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## An Overview of Engineering Courses in Brazil: Actual Challenges

### Abstract

Brazil is one of the largest countries in the world as well one of the greatest economies among developing countries. To be competitive, Brazil needs to be able to develop technology, research and knowledge. In this sense, we argue that economic growth is directly related to technological development, which is linked to the investments in infrastructure, education, technologies and research mainly from engineering. Engineers must be prepared to develop solutions and technologies and to contribute to the well-being of society. The main purpose of this paper is to present an exploratory study concerned with the general overview of Brazilian engineers' graduate and postgraduate courses as well as their current occupation.

Keywords: engineering, education, Brazil, competitiveness

### Introduction

Brazil, as several other developing countries, is facing a number of challenges to remain competitive in the world scene. One way to achieve this is to develop technologies to ensure the country's differential based on knowledge capital (Cordeiro et al, 2008). Ferreira (2015) argued that universities have a crucial role in finding ways to improve Brazilian industrial competitiveness through improvements in education, research, knowledge and new technologies aligned to labour market and society's needs.

According to Oliveira et al (2013), the sectors that compound countries' GDP are related to international competitiveness. The researchers concluded that countries' continued economic growth is connected directly to technological growth, which is linked to investments in the infrastructure, research and development of technology and engineering professional education.

Cirani et al (2014) and Salvador et al (2014) also highlighted the relevance of postgraduate studies' programs to the process of nations development. The authors pointed out that postgraduate research must go hand in hand with society's technological and social needs and that applied knowledge is an important asset for countries' economic growth that is disseminated through publications and scientific research from postgraduate programs.

In addition to boosting the country's competitiveness, Cordeiro et al (2008) argued that engineers must be prepared to develop solutions according to the needs of the population and contribute to the well-being of society. Thus, graduate and postgraduate programs in engineering should be able to provide students with tools and knowledge to allow them a systemic analysis of not only productive factors, but also the society as a whole, going beyond technical and traditional knowledge of engineering. This exploratory research is a part of a broader research on the engineering courses in Brazil, which characterizes the limitation of this study.

## Prospects of engineering graduation in Brazil

Engineering education emerged in Brazil motivated by the need to create and maintain military capabilities at a time when the country was still a part of the Portugal kingdom. In 1699, the first school for military engineers was instituted. In 1738, the military engineering education was formalized, requiring a minimum of five years for engineers training and education, which is still in effect today for both civilian and military engineers (Moraes et al, 2009).

OECD (Organization for Economic Co-operation and Development) developed an international standard for “engineering degree” divided into 55 engineering modalities. Thus, to allow for international comparisons, the Ministry of Education (MEC) in Brazil adopted this standard.

In this paper, the analyses were based on the data collected from the EngenhariaData Indicators System (EngenhariaData, 2015), reports from Innovation and Competitiveness Observatory (OIC, 2015), and INEP (2013) data related to engineering graduation courses. The previous results about number of courses, vacancies, freshmen and graduates of engineering courses in Brazil from year 2000 to 2013 are also discussed.

### *Number of courses offered*

According to INEP (2013), there are over 3,000 engineering courses in Brazil, and around 59,000 engineers have graduated in 2013, an increase of approximately 340% during the studied period.

The increase in the number of courses in Brazil can be explained by the significant economic growth observed in the country in recent years. The availability of courses is higher in the Southeast (54% of available courses), South (20%) and Northeast (14%) regions and lowest in North and Midwest (6% each). The Southeast region offers large number of courses primarily because it is heavily populated and most economic/productive activities of the country are carried out in this particular area.

Regarding graduate engineering programs, production, along with civil, electrical, mechanical and computer engineering have the highest number of courses available. In general, it can be noticed that the number of courses offered had grown throughout the country in all regions.

### *Number of vacancies*

During the 2000-2013 period, a growth in total vacancies offered for engineering graduations courses for undergraduate students around the country was recorded, a change of 450% (392,388 in 2013 against 71,095 in 2000). A higher concentration of vacancies is also offered in the Southeast area (63%), which also has the greatest concentration of courses. Civil engineering presented the largest number of vacancies (101,367), followed by production engineering (74,201), mechanical engineering (47,259), electrical (43,389), control and automation (24,250) and computing (16,175) (EngenhariaData, 2015).

