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Analyzing the competences of production engineering graduates: an industry perspective

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Abstract

This paper aims at conducting an analysis the competences of production engineering graduates, building on an industry view. To this end, we conducted a survey addressing 103 medium and large companies within the Brazilian manufacturing industry. The results suggest that companies do recognize the importance of competences. Some gaps in the competences of graduates were also pointed out by respondents. This study suggests the need for the development of efforts for providing the production engineer with a better professional background. The links between university and industry are likely to contribute towards such direction, notably as a starting point for institutions and industries to foster their student's competences, aiming their aptitude for an ever-competitive job market, which values the flexible, creative being, who is capable of creating innovative solutions.

Keywords

Transversal competences. Technical competences. Production engineer. Industries.

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1. Introduction

Companies are increasingly in need of qualified professionals who can deal with the rapid changes in the global environment. However, one of the critical problems that companies have been facing is the lack of qualified professionals, a problem is particularly important among the engineering profession, driven by the fact that due to some scarcity, are hired after having recently graduated or even while are still studying (Helleno et al., 2013; Chryssolouris et al., 2013).

In the survey conducted by Ragusa (2013) in six universities in the USA addressing 493 engineering students, concluded that the students have not been properly prepared for the job market which demands innovation, leading spirit and agility in problem-solving. Studies performed in a German machine and equipment industry, have identified that only 16.5% of the knowledge related to the application of management tools, are acquired during the engineering course (Paton et al., 2012). In Brazil, a survey performed by Borchardt et al. (2009), identified flaws in the production engineer's professional profile. After some exploratory analysis in order to understand the current profile of the professionals within the production engineering sector, the authors concluded that the production engineer is less qualified than the companies expect them to be.

The engineering students need an updated curriculum, which is connected to their real scenario (Deshpande & Huang, 2011). Therefore, institutions must consider the employers' requirements, since their students' employability depends on the competences they have to offer to the job market (Ayob et al., 2013).

By considering the current scenario, this paper aimed at conducting a diagnosis about the competences required from production engineering graduates. Therefore, a survey was performed addressing medium and large companies within the Brazilian manufacturing industry, in the state of São Paulo. The study aimed to contribute with some relevant information so that the competent institutions are able to provide improvements for the professional background of the production engineer.

2. Evolution of production engineering programs in Brazil

In the current context of globalized production systems, companies are looking for highly qualified engineers capable of working in internationalized supply chains in an effective manner. This context creates new challenges to engineering schools. There is an increasing demand for engineers who are able to work on diverse functional areas, including research and development, design, production, services, and that can be placed anywhere in the world, in order to meet companies' requirements for integrating global supply chains. Such professionals have to be qualified to work with different cultures, notably to adapt projects to the language, the culture and to specific technical and legal requirements prevalent in each acting area, aiming to offer a competitive product within each market (Acosta et al., 2010). In order to successfully compete in the 21st century's professional environment, engineers must be suitable to address innovative entrepreneurial initiatives that require agility and flexibility in problem-solving (Streiner et al., 2014).

Production Engineering is a relatively recent field, as compared to other engineering disciplines. In the words of Oliveira et al. (2010), it emerged as man, became concerned with organizing, integrating, mechanizing, measuring and improving production. Fleury (2008) links the origins of production engineering to the application of economical rationalization to production systems that took place over a century ago. Despite its recent origins, the management and engineering of production has been evolving since the early prevalent principles of Taylor production systems. This creates continuous challenges for organizations', as well as for education and training systems, as it is necessary to permanently reflect on the relevance and applicability of the knowledge acquired in the existing programs and courses (Araújo et al., 2008; Oliveira et al., 2010; Oliveira et al., 2013).

In 1955, the field was known as Industrial Engineering in the USA, whereas in Brazil, following the definitions for industrial engineer advanced by the Federal Board of Engineering and Agronomy (CONFEA) and the Regional Boards of Engineering and Agronomy (CREA), the adopted label was production (Oliveira et al., 2010).

The prevalent approach for defining the professional field of industrial engineering builds on the identification of the key characteristics that distinguish it from other established engineering fields. The need for the application of multidisciplinary knowledge is commonly emphasized across the various engineering fields, but it is highlighted as being particularly important for industrial engineers (Amorim, 2012).

The offer of Production Engineering courses in Brazil, only started in 1958, by the Polytechnic School of the University of São Paulo (USP). At the time, Production Engineering was offered as an option in the Mechanical Engineering course, as a response to address the industry demands for engineering professionals with management profile. The integration of Production as an option within the Mechanical Engineering course prevailed until 1970 (Oliveira et al., 2010). In 1976, Brazil's Ministry of Education (MEC), following the Resolutions 48/76 and 10/77 from the Federal Board of Education (CFE), turned it into a secondary education, attached to six basic fields of engineering: Civil, Electrical, Mechanical, Materials, Metallurgy and Mining (Borchardt et al., 2009). In mid-1990 there were only five full-type courses in the country, from which four were offered by universities in Rio de Janeiro and one in São Paulo (Bittencourt et al., 2010). Following the Law of Directives and Bases of National Education - LDB (Law 9394 from 1996) and the end of the minimum curriculum, many existing courses were subject to reformulations in the curricular contents, aimed at expanding the load of specific contents focused on Production Engineering (Oliveira et al., 2010). In this vein, as advanced by the authors, LDB has put forward a new proposal for the formulation of Production Engineering education, as follows:

- Courses can be proposed having a technological basis specific to the field of Production Engineering, including: Product Engineering; Factory Engineering; Production Processes; Methods and Processes Engineering; Production Planning and Control; Production Costs; Quality; Maintenance Organization and Planning; Reliability Engineering; Ergonomics; Occupational Safety and Health; Logistics and Distribution; Operational Research;

- Courses can also include other qualifications related to the field of Production Engineering, as well as to any of the former wide areas of engineering or, derived from the need to meet regional needs identified by Education Institutions.

