International Journal of Engineering Education Vol. 32, No. 3(A), pp. 1250–1259, 2016
Printed in Great Britain

0949-149X/91 $3.00+0.00
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Mapping of the Undergraduate and Graduate Curriculum in Industrial Engineering in Brazil*

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In Brazil the number of public and private universities is increasing to improve the national development. In this way, undergraduate and postgraduate courses in Industrial Engineering have also increased. This paper aims to analyze undergraduate and postgraduate courses in Industrial Engineering in Brazil. To do this, we considered the emphasis of the classification, course, the geographical location and research areas. Methodological, a qualitative, quantitative and descriptive study was developed, with the plan to collect data from a literature search of the data available on the websites of the Brazilian Association of Industrial Engineering and the Ministry of Education. The study indicates that their distribution is heterogeneous and the quality is short of the market's requirements.

Keywords: industrial engineering; Brazil; undergraduate in industrial engineering; postgraduate in industrial engineering; mapping; industrial engineering education

1. Introduction

Education has strong impact in the national development [15, 23]. The developments of new products, technologies and product process, optimization, as well as the protection of their patents are attributes of the engineers in several areas, including in Industrial Engineering (IE) [20]. Following this concept, countries such Germany, Japan, South Korea, and, more recently, China, have demonstrated signals of interest in strengthening their engineering education [9, 17]. Due to the industrial facility of multinationals in Brazil, as well as development of domestic industries, a management and engineering gap in these industries has emerged, which benchmark the global examples with Taylors logic. Following, the first course in IE in the country has emerged in 1958 at the Polytechnic School of the University of São Paulo (USP), initially as an option in the Mechanical Engineering course [24].

Programs of Industrial Engineering (IE) are the least technologic, overarching and generic engineering [16]. Therefore, the IE professionals frequently have treated problems by analyzing problems holistically with systemic knowledge [12]. The IE professional considers the design, improvement and implementation of integrated systems of people, materials, information, equipment and energy for the production of goods and services, while respecting ethics and culture [11, 21]. Consequently, the capacity of the IE profession including but not limited to industrial and service sector [25]. Therefore, as the IE graduate levels (master, professional master and doctorate) are dedicated to cover various contents to develop, implement, manage, improve and/or optimize goods and services [19]. On the other hand, industrial engineering students require a high level of preparation and training for a future job [14].

That means IE professionals are important as transmitters and introducers of progress [13]. As the authors of this study continue, it is a "balanced combination of a solid scientific and technical education, different applied technologies and disciplines within the economic-business and social-humanistic areas, the understanding that comes from reality of the industrial sector and the ability to interrelate various disciplines involved in complex system, makes these studies a current and innovative model".

Al-Ghamdi [4] explains in his study that a gap exists between practitioners and academics as well as students from national and international universities. His solutions are to adopt a problem-based learning and take a look at the perception of their education from alumni. Kádárová et al. [13] are going a step forward, describing study and research activities, and graduate profiles in their paper.

Some papers, like Broday and Andrade Júnior [8] compare the teaching of IE in several countries, e.g. France and Brazil, showing similarities and differences between the courses. In the cases of France and Brazil, "it was found that the courses have big differences in their teaching and curricular structure" [8]. Palma, Ríos and Guerrero [18] spoke about the progress in IE in Peru. Santanreu-Mascarell, Canós-Darós and Pons-Morera [22] did a comparative study about Spanish universities regarding their competencies.

Primarily, in the 90s, in Brazil there were 15

* Accepted 4 February 2016.

curricula in IE, while in 2000 there were already 72 curricula, so there was an increase in the availability by a growth of 1.820%, far superior to other engineering curricula [5]. On that point, all are included in IE curricula, as well as other curricula with IE emphases such as: IE Mechanical; IE Civil; IE Agribusiness; IE and Quality; IE and Systems; IE Electrical; IE Chemistry, IE Electromechanical, amongst others [1]. The starting date of Brazilian undergraduate courses in IE was in 1967 with the implementation of this program at PUC-Rio and UFRJ [5]. Nowadays, the Rio de Janeiro State (RJ) has strong representation in the program modality previously cited, such as in IE with 53 undergraduate courses [2], so 10.31% of the total number of courses provided in Brazil. This share is even higher when it comes to the percentage of 26.32% graduate programs are available in the RJ State [3].

