COMPETENCES GAP IN THE EUROPEAN RAILWAYS EDUCATION

Vasco Reis (corresponding author – vreis@civil.ist.utl.pt)
Rosário Macário (rosariomacario@civil.ist.utl.pt)
Department of Civil Engineering
Instituto Superior Técnico, Technical University of Lisbon
T: +351218418424

Word count: 5.470 words; 7 Figures; 1 Table (7.470 words)
Submission date: November 15, 2011

ABSTRACT
This paper addresses the problem of the competences gap between the educational institutions’ offer and the firms’ requirements. Competences gap has been long recognized as contributing to low job satisfaction and productivity. It refers to the mismatch between the required competences to accomplish a task and the actual competences of the employee.

The purpose of the research was twofold: firstly, to develop a framework for the analysis of the competences gap between firms and educational institutions and secondly, to assess the competences gap in the European Union railways market and the higher-education teaching.

The key competences of a railways employee were identified, being: rolling stock and traction; systems engineering; civil engineering; control system; operations, economics; business and regulation; environment. The methodological approach included a survey to the railways firms, with the purpose of identifying the current demand of competences, and a review of the curricula of railways courses, with the purpose of assessing the offer of competences. The comparison of the demands with the offer revealed the existence of gaps on several competences.

Keywords: competence gap, knowledge, railways, university, industry.

INTRODUCTION AND METHODOLOGY
Competences gap results from a mismatch between the competences required by firms and those actually delivered by the educational institutions. Such gap raises problems at multiple levels. The students (prospective employees) are arguably the main victims as they enter the market in an inferior competitive position vis-à-vis other workers. Likely, they will have to endure further education, which will defer their actual entry in the market. The firms will incur in losses of competitiveness as employees (former students) fail to deliver as expected. To overcome this problem, they often invest in in-house training, increasing their cost structure. The universities fail their main purposes of educating and preparing the students for the job market.

Literature concerning the problem of the competence gap is available (1)(2)(3)(4)(5)(6)(7)(8), although somewhat limited. As a consequence, issues like the roots, nature and impacts of the gap remain to some extent unknown. In any case, relevant contributions have been made over time. Some authors developed frameworks and tools to evaluate the gap (9)(10)(11) (12). Others took a different approach and assumed the existence of the gap. They develop methods and tools to improve the relevancy of the courses and consequently fill the gap (10).

Studies analyzing the competences gap in the transportation sector are scarce, and focusing in the railways are even fewer. Fracchia and Macário (13) identified the educational offer on railways (higher educational level), and conducted a survey to the railways firms...
Vasco Reis
Rosário Macário

aiming to identify their training needs. The context of the study was the European Union.
They concluded that European railways firms were primarily looking for undergraduates and
post-graduates employees, in the following areas: train control, positioning and
communication, signaling, control command and interlocking. The demand for doctorate
employees was limited to very specific areas, such as: risk analysis, noise and vibrations.
Later, Lautala (14) conducted a study aiming to understand the quantitative and qualitative
demands for university graduates by the railways industry, in the United States. The author
concluded that railways firms placed higher emphasis in problem solving competences than
on technical competences.

The paper is structured in six sections. The next one briefly reviews the core concepts
applied in research. The third section presents the framework for the analysis of the
competences gap. The following section presents the methodological approach. The fifth
section presents the main results. The final section concludes the paper.

DEFINITIONS

This section presents the fundamental concepts utilized in the framework for the analysis of
the competence gap. The key concepts are: knowledge, skill, and competence.

Knowledge
Knowledge can be defined as the "inferred capability which makes possible the successful
performance of a class of tasks that could not be performed before [a] learning [process] was
undertaken" (15, pp 355). In turn, learning process can be understood as capacity of an
individual of, in face of a set of stimulus, to acquire the capability to solve a given class of
tasks. As such, knowledge is the outcome of the interaction between an individual's capacity
to learn (intelligence) and his opportunity to learn (16). Knowledge thus depends on the social
context where the individual is embedded.

Skill
Skill can be defined as "goal-directed, well-organized behavior that is acquired through
practice and performed with economy of effort" (17, pp 18). In other words, skill refers to
how good an individual is able of executing a given task.