Despite its recentness, as compared to other engineering fields, the offer of undergraduate courses on Production Engineering has experienced a substantial evolution. In 2001, 72 courses were offered in the country. Ten years later, this number escalated to 444 courses (Oliveira et al., 2013). Such increase abides with the advancement of engineering as a whole in the country, since there is an ascending demand for engineers in the job market (Klix, 2014). In 2013, the course was already offered by 537 institutions, and was present in every Brazilian state, as shown in Figure 1.

It is observed in Figure 1, that the biggest offer of undergraduate courses in Production Engineering is present in the regions with the most intense economic activity - the southeast region, notably the state of São Paulo (Brazil), which is considered the biggest economic pole, as well as the stronger consumption market of the country (Bittencourt et al., 2010; Invest São Paulo, 2014). According to Oliveira et al. (2013) the significant increase in the number of Engineering courses may be related to the evolving needs of organizations to address competitiveness and quality goals, for which they require qualified professionals able to effectively implement and manage logistic systems, and production management in general, i.e. professional profiles aligned with the scope of competences and knowledge of Production Engineers.

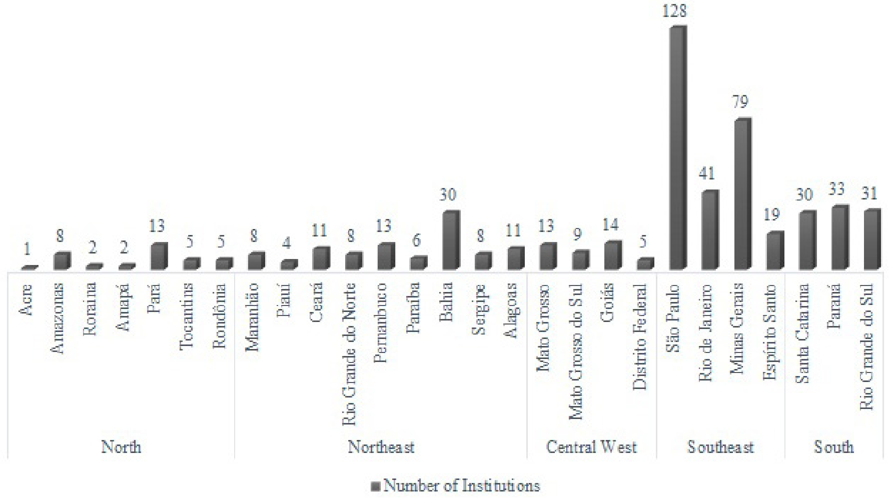

Figure 1. Number of institutions offering undergraduate courses in Production Engineering, accredited by the Ministry of Education, by Brazilian states. Source: Ministry of Education System (2013).

Nevertheless, and regardless of the progression in the number of institutions which offer undergraduate courses in production engineering in Brazil, existing studies still highlight a lack of engineers in the country (Nascimento et al., 2014). The debate performed by IPEA in 2013, concluded that the lack of undergraduate workers in the area is due to the poor quality of the education of some of them and to the deficit of specific skills (Salerno et al., 2014)

3. The professional profile expected for the 21st-century engineers

A professional profile can be defined as set of competences that can be related to three dimensions: knowledge, abilities and attitudes, that correspond to the technical issues, cognition and attitudes related to the job. The first dimension – knowledge - corresponds to the information that can be acquired and structured by individuals, building up on all the knowledge they have acquired throughout their lives. Abilities are related to knowing how to do something, or to the capability of making productive use of the acquired knowledge, i.e. turning it into actions. It can either be an innate or a developed competence, yet training and experience do allow for individuals to improve it (Chiavenato, 2010). Cunha (2002) defines ability as "[...] the dominance over the use of the intellect in way to perform specific tasks". The third aforementioned dimension – attitude – refers to social and affective aspects related to work. It is the predisposition towards the adoption of a specific action, with a particular occurrence pattern (Durand, 2000).

Regarding competences, the literature offers a variety of definitions to the term. Broadly, a competence can be defined as the complex ability of an individual or group to identify, select and combine a set of resources (e.g. materials, knowledge, etc.) with the purpose of performing a task, solve a problem or conduct a project (Fernandes et al., 2014; Rouvrais et al., 2006). A simple and coherent popular definition associates competences to a set of knowledge, abilities and attitudes (Neri, 2010). According to Piaget's theory, competences are built from the articulation and mobilization of the knowledge through mental schemes (physical and mental actions on objects which modify themselves and become more and more refined through successive processes of assimilation and accommodation), whereas abilities allow for the competences to be put into action (Ramos, 2002). The authors Green (2000) and Spencer & Spencer (1993) put forward a conceptualization of competences with a focus on behavior and results. This approach is justified by the fact that it allows for some objective observation and description, that is, by means of behavior it is possible to assess what really determines a superior work performance. Zarifian's definition (Zarifian, 2001) is focused on the idea of competence centered in the professional's reaction towards complex and challenging situations from work. To Fleury & Fleury (2001) competence is "[...] knowing how to act in a responsible and recognizable way, which implies in mobilizing, integrating, transferring knowledge, resources and abilities, which adds economical value to the organization, and social value to the individual". The definitions put forward by Green (2000), Spencer & Spencer (1993), Zarifian (2001) and Fleury & Fleury (2001) allow for understanding that professionals need to develop competences to take on responsibilities for addressing new and unexpected situations with adequate performance, i.e. to address emergent scenarios as this corresponds to circumstances that very common in competitive scenarios. To this end professionals are expected to mobilize the knowledge to deliver results that meet the required deadlines and quality specifications (Chiavenato, 2010).

