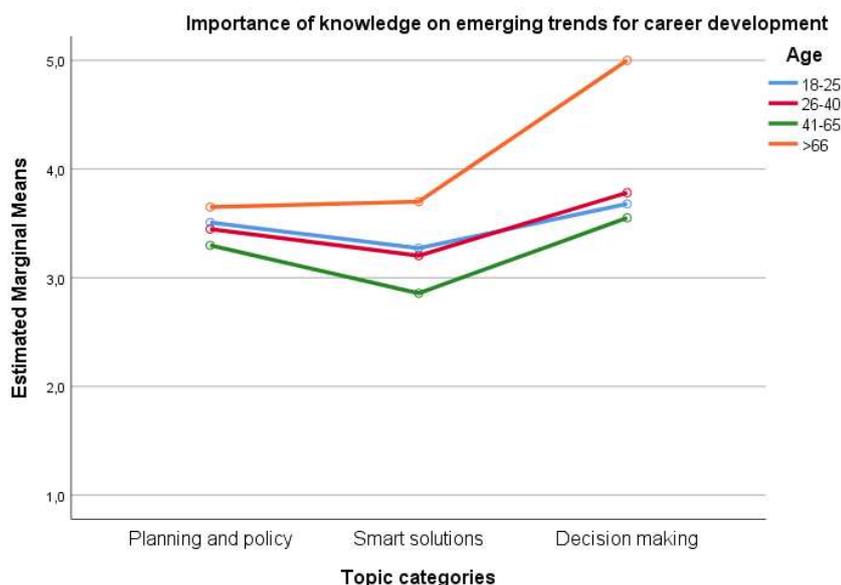


Figure 9. Estimated importance on knowledge on emerging trends for career development.

Next step in data analysis was the application of Importance-Performance Analysis (IPA), which is a simplified graphical tool that can feed authorities, managers and researchers with significant input about those attributes of service that they should focus on (de Oña et al., 2013; Jinca et al., 2014). This paper was based on the original IPA framework developed by Marilla & James (1977), to produce two-dimensional graphs.

The first graph represents importance of STIP courses in the vertical axis and the respective knowledge, which is represented as the performance of stakeholders on these courses in the horizontal axis, as illustrated in Figure 10. The order-winner criteria used in this case are the 12 STIP courses, as presented in Table 2, which also summarizes the mean rating and the standard deviation of perceived performance and importance.

Based on the location of the 12 criteria in each of the four quadrants of Figure 10 and the determination of the priorities that should be considered in improving performance (Marilla & Hames, 1977), the following are highlighted:

- Quadrant (Q) I – concentrate here: none of the criteria (courses) is classified as of high importance and low performance.
- Quadrant (Q) II – keep up the good work: Four courses are considered important, namely C3: transportation planning and sustainable development, C10: smart technologies for efficient transport logistics, C11: decision making methodologies and C12: data collection methods. The level of knowledge on all these courses is high. These courses should be kept in an educational program. Enrichment and update should be pursued.
- Quadrant (Q) III – low priority: Five courses are characterised low in acquired knowledge, but also low in importance, specifically C1: The European policy on intermodal transportation, C2: building business models for intermodal transport interchanges, C7: information systems of intermodal freight transportation, C8: design of passenger transport interchanges and C9: design of freight transport interchanges. Emphasis should be given in raising awareness of the stakeholders

in regards to these topics and in parallel increase their involvement through educational programs.

- Quadrant (Q) IV – possible overkill: none of the courses is classified as of high performance and low expectations.
- Course C6: Intelligent services of transport systems received rating both in perceived performance and importance equal to the respective median of the criterion means (referred to as median from this point onwards).
- Course C5: Optimization of intermodal transport systems was rated equally to the median in importance and higher than the median in performance thus this course is in the boundary of QII and QIV.
- Course C4: Operation and management of intermodal transport systems was rated equally to the median in performance and lower than the median in importance thus this course is in the boundary of QIII and QIV.

