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An evaluation of the competences and abilities of the production engineer in the industrial environment

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Uma avaliação sobre as competências e habilidades do engenheiro de produção no ambiente industrial

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Abstract: The objective of this work is to investigate how companies assess the competences and abilities of the production engineer to carry out their activities in the industrial environment. The methodology involved a literature review and survey research in 46 large-sized companies, in the manufacturing industry of the state of São Paulo. The results showed that companies recognize the importance of competences and abilities of the production engineer for the industrial environment, but at the same time, they point to deficiencies of the professional regarding them. The results of this survey conclude that efforts should be made to address these deficiencies in the professional qualification of the production engineers. It is understood, therefore, that in competitive scenarios it is necessary a stronger integration between educational institutions and companies so that in this way they can generate together more training and experience, which in turn improve the competences that, in turn, improve abilities, and result in more qualified professionals to create solutions and solve industry problems.
Keywords: Production engineer; Competences and abilities; Education in engineering.

Resumo: *Objetivou-se neste trabalho investigar como as empresas avaliam as competências e habilidades do engenheiro de produção para o desempenho de suas atividades no ambiente industrial. A metodologia envolveu uma revisão bibliográfica e uma pesquisa survey em 46 empresas de grande porte da indústria de transformação do Estado de São Paulo. Os resultados mostraram que as empresas reconhecem a importância das competências e habilidades do engenheiro de produção para o ambiente industrial, mas, ao mesmo tempo, elas apontam deficiências do profissional. A partir dos resultados desta pesquisa, conclui-se que esforços devem ser realizados para suprir tais deficiências na formação profissional do engenheiro de produção. Entende-se, portanto, que nos cenários de competitividade existe a necessidade de as instituições de ensino integrarem-se com as empresas para que juntas gerem mais treinamento e experiência, que, consequentemente, melhoram as habilidades que, por sua vez, melhoram as competências e resultam em profissionais mais qualificados para criar soluções e resolver os problemas da indústria.*
Palavras-chave: *Engenheiro de produção; Competências e habilidades; Educação em engenharia.*

1 Introduction

Competition within the job market has been causing several changes in the production systems, demanding new approaches for the productive activity (Batalha, 2008). The organizations need to be agile, effective and must have abilities, competences and people who are capable of developing. According to Jabbour et al. (2012) the human resources positively influence the organizations' performance. Therefore, the human element itself constitutes one key in achieving the competitive advantage. One manner of assuring such advantage, is profiting, at most, the individuals' knowledge and abilities, since they are responsible for converting information into knowledge and making use of their own (Nonaka & Takeuchi, 1997; Sveiby, 1998).

The companies are constantly in need of engineers who are capable of combining abilities and competences in an innovative and effective manner in order to handle the fast changes within the globalised world (Boahin & Hofman, 2014). However, one of the critical issues companies have been facing is the lack of qualified professionals, which becomes worse in the case of engineers who, due to scarcity, have been hired after having recently undergraduated and even before that (Helleno et al., 2013; Chryssolouris et al., 2013).

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The engineering teaching needs a curriculum which is related to the real world of its profession. (Rojter, 2010). To this end, it is necessary to provide regular updating and enhancement of the curricular content, so that the background of such professional meets the profile companies have been looking for. (Wade, 2013; Deshpande & Huang, 2011). It is the teaching institutions' responsibility, taking into account the requirements made by the employers, since their students' employability depends on the abilities they can offer to the job market (Ayob et al., 2013).

Nevertheless, a survey performed in six universities in the USA, with 493 engineering students, has concluded that the students are not being properly prepared for the working force which demands innovation, leadership spirit and agility on problem-solving (Ragusa, 2014). The survey performed by Paton et al. (2012) in the German company of machines and equipment, identified that only 16.5% of the knowledge related to management tools application, are acquired during the teaching of engineering. In Brazil, the survey performed by Borchardt et al. (2009) in the region of Porto Alegre, identified flaws in the professional profile of the production engineer. After an exploratory analysis in order to understand the expected profile for the production engineer and to identify the current profile of the professionals located in the production engineering areas, the authors concluded that the engineer, more specifically de production engineer, is less qualified than the companies' expectations.

In face of such scenario, this paper aims to investigate how companies evaluate the competences and abilities of the production engineering in the industrial environment. To this end, it has been performed a survey covering large-sized companies from the manufacturing industry. As a result, it is expected to contribute with some relevant information so that, the responsible institutions may offer improvements for the professional background of the production engineer.

Concerning the structure, this paper contemplates six sections, being the first of them, this introduction, which contextualizes the survey issue and delimits the objective of the article. Following it, a brief theoretical referential on the engineering teaching, and the professional profile necessary for the 21st-century engineers. The subsequent item displays the methodological approach. The results obtained, the data analysis and considerations are, eventually, described.

2 The education in Engineering

By the World War II, the engineering teaching was focused on the development of practical abilities which could be immediately used in the industry (Grinter, 1956). After the Grinter report, in 1956, the teaching has had, as its focus, the science turned to the academic research, which caused, in the companies' view, a distancing between what is taught by the university and what is necessary for the industrial environment. At the end of the 1980's, developed countries such as the USA, Germany and the United Kingdom, worried about filling in the existing gaps caused by the distancing between the universities and the industry, started a process by recommending to engineers, new abilities focused on the industrial environment (Lamancusa et al., 2008). For instance, considering the USA, the National Science Foundation (NSF) supported by the American industry, recommended that the engineering students developed abilities on enterprising, creativity and management for a further understanding of the social, political and economical contexts of engineering (Gwynne, 2012).