Given the broad range required from engineering professionals nowadays, generic and specific competencies have been put forward by professional engineering bodies. The prevalent approach distinguishes two overarching categories: transversal competencies, related to aspects such as the ability to engage in teamwork, project management, life-long learning and communication; technical competences, concerning aspects like designing, solving, planning, and making synthesis from a cross-disciplinary standpoint (Rouvrais et al., 2006). These distinct dimensions of competences are visible in the range of competences that are frequently listed as requirements in engineers' professional profiles. Oliveira & Pinto (2006) propose a set of competences that are expected to be a part of the professional profile of the 21st- century engineer. The engineer is profiled as an individual who:

✓ Always searches for new knowledge in order to express in an autonomous and independent way;

✓ Contributes to the scientific and technological development;

✓ Presents creative and original solutions to issues related to projects, production and administration;

✓ Develops a good job within multidisciplinary teams;

✓ Designs, executes and manages engineering enterprises;

✓ Cares about the impact of his work, notably concerning the ethical, environmental and political implications.

It stands out that the professional profile expected for the 21st century engineer, is that of an analytical, enterprising and creative professional, that is capable of delivering suitable solutions to new issues. This results from a transformation dynamics that has happened in an intense way across all the sectors (Oliveira & Pinto, 2006).

According to Sonmez (2014), the North American Accreditation Board for Engineering and Technology (ABET) has identified a set of competences for undergraduate students of engineering, regardless of the specialization field, which must be integrated in the course's curriculum, namely:

✓ The ability to apply knowledge of mathematics, science and engineering;

✓ The ability to design and conduct experiments, as well as to analyze and interpret data;

✓ The ability to design a system, a component or a process in order to meet requirements;

✓ The ability to function on multidisciplinary teams;

✓ The ability to identify, formulate and solve engineering issues;

✓ The understanding of professional and ethical responsibilities;

✓ The ability to communicate effectively;

- ✓ The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
- ✓ Knowledge of contemporary issues;
- ✓ The ability to make use of techniques, skills, and modern engineering tools necessary for the engineering practice.

To the Higher Education Chamber of the National Education Council (Ministry of Education, 2002, Res. CNE/CES 11/2002) the engineer's professional profile, is defined by a general, humanistic, critical and reflexive education, capable of developing new technologies for solving relevant issues to society. The engineer's education aims to provide the professionals with the required knowledge for exercising the following competences:

- ✓ Applying mathematical, scientific, technological and instrumental knowledge to engineering;
- ✓ Designing and conducting experiments, and interpreting results;
- ✓ Conceiving, designing and analyzing systems, products and processes;
- ✓ Planning, supervising, elaborating and coordinating engineering projects and services;
- ✓ Identifying, formulating and solving engineering issues;
- ✓ Developing and/or making use of new tools and techniques;
- ✓ Supervising systems' operation and maintenance;
- ✓ Critically evaluating systems' operation and maintenance;
- ✓ Efficiently communicating in written, oral and graphical terms;
- ✓ Working in multidisciplinary teams;
- ✓ Understanding and applying professional ethics and responsibilities;
- ✓ Evaluating the impacts of the engineering activities within the societal and environmental contexts;
- ✓ Evaluating the economic viability of engineering projects;
- ✓ Having an attitude of always seeking for professional updating.

The production engineer is attributed with the responsibility of performing activities aligned with the procedures prevalent in industrial manufacturing, as well as with industrial production methods, with industrialized product standards, and associated services (Federal Council for Engineering and Agronomy, 2005).

The Brazilian Association of Production Engineering also defines the desired professional profile for the production engineer (Borchardt et al., 2009). In short, it proposes a characterization along the following dimensions:

- ✓ **Technique:** The Production Engineer must be able to act fundamentally in the organization of production activities, thus receiving training in management methods and production optimization techniques.
- ✓ **Mode of operation (acting):** The Production Engineer should be able to promote the interface between the areas that act directly on technical systems, and between these and the administrative areas of the company.
- ✓ **Vocation:** The Production Engineer must hold interest, vision and skills that are consistent with managerial approaches, while maintaining interest in matters within the area of technical systems. At the same time, a problem-solving spirit is required.

Building on the literature, as well as on data collection from employers and from representatives of the corporate class, the Brazilian Association of Production Engineers defined 10 competences of technical nature and 14 competences of transversal nature aimed for the graduates of production engineering, which served as reference to the survey conducted in this study, as displayed in Table 1. Mesquita et al. (2015) presented a framework of competences for the Industrial Engineering and Industrial Management, and classified competences as technical or transversal. Technical competences are fundamentally linked to knowledge areas, and to different actions such as analysis, design, planning, implementation, control and improvement. The second category, transversal competences, is associated with dimensions considered relevant to several areas of activity (e.g. teamwork), but are mobilized in conjunction with technical competences in the professional practice. This work presents a set of competences that have strong links with the competences presented in Table 1.

Table 1. Competences for production engineering graduates.