The availability and growth of both the undergraduate and graduate programs in IE, is still negligible when compared with the country demand. According Faé and Ribeiro [10] on average are offered 7.7 jobs in IE per each millions of Gross Domestic Product (GDP). In this way, in terms of population, 54.2 jobs are offered for every million inhabitants. Given that the more well-qualified population, this provides greater potential for the development of the nation, and that this gap contributes to the professional profile in which primary production dominates.

2. Research questions

The IE undergraduate and graduate programs are maturing as a disciplinary field, with the trend of convergence of programs into a dedicated IE program [24]. In this sense, it is projected for the coming years that this convergence will challenge improvement and quality of teaching in order to improve market demand response.

The present research study was designed to investigate and identify the reality about localization and concept of the Brazilian IE programs. Consequently, in this study, three questions were proposed to specifically guide the research:

1. Is there some concentration in dedicated IE programs and IE emphasized programs under graduation courses in Brazil? Furthermore, which courses have the better performance?
2. Is there some influence on the concept of IE undergraduate programs if in the same institution as have graduate programs in the same area?
3. How is the impact of the line of research in the concept of the IE graduate programs?

3. Method

The survey was conducted between the months of April 2011 to December 2013 with the following three steps, as shown in Fig. 1. The first step of research was conducted with the collection of secondary data through analysis of documents and literature.

As a database, the following sites were used: Abepro [1–3] and the site of the Ministry of Education—e-MEC [7]. The organization of the data was performed to contemplate the focus of the paper, which analyzes the Brazilian undergraduate and graduate IE programs, considering especially the geographical location as well as the quality classification of them. As for treatment and analysis of data, these have been based on a critical reading of the material collected during the period and statistical analyzes.

4. Real-life example

4.1 Mapping of undergraduate courses

Currently, there are 531 IE undergraduate programs offered in Brazil. Of these, 17 are in the process of closing or suspension and, therefore, they were not considered in the following survey. Of the remaining courses (514), the majority (457) are courses dedicated IE programs (Fig. 2).

Before the presentation of the Brazilian Political Map, it was subdivided into five regions:

1. South: Rio Grande do Sul (RS), Santa Catarina (SC), and Paraná (PR);
2. Southeast: São Paulo (SP), Rio de Janeiro (RJ), Espírito Santo (ES), and Minas Gerais (MG);
3. Midwest: Mato Grosso do Sul (MS), Goiás (GO), Distrito Federal (DF), Mato Grosso (MT);
4. North: Rondônia (RO), Acre (AC), Amazonas (AM), Roraima (RO), Pará (PA), Amapá (AP), and Tocantins (TO);
5. Northeast: Maranhão (MA), Piauí (PI), Ceará

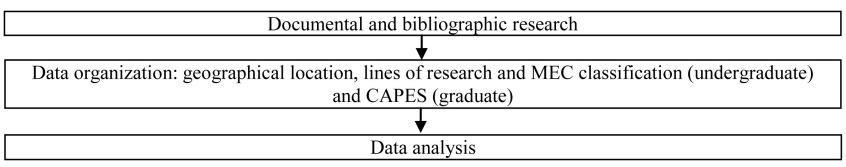

Fig. 1. Map of the study. Source: Authors.