In accordance with Acosta et al. (2010) universities, pressured by the industry's needs, have been attempting to incorporate globalization as an essential topic in their engineering curriculums once, in a globalised environment, companies expect to hire engineers who are highly qualified for an effective acting, which brings new challenges for the engineering schools. The engineers who work on research and development, design, manufacturing, services and other sectors, may be allocated in any place in the world, according to the company's needs. That makes with such professionals work with different cultures from their home countries, therefore, enlarging their qualifications for adapting projects to the language, culture and technical requirements specifically from the area where they are acting in, aiming to offering a competitive product within each market. In order to successfully compete in the professional environment of the 21st century, engineers must be capable of innovating, having enterprising initiative, acting and being flexible for solving problems (Streiner et al., 2014).

Regarding the Production Engineering, it is a recent modality if compared to the other modalities of engineering. "The most remote origin of such modality was when man, besides manufacturing, worried about organizing, integrating, mechanizing, measuring and enhancing such manufacturing" (Oliveira et al., 2010, p. 21). To Fleury (2008), the production engineering began over a century ago, through the economical rationalization applied to the changes concerning the taylorist production systems, and in order to follow such changes, knowledge itself, is not enough, it is necessary to know what to do if what is learnt in the courses (Araújo et al., 2008; Oliveira et al., 2013).

In 1955 this modality of engineering was known as Industrial Engineering in the USA, but since the Federal Board of Engineering and Agronomy (CONFEA) and the Regional Boards of Engineering and Agronomy (CREA), had already chosen a definition for industrial engineer, the name here, in Brazil, was defined as production (Oliveira et al., 2010). However, the undergraduation course in

Production Engineering started only in 1958, offered by the Polytechnic School of the University of São Paulo (USP). Initially, it was offered as an option for the Mechanical Engineering course, as a response to address the industry demands for engineering professionals with a management profile.

The option as Production for the undergraduation in Mechanical Engineering prevailed until 1970 (Oliveira et al., 2010). In 1976, Brazil's Ministry of Education (MEC). passed a course through the Resolutions 48/76 and 10/77 from The Federal Education Board (CFE), turning it into a secondary course, attached to six basic areas of engineering: Civil, Electrical, Mechanical, Materials, Metallurgy and Mining (Borchardt et al., 2009). Until the mid of the 1990's, there were only five full-type courses in the country, from which four were offered by universities from Rio de Janeiro, and one from São Paulo (Bittencourt et al., 2010). Following the Law of Directives and Bases of National Education - LDB (Law 9394 from 1996), a clear change on the Production Engineering courses happened, in order to get full undergraduation in production. Due to the validity of the Resolutions 48/76 and 10/77 (CFE), the Production Engineering attended the basic background of engineering, a minimum curriculum that, in general, was from the Mechanical Engineering. With the LDB and the end of the minimum curriculum, many existing courses passed reformulations in the curricular content, in order to provide the course with a larger load of contents turned to the Production Engineering (Vieira & Maestrelli, 2001). Yet, to the authors, the LDB provided a new proposal of formulation of the Production Engineering, in such manner that:

- 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.

From the LDB and the end of the minimum curriculum, it is aimed the formation of a production engineer through the full undergraduation, and not an accreditation from another traditional area of the engineering. Even being a new modality if compared to the other engineerings, there has been a great revolution in the offer of undergraduation courses in Production Engineering. In 2001, 72 courses were offered in the country; tem years later, that number escalated to 444 courses (Oliveira et al., 2013). Such increase abides with the evolution of engineering as a whole in the country, since there has been an increasing demand for engineers in the job market (Klix, 2014).

In 2013, the course was already offered by 537 institutions in every Brazilian state, as displayed in Figure 1.

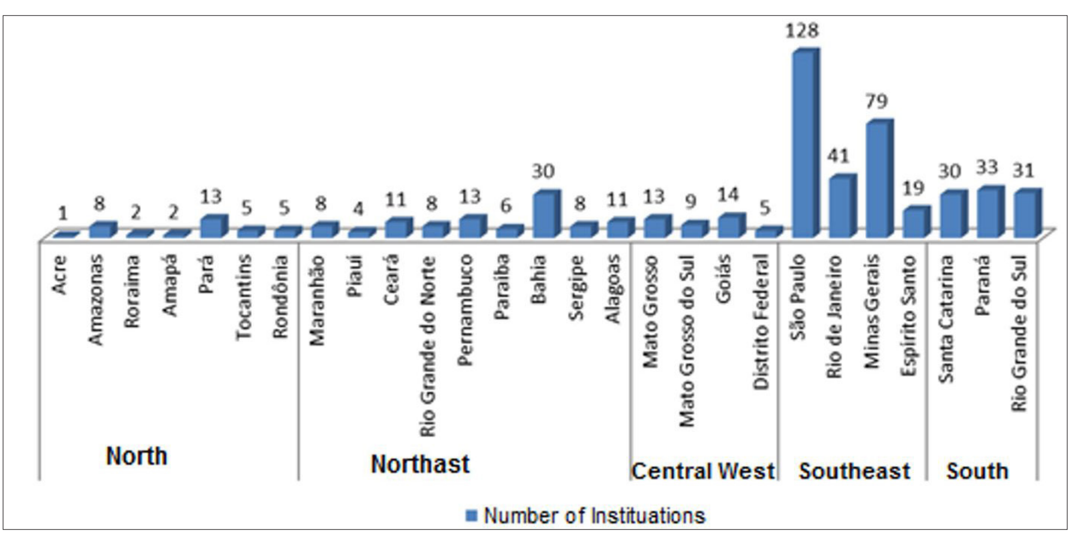

Figure 1. Number of institutions offering undergraduate courses in Production Engineering, accredited by the Ministry of Education, by Brazilian states. Source: Brazil (2013).