Table 2. Model of Importance-Performance for STIP courses.

Notation	Order-winner criteria	Perceived performance		Importance	
		Mean	SD	Mean	SD
C1	The European policy on intermodal transportation	2.5	1.12	3.5	1.16
C2	Building business models for intermodal transport interchanges	2.4	1.04	3.5	1.15
C3	Transportation planning and sustainable development	3.2	1.20	4.0	1.02
C4	Operation and management of intermodal transport systems	2.6	1.12	3.5	1.12
C5	Optimization of intermodal transport systems	2.7	1.19	3.7	1.08
C6	Intelligent services for transport systems	2.6	1.23	3.7	1.18
C7	Information systems of intermodal freight transportation	2.5	1.12	3.5	1.27
C8	Design of passenger transport interchanges	2.4	1.11	3.4	1.18
C9	Design of freight transport interchanges	2.2	0.97	3.1	1.15
C10	Smart technologies for efficient transport logistics	2.7	1.13	3.8	1.16
C11	Decision making methodologies	3.2	1.14	4.1	1.02
C12	Data collection methods	3.4	1.13	4.1	0.96
<i>SD: Standard Deviation</i>					

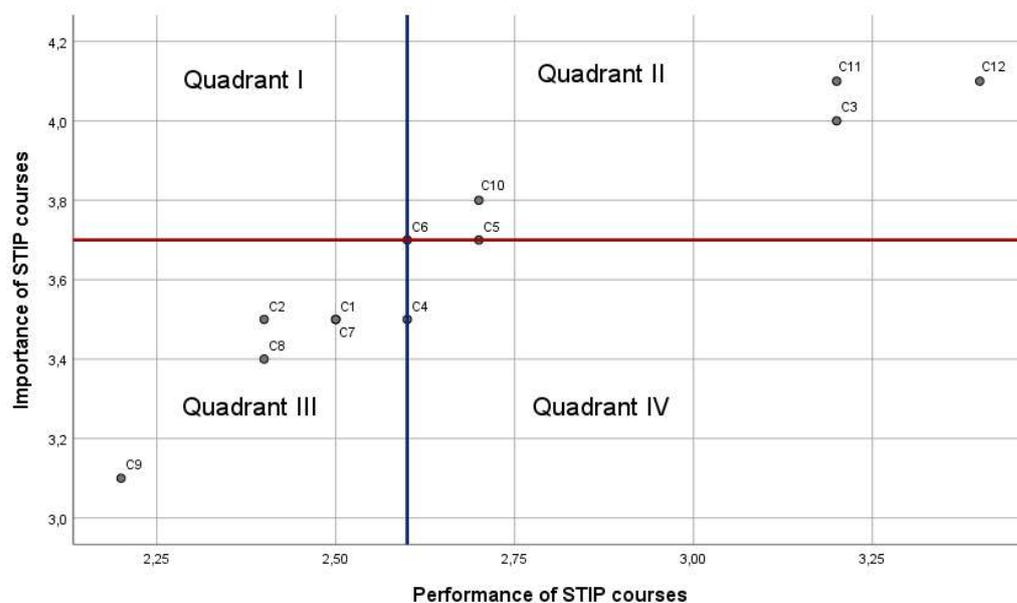


Figure 10. Importance-Performance Analysis for STIP courses.

The second graph represents importance of emerging topics in the vertical axis and the knowledge expressed as performance of stakeholders on these topics in the horizontal axis, as presented in Figure 11. The order-winner criteria used in this case are the 15 emerging topics, as shown in Table 3, including also the mean of rating and the standard deviation of perceived performance and importance. Based on the location of the 15 topics in each of the four quadrants of Figure 11, the following are noted:

- Quadrant (Q) I – concentrate here: none of the 15 topics is classified as of high importance and low performance.
- Quadrant (Q) II – keep up the good work: five topics, namely E1: Utilization of big data for policy making, E2: Innovative organizational and governance concepts for mobility solutions at neighbourhood and district level, E4: Optimization methods improving resilience of interchanges, E13: Information and Communication Technologies and cooperative Intelligent Transportation Systems for smart, safe, accurate and reliable interchange operations and E14: 3D printing in supply chain should be kept in educational/training programs, as they are identified as important. As the level of knowledge they provide is perceived high, efforts to maintain or even strengthen this level should be considered.
- Quadrant (Q) III – low priority: Stakeholders indicated low knowledge on seven topics, specifically E5: Incorporation of Vehicle-to-Infrastructure and Infrastructure-to-Vehicle systems and information-sharing in efficient operation and management of interchanges, E6: Benefits of connected-automated vehicles in the operation and management of interchanges, E8: Unmanned aerial systems in logistics, E9: Innovative design methods and green buildings at interchanges, E10: Incorporation of alternative fuel vehicles in smart transshipment, E12: Physical and cybersecurity at transport interchanges and E15: Collection, storage, processing and visualization of big data to support decision making in transportation. Stakeholders also showed perceived low importance in these topics. This highlights the need for increasing familiarity and raising awareness

through educational programs, as these topics reflect the current advances in transport interchanges and intermodality in general.

- Quadrant (Q) IV – possible overkill: none of the topics is classified as of high performance and low expectations.
- Topic E3: Public procurement of innovative sustainable transport and mobility solutions in urban areas received rating both in perceived performance and importance equal to the respective median.
- Topics E7: Shared-use services and solutions promoting interchange sustainability and E11: Promoting accessibility, inclusive mobility and equity in interchange design were rated equally to the median in importance and higher than the median in performance thus these topics are in the boundary of QII and QIV.

Table 3. Model of importance-performance for emerging topics.

Notation	Order-winner criteria	Perceived performance		Importance	
		Mean	SD	Mean	SD
E1	Utilization of big data for policy-making	2.9	1.13	3.8	0.95
E2	Innovative organizational and governance concepts for mobility solutions at neighborhood and district level	2.8	1.14	3.5	1.08
E3	Public procurement of innovative sustainable transport and mobility solutions in urban areas	2.7	1.20	3.4	1.19
E4	Optimization methods improving resilience of interchanges	2.8	1.19	3.5	1.10
E5	Incorporation of Vehicle-to-Infrastructure (V2I) and Infrastructure-to-Vehicle (I2V) systems and information-sharing in efficient operation and management of interchanges	2.5	1.18	3.2	1.20
E6	Benefits of connected-automated vehicles in the operation and management of interchanges	2.6	1.27	3.3	1.16
E7	Shared-use services and solutions promoting interchange sustainability	2.8	1.10	3.4	1.08
E8	Unmanned aerial systems in logistics	2.1	1.09	2.8	1.16
E9	Innovative design methods and green buildings at interchanges	2.6	1.13	3.2	1.05
E10	Incorporation of alternative fuel vehicles in smart transshipment	2.5	1.17	2.9	1.15
E11	Promoting accessibility, inclusive mobility and equity in interchange design	2.8	1.28	3.4	1.10
E12	Physical and cybersecurity at transport interchanges	2.4	1.18	3.2	1.14
E13	Information Communication Technologies and cooperative Intelligent Transportation Systems for smart, safe, accurate and reliable interchange operations	3.1	1.29	3.7	1.11
E14	3D printing in supply chain	3.0	1.25	3.9	1.03
E15	Collection, storage, processing and visualization of big data to support decision making in transportation	1.8	1.0	2.8	1.27