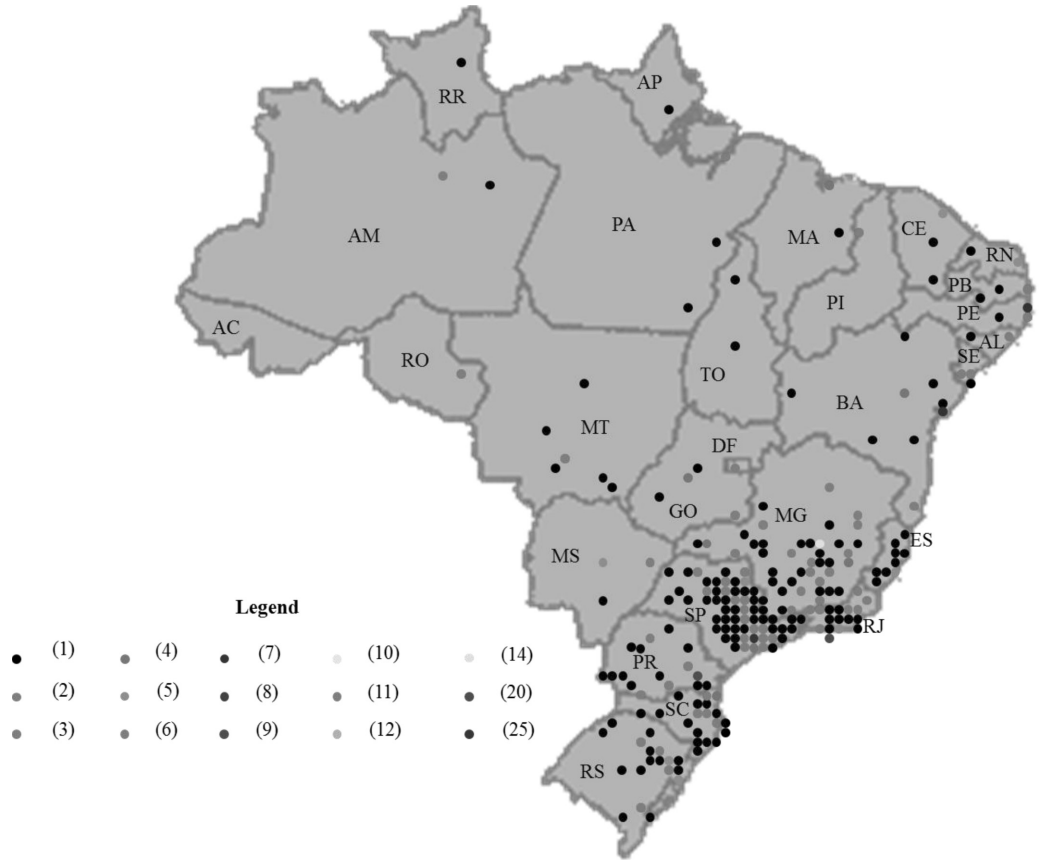

Fig. 2. Map of under graduation courses in IE. Source: Authors.

(CE); Rio Grande do Norte (RN), Paraíba (PB), Pernambuco (PE), Alagoas (AL), Sergipe (SE), and Bahia (BA).

An attention aspect regarding Fig. 2 is the concentration of IE programs in some States: São Paulo (SP)—(114), Minas Gerais (MG)—(79) and Rio de Janeiro (RJ) (51). The city of São Paulo alone has 25 IE programs; while in the city of Rio de Janeiro 20 IE programs are offered. Given these data, we can say that they are certainly a reflection of the dynamism of the market and the economic situation of these regions.

In addition to the dedicated IE programs, some Universities and Colleges provide curricula with emphasis on a particular area, such as IE with emphasis in Mechanical Engineering (Fig. 3) or IE with Civil Engineering. Figure 4 displays the map of graduate programs in IE with several emphases. As previously mentioned, in addition to dedicated IE programs there are also 38 undergraduate programs in IE with emphasis in Mechanical engineering (Fig. 3). These programs have geographical concentration especially in the States of: São Paulo (SP) - (26); Santa Catarina (SC) - (5); and Amazonas (AM) - (2). Again, the city highlighted is São Paulo, with seven graduate programs in IE. An atypical point is the city of Manaus with two programs, which probably seek professional training to work in the Manaus Duty Free Zone, a strong industrial area in AM.

Some IE programs have emphasis (Fig. 3) as: IE Civil (eight programs); IE Agribusiness (five programs); IE Quality (one program); IE and Systems (one program); IE Electric (one program); IE Chemistry (two programs); and IE Electromechanical (one program).

These programs with emphasis have a dominant emphasis in the states PR, MG and SC. The courses in IE with emphasis in some field are a minority (57 programs), i.e., only 11% of the programs are not as dedicated IE courses (Table 1). Programs in IE, in addition to the dedicated programs, highlight the IE undergraduate programs with emphasis in Mechanical engineering with 7.39%, as shown in Table 1.