In Figure 1, it is observed that most of the offers for undergraduation courses in Production Engineering are concentrated in regions with a more intense economic activity, the southeast region, notably in the state of São Paulo, which is considered the largest economic pole as well as the strongest consumption market of the country (Bittencourt et al., 2010; Investesp, 2014). To Oliveira et al. (2013) the significant increase in the number of Production Engineering courses may be related to the evolving needs of companies in terms of competitiveness and quality of their products, besides the logistic systems and other aspects related to manufacturing as a whole, which is from the scope of the Production engineer's professional profile.

Nevertheless, despite the progression in the number of institutions which offer the undergraduation course in production engineering in Brazil, plenty are the existing studies on the scarcity of engineers (Nascimento et al., 2014). The debate performed by the IPEA in 2013, concluded that the lack of undergraduated professionals from the area is due to the poor quality of their background, and to the deficit of specific competences (Salerno et al., 2014).

2.1 The professional profile expected for the 21st-century engineers

The professional profile is the set of competences which are divided into three dimensions: knowledge, abilities and attitudes, corresponding to technical issues, cognition and attitudes related to the job. The first dimension, knowledge, corresponds to a series of information acquired and structured by the individual, all the knowledge they acquired throughout their lives. Ability, in turn, is related to the knowledge on how to do something, or to the capability of making effective use of the knowledge, i.e., turning it into action. It may be an innate aptitude or a developed one, yet, some training and experience do allow for the individual to improve it (Chiavenato, 2010). Cunha (2007, p. 4) defines ability as "[...] the dominance over the use of the intellect in a way to perform specific tasks". The third aforementioned dimension, attitude, refers to social and affective aspects related to the job; it is the predisposition towards the adoption of a specific action, with a particular occurrence pattern (Durand, 2000).

Concerning such competence, a variety of definitions to the term, is found in literature. The simplest and most coherent one is the definition formed by the set of knowledge, abilities and attitudes (Ferreira, 2010). According Piaget's theory, competence constitutes itself at the articulation and mobilization of the knowledge mental schemes (physical or mental actions over objects which modify themselves and become more refined by a succession of assimilation and accommodation processes), whereas ability allows for the competence be put into practice (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. Zarafian's definition (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, p. 187) 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), Zarafian (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 are common in competitive scenarios.

According to Chiavenato (2010), it is expected that the professionals acquire competences to mobilize knowledge, abilities and attitudes in order to deliver results, within the quality and the deadline expected.

The authors Oliveira & Pinto (2006) propose a set of competences, abilities and attitudes that are expected for the professional profile of the 21st-century engineer, as shown in Chart 1.

In Chart 1, it is possible to notice that the professional profile expected for the 21st-century engineer is of an analytical, enterprising and creative professional, who is capable of delivering suitable solutions to new issues, resulting from a transformation dynamics which has been happening in an intense way across all sectors (Oliveira & Pinto, 2006).

In Nose & Rebelatto's studies (2001), are presented the competences which form the professional profile expected from the production engineer, as shown in Chart 2.

The ABEPRO (Brazilian Association of Production Engineering) also defines the desired professional profile for the production engineer, characterizing it within their technical capability, mode of operation and vocation, as presented in Chart 3.

It is observed in Charts 1, 2 and 3 that the authors define the professional profile expected for the engineer, as well as for the production engineer as similar. As an example, the six competences presented in Chart 1 for the engineer's professional profile can also be found in Chart 2, which, here, are for the production engineers. Thus, it is understood that such competences must be acquired by the engineering professional despite their modality. Those are:

- ✓ Be always in search of new knowledge;
- ✓ Contribute to the scientific and technological development;
- ✓ Present creative and original solutions to issues;
- ✓ Know how to work within multi-disciplinary teams;
- ✓ Design, execute and manage engineering enterprises;
- ✓ Cares about the impacts of their work, notably concerning the ethical, environmental and political implications;

Similarities on Charts 2 and 3 can also be noticed. In the sense that the TECHNICAL CAPABILITY may involve the competences on solid technical knowledge in order to consolidate decision-making; the capability of managing changes, the knowledge of the English language and the computer literacy. The ACTING CAPABILITY may involve the competences of working in teams, taking ethics, flexibility, pro-activity and enterprising spirit into consideration. And VOCATION, which is the vision and aptitudes for the managerial approaches, may involve competences on leadership, working under pressure, negotiation and decision-making capabilities. Thus, it is understood that according to the view of different authors, the professional profile must be of an engineer with a constructive and responsible acting, to agilely solve the companies' issues.

To the Higher Education Chamber of the National Education Council (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.

Chart 1. The professional profile of the 21st-century engineer.

