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# Entrepreneurship in Engineering Education: A Literature Review*

GLAUCO BARBOSA DA SILVA
Centro de Análise de Sistemas Navais (CASNAV), Praça Barão de Ladário, s/n, Centro, Rio de Janeiro, Brasil.
E-mail: glaucos@id.uff.br

HELDER GOMES COSTA and MARTA DUARTE DE BARROS
Universidade Federal Fluminense (UFF), Rua Passos da Pátria, 156, Bloco D, sala 309, Niterói, Brasil.
E-mail: helder.hgc@gmail.com, marta_uff@hotmail.com

The main purpose of this paper is to present a literature review of Entrepreneurship Education in engineering courses. From an initial search in Scopus, 16,835 documents were collected. This search was enhanced by applying filters to the documents. Conducting a new research with the keywords Entrepreneurship and Education, and restricting to articles in journals and the engineering field, 74 articles were selected and mapped by a Webibliomining model. A few research studies have examined the practices and beliefs in entrepreneurship education. Thus, this paper consolidates concepts from literature to help understand, develop and drive models of the entrepreneurship education in engineering. Based on the literature review, this paper provides a useful core of references that includes the oldest, the newest and the highest citations of Entrepreneurship Education in engineering.

**Keywords:** entrepreneurship education; technology transfer; entrepreneurship business

## 1. Introduction

Due to its great importance in the establishment of companies to contribute to economic growth around the world, entrepreneurship is one of the most currently discussed academic subjects. According to Stamboulis and Barlas [1], entrepreneurship and new businesses have become a valuable potential for development and economic growth in modern society.

Since the 1960s, the number of entrepreneurship courses offered by universities has increased expressively; primarily due to increased government emphasis on creating new ventures and alleviating unemployment. The increase in entrepreneurship education opened a number of issues that still surrounds the delivery of entrepreneurship in universities [2].

It has become a necessity for universities to cultivate students' entrepreneurial ability to adapt to the economic transformation and upgrading, as well as to construction and development of entrepreneurial economy. It is also important to improve education system in colleges and universities, strengthening innovation training of entrepreneurial talent[3]. Universities are increasingly including technology entrepreneurship in engineering education to follow expansion of the subject of engineering design education in recent decades [4].

Ruda, Martin, Arnold and Danko [5] suggest that innovative opportunities at regional, national and international level are able to build basic conditions for achieving economic stability. A proposal to deal with such innovative issues is through the spread of entrepreneurial culture, i.e., in educational projects in production engineering undergraduate courses where the entrepreneurship discipline has been implemented.

Advanced countries, such as the United States and Japan, have been strongly promoting entrepreneurship education. In addition, they also provide relevant supporting measures to encourage graduates to start an enterprise as one of the major measures to increase the employability of students [6].

The involvement of undergraduates in intellectual property protection leads to interesting questions related to how best to align student interests with institutional policies and practices since most are not employed by their universities in the way that faculty and many graduate students are [7].

The number of entrepreneurship programs at universities targeting engineering students has grown substantially in the last decade. However, few research studies have examined the practices and beliefs of instructors in these programs. Understanding these practices and beliefs will help the development of pedagogical and theoretical models to drive entrepreneurship education [9].

To develop an exploratory study about entrepreneurship education in engineering, a bibliometric tool was chosen to trace the knowledge. Guedes and

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Borschiver [10] define bibliometrics as a statistical tool that allows mapping and generates different indicators of treatment and management of information and knowledge, necessary for the planning, evaluation and management of science and technology of a particular community or scientific parents. Others related terms as: Informetric—more recent term that used bibliometric concepts in a non-academic context; Scientometrics, used for the study of all aspects of the literature of science and technology; webmetric, as an emergent area in information science that consists in the application of informetric methods in the World Wide Web. (More details about bibliometric see: [11]).