While the undergraduate programs in IE are designed to satisfy the special demands of an IE professional, present greater difficulties to found. To create these programs, you need more resources, as well as equipment and laboratories, as for dedicated programs, that need to create any structure for that qualifies. The private universities incentive of profitability induces them to prefer to avoid the investment to provide dedicated IE programs. Per-

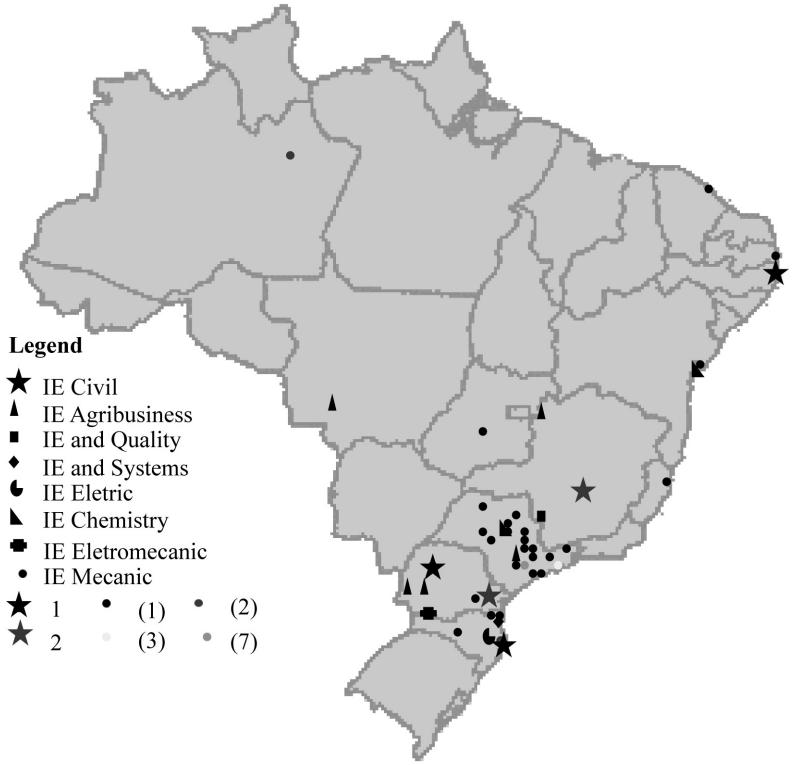

Fig. 3. Map of IE undergraduate programs with some emphasis. Source: Authors.

Table 1. IE undergraduate courses

Courses	Amount	Percentage (%)
IE (full)	457	88.91
IE Mechanic	38	7.39
IE Civil	8	1.56
IE Agribusiness	5	0.97
IE and Quality	1	0.19
IE and Systems	1	0.19
IE Electric	1	0.19
IE Chemistry	2	0.39
IE Electromechanical	1	0.19
Total	514	100.00

Source: [1] and [7].

haps this explains, in part, the trend in recent years to reduce the amount of IE programs which are not dedicated, since the vast majority of universities offering IE programs are in public universities, i.e. state and federal universities.

4.2 IE graduate program map

Varied from undergraduate IE programs in Brazil, there are currently only 38 (thirty eight) graduate IE programs, being classified into academic masters, professional masters and doctorate degrees. In the case of the IE graduate, 38 higher education institutions (private and public) have courses of this nature [3].

Of these, 9 are more specific, such as metrology, Material Handling and Artificial Intelligence in Industrial Engineering, scientific and industrial metrology, metrology and quality, operational research and computational intelligence, energy planning, systems management, systems and industrial processes and technology and 29 remaining are titled as: Graduation program in IE or in IE and Systems. Fig. 4 shows that there is a concentration of graduation courses in SP, RJ and RS. Following appear the states of PR, SC and MG. Besides these, there are IE graduate programs in 7 States, and that most have only masters degrees. The 38 programs, specifying academic masters, professional masters and doctorate, are presented in Fig. 4. The IE graduate programs in Brazil have in total 121 (one hundred and twenty one) lines of research, and they are distributed in the ten large areas of IE, according to Abepro (Table 2). The variation in the supply of these areas is sensitive, the area one (1), Engineering and operation of the production process is the most available, with 24 programs. Sequentially, in the eighth area, organizational engineering 21 programs are available. The availability of research is exposed in more detail in Table 2.

The research areas enumerated in the first column of the Table 2 are: (1) Production Systems Design, Planning and Control; (2) Materials Handling; (3) Artificial Intelligence in Industrial Engineering; (4) Total Quality Management; (5) Consumer Product Design; (6) Productivity and Business Strategies; (7) Engineering Economy and Cost Estimation; (8)

Fig. 4. Graduation Courses in IE (full). Source: Authors.