Always searches for new knowledge in order to be express in an autonomous and independent manner;
Contributes to the scientific and technological development;
Presents creative and original solutions to issues related to the production;
Develops a good job within multidisciplinary teams;
Designs, executes and manages engineering enterprises;
Cares about the impacts of their work, notably concerning the ethical, environmental and political implications.

Source: Oliveira & Pinto (2006).

Chart 2. The profile of the Production Engineer according to the companies' view.

Being capable of working in teams;
Being capable of working while always taking ethics into consideration;
Having solid technical knowledge in order to consolidate the decisions to be made;
Being capable of managing changes;
Having leadership spirit;
being capable of working under pressure;
Having negotiation competence;
Being capable of making decisions;
Being flexible;
Being proactive and having entrepreneurial spirit;
Being good at working with people;
Having good command of the english language;
Having computer literacy

Source: Nose & Rebelatto (2001).

Chart 3. Professional profile expected for the Production engineer.

Technique	Acting	Vocation
Must be able to act fundamentally in the organization of the production activities, thus receiving training in management methods and production optimization techniques.	Must be able to promote the interface between the areas which act directly on the technical systems, and between these and the administrative areas of the company.	Interest, vision and competences 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.

Source: Cunha (2002).

According to Sonmez (2014), the North American Accreditation Board for Engineering and Technology (ABET) has identified a set of competences and abilities 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 recognition of the need for knowledge throughout life;
- ✓ The ability to make use of techniques, competences, and modern engineering tools necessary for the engineering practice.

For the Resolution CNE/CES 11/2002 (Brasil, 2002) the engineer's education aims to provide the professionals with the required knowledge for the exercise of the following competences and abilities:

- ✓ 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 multi-disciplinary 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 (CONFEA, 2005).

The ABEPRO, based on the CES/CNE 11/02, and on the employers and professionals of its class, defines tem competences and fourteen abilities for the production engineer as shown in Charts 4 and 5.

3 Methodological approach

This study employed survey, since it aims to investigate the companies' opinions regarding the competences and abilities of the production engineer in the industrial environment.

The developed survey can be classified as exploratory, for providing a preliminary view on a theme that is, obtaining a preliminary perception of it, providing the basis for a deeper survey (Miguel & Ho, 2012; Forza, 2002).

To this end, the steps involved in the survey are displayed in Figure 2.

3.1 Construction of the theoretical foundamentation

For the literature review, national and international databases within the last five years, such as Journals, scientific publications, congresses and websites have been used, as presented on item 2 of this paper. Some other publications, older than five years old were also considered due to their relevance. The literature review has contributed to the elaboration of the data collection tool.

Chart 4. Competences expected for the Production Engineer.

Competences
Scaling and integrating physical, human and financial resources, in order to efficiently manufacture at the lowest cost, considering the possibility of permanent improvements;
Making use of mathematical and statistical tools to model production systems and help with decision-making;
Designing, implementing and upgrading systems, products and processes, respecting the limits and features of the communities involved;
Predicting and analyzing demands, selecting technologies and know-how, designing products or improving their features and functionality;
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;
Predicting the evolution of productive scenarios, noticing the interaction among the organizations and their impacts on competitiveness;
Accompanying technological advances, organizing them and making them available according to the companies and the society's demands;
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;
Making use of performance indicators, costing systems, as well as evaluating the economic and financial viability for projects;
Managing and optimizing the information flow within companies by using proper technologies;

Source: Cunha (2002).

Chart 5. Abilities expected for the Production Engineer.

Abilities
Commitment to professional ethics;
Enterprising leads;
Willingness for self-learning and continued education;
Oral and written communication;
Domain of a foreign language;
Critic view of orders of magnitude;
Computer literacy;
Reading, interpreting and expressing through graphics;
Knowledge of the pertinent legislation;
Capability of working in multidisciplinary teams;
Capability of identifying, modeling and solving problems;
Understanding management, socioeconomic and environmental issues;
Societal and environmental responsibility;
Think globally, act locally.

Source: cunha (2002).

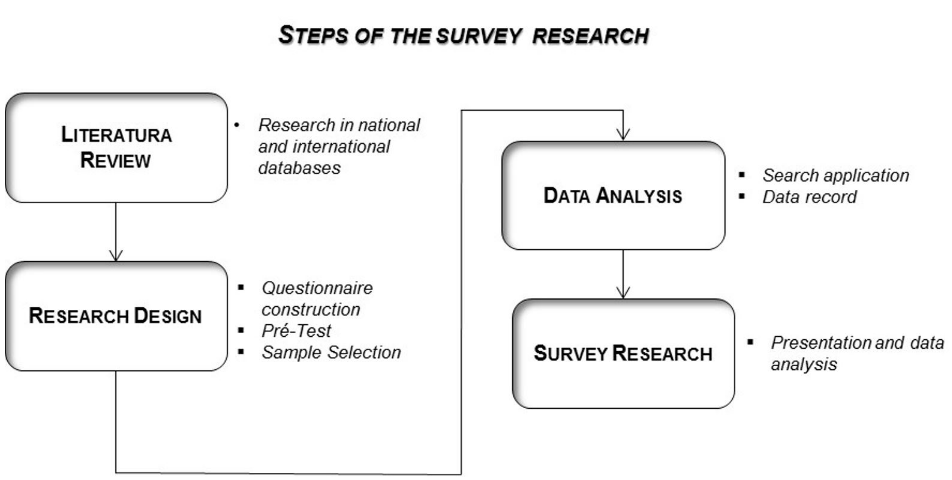

Figure 2. Methodological approach. Source: adapted from Miguel & Ho (2012).