The definition of skill requires further explanations. First, a skill is a goal-oriented
behavior denoting that it is manifested in response of an external demand. Second, a skill is a
well-organized behavior meaning that it exhibits structure and a coherent set of patterns.
Third, a skill is acquired and improved over time through repetition. Four, the efforts and
cognitive demands reduce as the skill improves (16). Thus skill is dependent upon intellectual
and mental models.

Competence
The literature is populated with definitions on the concept of competence and, the related
term, competency (16)(18)(19), yet, thus far no consensus has been reached. The reasons are
discussed elsewhere in detail (20)(21)(22), but may be ascribed to different epistemological
assumptions, cultural differences or, even, differences in the context of the study (or nature of
object of analysis).

Indeed, Mansfield (7) identified three different contexts where the notion can be
applied, being:

- Competence is a characteristic that describes how an individual performs (and
  fulfills) his job's demands. The better he meets (and fulfills) his job's demands,
  the higher his competence will be. This notion is focused on the outcome of an
  individual's job's activity;
Vasco Reis
Rosário Macário

• Competence refers to an individual's attributes and traits to meet the job's demands. This notion is focused on the individual's intrinsic properties;

• Competence refers to the tasks that an individual do. The tasks are defined by the type of demands of the job. This notion is related with the individual's job's tasks.

For the purpose of this study, we adopted Woodruffe’s (23) definition on competence and competency. This author defines competence as a (job’s) task that an individual can perform, and competency as an individual’s capability (or characteristic) of doing well a given (job’s) task. This definition was supported by other authors, such as Le Deist and Winterton (24) or Hartle (25). The definition of competence has a functional nature, being related with the properties (and functions) of a task or job; while competency has a behavioral nature being related with an individual’s can achieve.

The individual’s competence is built over time, and several factors influence its development, namely: ability, knowledge, understanding, skill, action, experience or motivation (26). Among these, skill is a fundamental prerequisite.

Interaction between Knowledge, Skill and Competence

Although knowledge, skill and competence refer to different psychological components of human development, they influence each other and their development is determined by the others. Yet, it should be noted that as with any psychological component, many other factors influence their development.

In any case, and for purposes of this research, it is relevant to highlight the influence between these three components. Figure 1 shows the cascade of influence between the three components. An individual's intellectual capabilities are required for the development of knowledge. In turn, the practical utilization and operationalization of knowledge is condition for developing skills. Finally, all these components are necessary prerequisites for the development of competences.

FRAMEWORK FOR THE ANALYSIS OF THE COMPETENCES GAP

Figure 2 presents the framework developed to analyze the competences gap. The fundamental building blocks of the framework are the four agents that ultimately are responsible for the emergence of the competences gap. These four agents are: university, firm, student and employee. University is the agent responsible for providing students with knowledge and
Vasco Reis  
Rosário Macário

This agent must understand the market’s needs in order to teach the most suitable competences. Firm is the agent that hires employees (former students) in the production of its services and products. Firm’s production processes require a specific set of competences that employees must have. Student is the learning agent that while at the university acquires new knowledge and develops new competences. A student becomes employee when enters into the market. The employee uses his competences and knowledge while working for a firm.

We identified a competence gap between each pair of agents, in a total of four (as presented in Figure 2):

- Gap 1 – gap between the competences that the firm needs and those the university teaches their students. This is arguably the most relevant gap as it will define the students’ competences and ultimately their success as employees. The causes for this gap are discussed in the first section of this paper. This gap is analyzed in this paper.

- Gap 2 – gap between the competences that a person as employee needs to get and keep a job, and those that he has learnt as student. Indeed, a good student (with high marks) may reveal being inadequate for working in the area of his studies. This may be either because he learnt and acquired a wrong set of competences at school, or because he is unable to apply his knowledge and competences. In both cases, the student when enters the market founds more or less difficulties to keep a job.

- Gap 3 – gap between the competences that the firm needs and those actually delivered by the employee. An employee with non-adequate competences will underperform, contributing for a reduction in the firm’s competitiveness. This gap is typically consequence of an inadequate recruiting process that was unable to identify the non-competent candidates.

- Gap 4 – gap between the competences that the university expects to develop in their students and those actually acquired by the students. This gap can have multiple causes, such as: inadequate or demanding curricula, deficient
teaching skills, or insufficient aptitude by the students that increases the difficulty of understanding the subjects and, in parallel, reduces the students’ motivation for learning.