One of the drivers of the number of the growth of vacancies offered are the expansion programs of universities promoted by the government, such as the Program of Support for the Restructuring and Expansion of Federal Universities (REUNI) (OIC, 2015).

### *Number of freshmen students*

The admission of students to graduate engineering courses is related to the amount of vacancies offered. Regarding geographical dispersion, 58% of enrolments were noted in the Southeast region and 15% in the South. This is due to several courses options, the positive development of infrastructure and construction of various facilities in the period, which attracted 34% of enrolments in civil engineering, followed by production engineering with 17% of admissions and mechanical engineering with 12% in third place (EngenhariaData, 2015).

### *Number of graduating students*

Among the analysed variables, the number of graduating students has the greatest effect on the country's development. The analysis by region shows the strong relationship between the national performance and the performance of the Southeast region, as it corresponds to the majority of graduates. Regarding engineering graduation, since 2010, production engineering has had more graduates, e.g., 10,938 engineering graduates in 2013, compared to other fields, such as civil engineering, with 5,526 graduates.

The data from OIC (2015) showed that the overall dropout rate in engineering courses in 2013 in Brazil was 22%, higher compared to the average of other graduate courses due to the precarious and incipient basic training of these students in sciences and math in elementary school (Nascimento et al, 2014; Saboia & Salm, 2010; Pereira et al, 2013; Salerno et al, 2014).

The duration of an engineering course in Brazil is five years as already mentioned above. In 2013, out of 148,452 students who enrolled in 2009, 59,798 completed degree in engineering indicating that only 40% of students who started the program completed it.

Compared to other countries, Brazil had 2.97 new engineers in the labour market for every 10,000 inhabitants in 2013. Regarding economic, social, and cultural differences, Finland (first in ranking), South Korea (second) and Slovakia (third) graduated 34.02, 32.73 and 28.41 engineers per 10,000 inhabitants in the same year, respectively (OIC, 2015). A study presented by Rydlewski (2014) showed that among all the graduates in the country in 2011, only 5% were from engineering modalities while in China, over 40% of the graduates were from engineering program in the same year. In 2013, the numbers in Brazil improved, as 7% of all new graduates were engineers.

Although much has been done to boost the number of graduates in engineering in Brazil, and the results show significant improvements compared to the previous years, external comparison, on the other hand, shows that much needs to be done to improve competitive rates internationally. This is a challenge for all the regions of Brazil.

### **Postgraduate programs in engineering in Brazil**

According to Geocapes (2015), the data on postgraduate engineering programs, in Brazil showed the total number of enrolments in 2013 were 28,409, with 14,900 students in master's degree programs, 2,909 in professional master's degrees and 10,600 in doctoral degrees. In the same year, 5,591 engineers received a master's

degree and 1,568 engineers received a doctor's degree. Of those enrolled in all postgraduate programs across the country, 13% were in engineering programs, and 11% of those who graduated in 2013 were engineers.

Additionally, Farjado (2012) presented a study on the destination of masters and doctors in Brazil. According to the author, 48% of doctors and 32% of masters landed jobs related to education. In contrast, only 2% of the doctors and 5% of masters were working directly in the manufacturing industry. The data presented by Teixeira et al (2012) highlighted that the global average placement of researchers in industry is about 39%. According to the author, Brazil has 50,000 researchers working in the domestic industry while South Korea has 160,000 and the United States has more than 1 million researchers in the industry.

Low placement rate of researchers in Brazilian companies could be one of the main factors that might limit the performance of the domestic industry (Teixeira et al, 2012). According to the author, the country needs to increase the direct and indirect placement of researchers (mostly engineers) in the industrial sector to ensure that national research generates knowledge able to meet the country's technological and social demands.

Thus, a challenge seems to lie on the postgraduate engineering programs, specifically in being able to generate enough knowledge to leverage the domestic industry. In addition to boost in the education of masters and doctors in engineering, it needs to ensure that the studies are aligned with the needs of the Brazilian business sector, and they promote technological development and innovation.

Regarding the expansion of postgraduate studies in engineering, data from Geocapes (2015) showed that postgraduate studies have not followed the growth of other graduate courses in the last years. In this scenario, training and qualifying engineers seems even more aggravating in postgraduate courses. Although the quality of postgraduate programs in engineering in Brazil is internationally recognized, the number of vacancies is limited compared to international programs (Teixeira et al, 2012).