➢ **Data collection tool structure**

The data collection tool was built based on the chief national and international publications on the professional profile, competences and abilities of the engineer, as presented in Chart 6.

The questionnaire is composed of five structured (closed) questions, offering multiple choice answers, in which are enlisted the competences and abilities expected for a production engineer. Questions 1,2, 3 and 4, in which companies evaluate the level of importance of the competences and abilities, the alternatives provided were organized into a five-point Likert scale, to rate the answer from VERY IMPORTANT to NOT IMPORTANT. For question 5, company respondents assesses the level of deficiency of the competences and abilities, using an ordinal scale in which 1 represented the best evaluation (No DEFICIENCY) and 5, the worst evaluation (MAXIMUM DEFICIENCY).

➢ **Pre-test**

In the preliminary version of the questionnaire, ten interviews were conducted with academics and industry professional, in order to identify its clarity, scope and acceptability (Rea & Parker, 2002). Sequentially, the questionnaire was submitted to one more large company, in order to verify its applicability before being definitively (Forza, 2002). The questionnaire, on its final version, can be seen in Appendix A in the supplementary material.

➢ **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 is justified by the fact of the sector being 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 (Brasil, 2012; FIESP, 2014). Concerning the state of São Paulo, it hosts most of the large-sized companies, besides being responsible for one third of the Brazilian GDP, therefore being considered the main economical pole and consumption market of the country (Investesp, 2014).

➢ **Survey application and data collection**

The survey constituted of emailing a questionnaire to 728 large-sized companies within the manufacturing industry in the state of São Paulo. The email addresses of the respective companies were given by Unions, the National Federation of the Industry of the State of São Paulo – FIESP, and searches conducted by the author 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 questionnaires were compiled into spreadsheets, by using the Microsoft Excel 2010 software, which was also employed for generating graphics for the data analysis.

4 Data analysis and presentation

46 large-sized companies from 8 subclasses within the manufacturing industry, participated in the survey, as presented in Figure 3.

In Figure 3, it is possible to observe that most of the companies belong to the business segments of Automotive Vehicles, Metallurgy and Machine

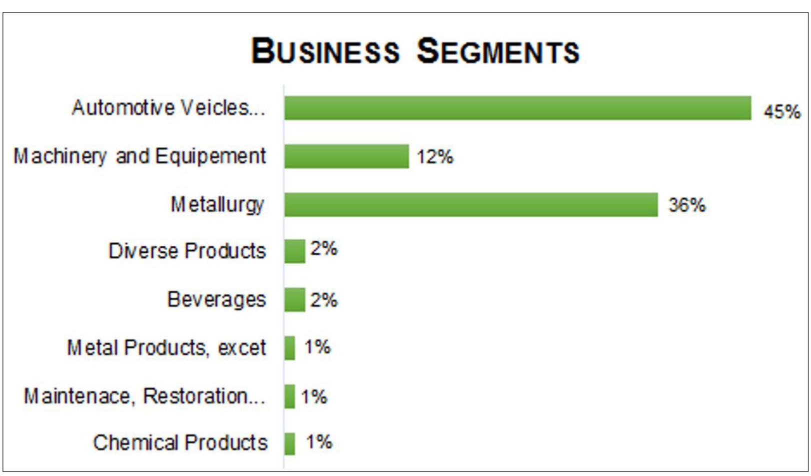

Figure 3. Business segments of the respondent companies according to CNAE (National Classification of Economic Activities). Source: Survey data.

Chart 6. Main publications used on the definition of the competences and abilities.

Publications	Competences										abilities													
	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		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
Machado & Luz (2013)			x				x					x		x						x	x			
Brasil (2002)		x						x	x		x		x	x			x			x	x			
Nose & Rebelatto (2001)		x									x	x			x	x	x			x				
Oliveira & Pinto (2006)									x	x		x	x						x	x				
Póvoa & Bento (2005)							x			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
Zarafian (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.

and Equipment, representing 93% of the sampling. The respondents' respective business segments are shown in Chart 7.

The activities of the manufacturing industry reflect, in general, differences in the production process related to types of input, production equipment and expertise/qualification of the working force (CNAE, 2014; CONCLA, 2014). In Chart 8 is displayed the occupation and the sectors to which belong the respondents who contributed to the survey.

It is observed in Chart 8, that all the respondents who collaborated to the survey occupy positions in areas related to Production Engineering, what qualifies them to answer the questionnaire

After acknowledging the respondents' profile, the next topic presents the evaluation of the competences and abilities of the production engineer according to the companies' view.

- **Evaluation of the competences and abilities of the production engineer in the industrial environment**

The companies evaluated the level of importance of the competences and abilities expected for the production engineering within a 5-point Likert Scale, which ranges from very important to not important. Figures 4 and 5 show the evaluation of the ten competences and the fourteen abilities.