METHODOLOGICAL APPROACH
This paper presents the results of the analysis to Gap 1 – competences gap between firms and educational institutions (universities). A 4-step methodology was deployed to assess the competences gap, being:

- Step 1 – Core competences in railways;
- Step 2 – Industry survey;
- Step 3 – Course Survey;
- Step 4 – Gap Assessment.

Step 1 provided the list of core competences that any employee must have to succeed in a railways job. Step 2 and Step 3 provided information about the current demand and supply of competences, respectively. Finally, Step 4, based on the information collected in the previous steps, assess the gaps on the various core competences. Each step is now briefly presented.

Step 1 – Core competences in railways
The identification of the core competences was based on the earlier works developed by Franchia and Macário (14). These authors conducted a thorough evaluation and characterization of the competences used nowadays by the railways industry. They identified a total of 35 competences, clustered around 7 core competences. The core competences are considered essential for anyone aiming to succeed as railways employee. It should be noted however that these core competences are likely to change in the future as the railways market evolves and, consequently, the firms’ needs.

The core competences are:
- **Rolling stock and traction** – includes competences of conception, design and construction of: car body bogies, running gear and breaking systems, interiors, heating, ventilation, and air conditioning, traction and power supply.
- **Systems Engineering** – includes competences of testing, verification and qualification of interoperability, integration and interfaces of railways systems;
- **Civil Engineering** – includes competences of conception, design and construction of the railroad (tracks, switches or crossings) and other infrastructure (bridges and structures, tunnels, or stations);
- **Control System** – includes competences on signaling, control-command and interlocking, train control, positioning and communication, and electromagnetic compatibility;
- **Operations** – includes competences on railways services (passenger and freight), resources management, technical and commercial exploitation, or intermodality;
- **Economics, Business and Regulation** – includes competences on costs, asset management, life cycle costs, market analysis, business management, r, public service, social and political issues;
- **Environment** – includes competences on noise and vibrations of train operations, air pollution, energy consumption, sustainable development, and recycling and waste management;

In addition to the core competences, we also included in the research an analysis to the domain of knowledge. A person’s domain of knowledge, as explained in the second section,
Vasco Reis  
Rosário Macário

sets the foundation upon which the competences are developed. In this research, a student’s domain of knowledge was considered to be defined by the program in which he is enrolled.

The rationale is that the level of proficiency achieved by an employee on a given competence is influenced by his domains of knowledge. In addition, the domain of knowledge may influence an employee’s ability to acquire other competences.

Two employees may hold the same competence but if they have different domains of knowledge (graduation in distinct program) then we may expect that they will likely perform differently. This is because they may deploy the same competence is different manners. Let us give an example:

- Considering the competence maintenance of railways infrastructure. An employee with background in civil engineering is expected to deploy it differently than an employee with a background in mechanical engineering, simply because the former acquired knowledge in areas related with infrastructure (such as material construction, design and architecture of structures, geotechnics, etc.) that the latter did not. Such additional knowledge will influence the way the tasks are performed, although both could be competent on this matter.

We considered a total of sixteen domains, of which twelve are related with engineering programs and the remaining four related with other programs. The choice of these domains was again based on the works developed by Franchia and Macário (14). The dominance of engineering-related program is justified with the fact that the vast majority of the employees in railways have a degree in this area. It The domains are:

- Aerospace Engineering;
- Automotive Engineering;
- Chemical Engineering;
- Civil Engineering;
- Communication Engineering;
- Computer/Software Engineering;
- Electrical/Electronics Engineering;
- Industrial Engineering;
- Materials Engineering;
- Mechanical Engineering;
- Railways Engineering;
- Systems Engineering;
- Economics and Law;
- Social Science;
- Marketing and International Relations;
- Political Sciences.

Step 2 - Industry survey

The objective of the industry survey was to obtain information on the current needs and relevancy of the core competences for the railways industry. The survey is explained in detail elsewhere (27). The survey targeted the human resources and recruitment departments of railways firms. Among other questions, the respondents were requested to rank between 1 (low relevancy) to 5 (high relevancy) the relevancy of the abovementioned core competences and domains of knowledge. The survey was done over the internet and it was on-line for five months, from August to November 2010. Multiple channels were used to advertise the survey, such as: research partners’ mailing lists, announcement in the associations’ newsletter, and publication on the research partners’ social networks. The survey obtained a total of 596
responses, of which 147 from firms operating in Europe. The respondents’ educational background (graduation major) is as follows:

- Mechanical Engineering – 34 respondents;
- Civil Engineering – 17 respondents;
- Electrical Engineering – 14 respondents;
- Business – 11 respondents;
- Other (including areas, such as: mathematics, physics, law or mining engineering): 55 respondents;
- No answer - 16

**Step 3 – Course Survey**

The objective of the course survey was to obtain information on the likely competences that students are acquiring in higher-education railways-related courses.