TECHNICAL COMPETENCES
(C1) Scaling and integrating physical, human and financial resources, on order to efficiently manufacture at the lowest cost, considering the possibility of permanent improvements;
(C2) Making use of mathematical and statistical tools to model production systems and help with decision-making;
(C3) Designing, implementing and upgrading systems, products and processes, respecting the limits and features of the communities involved;
(C4) Predicting and analyzing demands, selecting technologies and know-how, designing products or improving their features and functionality;
(C5) Incorporating quality concepts and techniques to the whole productive system, regarding both their technological and organizational aspects, upgrading products and processes and creating control and auditing norms and procedures;
(C6) Being capable of managing and optimizing the information flow within companies by using proper technologies;
(C7) Predicting the evolution of productive scenarios, noticing the interaction among the organizations and their impacts on competitiveness;
(C8) Accompanying technological advances, organizing them and making them available according to the companies and the society's demands;
(C9) Understanding the interrelationship between the production systems and the environment, regarding both use of scarce resources and the final disposal of residues and wastes, not neglecting the requirement for sustainability;
(C10) Making use of performance indicators, costing systems, as well as evaluating the economic and financial viability for projects.
TRANSVERSAL COMPETENCES
(A1) Commitment to professional ethics;
(A2) Enterprising leads;
(A3) Willingness for self-learning and continued education;
(A4) Oral and written communication;
(A5) Domain of a foreign language;
(A6) Critic view of orders of magnitude;
(A7) Knowledge of computers;
(A8) Reading, interpreting and expressing through graphics;
(A9) Knowledge of the pertinent legislation;
(A10) Capability of working in multidisciplinary teams;
(A11) Capability of identifying, modeling and solving problems;
(A12) Understanding management, socio-economic and environmental problems;
(A13) Societal and environmental responsibility;
(A14) Think globally, act locally.

Source: Adapted from Cunha (2002).

Overall, the recent studies and multiple efforts to advance the competences required for the 21st-century engineer point towards a professional that must be analytical, entrepreneurial and creative, one that is capable of providing timely and adequate answers to new issues. Magdalena et al. (2013) suggest that teaching institutions must be aligned with companies in order to define the professional abilities which have to be integrated to the courses, in order to be able to offer learning models that are active, reflexive and consistent with the best education for future professionals for the industry.

4. Methodological approach

The purpose of this study was to conduct an exploratory investigation of the competence profile of industrial engineering professionals, in order to inform a discussion about its adequacy and alignment with industry requirements. The study aimed at offering a contribution to the understanding of the profile expected by industry from these professionals, in order to devise ways to develop the existing educational offers in a meaningful and adequate manner. To this end the research design targeted the collection of primary data directly from industry respondents with the purpose of getting real insights about the competence profile exhibited in loco, i.e. in the performance of concrete industrial tasks by industrial engineering graduates. Industrial engineering is a multidisciplinary field, and for this reason the competence profile of industrial engineers includes a wide spectrum of domains, including both technical and transversal competences. Whereas the technical competences are traditionally more explicitly embodied in the education and training curriculums for these professionals, the elements supporting the acquisition of the transversal competences are naturally more fragmented across the formal learning paths (for example by the adoption of different learning methodologies) as well as in learning experiences enabled by the real contact with industrial practice (e.g. be means of internships, projects, etc.). For this reason, the assessment on the domain of the transversal competences can benefit from investigating the perceived performance of industrial engineers directly from their working contexts. In this vein the research design privileged the collection of data from industry respondents.

This study involved the development of a survey instrument (see Appendix 1) in order to investigate the companies' perceptions about the competences of the production engineer in industrial environments. The developed survey can be classified as exploratory, as it aimed to provide a preliminary view on a theme, that is, to obtain a preliminary perception about the theme, providing the basis for a deeper survey (Miguel & Ho, 2012; Forza, 2002). The steps involved in the design, application and use of survey are displayed in Figure 2, and described in the following paragraphs.

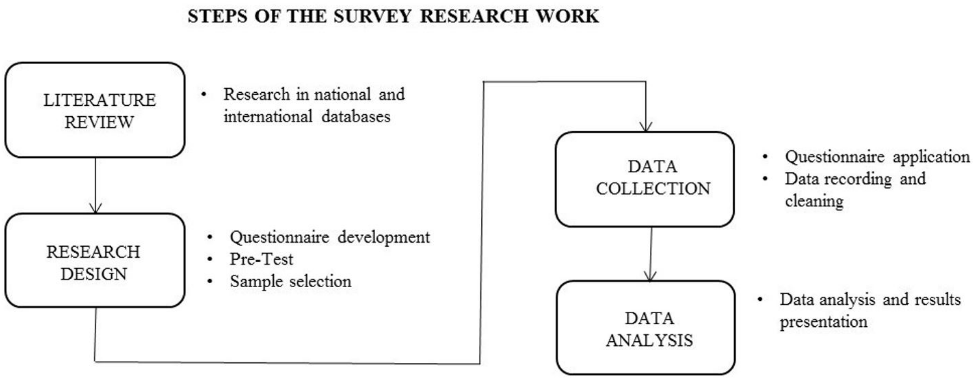

Figure 2. Methodological Approach. Source: adapted from Miguel and Ho (2012).

➢ Preliminary literature review

The first step involved a literature review, addressing national and international databases, and including journals, scientific publications, congresses and websites. Most of the publications considered dated from the last five years. Some older publications were also considered due to their relevance for the field of education in industrial engineering. The literature review informed the elaboration of the data collection tool, notably by enabling the identification of different perspectives about the range of competences that are relevant for the qualification of industrial engineers, as reported in Table 2.

The competences proposed by Cunha (2002) were defined as the basis for the survey instrument. This approach was considered relevant and adequate as it incorporates the perspectives of employers, associations and corporate bodies, i.e. the parties involved in the education and training of the production engineer.

Table 2. Main publications used for identifying and defining competences.