It is observed in Figure 4 that the competences were well evaluated, between vety important and important for the most the companies. Among them, are highlighted as very important:

C1 - Scaling and integrating physical, human and financial resources, in order to efficiently manufacture at the lowest cost, considering the possibility of permanent improvements;

Chart 7. Activities of the business segments Automotive Vehicles, Tows and Bodies; Metallurgy and Machine and Equipment.

	automotive vehicles...	**Metallurgy**	**Machine and Equipment**
ACtivities	Manufacturing of automobiles, vans and utility vehicles; Manufacturing of trucks and buses; Manufacturing of cabins, bodies and tows for automotive vehicles; Manufacturing of parts and accessories for automotive vehicles; Reconditioning and recovery of motors for automotive vehicles.	Production of pig iron and ferroalloys; Steel industry; Production of steel pipes, except seamless ones; Metallurgy of the non-ferrous metals; Foundry.	Manufacturing of motors, pumps, compressors and transmission equipment; Manufacturing of tractors and machines and equipment for agriculture and livestock; Manufacturing of tool-machines and equipment for general use; Manufacturing of machines and equipment used for mineral extraction and Construction; Manufacturing of machines and equipment for specific industrial use;

Source: CNAE (2014) and CONCLA (2014).

Chart 8. Respondents' occupations and sectors.

Respondent (s)	**respondeNT's occupation**	**Sector/ Department**
1	Corporate Logistics Manager	Logistics
4	Factory Managers	Production
4	Maintenance Managers	Maintenance
2	Manufacture and Operations Managers	Operation
1	Research and Development Manager	Research, Development and Innovation
3	Process Managers	Process Engineering
11	Product Managers	Production Engineering
2	Project Managers	Project Engineering
1	Institutional Relations Manager	Strategy and Governance Department
1	Quality System and Production Manager	Quality Engineering
4	Industrial Managers	Industrial
1	Process Engineering Supervisor	Process Engineering
1	Maintenance Supervisor	Maintenance
1	Quality Supervisors	Quality Engineering
9	Production Chiefs	Production

Source: Survey data.

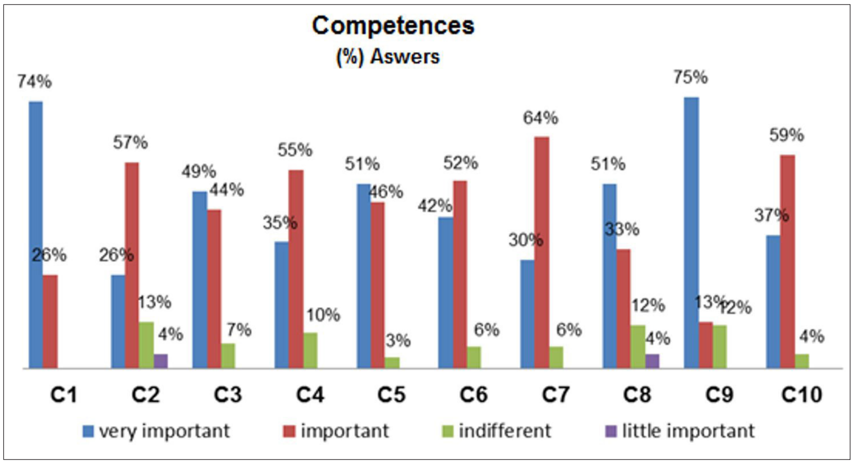

Figure 4. Level of importance of the production engineer's competences according to the companies' view. Source: Survey data.

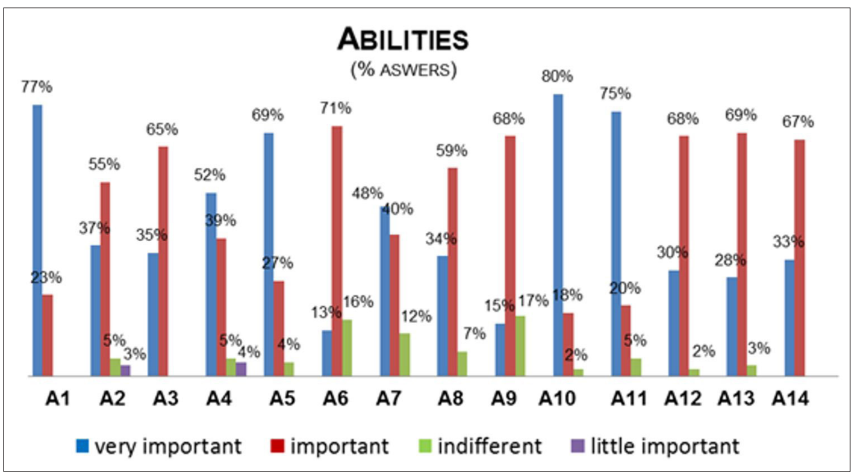

Figure 5. Level of importance of the production engineer's abilitites according to the companies' view. Source: Survey Data.

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;
C8 - Understanding the interrelationship between the production system and the environment, regarding both use of scarce resources and the final disposal of residues and wastes, not neglecting the requirement for sustainability;
C9 - Making use of performance indicators, costing systems, as well as evaluating the economic and financial viability for projects;

In Figure 5, it is observed that the abilities were well evaluated by the companies as well. Among them, are highlighted as very important:
A1 - Commitment to the professional ethics;
A4 - Oral and written communication;
A5 - Domain of a foreign language;
A10 - Capability of working in multidisciplinary teams;
A11 - Capability of identifying, modeling and solving problems

Data showed that within the companies' evaluation, all the competences and abilities are of utmost importance for the performance of the production engineer's activities in the industrial environment.