We adopted the following procedure to analyze the courses’ competences:

- Identification of the Universities with railways-related courses;
- Review of the contents and syllabus of the course;
- Identification of the Program of the course;
- Identification of the Department (or Faculty) that provides the Program.

The competences were identified based on the courses’ contents and syllabus; while the Department or Faculty providing the course defined the domain of knowledge. One competence and one domain of knowledge were attributed for each course. We acknowledge that certain courses (in particular those lectured in the first years or as introduction) can potentially offer several competences. In such cases, we chose the competence that students would likely achieve higher proficiency. Only on those cases where such identification was manifestly unfeasible, we labeled more than one core competences (but never more than three).

A total of 222 courses were surveyed. The distribution of reviewed courses per country is presented in the next graph (Figure 3). The dominance of German is explained by the long tradition of railways teaching and high number of universities (in turn, related with the geographical dimension of the country) \(^1\).

**Step 4 – Gap Assessment**

This objective of this step was to assess the competence gap in the European railways sector (Gap 1 of Figure 2). In face of a lack of a robust method in the literature, we followed a qualitative approach in which we compared the relative amount of available courses against the relevancy attributed by the industry for every core competence.

We consider that the relative amount of available courses on each core competence is a proxy to infer the relative importance assigned by the educational sector. The higher is the relative amount of courses, then the higher is importance of that core competence.

We considered the existence of a competence gap when one of the following conditions was met:

- No courses found on a given core competence;
- The relevance attributed by the industry to a given core competence was not reflected in the relative amount of courses.

The same procedure was adopted for the analysis of gaps in the domains of knowledge.

---

\(^1\) More information on the courses can be obtained elsewhere (28).
FIGURE 3 – Courses reviewed by country

DISCUSSION OF THE RESULTS AND ASSESSMENT OF THE COMPETENCES GAP

Industry Survey

Figure 4 and Figure 5 display the results of the industry survey. In what concerns the domains of knowledge (Figure 4) the top three were: railways (3.79), mechanical (3.48), and electrical and electronics (3.23), while the bottom three were: chemical (1.65), automotive (2.00) and aerospace (2.00). The top place for the railways is understandable, as we can expect that any firm would prefer students graduated in its core business. Likewise, the domains ranked in last are also comprehensible since all of them are little related with railways industry.

Recalling that the classification ranged between 1 (low relevancy) and 5 (high relevance), than the middle line is set to 3. Looking again to Figure 5, we can observe that only four of the sixteen domains were ranked above this line. Furthermore, there is a visible gap of 0.4 points between the domain above (system, 3.2) and below (economics and law, 2.8) the middle line. These results may evidence a concentration of industry’s needs in specific areas of knowledge.

Looking now to the demand of competences (Figure 5), the top ranked was environment, while the bottom ranked was: civil engineering and infrastructures. The top position achieved by the competence environment can be justified by the fact that environmental protection and sustainable development are currently key political issues and major drivers of development in Europe. Most interesting is the bottom position occupied by the competence civil engineering and infrastructure that traditionally played an important role. This may justified by the mature development of European railways network that provides
little scope for expansion\(^2\), resulting in a lower need of competences in railways in comparison with others.

---

\(^2\) We could expect that the construction of the European high speed rail would render a higher rank for this competence. The reduced size of this network (in comparison with the conventional one) and the lack of respondents working on this field are the probable causes for this result.
Course Survey

Figure 6 and Figure 7 present the results of the course survey. The results exhibit a strong concentration of the teaching of railways in two domains of knowledge: railways engineering and civil engineering. Civil engineering is the traditional program for the teaching of railways. The progressive importance of railways resulted in the emergence of autonomous rail programs and teaching institutions. Other domains with teaching in railways are: mechanical engineering, electrical and electronics engineering, industrial engineering and automotive engineering. Such unbalance on the presence of domains evidences that students’ knowledge is concentrated on few domain, while lacking (or having deficit) on others, that depending on the needs of the firms could results in gaps.