Publications	Technical competences										Transversal Competences													
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14
Acosta et al. (2010)	x[1]		x			x			x		x	x			x	x					x	x	x	x
Ayob et al. (2013)		x	x			x	x				x		x	x		x		x			x		x	x
Borchardt et al. (2009)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Chryssolouris et al. (2013)	x	x				x			x		x	x			x	x					x			x
Cunha (2002) - ABEPRO	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fleury & Fleury (2001)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Green (2000)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Ministry of Education (2002)		x						x	x		x		x	x			x			x	x			
Mesquita et al. (2015)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Oliveira & Pinto (2006)									x	x		x	x						x	x				
Spencer & Spencer (1993)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Zarifian (2001)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Source: elaborated by the authors. [1]The literature review conducted by the authors aimed at identifying mentions to relevant technical and transversal competences in the context of production engineering. This table presents a list of the relevant references used in the study, together with the information about the technical and transversal competences that were found in each manuscript, although in some cases the authors did not used the terms technical or transversal explicitly, but employed other formulations that could be related to the ones adopted in this paper. The information about the competences identified in each paper are marked with the symbol "X" for each pair paper/competence in the Table.

➢ Questionnaire design

The proposed questionnaire included structured questions, offering multiple choice answers, that addressed the competences expected from a production engineer. In some questions respondents were asked about the level of importance of the competences. To answer these questions they were instructed to use a five-point *Likert scale*, to express their evaluation on a range from *Very Important (1)* to *Not Important (5)*. Other questions asked the company respondents to assess the level of deficiency of competences in existing professionals, using an ordinal scale in which 1 represented the best evaluation (No Deficiencies at All) and 5, the worst evaluation (*Maximum Deficiency*).

➢ **Pre-test**

For Rea & Parker (2002) highlight that every instrument of data collection must be assessed for its clarity, scope and acceptability, in order to achieve a robust final version. Therefore, a first test was performed in the preliminary version of the questionnaire, for which ten interviews were conducted with academics and industry professionals. The interviews were directed to the critical evaluation of the questionnaire. The observations collected were analyzed and an adjusted version was generated. According to Forza (2002), when the questionnaire is submitted to a target group of respondents, it can provide feedback on any parameter that may affect the answers before being sent definitively. The adjusted version of the questionnaire was then applied to twenty two professionals in a large company, where its applicability and clearness was verified, leading to the final version.

➢ **Sample selection**

The scope delimited for the application of the survey was the population from medium and large companies within the manufacturing industry in the state of de São Paulo. Such choice was made due to the fact that the sector is the responsible for 57% of the hiring of production engineers, as compared to other sectors of the Brazilian economy. Once the sector was defined, the size of the companies which most hire such professionals was set. The reason why the large-sized companies were chosen, is related to the fact that they are responsible for 60% of the hiring of production engineers in the Brazilian manufacturing industry (Ministry of Labor and Employment, 2014; Federation of Industry, 2014). The state of São Paulo hosts most of the large-sized companies, and is responsible for one third of the Brazilian PIB, therefore being considered the main economical pole and consumption market of the country (Invest São Paulo, 2014).

➢ **Survey application**

The application of the developed survey involved sending a questionnaire by email to the 728 large-sized companies in the state of São Paulo. The email addresses of the respective companies were given by industry bodies and representatives, such as the Federation of Industries of the State of São Paulo – FIESP. The researchers complemented this information by conducting information search in the companies' websites. After sending the emails, biweekly collections were performed directing the increase in the rate of return (Miguel & Ho, 2012). The collected questionnaire data was compiled into a spreadsheet database, using Microsoft Excel 2010 software, also employed for data analysis.

5. Sample characterization

One hundred and three companies responded to the survey, therefore registering a response rate of 14%, and from which 55% were medium sized and 45% are large ones. Figure 3 depicts the companies' profile across business segments.

It is possible to observe that most of the companies belong to the subclasses of Automotive Vehicles, Metallurgy and Machine and Equipment, representing 52% of the sampling. Table 3 shows the respondents occupation/sector.

Table 3, shows that all the respondents from the survey occupy positions in areas related to Production Engineering, what qualifies them to answer the questionnaire

6. Analysis of the competences of production engineers: an industry perspective

The companies evaluated the level of importance of the competences required from production engineering professionals, using a 5-point *Likert scale* (ranging from *Very Important* to *Not Important*). Figure 4 presents the analysis of such competences.

Figure 4 illustrates that all the competences were well evaluated by the companies. Among them, C1, C3, C5 and C9 were particularly highlighted as very important. Such competences are related to knowledge on scaling and integrating physical, human and financial resources in order to efficiently produce at the lowest cost; designing, implementing and improving systems, products and processes; incorporating techniques and quality concepts to the whole productive system; the use of performance indicators, costing systems and the projects' economical and financial viability. Figure 5 offerns the corresponding analysis for the transversal competences.

Figure 5 highlights that the transversal competences were also very well evaluated by the companies. Among them, A1, A4, A5, A6, A10 and A11 were considered very important. Such competences concerned the knowledge on the commitment to professional ethics; the capability of interacting, making use of proper