Table 2. Lines of research in the IE graduation programs

Research Line\State	Southeast			South			Northeast					Midwest	North	
	RJ	SP	MG	SC	PR	RS	BA	CE	PB	PE	RN	GO	AM	Total
1	3	6	3	2	2	3	1	0	1	1	0	1	1	24
2	1	3	2	1	1	1	0	1	0	0	1	1	0	12
3	4	3	2	1	0	2	0	0	0	0	1	0	1	14
4	3	1	0	0	1	0	0	0	0	0	0	0	1	6
5	1	2	1	1	1	1	0	0	1	0	1	0	0	9
6	0	1	2	2	1	1	1	0	0	0	1	0	0	9
7	6	4	3	0	1	0	0	1	0	1	1	1	0	18
8	6	6	1	1	1	2	0	0	1	1	1	0	1	21
9	2	3	1	0	1	0	0	0	0	0	1	0	1	9
10	0	1	0	0	0	0	0	0	0	0	0	0	0	1

Source: Adapted from [3].

Work Measurement and Methods of Engineering; (9) Sustainability Engineering and Development; and (10) Industrial Engineering Education and Practices. Table 2 shows that the IE Operations and Processes (1st line) is the focus of research in 11 states and encompasses the whole of Brazil. Already, research on second line Material Handling has predominance in São Paulo State. Artificial Intelligence in Industrial Engineering is concentrated in the South, Southeast, Midwest and Northeast of Brazil and the fourth line (Total Quality Management) generally are situated in the South, Southeast and North. The SC, PR, SP and MG have two graduate programs addressing the Consumer Product Design as a research line. The states of RS, BA and RN have this line in just one program. Already, Productivity and Business Strategies is addressed in all graduate programs of the State of Rio de Janeiro, Amazonas, and even in some graduate programs in the South, Southeast, Midwest and Northeast. Engineering Economy and Cost Estimation is a line rarely addressed, being contemplated in only six (6) programs, and that half of these are concentrated in the State of Rio de Janeiro. Already, Work Measurement and Methods Engineering is searched in 7 states: Rio Grande do Sul; Santa Catarina; Paraná; São Paulo; Minas Gerais; Paraíba; and Rio Grande do Norte. A relatively new line is the Sustainability Engineering, which is studied in six states such as: Amazon, Rio Grande do Norte, Minas Gerais, Rio de Janeiro, São Paulo and Paraná. The last line Education in IE is only in a graduate program offered.

4.3 Lines of research and the relationship between the undergraduate and graduate IE programs

We only considered those whose undergraduate programs in IE reached the highest national grade

Table 3. Lines of research in university with IE graduate programs whose IE undergraduate programs have bigger concept

Universities\ Lines of research	1	2	3	4	5	6	7	8	9	10	Total
UFF	0	0	0	1	0	0	1	1	0	0	3
UFSCAR	1	0	1	0	1	0	0	1	0	0	4
UNIMEP	1	1	1	0	1	0	0	1	1	0	6
PUC/PR	1	1	0	0	0	0	0	0	0	0	2
UFRGS	1	1	1	0	1	1	0	1	0	0	6
UFC	0	1	0	0	0	0	1	0	0	0	2
UFPE	1	0	0	0	0	0	1	1	0	0	3
Total	5	4	3	1	3	1	3	5	1	0	

Source: Adapted from [3].

by ranking, equal to 5, which also have IE graduate programs. We listed the lines of research that these institutions operate (Table 3). The grades in the national ranking go from 1 (lowest) to 5 (highest). To continue teaching the grade must be 3 or higher.

From Table 3 it is possible to see that of 7 institutions of excellence, 3 are located in the southeast, 2 in the south and 2 in northeast. The lines of research vary considerably, of 2 in UFC and 6 in UNIMEP and UFRGS. One emphasis is that the IE programs in UFRJ, where despite its evaluation concept Capes 6 in the graduate program, only has a grade 4 in the MEC ranking. About the research line, the 1st line, Production Systems Design, Planning and Control has the biggest score and the 8th line, Work Measurement and Methods Engineering has the biggest proportion of courses (5), being followed by the 2nd line, and Material Handling with research in 4 of 7 universities. In research in three (3) universities the following areas were found: Operational research, Consumer Product Design and Engineering Economy and Cost Estimation.

Only one university has the following lines of research: Quality Engineering, Productivity and Business Strategies and Sustainability Engineering. In the 10th line, Industrial Engineering Education and Practices there is not research group identifies in these universities. Only one program has this line of research.