In what concerns the core competences, several conclusions may be drawn. First, there is a strong concentration on a single core competence: operations. Also, the amount of courses concerning the competence civil engineering and infrastructure do not match the predominance of the respective domain of knowledge. Indeed, the survey revealed that majority of the courses on this domain deal with the competence operations. Both observations evidence that the educational institutions found this competence of utmost relevance. Second, no course was found aiming to develop environmental competences on railways. This result was rather unexpected since environmental protection and sustainable development are topics of high relevancy in Europe. Some possible explanations for this result are: railways being already regarded as an sustainable mode of transport with low environmental issues; or rich offer programs on environmental programs (and courses), although not related with transport or railways. Third, we found courses aiming to develop the remaining core competences.

Based on these results, we may conclude that the European students are learning almost all core competences, with a strong bias towards operations and with an unexpected

---

3 More information could be found in (28).
absence of courses concerning environmental issues on railways. Yet, we acknowledge that
this conclusion may be biased by the available data, as discussed at the end of this chapter.

The next table maps the domains of knowledge with the core competences. There is a clear
division between the domains railways and civil engineering and the others. The former
domains provide all competences, while the latter only provide certain types of competences.
The core competence operations is as expected the one with higher number of courses;
follows the competence rolling stock and traction, in the domain railways, and civil
engineering and infrastructure, in the domain civil. These results are as expected with a
specialization in the competences directly related with the domain of knowledge.

<table>
<thead>
<tr>
<th>Core Competences</th>
<th>Railways</th>
<th>Civil</th>
<th>Mechanical</th>
<th>Industrial</th>
<th>Automotive</th>
<th>Electrical Electronics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil Engineering and Infrastructure</td>
<td>2</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Operations</td>
<td>73</td>
<td>64</td>
<td>4</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Systems Engineering</td>
<td>5</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Rolling Stock and Traction</td>
<td>18</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Control Systems</td>
<td>6</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Economics, Business and Regulations</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
From the analysis of the results we may claim for the likely existence of several competences gap between the railways industry and the educational institutions. This claim is grounded on several evidences. Recalling that the quantity of courses is a proxy to the competence’s relative importance, comparing Figure 5 against Figure 7, we can observe an overall mismatch between the valuation given by the firms and the valuation exhibited by the educational institutions. In a situation of no competence gap, we would expect that the relative quantity of the courses per competence would reflect the relative importance assigned by the industry (that is: more courses on environment, than on systems engineering, than on economics, business and regulation, and so forth). Visibly this is not the case, which evidences the present of competences gap.

Gaps are visible in every competence, yet, in this paper, we focus our attention in two of them: environment and operations. In what concerns the competence environment. The results evidence a undervaluation of this competence by the educational institutions, as the railways industry ranked as it in first but no related course was found. This may be caused either by a misreading of the industry’s needs reducing the educational institutions’ ability in recognizing the relevancy of such competence; or, if this is not the case and they are aware of the relevancy, then they may be in a process of adaption of the programs’ curricula (which is rather lengthy). In any case, students are likely lacking this competence, which to some extent might be jeopardizing their labor productivity and competency. Looking now to the competence operations. The results suggest an overvaluation of this competence by the educational institutions, as it was ranked in fifth place by the industry, but it is the competence with higher amount of courses. Such gap is not necessarily negative, since there is not lack of competent students, however a better allocation of resources could be attained if they were channeled towards the teaching of other more relevant competences.

The analysis of the results of the domains of knowledge also offers interesting conclusions. First, there is an overall misalignment between the industry’s requirements and the educational institutions’ offer. The only exception being the domain of railways engineering that was considered most relevant by the industry and it is the one with more courses found. For all other domains, the relative importance assigned by the industry is not reflected in the amount of courses. As a matter of fact, the concentration of the courses in two domains was a clear sign for the presence of a misalignment. Second, there are multiple domains with no interest in the teaching of railways, despite the high relevancy given by the industry, like for example: mechanical engineering, electric and electronics engineering or systems engineering. The absence of certain domains of knowledge in the teaching of railways does not necessarily imply the emergence of competences gap, as competences may be provided by others. However, as discussed above, a domain of knowledge not only helps the employee to achieve different higher levels of proficiency, as well as, is a leverage to other achieve other competences.