Proposed by Costa [12], the Webbliomining Model is a bibliometric model that integrates concepts of different areas, and it was applied in a bibliographical study of adoption of MCDA methods in the management and planning of the petroleum and gas industry [13] and in mapping a core starting of references in Data Mining from journals published in Brazil [14].

The main purpose of this paper is to present a literature review of Entrepreneurship Education in engineering courses through *Webibliomining* model. As a contribution, this study is expected to provide an initial core of references that enables to reveal ideas or criteria to be used in a building process of a model that can be able to evaluate the influence of entrepreneurship education in engineering courses.

## 2. Concepts and definitions

In this section, theoretical and conceptual foundations about Entrepreneurship are described. Also, some previous studies that used the entrepreneurship education as a differential in economic development are cited.

### *2.1 Entrepreneurship*

Karimi, Chizari, Biemans and Mulder [15] define Entrepreneurship like the behavior of a person who displays the traits (need for achievement, need for power, risk-taking tendency and competitiveness) necessary to obtain or attain something in life, to research and become self-sufficient.

Gomezelj and Kušce [16] provide another definition that Entrepreneurship is a global process and a phenomenon of recent decades, and it seems it will be even more prominent in the coming years. Cristian-Aurelian and Cristina [17] consider Entrepreneurship as an innovative process through which entrepreneurs identify business opportunities and exploit them by allocating resources, and creating value.

Entrepreneurship is relevant for all sectors, technological or traditional, for small and large firms and for different ownership structures. Entrepreneurship contributes to job creation and economic growth and competitiveness, unlocks personal potential and provides a focal point for many local communities. Furthermore, it has been increasingly recognized as a major driver of economic development [17, 18].

In the recent decades, the role of new firms has been recognized as one of the key elements for economic and social development. While governments dedicated their efforts to design polices and strategies for the support of the entrepreneurial activity, the academy has focused its interest, among other topics, on the analysis of conditioning factors to entrepreneurship [19].

Rezai, Mohamed and Shamsudin [20] introduce Agri-entrepreneurship as a means of coping with the changes in the environment and thus contributing to the survival and success of farming businesses in the present, as well as in the future.

Entrepreneurship is a powerful tool for economic growth as it facilitates the creation of new companies and jobs, develops new markets and demonstrates new skills and capabilities. Investing in the promotion of entrepreneurship and education for engineers is one of the best return investments that countries around the world can make [21].

#### *2.1.1 Entrepreneurship education*

Hamilton, Crawford and Suuberg [22] claim that, despite the existence of entrepreneurship for a long time in organized societies, the idea of educating entrepreneurs, as such, is a new concept; and that eighty per cent of students surveyed at the end of an entrepreneurship course said they plan to start their own business at some point in his career.

Entrepreneurship education tries to prepare people, particularly youth, to be responsible, take risks, manage the business and learn from the outcomes by immersing them in real life learning experiences [15]. Entrepreneurship presents a good career opportunity for engineering students, because of its increasingly importance in developed countries as well as in developing countries [23].

A technology-based entrepreneurship course can be an educationally rewarding experience for both students and faculty. Providing students with a simulated, but realistic, entrepreneurship experience allows them to gain a greater understanding of what it truly means to be an entrepreneur. This 'real-world' experience helps students decide whether or not a career as a high technology entrepreneur appeals to them [22].

Entrepreneurship educators have an opportunity to learn from the entrepreneurship programs at both small colleges and large universities that have already emerged and with experienced growth,

challenges, failures, and ultimate successes. In addition, implementing a strategy that includes faculty partnerships, designated advisory boards, and refined bootstrapping skills helps to ensure that robust human and capital resources are available for program delivery, growth, and sustainability [24].

The new imperatives of the knowledge-based society require engineering students to equip themselves with a broad range of skills, among which entrepreneurship plays a critical role. The purpose of entrepreneurship education should not only be the foundation sensitization but also in general entrepreneurial competences within the scope of an interdisciplinary intersection. This approach to teaching entrepreneurial foundation in effect encourages of new business ideas by the students [25].