5. Statistical analysis

5.1 Statistical Analysis of IE undergraduate programs

In this research not only was the general data of IE undergraduate programs considered. Indicators had been assembled such as: General Indicator of Courses (IGC); Preliminary Grade of Course (CPC); e Grade of Course (CC). According the National Institute of Educational Studies and Research Anísio Teixeira—INEP (2013), the IGC is a quality indicator of institutions of higher education that consider, in its composition, the quality of undergraduate programs as well as graduate. While the CPC is composed by the results of *Enade* and factors, that consider the qualifications of professors, the perception of academics that comply parcel or integral regime, didactic and pedagogic resources, infrastructure and layout [6], so it is one medium between different quality measures of the course (Table 4).

The third quality indicator is the grade of course, which is calculated with basis on course evaluation *in loco* for the Ministry of Education [6]. The CC can confirm or modify the CPC. These three indicators

Table 4. Medium of Courses in IE under graduation

Courses	General Indicator of Courses	Preliminary Grade of Course	Grade of Course
IE (full)	3.1504	3.2205	3.7895
IE Mechanical	3.5676	3.5200	3.5000
IE Civil	3.6250	3.0000	3.0000
IE Agribusiness	3.6000	3.0000	4.0000
IE and Quality	3.0000	3.0000	4.0000
IE and Systems	4.0000	4.0000	–
IE Electric	5.0000	4.0000	–
IE Chemistry	4.0000	3.0000	–
IE Electromechanical	4.0000	–	–
IE in institutions with master/doctorate or professional master	3.8065	3.6875	4.6000
Total	3.2063	3.2638	3.7730

Source: Data of resource (2014).

Table 5. Variance of IE under graduation courses

Courses	General Indicator of Courses	Preliminary Grade of Course	Grade of Course
IE (full)	0.3425	0.4711	0.5054
IE Mechanical	0.3535	0.4896	1.0500
IE Civil	0.4844	0.5000	0.0000
IE Agribusiness	0.6400	0.6667	1.0000
IE and Quality	0.0000	0.0000	0.0000
IE and Systems	0.0000	0.0000	–
IE Electric	0.0000	0.0000	–
IE Chemistry	1.0000	0.0000	–
IE Electromechanical	0.0000	–	–
IE in institutions with master/ doctorate or professional master	0.4142	0.3398	0.4400
Total	0.3785	0.4887	0.5431

Source: Data of resource (2014).

for undergraduate programs vary their grade from 1 to 5 (5 being the maximum value). Based on data from the e-MEC, the averages were calculated for each type of IE undergraduate program, as shown in Table 4. As we used only programs in progress, the average of the grades should be above three. It can be seen in Table 4, several courses are so new, that they do not have a program grade, such as IE and Systems, IE Electrical, IE Chemistry, IE Electromechanical. In general, we can say that the courses in dedicated IE have an IGC smaller but receive a greater program grade. Only the IE Agribusiness has an average of CC with a value greater than 4.0. You can see also in Table 4, those IE undergraduate programs in one institution that have IE masters and/or doctorate or professional master's, obtain highest CC. In sequence, Table 5 shows the variances of indicators in the IE undergraduate programs.

Verifying the variances for each type of course (Table 5), the course in IE full has three indicators with the lowest variance, these indicators are respectively, 0.3425 (IGC), 0.4711 (CPC) and 0.5040 (CC).The largest variations are in the course of IE Agribusiness where the CC indicator has a values of 1. The two courses in IE Chemistry IGC have the same result, what means, one course with a grade 5 and the other with a grade 3. Further, Table 6 shows the correlation between the indicators and programs, where only the programs in IE Agribusiness have a more significant correlation. The other courses have very weak correlations in a positive or negative way. Noteworthy is the strong correlation between the CPC and CC with a value of 0.8863, meaning a high CPC, usually also causes a greater grade of the course.

5.2 Statistical analysis of IE graduate programs

The average of the IE graduate programs is 3.27 with a standard deviation of 1.77. The correlation measures the degree of relationship between two variables (Barbetta, 2005; Moore, 2006). The correlation measures the degree of relationship and is represented by the letter ''r'', whose value ranges between –1 and 1 (Bankhofer and Vogel, 2008). The possible outcomes are not correlated ($r \approx 0$), positive correlation (r +) (Barbetta, 2005). This possibility occurs when the values of a variable have ascending (or descending) tendency and the values of the other variable have the same tendency at first, negative correlation (r–). In this case, when the values of a variable are increasing (or decreasing), the values of other variables are decreasing (or increasing). To determine the weight of correlation, the range of values between 0 and 1 is used, as suggested by Smith (2006).