The validity of the assessment is conditioned by the limitations of the available data that are now briefly discussed:

• Not exhaustive review of the courses. The analysis spans 14 countries and more than 200 courses, which provides good confidence on the results;
• Only railways-related courses were reviewed, we acknowledge that other courses may provide competences related with railways. The amount of such courses is likely to be reduced, their identification is rather difficult, and we do not believe that railways firms would primarily target these students;
• Only one competence (in few cases more than one) was identified, we acknowledge that many courses may provide several competences. We eliminated introductory and generalist courses, in order to reduce the bias.
Vasco Reis  
Rosário Macário

- The universe of respondents to the industry survey was not very large, and some domains of activity could be underrepresented. The universe of respondents is around 150, which we believe to be representative of the industry.

CONCLUSIONS

In this paper we address the problem of competences gap between the industry and the educational institutions. Indeed, despite the progressive integration of the educational institutions and the Societies, often there are barriers preventing an alignment between the curricula offered and the actual educational needs of the firms. As a consequence, students may enter the market having competences that are not necessarily those sought by the firms.

The paper presents a framework for the analysis of the competences gap. The framework is structured around four agents, being: firm, educational institution, student and employee. The framework arranges the agents along two vectors. One vector makes the distinction between the demand of competences (firm and employee) and the supply of competences (educational institution and students). The other vector makes the distinction between the expectation of competences (firm and university) and the actual delivery of competences (employee and student). Finally, the framework identified four types of competences gap, each one established between a pair of agents.

The framework was then applied to the higher-education of railways in Europe to assess the competence gap between firms and educational institutions. A 4-step method was developed, including:

- Identification of seven core competences for working in railways, being: environment; systems; economic, business and regulations; control systems, operations, rolling stock and traction, and civil engineering and infrastructures.
- Two surveys: one to the industry aiming to identify the needs of competences, other to the available courses in railways aiming to identify the offer of competences.
- Assessment of the gap

The assessment exercise revealed several competences gap, namely: overall misalignment between the relative importance of the competences assigned by the firms and the relative importance attributed by the educational institutions; undervaluation of the competence environment, ranked in first by the firms but no course found; and overvaluation of the competence operations, ranked in fifth by the firms but with more courses found.

Gaps in terms of domain of knowledge were also assessed. Although such gaps do not preclude the acquisition of competences, they influence the employee’s level of proficiency on a given competence. The analysis also evidences a strong misalignment between the firms’ needs and the educational institutions’ offer. There is a concentration of the education offer in six domains, of which: railways engineering and civil engineering account for around 93% of total offer. This is in total contrast with the demand that valuates other domains with low offer or no offer at all, such as: mechanical engineering, electric and electronics engineering, and systems engineering. Yet, it should be noted that the data presents some limitation and bias, which may undermine the conclusions of the study.

The causes of the competence and domains of knowledge gaps remain to some extent unknown but may include: lack of awareness to the permanent changes of the firms’ needs, misreading of the firms’ needs, or time delay for updating curricula and programs.

Some recommendations for the European Union educational institutions start bridging the gaps can now be drawn, including:

- To start new courses related with the competence environment applied to railways.
To progressively reduce of courses related with the competence operations.

To progressively increase of courses related with the following competences: systems engineering; economics, business and regulation; and control systems.

To progressively increase the amount of courses in the following program: mechanical engineering.

To develop courses related with railways on the following programs: electrical and electronics engineering; systems engineering; and economics and law degrees.

ACKNOWLEDGMENTS

The research was made possible through an E.U.-U.S. Atlantis grant from the Fund for the Improvement of Postsecondary Education, U.S. Department of Education and the Executive Agency for Education Audiovisual and Culture, European Commission.

REFERENCES


Vasco Reis
Rosário Macário


(26) WEINERT, F. (1999) - Concepts of Competence, Munich: Manx Planck Institute for Psychological Research [Published as a contribution to the OECD project Definition and selection of competencies: Theoretical and conceptual foundations (DeSeCo), Neuchâtel.


Vasco Reis (vreis@civil.ist.utl.pt)
Rosário Macário (rosariomacario@civil.ist.utl.pt)
Department of Civil Engineering, Instituto Superior Técnico, Technical University of Lisbon