Higher education plays an important role in laying the foundation for competence development for sustainable entrepreneurship. Whereas entrepreneurship education is traditionally located in the business schools, education for sustainable development often has its origin in the environment education faculty. There is little work from an educational point of view which explores and/or crosses the boundaries of these two disciplines, let alone work in which an effort is made to integrate these perspectives [26].

Entrepreneurship Education consists in teaching students the process, knowledge and skills required for starting a new business. The skills that the students need to develop during the course are very different to those acquired in other courses. For example, while most IT courses focus on developing inquiry/research and problem-solving skills, the Entrepreneurship course places a strong emphasis on writing and speaking skills and aims to improve the broader business, communication, and management skills that graduates need in order to succeed in starting a business enterprise [27].

According to Yang and Zhao [3], if universities actively cultivate the entrepreneurial ability in their students, they will improve the system of entrepreneurship education management and entrepreneurship education system and create entrepreneurship training base and so on. Therefore, in the process of entrepreneurship education, universities should pay more attention to the core and important business knowledge, while the simple and easy knowledge can be learned by students themselves.

The entrepreneurial university thus responds by generating technology transfer, knowledge-based start-ups and human capital. However, in the entrepreneurial society, the focus should be broadened by enhancing entrepreneurship capital and facilitating behavior to prosper [28].

Due to professional requirements, many of the institutes of science and engineering require some business education for membership. Enterprise education is particularly relevant and important in that it has a role in promoting enterprise within the SET (economy Science, Engineering and Technology) industries and it is this 'enterprise' ability and orientation that is acknowledged by government, industry and research as a driver in terms of maintaining and developing competitiveness [29].

Scholars widely acknowledge that university research is critical to innovation and entrepreneurship. Much of the literature on university research, however, evokes a linear model from "science to products" and focuses, therefore, upon a limited set of indicators such as patents and licenses. Such perspective risks missing the myriad ways in which science and commerce are intertwined and the myriad ways in which these activities might be assessed [30].

Many engineering programs emphasize the importance of technological innovation by offering entrepreneurship electives and programs. Integration of entrepreneurship into the required engineering curriculum has predominantly focused on senior capstone design courses [31].

Engineering education has an indomitable role in entrepreneurship development. Since entrepreneurship is a dynamic process of vision, change and creation, the education provides energy and passion towards creation and implementation of new ideas on a continual basis. Engineering institutions have mostly played a passive role, resulting in many myths and fears among students on entrepreneurship [32].

While entrepreneurship has emerged as an important mechanism for the generation of social returns in terms of economic growth and job creation, entrepreneurship education is still something new in Europe and the debate about the need and the way of introduction of specific entrepreneurship courses in higher education is ongoing [33].

### *2.1.2 Entrepreneurship business*

Li [34] defines entrepreneurship as a particular condition of people finding business motivation and then integrates resources related to entrepreneurship, thus forming a valuable capacity that is the ability of entrepreneurs in performing business processes.

According to Novotny [35], in East Europe, the relatively weak links between universities and the industry derives mainly from the socialist past of the countries that still has repercussions on the environment, governance and culture of institutions, as well as on faculties attitude to entrepreneurship.

A prototype of academic entrepreneurship, Stan-

ford University, developed its technology transfer skills in parallel with the rise of Silicon Valley. Despite these early archetypes, university technology transfer in the U.S. began to receive increased attention from scholars only in the aftermath of the Bayh-Dole Act (1980) [36].

Entrepreneurship can happen in any business context, all the way from large corporations (that can afford to take on large opportunities, yet often encounter difficulties executing new ideas), to start-up companies (are the best way to pursue point solutions that extend an existing context or pursue ideas that are more radical and yet require fewer resources) [23].

Definitions of enterprise education describe something around innovation or the creation of new ventures and some encouragement for individuals to take responsibility for their own learning, careers and life. It may focus on entrepreneurship or on intrapreneurship or social entrepreneurship [37].