After having evaluated the level of importance, the companies evaluated the level of deficiency production engineers present regarding the competences and abilities. For that second evaluation, a ordinal five-point scale was used, considering from (1) No deficiency to (5) Maximum Deficiency, as shown in Tables 1 and 2.

Table 1 shows that the production engineer presents some deficiency in all the competences. In Table 2, it is possible to notice that, according to the companies' view, the production engineer presents deficiency in twelve abilities, from the fourteen existing ones.

By considering the most frequent value from the set of observations for each competence and ability, Figure 6 is presented (Favéro et al., 2009).

Table 1. (%) of responses on the deficiency level of the production engineer regarding the competences, according to the companies' view.

Deficiency Level		No Deficiency Level 1	Deficiency Level 2	Deficiency Level 3	Deficiency Level 4	Maximum Deficiency Level 5	Total
Competences	C1	29%	29%	33%	7%	2%	100%
	C2	17%	41%	26%	16%	0%	100%
	C3	12%	42%	31%	13%	2%	100%
	C4	24%	29%	33%	14%	0%	100%
	C5	29%	43%	19%	7%	2%	100%
	C6	14%	45%	21%	18%	2%	100%
	C7	21%	30%	38%	11%	0%	100%
	C8	12%	40%	36%	7%	5%	100%
	C9	24%	24%	35%	17%	0%	100%
	C10	26%	26%	36%	10%	2%	100%

Source: Survey data.

Table 2. (%) of responses on the deficiency level of the production engineer regarding the abilities, according to the companies' view.

Deficiency Level		No Deficiency Level 1	Deficiency Level 2	Deficiency Level 3	Deficiency Level 4	Maximum Deficiency Level 5	Total
Abilities	A1	52%	33%	8%	2%	5%	100%
	A2	17%	34%	40%	9%	0%	100%
	A3	29%	48%	19%	2%	2%	100%
	A4	21%	33%	40%	4%	2%	100%
	A5	17%	31%	34%	13%	5%	100%
	A6	19%	40%	24%	17%	0%	100%
	A7	30%	48%	10%	10%	2%	100%
	A8	30%	48%	10%	10%	2%	100%
	A9	7%	29%	38%	21%	5%	100%
	A10	31%	40%	22%	5%	2%	100%
	A11	40%	24%	27%	7%	2%	100%
	A12	31%	21%	34%	12%	2%	100%
	A13	24%	43%	25%	6%	2%	100%
	A14	26%	36%	21%	17%	0%	100%

Source: Survey data.

In Figure 6, it is observed that the production engineer presents some deficiency in all the competences, since Level 1 is considered with No Deficiency.

Among the competences, the ones which are considered the most deficient ones by the companies are:

C1 - Scaling and integrating physical, human and financial resources, in order to efficiently manufacture at the lowest cost, considering the possibility of permanent improvements;

C4 - Being capable of predicting and analysing demands, selecting technologies and know-how, designing products or improving their features and functionality;

C7 - Accompanying technological advances, organizing them and making them available according to the companies and society's demand;

C9 - Making use of performance indicators, costing systems, as well as evaluating the economic and financial viability for projects;

C10 - Managing and optimizing the information flow within companies by using proper technologies.

Yet, in Figure 6, it is verified that from all the fourteen abilities, only in two of them, the production engineer does not present any deficiency, the "**A1-** Commitment to the professional ethics"; and the "**A11 –** "capability of identifying, modeling and solving problems". Among the abilities, are considered the most deficient ones:

A2 - Enterprising leads;

A4 - Oral and written communication;

A5 - Domain of a foreign language;

A9 - Knowledge of the pertinent legislation;

A12 - Understanding management, socioeconomic and environmental issues.

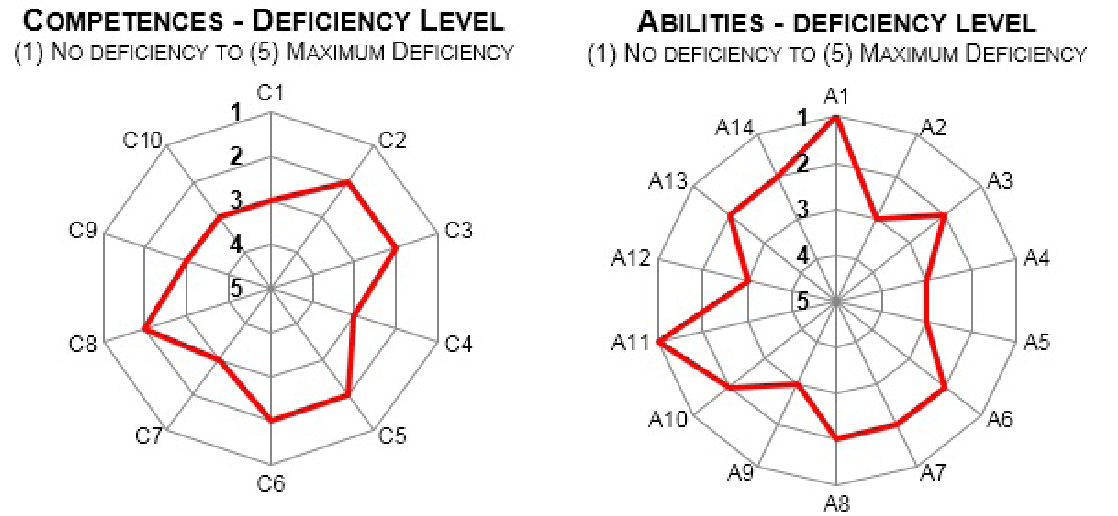

Figure 6. Deficiency level of the production engineer regarding the competences and abilities, according to the companies' view. Source: Survey data.