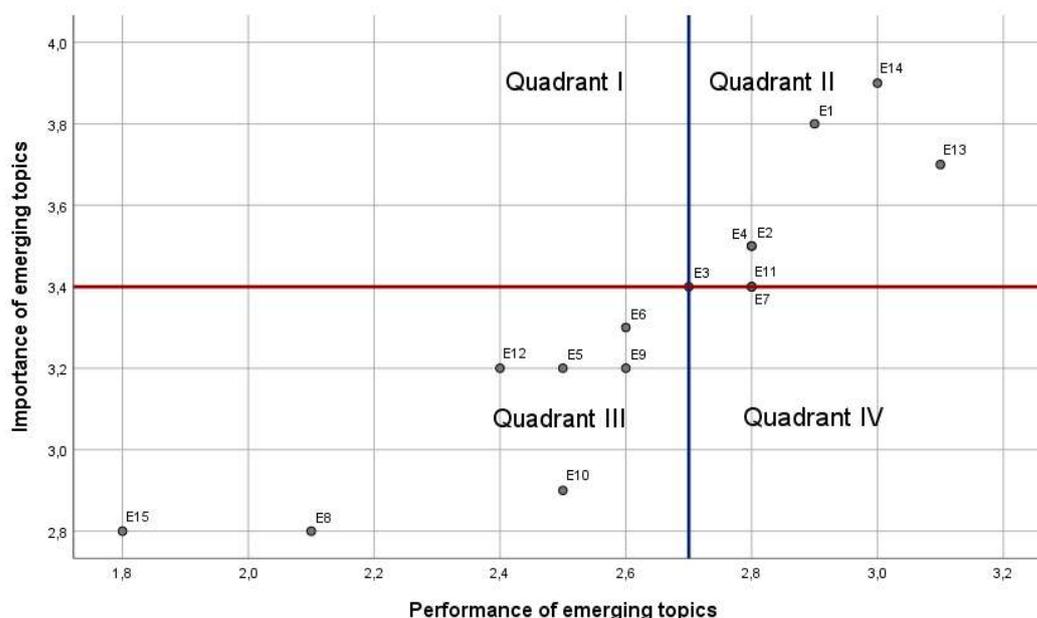


Figure 11. Importance-Performance Analysis for emerging topics.

6. Discussion and conclusions

Literature review already revealed the need for new skills in the domain of transportation industry and identified the lack in such a provision by the existing educational systems (US DOT, 2015). Likewise, research done in the individual modes, i.e. rail, air and public transport showed the need for updated skills in the profession (Macário and Reis, 2014). The current work addresses the current status, gaps and requirements of educational programs which emphasize on transport interchanges, as these are the main drivers for an intermodal, sustainable and seamless transportation system (Adamos et al., 2015), however not specifically analysed in previous researches.

Taking into consideration the importance of transport interchanges in the roadmap of the transportation system, it is important that professionals are appropriately educated and trained on relevant topics with the sustainability and the emerging trends of these interchanges. Towards this direction, the present paper aimed to determine the relevance of the existing knowledge, importance and requirements for skills and competence on job as perceived by four different stakeholder categories: policy makers, industry, academia/research and students, highlight strengths and weaknesses and provide some guidance to the content and context of appropriately designed educational programs on transport interchanges.

Knowledge acquisition on all topics defined in this study were considered by the stakeholders as of high importance and as a means for helping them enhancing their career pursuance. In particular, decision making topics were considered of higher importance by all stakeholder categories, followed by planning and policy and smart solutions. It is concluded that decision making skills are required to enable integration of policy making, transportation planning and innovative technologies, sustainable design and operation of transport interchanges.

Assessing the results of this survey in combination with the state-of-the-art review findings and the analysis of various curricula provided by well-known European educational institutions (Mitropoulos et al., 2017a), it is clear that all categories of

stakeholders require skills development on the strategic planning of transport interchanges, including sustainability concerns, new technology achievements and coherent decision making processes.

The analysis of survey data showed that current educational and training programs provide satisfactory skills on “traditional” issues of transportation engineering, like transportation planning and decision making methodologies. It also revealed that university studies do not help develop skills directly associated with design and operation of transport interchanges, resulting in a significant deficiency of knowledge in topics such as the European policy on intermodal transportation, business models building and the design of passenger and freight interchanges.