Currently, the new role of higher education has tended to concentrate on describing infrastructural reform and institutional innovation that promote a culture of entrepreneurship within the academic institutions [38]—Education entrepreneurship. Entrepreneurship skills and attitudes can be trained through business simulations experiences [39].

Entrepreneurial-minded individuals around the world play an extremely vital role in society performance businesses that contribute to the growth of the national economy, create new jobs, and when producing new products and services they improve the quality of life [16].

Foster and Lin [40] claim that the concept of entrepreneurship is often allied with the concept of innovation. Such innovation does not always have to be technical or even result in a tradeable product. Innovation can be social. Changes for example in an education system or a national health service can be considered to be social innovations, because they have a profound impact on society and economy as a whole.

## 3. *Webibliomining* model

*Webibliomining* model has the purpose of providing an initial set of references for a literature review. It integrates concepts of Bibliometrics, Webmetrics, Informetrics and Biblioming and consists of the following six steps:

- Define survey sample;
- Research in the sample, with the keywords;
- Identify journals with the largest number of published articles on the subject;
- Identify authors with the highest number of publications;
- Identify "the largest production cycles" (Chronology of production);
- Selection of references for the composition of *starting core* (SC) for literature review. SC must include:
  - the most relevant references;
  - the first authors to write about the subject;
  - the latter authors to write on the subject;
  - the most relevant references in each "major production cycle."

## 4. *Webibliomining* model application

In this section, the *Webibliomining* model is applied at the literature review from Entrepreneurship Education in engineering.

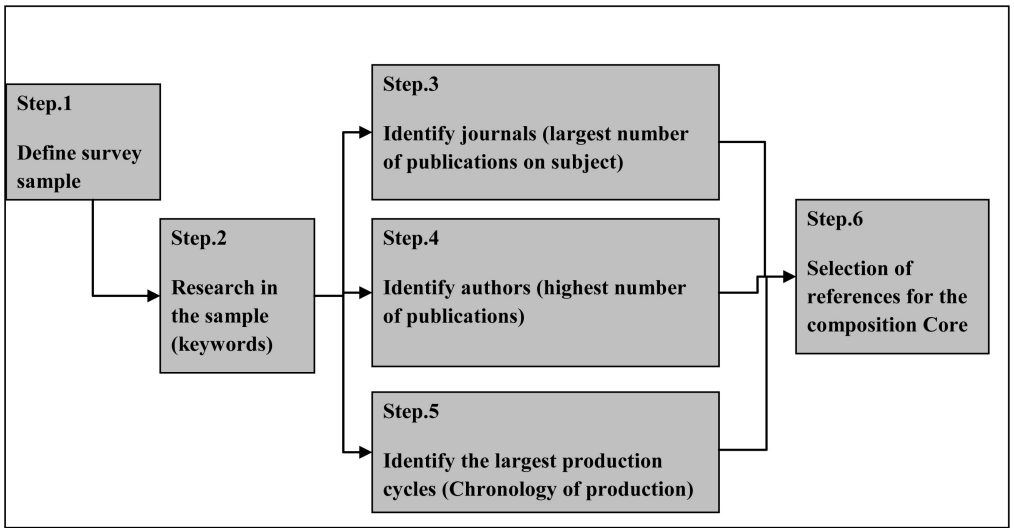


**Fig. 1.** *Webibliomining* Model.

### *4.1 Definition of the survey sample; and Research in the sample, with the keywords*

Sample corresponds to articles indexed in Scopus library database. The choice of this database was due to accessibility and because the admission criteria of the documents in the collection are representative and that provides the most valuable information to researchers and practitioners. Contemplating all the years that were available in the database, the research was undertaken until October (2014).

First, the term ''Entrepreneurship'' was defined like keyword for research; as a result 16.835 documents were obtained. In complement of initial research, seeking to filter the documents, a new research was conducted with a combination of terms ''Entrepreneurship'' and ''Education'' and with restriction to articles in journals and engineering area, resulting in 74 articles.