Oliveira et al (2013) showed that education and training of researchers (masters and doctors) in engineering in Brazil is far below compared to those in developed countries, which might limit the quality and quantity of technological knowledge produced in the country. According to Steiner (2005), a university with postgraduate courses that focus on research can be seen as a strategic factor for competition in the era of the knowledge society.

## **Looking for the engineers in Brazil**

As shown in previous sections, even with high dropout rates, engineering as a whole is facing a period of expansion in Brazil driven mainly by the economic recovery experienced in the last decades (Nascimento et al, 2014). It is important to point out that in Brazil, there are both public (maintained by the federal and state governments) and private universities and that the number of engineering courses offered by private universities is much higher compared to the public ones. The data presented and discussed present the average of all engineering students from both public and private universities in Brazil.

Regarding to female participation among newly graduated engineers, the focus relies on chemical and food engineering, with 54.9% of female graduates, nearly 2.5

times higher than the engineering average. It can be seen that engineering courses and areas of technology in Brazil, in general, still have low female participation, as well as low placement in labour market, which further reduces the interest of women (Maciente et al, 2015).

Concerning the occupation of the new graduates, civil engineering presents the largest number of the professionals working in their field (53.4%). On the other hand, for professionals from production engineering (7%), and environmental and mining engineering (4%) that proportion is less than 10% (Maciente et al, 2015).

When considering the relevance of engineering for the country's technological development process, the general numbers sound alarming, since these activities are usually not the main leading areas of choice for the new graduates. Education and research in engineering and science and technology fields are activities most related to technological development, as the numbers show that 3.8% of new graduates are dedicated to such activities. A large number of engineers (25.6%) are working in different fields outside of engineering in Brazil.

Salerno et al (2014) also argued about where the engineers trained in Brazil would be working. Service sector and manufacturing industry appear to be the main employers of engineers in the country, with a considerable increase in contracts from year 2005 accompanied by significant economic growth.

According to the mentioned author, companies with 100 or more employees are more likely to hire engineers in Brazil due to potentially concentrated complex operations with high benefit. Employing engineers in micro and small enterprises still represents a small portion of the total amount. Thus, it can be seen that the main destination for engineering professionals has been the service sector and the manufacturing industry, especially in large enterprises.

The data from INEP (2013) shows that out of 272,110 engineers working in Brazil, 268,940 are Brazilians and 3,170 are foreigners. Among the foreigners, most of them are Portuguese and Latin Americans. Concerning the geographical areas of the country, the Southeast region has the vast majority of the employed engineers (169,006), followed by the Southern region (40,801), Northeast (34,271), Center-West (17,817) and North (10,214).

## Conclusions

The aim of this paper was to present an exploratory study to offer an initial overview of Brazilian engineers' graduate and postgraduate courses as well as their current occupation.

The numbers of courses, vacancies available at the universities, and freshman and graduate students enrolled in engineering graduate courses in Brazil have shown a significant increase in the past years due to economic growth and in part due to the understanding of the important contributions of these professionals to the country's development and competitiveness.

Another point to consider is that most courses are offered in the Southeast region, which has also the greatest numbers of graduated engineers. This region has the highest population in the country as economic development. This supports the statements of Oliveira et al (2013) and Cordeiro et al (2008) that economic growth is related to technological development and investment in technology and engineering, which are most pronounced in the Southeast region of Brazil.

Regarding the number of engineers employed in Brazil, the percentage of foreign engineers working in the country does not reach 0.5%. It cannot be said that foreign engineers are taking place of Brazilian engineers in companies. In fact, placement of engineers in companies in general, especially in micro and small enterprises, is low, as the importance of these professionals in the improvement of products and processes, benefit enhancement and cost reduction has not been acknowledged. It is also important to highlight that the low number of foreign engineers in Brazilian companies may limit the exchange of cultural experiences and understanding of multiculturalism as a factor that leads to competitiveness, as mentioned by Canen & Canen (2005).

In future research, we intend to expand this exploratory study, since this is part of a larger research aimed to study the engineering courses in Brazil in greater depth.

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