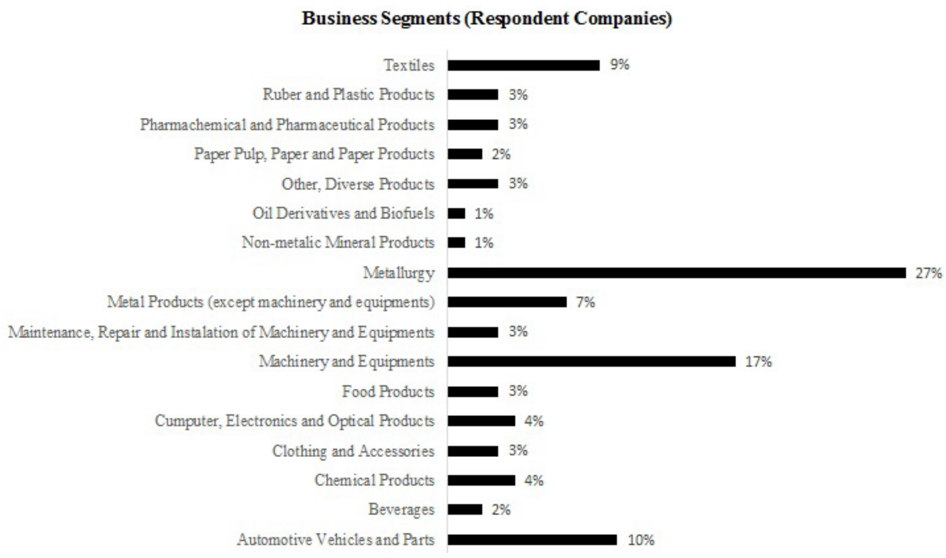

Figure 3. Business segments of the respondent companies. According to the Classification of Business Activities (2014).

Table 3. Respondents occupation and sector.

RESPONDENTS' OCCUPATION(S)	SECTORS/ DEPARTMENTS
Corporate Logistics Manager	Logistics
Factory and Production Managers (5+3)	Production
Maintenance Managers and Supervisors	Maintenance
Manufacture and Operations Managers	Operation
Research and Development Manager	Research, Development and Innovation
Process Managers and Supervisors	Process Engineering
Project Manager	Project Engineering
Institutional Relations Manager	Strategy and Governance Department
Quality System and Production Manager Quality Supervisors	Quality Engineering
Industrial Managers	Industrial
Senior Technical Designer (2)	Production Engineering

Source: Survey Data.

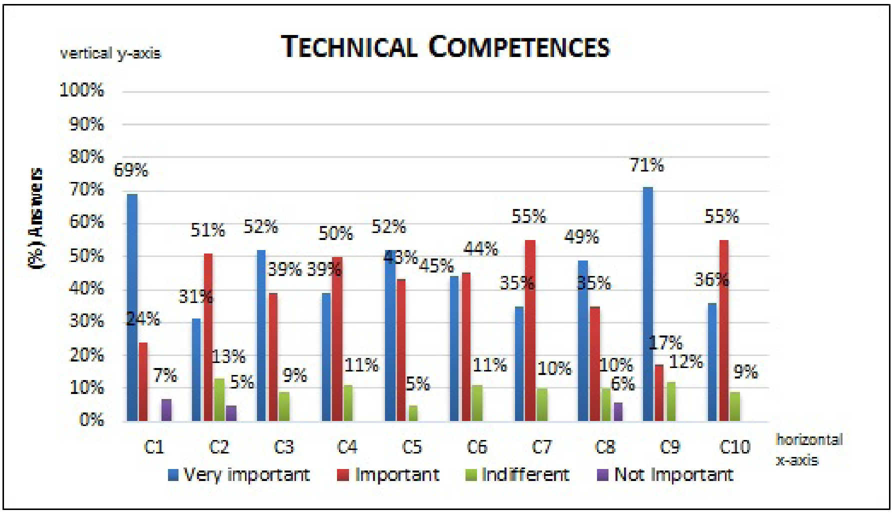

Figure 4. Level of importance for technical competences of production engineers.

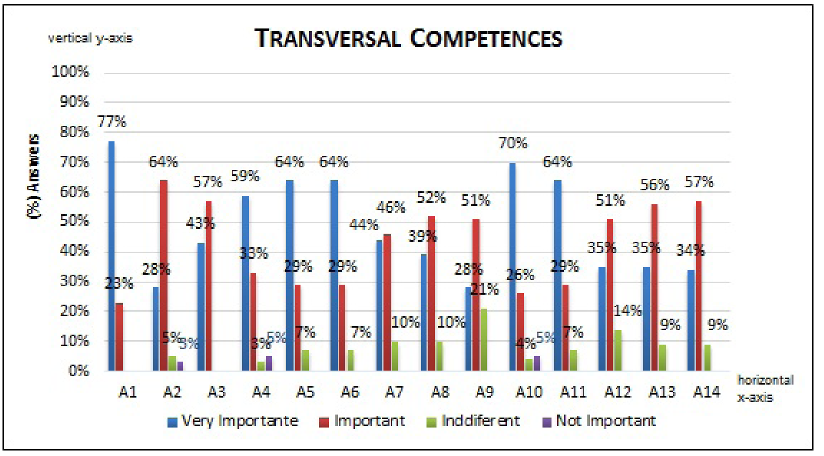

Figure 5. Importance level for transversal competences of the production engineer.

language, writing good texts, selecting useful reading material for the working routine; on properly scaling the productive resources in order to meet the expected demand, the capability of working in multidisciplinary teams, and the capability of identifying, modeling and solving problems.

After having evaluated the importance level, the companies also evaluated the deficiency or gap level by making use of a 5-point numerical scale, considering 1 (No Deficiencies at all) for the best performance, and 5 (Maximum Deficiency) for the worst performance.

For the graphical presentation of these results the most frequent value for each competence was considered, thus facilitating the visualization in Figure 6 and Figure 7 (Favéro et al., 2009).

It is noticed on Figure 6 that the technical competences pointed as the most deficient were: C1, C4 and C9. Those refer to the knowledge about scaling and integrating resources in order to efficiently manufacture at the lowest cost; analyzing demands; selecting know-how and technology selection, and using performance and costing systems. Figure 7 displays the corresponding evaluation for transversal competences.

Figure 7 shows that the transversal competences pointed as the most deficient were: A2, A4 and A5, A9, and A12. Those refer to entrepreneurial lead, oral and written communication, knowledge of a foreign language, knowledge of pertinent legislation, socio-economic and environmental issues. It was verified that the production engineer does not present any flaws concerning two transversal competences: A1 and A11. Those are related to commitment to professional ethics and the capability of identifying, modeling and solving problems.