A list was created with 205 Keywords and from this a cloud of words was generated, as shown in Fig. 2. The highest occurrences were: Entrepreneurship (31), Entrepreneurship Education (11), Technology Transfer (6), Education (6), Higher Education (5) e Academic Entrepreneurship (4).

Figure 3 shows a tree formed from the abstracts of the articles found during the mapping of the literature review. As recommended by Gambette and Véronis [42], all abstract words were placed in lower case. A total of 12,517 words the terms Universities and Courses University were replaced by University and course (25) respectively. A custom stoplist with the words: (study, purpose, research, paper, should, support, based, findings, related, approach, start, results) were removed because they were not significant for the analysis of the context.

A visual inspection indicates that two major segments can be identified and sectioned in Fig. 3

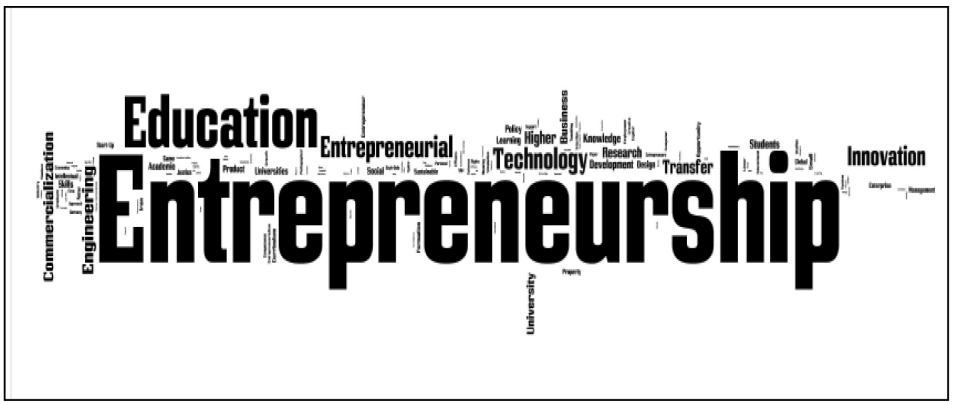


**Fig. 2.** Keywords cloud from researched articles [41].

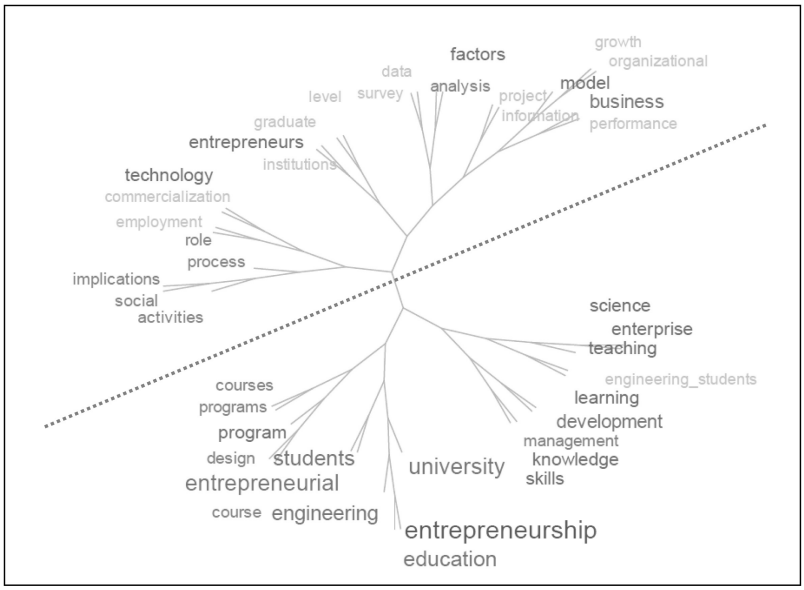


**Fig. 3.** Tree built from abstracts of the researched articles [43].

by a dotted line: *a business area* that encompasses organizational issues to implications and social aspects; and *an academic area* (the larger one), which appears to cover two branches: the structuring of courses/programs and another focused on the development of science and on learning theme.