Table 7 presents the correlations between the three (3) graduate programs and amongst the ten (10) IE lines of research. It also indicated a strong correlation (0.70) between the master's and doctoral degrees. It is concluded that when the master's is well evaluated, there is a strong tendency that the doctorate also be. Already, between the academic master's and professional master's the correlation is

Table 6. Correlation between IE under graduation indicators

	General Indicator of Courses	Preliminary Grade of Course	Grade of Course
General Indicator of Courses	1		
Preliminary Grade of Course	0.4063	1	
Grade of Course	0.6313	0.8863	1

Source: Data of resource (2014).

Table 7. Interval of correlation values

	Master	Doctorate	Professional Master	1	2	3
Master	1					
Doctorate	0.70	1				
Professional Master	–0.34	0.16	1			
Production Systems Design, Planning and Control	0.03	0.07	0.14	1		
Material Handling	0.31	0.27	–0.05	0.17	1	
Total Quality Management	–0.06	0.08	0.12	–0.10	0.30	1
Engineering Economy and Cost Estimation	0.17	0.30	0.04	–0.12	0.02	0.12
Work Measurement and Methods Engineering	0.06	0.15	0.03	0.17	0.29	0.34
Consumer Product Design	0.10	0.18	0.18	0.17	0.42	0.22
Operational Research	0.18	0.05	–0.27	–0.01	0.11	–0.21
Productivity and Business Strategies	0.20	0.26	–0.02	–0.03	0.04	0.03
Sustainability Engineering and Development	–0.14	–0.05	–0.12	–0.09	–0.11	0.09
Industrial Engineering Education and Practices	–0.33	–0.12	0.20	0.13	–0.11	–0.13

	4	5	6	7	8	9	10
Engineering Economy and Cost Estimation	1						
Work Measurement and Methods Engineering	–0.07	1					
Consumer Product Design	0.10	0.42	1				
Operational Research	0.07	–0.10	0.03	1			
Productivity and Business Strategies	–0.21	0.07	–0.10	0.03	1		
Sustainability Engineering and Development	0.10	0.27	–0.02	0.15	0.12	1	
Industrial Engineering Education and Practices	–0.07	–0.09	–0.09	–0.14	0.15	–0.09	1

Source: Data of resource (2013).

weak (–0.34). That is, the better the master's, the worse the professional master's. And between doctoral and professional master's is even less, with a value of 0.16. It can be stated that the professional master's cannot benefit from good doctorate evaluation. The correlation between the ten (10) research lines presents, in the major part, really weak correlation. The highlighted correlations are between Consumer Product Design and Material Handling, such as Consumer Product Design and Work Measurement and Methods Engineering that have medium correlation with value of 0.42. The Total Quality Management and Material Handling, and Total Quality Management with Work Measurement and Methods Engineering such as Consumer Product Design and Productivity and Business Strategies provide weak correlation with values: 0.30, 0.34 and 0.38, respectively.

6. Discussions

With the realization of this study can be seen that amongst the trends of IE programs in Brazil, the convergence of different emphases on dedicated IE programs is a sizeable phenomenon. Insofar as, only 11% of programs in IE have some emphasis, and these programs are arranged mainly in the States of Paraná, Santa Catarina and Minas Gerais. Although the Government has a major impact on this system, considering that these programs are available in the public, largely responsible for this phenomenon is of course the market. This is justified by the fact that the market itself is demanding a professional with a particular emphasis on a curriculum area and more general in another. Another important point concerns the fact that the capitals of the states of São Paulo and Rio de Janeiro, possessing the highest incidence of the dedicated IE programs, have a tiny amount of courses with emphasis in IE (State of SP) or do not have any dedicated programs (State of RJ).

So in the general form, it is noteworthy that the highest incidences of IE courses are in descending order in the regions: Southeast, South, Northeast, Midwest and finally North. Contrasting this data with regional industrial development, it is clear that, as the regional market has greater need for IE professionals, the greater the availability of courses in IE by both private colleges as public universities. As for graduate courses, the distribution of programs focuses on the states of the Regions: South and Southeast over the States of Goiás, Ceará, Paraíba, Rio Grande do Norte and Amazonas. We find large differences in the distribution of the research. Industrial Engineering Education and Practices is performed only in one university. However, the research line of Engineering Operations and Process of Production, is searched in 24 (twenty four) programs. Engineering Economy and Cost Estimation, on the other hand, is a concentered line of research in the Rio de Janeiro State, where there are 3 of 6 graduate programs.