5 Results discussion

The results of this survey showed that the competences and abilities were very well evaluated within the industrial environment. However, the production engineer presents deficiencies in all the competences, and in twelve of the fourteen abilities.

It is observed that in two competences which are cosidered highly important to the industrial environment, the production engineer presents more deficiencies. Those are:

C1 - Scaling and integrating physical, human and financial resources, in order to efficiently manufacture at the lowest cost, considering the possibility of permanent improvements;

C9 - Making use of performance indicators, costing systems, as well as evaluating the economic and financial viability for projects;

The abilities on commitment with professional ethics and the capability of identifying, modeling and solving problems, are not deficiencies for the production engineer according to the companies' view. Nevertheless, such professional presents deficiencies on the other abilities. The ones considered more deficient by the companies are:

A2 - Enterprising Leads;

Enterprising leads are usually associated to the possibility of doing something new or in a different way, as well as the capability of taking risks. Professionals with enterprising leads are always ready for action, since there are, within the environment they act, proper conditions and support (Teixeira et al., 2011; Ruppenthal & Cimadon, 2012).

Enterprising leads collaborate to the enhancement of the other abilities, such as the capability of working in team, the capability for oral and written communication, the capability of e performing and offering ideas, time management, autonomy to learn, and general and specific technical abilities, according to the field of interest (Póvoa & Bento, 2005).

A4 - Oral and written communication;

Having professionals who know how to interact, to use language, who are able to properly write a text, select readings and materials which are useful FOR their daily job, makes a difference f to produce texts in their professional field, in a clear, coherent, COESA and objective manner. However, the engineer, not rarely, learns how to do it by themselves, in their daily life, once such issues as not debated at college. (Franzen et al., 2011).

A5 - Domain of a foreign language;

The domain of a foreign language is of UTMOST importance in the globalized market. Such domain facilitates communication and the power of negotiation within different markets. (Tondelli et al., 2005). English is the language which assumed a global character and presented itself as an essential requirement for the 21st-century professionals (Fogaça & Gimenez, 2007). However, in to a research performed in 2012, it was verified that only 5% of Brazilians have fluency in the English language (Amorin, 2012).

A9 - Knowledge of the pertinent legislation;

The ability of the knowledge on the pertinent legislation is attached to the knowledge on the laws which are pertinent to the acting Field of the production engineer. There is a need for leaders (directors, managers, department heads) have very clear knowledge of the legislation and its flexibility. Nevertheless, it is common that people who do not have previous knowledge of the pertinent legislation commonly occupy positions which need them to. That causes distortions and equivocated interpretations, making that concomitant actions do not reach the desired goals (Cordeiro, 2001), that is why developing such ability is so important.

A12 – Understanding management, socioeconomic and environmental problems.

In face of the importance of innovation with a real concern about society, the responsibilities of the engineer go beyond ethics, to a more comprehensive field, the social, the legal and the technical one. The understanding of management, socioeconomic and environmental problems is an important aspect for a country to grow (Mayr et al., 2010).

Eventually, it is noticed that the abilities related to "oral and written communication" and to the "domain of a foreign language" are among the ones which are considered very important and also among the ones which are the most deficient, according to the companies' view. To Borchardt et al. (2009) definying the competences and habilities of the production engineer is a demand to industrial companies and education institutuions as well.

6 Final considerations

This paper aimed to investigate how companies assess the competences and abilities of the production engineer while carrying out their activities in the industrial environment. To this end, a survey research was performed in 46 large-sized companies in the manufacturing industry of the state of São Paulo, whose sector and size are those which most employs production engineers in the country. The results obtained from the analysis of the questionnaire have shown that companies do recognize the importance of the competences and abilities of the production engineer within the industrial environment. However, they have also pointed out deficiencies in such professionals regarding those. The competences related to i) s*caling 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 evaluating the economic and financial viability for project* are considered very important, nevertheless, are considered the most deficient ones as well. The same occurs to the abilities related to "oral and written communication" and the "domain of a foreign language". Thus, it has been concluded that efforts must me made aiming a better professional education for the production engineer. Part of such responsibilities belongs to the education institutions, as mediators of knowledge and abilities developers. However, the university itself can not provide students who meet the needs of the industrial environment, mainly because the final education of the production engineer's professional profile is shaped by the industry's needs. Thus, it is understood that within competitiveness scenarios, there is a need for education institutions to integrate with companies so that, together, they provide more training and experience, which will, consequently, improve abilities that, in their turn, will improve competences and result in more qualified professionals who are capable of providing solutions and solving the industry's issues. One of the initiatives which have contributed is the partnership between university and industry. It is believed that such partnership is a starting point for the education institutions and industries to provide their students with competences and abilities so that they participate of a highly competitive market, which values the flexible, creative and being, who is capable of offering innovative solutions. For future researches, it has been suggested an investigation on the causes of the production engineer's deficiencies regarding the competences and abilities expected by the industrial environment.

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Appendix A. Assement questionnaire of the production engineer in companies.

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