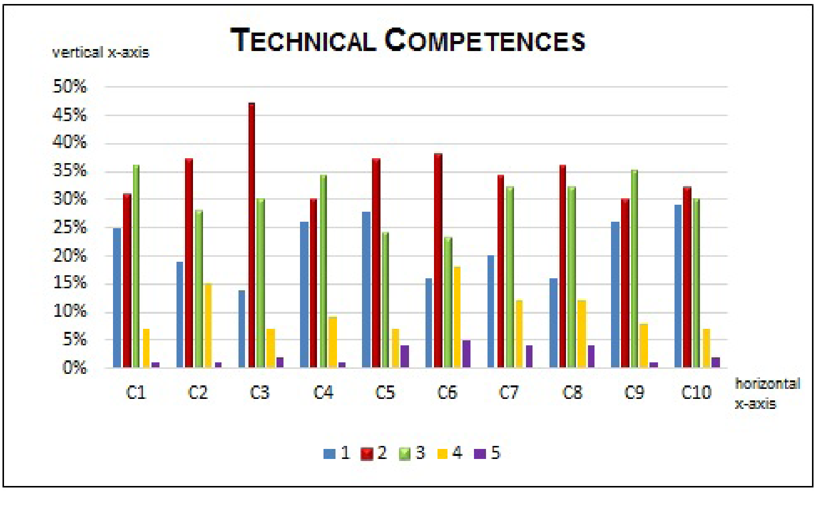

Figure 6. Deficiency level for technical competences.

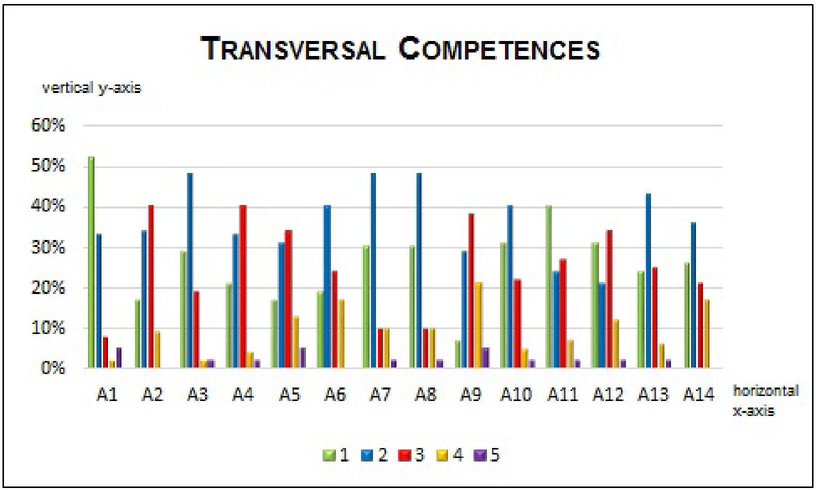

Figure 7. Deficiency level for transversal competences.

7. Final considerations

This study aimed at conducting an exploratory diagnosis of the importance and level of the production engineer's competences from the perspective of companies who integrate them following graduation and are privileged observers for their performance. To this end a survey was conducted, collecting answers from 103 medium and large companies from the manufacturing industries in the state of São Paulo. This state is the largest hiring pole for production engineers in Brazil. The results suggest that, while companies acknowledge the importance of competences of the production engineer's, they identify some gaps in the profiles of these professionals. In particular the average gap in the domain of technical competences seems to be stronger than the deficiencies in the domain of transversal competences. The technical competences related to i) Scaling and integrating physical, human and financial resources, in order to efficiently manufacture at the lowest cost; ii) Making use of performance indicators, costing systems, as well as evaluate the projects' economical and financial viability are considered very important, however, are also considered the most deficient ones. The same happens with transversal competences concerning "oral and written communication" and the "domain of a foreign language". Therefore, it has been concluded that efforts must be made for a better professional education for the production engineer, as well as for a stronger alignment with market and industry requirements. Part of such responsibility can be allocated to universities for their acknowledged role in the production and transfer of knowledge. There has been an extensive debate about the alignment between the university experience and the market demands for qualified and employable individuals (Tomlinson, 2012). Nevertheless, the fast pace of chance in in industry's needs will continuously challenge higher education institutions to develop and maintain effective models of dialogue with the companies in order to provide its students and employees, adequate training and background for creating solutions and solving the industry's problems. It is believed that the partnership between university and industry might be a starting point for both the education of engineering students who are apt for a highly competitive market, which values the flexible, creative being, who is capable of creating innovative solutions. Building upon the feedback collected from respondents to this study, it is suggested that future studies should inquire causes for the identified gaps in the performance of production engineers, regarding the competences required by the industrial environment.

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Appendix 1. Survey instrument.