Generically, it is possible to identify that, dedicated IE undergraduate programs are concentrated in the Southeast region; IE undergraduate programs with emphasis are concentrate in Southeast

and South region. Dedicated IE undergraduate programs are concentrated in the southeast region, principally in the States of São Paulo (114 courses), Minas Gerais (79 courses) and Rio de Janeiro (51 courses). IE with some emphasis is not so common in the country as are dedicated IE undergraduate programs, where IE Mechanic is the most offered with strong concentration in São Paulo State, with 26 programs, which represents 68.42% of national programs in these areas. Following, Paraná has the majority of IE Civil programs, 3 of 8 programs in the country, while the other programs with emphasis are IE Agribusiness, IE Chemistry, IE Quality, IE and Systems, IE Electric, and IE Electromechanical. Considering all IE emphasis programs, we find São Paulo as the State with more concentration, followed by Paraná, Minas Gerais and Santa Catarina. For opportunely, we appoint the Southeast and Southern Region as the more concentrated of this class of programs.

When checking the correlations between masters, doctoral and master's professional a strong correlation (0.70) is observed between master's and doctoral, while weak (–0.34) between academic master's and professional master's and even weaker (0.16) between doctoral and professional master's. Already, the correlations between the research lines are very weak. Only two lines of research could reach moderate correlation levels, they are: Consumer Product Design and Material Handling and Consumer Product Design and Work Measurement and Methods Engineering. In addition, three other combinations reached a weak correlation.

The quality of teaching in these institutions, both public and private, is evaluated by the MEC to keep them running. The assessment of programs for IE Civil showed the lowest average CC within the limits of acceptable (3), the modality and IE Agribusiness and IE and Quality showed average (4), while the dedicated modality was evaluated with a grade (3.79), approximately. Since assessing the 3 indicators, dedicated IE programs have the lowest variance, an expected situation, because of the dominance of the number of dedicated IE programs against the other. Regardless of the mode of travel, the challenge of these educational institutions and society is evident; education needs considerable development.

The IE graduate programs as with IE undergraduate programs are concentrated strongly in the regions Southeast and South, Other curios characteristic identify is the concentrate of the courses in Atlantic littoral region. Consequently there are few courses in the central of the country. We recognized that programs in IE undergraduate programs in institutions with master's/doctorate or professional master's has the best medium CC (4.600) and variance of 0.4400 in the rating. The dedicated IE programs have the second lowest medium grade in IE undergraduate programs (3.7895) with variance of 0.5054. Facing this point, we identify that, IE graduate programs influence positively the CC concept of IE undergraduate courses. It's possible to see that, IE with emphasis; IE Mechanic, has better CC if compared to dedicated IE undergraduate programs that do not have an IE graduated programs in the same institution.

The research lines of graduate programs, whose undergraduate program is in the same institution, have excellent ratings. We identify that the first and eighth areas, Production Systems Design and Planning and Control, had the higher incidences, while the tenth area has not one incidence.

Finally, it is clear that despite the existence of 38 programs, there is still an asymmetry with respect to lines of research. There is a great potential for expansion and deepening of postgraduate in IE in Brazil.

7. Conclusions

The knowledge arising from the university influences people, at the same time, interrogate, seek, cultivate and challenge the knowledge, science, technology, the arts as well as investigate and create new knowledge and assume social and political research dimension and prepare the students to enter into the labor market, through skills acquired in the academic environment. In this context, in view of the analysis previously prepared, this article sought to contribute to the knowledge of the national IE programs, considering aspects such as the category of teaching unit nomenclature of programs and emphasis, as well as geographical location. Through this analysis, we conclude that there is a heterogeneous distribution of courses with a concentration in industrial areas and more economically developed, mainly in the Southeast and South; and these must restructure to efficiently meet the real business need. For future research, it is possible to replicate this study: (a) in others programs, such as mathematics, management, (b) in others countries, and then compare the similarity and the differences of the lines of research, and (c) identify more specifically the conjuncture, and the developing factors of the best concept of programs in IE.

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