Focusing on the emerging trends in the transportation domain, there is little comparative knowledge on recent developments involving big data, unmanned systems and alternative fuels. An important finding is that inadequate knowledge applies on topics related with the operation of transport interchanges, such as information communication systems and security related topics. This conclusion is particularly enlightening for the educational program development and reveals the need for a higher exposure level of the various stakeholder groups with the specific emerging topics, which are documented by European Union and US research and development programs (HORIZON 2020, Transportation Research Board, 2016). Therefore, educational programs should be formulated in such a way so that they accomplish a two-folded task; enhance knowledge on the design and operation of transport interchanges by offering designated courses; raise awareness on the necessity of acquiring knowledge and developing skills to accomplish efficient and sustainable operation of transport interchanges.

Finally, incorporation of the project-based learning can help to improve student learning outcomes. Fini et al. (2017) investigated the impact of this approach on sustainability concepts in transportation engineering courses and concluded that project-based learning enhanced self-efficacy, teamwork, high cognitive and communication skills of students. Towards this direction, if project-based learning involved practitioners, having the role of coaches for example, the liaison between academia and industry could be easier to achieve.

To this end, it can be concluded that there is a significant need for the current educational and training programs to adjust or extend their curricula, methodologies, techniques and applications, in order to prepare their students to become successful professionals of future.

References

- Adamos, G., Nathanail, E. & Zacharaki, E. (2012) “Developing a Decision-Making Framework for collaborative practices in long-short distance transport interconnection”, *Procedia – Social and Behavioral Sciences*, Volume 48, 2012, Pages 2849-2859.
- Adamos, G., Tsami, M. & Nathanail, E. (2015) “Urban interchanges: Moving towards a seamless transportation solution”, International Conference on Environmental Management, Engineering, Planning and Economics (CEMEPE) and SECOTOX Conference, Proceedings from the 5th International Conference on Environmental Management, Engineering, Planning and Economics (CEMEPE) and SECOTOX Conference, Mykonos Island, Greece, June 14-18, 2015.
- ALLIANCE project: Enhancing excellence and innovation capacity in sustainable transport interchanges. <http://alliance-project.eu/>.

- Banister, D. and Berechman, Y. (2001), "Transport investment and the promotion of economic growth", *Journal of Transport Geography*, 9(2001) 209-218.
- CAPITAL project: Collaborative capacity programme on ITS training-education and liaison. <http://capital-project.its-elearning.eu/>.
- Cohen, W.M., Nelson, R.R., Walsh, J.P. (2002), "Links and impacts: the influence of public research on industrial R&D", *Management Science* 48, 1–23.
- Collet R., Kuhnimhof T. (2008), "Relevant Market Segments in Intermodal Passenger Travel", European Project: KITE (a knowledge base for intermodal passenger travel in Europe), 2008.
- Communication from the Commission (2007), "Improving knowledge transfer between research institutions and industry across Europe", Luxembourg: Office for Official Publications of the European Communities, 2007. ISBN: 978-92-79-05521-8.
- CORDIS, European Commission. Innovation Relay Centre Network. http://cordis.europa.eu/project/rcn/71370_en.html.
- Cronbach, L.J. (1951), "Coefficient alpha and the internal structure of tests", *Psychometrical*, 16 (3), 297-334.
- De Oña, J., De Oña, R., Eboli, L., & Mazzulla, G. (2013), "Perceived service quality in bus transit service: a structural equation approach", *Transport Policy*, 29, 219-226.
- DETRA project: Developing the European Transport Research Alliance, 7th FP Grant n°266051, <http://detra.fehrl.org/>.
- ENAAE (2015), "Best practice in accreditation of engineering programmes: An exemplar", European network for engineering education, 2015. http://www.enaee.eu/wp-assets-enaee/uploads/2014/11/BestPractice_full_septII.pdf.
- European Commission (2007), "GREEN PAPER - Towards a new culture for urban mobility", Brussels, 25.9.2007 COM (2007) 551 final.
- European Commission (2014a), "Innovation Union Scoreboard 2014. The Innovation Union's performance scoreboard for Research and Innovation".
- European Commission (2014b), "Research and Innovation performance in the EU. Innovation Union progress at country level". http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2014/iuc_progress_report_2014.pdf.
- European Commission (2014-2015), Technology readiness levels (TRL), HORIZON 2020 – WORK PROGRAMME 2014-2015 General Annexes, Extract from Part 19 - Commission Decision C(2014)4995.
- European Institute of Innovation and Technology. <https://eit.europa.eu/>.
- HORIZON 2020. The EU Framework Programme for Research and Innovation. <https://ec.europa.eu/programmes/horizon2020/>.
- Fini, E., Awadallah, F., Parast, M. & Abu-Lebdeh (2017), "The impact of project-based learning on improving student learning outcomes of sustainability concepts in transportation engineering courses", *European Journal of Engineering Education*, Vol. 43, No. 3, pp. 473-488.
- Jinca, A., Yamin, M., Riyanto, B., & Mulyono, A. (2014), "The satisfaction analysis for the performance of public transport urban areas", *International Refereed Journal of Engineering and Science (IRJES)*, Volume 3, Issue 8, pp. 38-44.
- Kahn, W. A. (1990), "Psychological conditions of personal engagement and disengagement at work", *Academy of management journal*, 33(4), 692-724.
- Macário, R. and Reis, V. (2014), "Uncovering Competence Gaps Across the Transport", *ETRA Invited Session* no 43, in TRA 2014, Paris 17-4-2014.