O DESEMPENHO DO ENGENHEIRO DE PRODUÇÃO NAS EMPRESAS

Nome da Empresa:	
Unidade Respondente:	
Endereço:	
Porte: ( ) Micro: com até 19 empregados ( ) Média: 100 a 499 empregados	( ) Pequena: de 20 a 99 empregados ( ) Grande: mais de 500 empregado
Segmento: ______________________________	A empresa tem Departamento de RH? ( ) Sim ( ) Não
Nome do respondente:	
Área:	
Cargo:	

GESTORES RESPONSÁVEIS PELAS ÁREAS ONDE ESTÃO ALOCADOS OS ENGENHEIROS DE PRODUÇÃO

Nome do respondente:
Cargo:
Área:

1 - Considerando as competências e habilidades esperadas para o engenheiro de produção, identifique o grau de importância destas para a sua empresa:

Competências (Importante: verificar junto às áreas que contratam)				
Dimensionar e integrar recursos físicos, humanos e financeiros a fim de produzir, com eficiência e ao menor custo, considerando a possibilidade de melhorias contínuas;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Utilizar ferramental matemático e estatístico para modelar sistemas de produção e auxiliar na tomada de decisões;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Projetar, implementar e aperfeiçoar sistemas, produtos e processos, levando em consideração os limites e as características das comunidades envolvidas;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Prever e analisar demandas, selecionar tecnologias e know-how, projetando produtos ou melhorando suas características e funcionalidade;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Incorporar conceitos e técnicas da qualidade em todo o sistema produtivo, tanto nos seus aspectos tecnológicos quanto organizacionais, aprimorando produtos e processos, e produzindo normas e procedimentos de controle e auditoria;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Prever a evolução dos cenários produtivos, percebendo a interação entre as organizações e os seus impactos sobre a competitividade;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Acompanhar os avanços tecnológicos, organizando-os e colocando-os a serviço da demanda das empresas e da sociedade;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Compreender a interrelação dos sistemas de produção com o meio ambiente, tanto no que se refere à utilização de recursos escassos quanto à disposição final de resíduos e rejeitos, atentando para a exigência de sustentabilidade;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Utilizar indicadores de desempenho, sistemas de custeio, bem como avaliar a viabilidade econômica e financeira de projetos;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Gerenciar e otimizar o fluxo de informação nas empresas utilizando tecnologias adequadas.				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
1.a – Há alguma competência não citada anteriormente que a empresa julga importante para o engenheiro de produção? ( ) Sim ( ) Não Quais?______________________________ ______________________________				

Appendix 1. Continued...

Habilidades

(Importante: verificar junto às áreas que contratam)

Compromisso com a ética profissional;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Iniciativa empreendedora;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Disposição para auto aprendizado e educação continuada;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Comunicação oral e escrita;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Domínio de língua estrangeira;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Visão crítica de ordens de grandeza;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Domínio de técnicas computacionais;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Leitura, interpretação e expressão por meios gráficos;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Conhecimento da legislação pertinente;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Capacidade de trabalhar em equipes multidisciplinares;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Capacidade de identificar, modelar e resolver problemas;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Compreensão dos problemas administrativos, socioeconômicos e do meio ambiente;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Responsabilidade social e ambiental;				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância
Pensar globalmente, agir localmente.				
( ) Muito Importante	( ) Importante	( ) Indiferente	( ) Pouco Importante	( ) Sem Importância

1.b – Há alguma habilidade não citada anteriormente que a empresa julga importante para o engenheiro de produção?

( ) Sim ( ) Não

Quais?____

2 - Definir o grau de deficiência de um engenheiro de produção para as seguintes competências e habilidades:

Competências

*Considere (1) Não tem Deficiência até (5) Deficiência Máxima

	1	2	3	4	5
Dimensionar e integrar recursos físicos, humanos e financeiros a fim de produzir, com eficiência e ao menor custo, considerando a possibilidade de melhorias contínuas;					
Acompanhar os avanços tecnológicos, organizando-os e colocando-os a serviço da demanda das empresas e da sociedade;					
Utilizar ferramental matemático e estatístico para modelar sistemas de produção e auxiliar na tomada de decisões;					
Compreender a interrelação dos sistemas de produção com o meio ambiente, tanto no que se refere a utilização de recursos escassos quanto à disposição final de resíduos e rejeitos, atentando para a exigência de sustentabilidade;					
Projetar, implementar e aperfeiçoar sistemas, produtos e processos, levando em consideração os limites e as características das comunidades envolvidas;					
Gerenciar e otimizar o fluxo de informação nas empresas utilizando tecnologias adequadas.					
Utilizar indicadores de desempenho, sistemas de custeio, bem como avaliar a viabilidade econômica e financeira de projetos;					
Prever e analisar demandas, selecionar tecnologias e know-how, projetando produtos ou melhorando suas características e funcionalidade;					
Incorporar conceitos e técnicas da qualidade em todo o sistema produtivo, tanto nos seus aspectos tecnológicos quanto organizacionais, aprimorando produtos e processos, e produzindo normas e procedimentos de controle e auditoria;					
Prever a evolução dos cenários produtivos, percebendo a interação entre as organizações e os seus impactos sobre a competitividade;					

Appendix 1. Continued...

Habilidades *Considere (1) Não tem Deficiência até (5) Deficiência Máxima					
	1	2	3	4	5
Compromisso com a ética profissional;					
Iniciativa empreendedora;					
Disposição para auto aprendizado e educação continuada;					
Comunicação oral e escrita;					
Domínio de língua estrangeira;					
Visão crítica de ordens de grandeza;					
Domínio de técnicas computacionais;					
Leitura, interpretação e expressão por meios gráficos;					
Conhecimento da legislação pertinente;					
Capacidade de trabalhar em equipes multidisciplinares;					
Responsabilidade social e ambiental;					
Capacidade de identificar, modelar e resolver problemas;					
Pensar globalmente, agir localmente.					
Compreensão dos problemas administrativos, socioeconômicos e do meio ambiente;					

Fontes:

ABEPRO. Referências de Conteúdo da Engenharia de Produção. Documento Elaborado pela Comissão de Graduação e referendado no GT de Graduação do Encep 08 e Enegep 08 – 16/10/08. http://www.abepro.org.br/arquivos/websites/1/%C3%81reas%20da%20Engenharia%20de%20Produ%C3%A7%C3%A3o.pdf. Acesso em 21/03/2014.

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