- Markman, G., Siegel, D., Wright, M. (2008), “Research and technology commercialization”, *Journal of Management Studies* 45, 1401–1423.
- Martilla, J. A., & James, J. C. (1977), “Importance performance analysis”, *Journal of marketing*, 41(1), 77-79.
- Mitropoulos, L., Adamos, G., Nathanail, E., Yatskiv, I. & Kabashkin (2017a), “Building on European scientific excellence to develop an educational program on intermodal connections for Latvia and the region”, *Transport Journal*, 2017, Vol. 32, Iss. 1.
- Mitropoulos, Lambros, G. Adamos, E. Nathanail, I. Yatskiv, I. Kabashkin (2017b), “Developing an Educational Program for Transportation across Regions: The Case for Intermodal Connections for Latvia and the Region”, Annual Meeting of Transportation Research Board, from Proceedings of 96th Annual Meeting of Transportation Research Board, Washington D.C. January 2017.
- MORE and MORE2 projects: MObility patterns and career paths of Researchers, <http://www.more-2.eu/>.
- Park, H.M. (2009), “Comparing Group Means: T-test and One-Way ANOVA Using STATAM, SAS, R, and SPSS”. *Working paper* The University Information Technology Services (UITS) Center for Statistical and Mathematical Computing. Indiana University.
- Perkmann, M. et al. (2013), “Academic engagement and commercialization: A review of the literature on university-industry relations”, *Research Policy* 42 (2013) 423-442.
- Siegel, D.S., Waldman, D., Link, A. (2003), “Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study”, *Research Policy* 32, 27–48.
- SKILLFUL project: Skills and competences development of future transportation professional at all levels. <http://skillfulproject.eu/>.
- SKILLSEA project: Future-proof skills for the maritime transport sector. <https://www.skillsea.eu/>.
- S.T.R.E.E.T. project: Sustainable Transport Education for Environment and Tourism. <http://www.streetproject.eu/>.
- Transportation Research Board (2016), Transportation Research Circular, Number E-C208, Transformational Technologies in Transportation. State of the Activities. <http://onlinepubs.trb.org/onlinepubs/circulars/ec208.pdf>.
- U.S. Departments of Education, Transportation and Labor (2015) “Strengthening Skills Training and Career Pathways across the Transportation Industry”, Data Report on Future Transportation Workforce Needs. https://s3.amazonaws.com/PCRN/docs/Strengthening_Skills_Training_and_Career_Pathways_Across_Transportation_Industry_Data_Report_091115.pdf.