### *4.2 Identification of the journals with the largest number of published articles on the subject*

The 74 articles selected from research are distributed in 38 different journals that were ranked in Table 1 by SJR index.

SCImago Journal Rank (SJR) is weighted by the prestige of a journal. Subject field, quality and reputation of the journal have a direct effect on the value of a citation. SJR also normalizes for differences in citation behavior between subject fields. For details about SJR, see [44].

Source Normalized Impact per Paper(SNIP) measures contextual citation impact by weighting citations based on the total number of citations in a subject field.

### *4.3 Identification of the authors*

There were no observed authors that stand out compared to the others by the number of articles published on the subject. Aside from Audretsch, D.B, with three articles; Buang, N.A.; Danko, B.; and Galloway, L. with two articles, the other authors had only one work related. From the Gephi tool, where each node represents one author (176 nodes) and each edge represents at least one article published between authors (173 edges), some statistics about authors network graph (Fig. 4) were obtained: Average degree—1.97; Density—0.01; Connected components—69.

For grouping the authors, as a criteria: *Country—Institute of affiliation* was adopted; Fig. 5 summarizes the countries that have at least 5% of all authors and which together account for over 70% of the total, i.e.: United States (22.73%); Spain (13.05%); United Kingdom (7.95%); Malaysia (7.39%); Netherlands (6.25%); Iran (5.68%); Romania (5.68%), and China (5.11%), as shown below.

**Table 1.** List of Journals ranked by SJR index

| Journals | QTD | ISSN | SJR | SNIP |
|---|---|---|---|---|
| Journal of Engineering Education | 1 | 1069-4730 | 6,515 | 13,976 |
| Research Policy | 4 | 0048-7333 | 2,635 | 2,883 |
| Technovation | 2 | 0166-4972 | 2,027 | 2,139 |
| IEEE Signal Processing Magazine | 1 | 1053-5888 | 1,831 | 4,906 |
| Journal of Cleaner Production | 1 | 0959-6526 | 1,699 | 2,516 |
| Journal of Technology Transfer | 6 | 0892-9912 | 1,558 | 1,509 |
| British Journal of Educational Technology | 1 | 0007-1013 | 1,523 | 1,709 |
| Annals of Biomedical Engineering | 1 | 0090-6964 | 1,302 | 1,414 |
| International Journal of Engineering Education | 7 | 0949-149X | 1,280 | 1,096 |
| Engineering Management International*/Journal of Engineering and Technology Management | 1 | 0923-4748 | 1,273 | 1,701 |
| IEEE Transactions on Education | 1 | 0018-9359 | 1,205 | 2,500 |
| European Journal of Engineering Education | 2 | 0304-3797 | 1,040 | 1,206 |
| Advances in Engineering Education | 2 | 1941-1766 | 1,029 | 3,010 |
| Maritime Policy and Management | 1 | 0308-8839 | 1,009 | 1,497 |
| Industrial Management and Data Systems | 3 | 0263-5577 | 0,989 | 1,381 |
| IEEE Antennas and Propagation Magazine | 1 | 1045-9243 | 0,757 | 1,249 |
| Journal of Manufacturing Technology Management | 1 | 1741-038X | 0,656 | 1,196 |
| International Journal of Technology Management | 1 | 0267-5730 | 0,324 | 0,510 |
| Kybernetes | 1 | 0368-492X | 0,298 | 0,670 |
| International Journal of Mechanical Engineering Education | 1 | 0306-4190 | 0,274 | 0,232 |
| Mathematical Problems in Engineering | 1 | 1563-5147 | 0,267 | 0,746 |
| Human Factors and Ergonomics In Manufacturing | 1 | 1090-8471 | 0,256 | 0,798 |
| Acta Polytechnica Hungarica | 2 | 1785-8860 | 0,245 | 0,828 |
| Research Journal of Applied Sciences | 1 | 1815-932X | 0,237 | 0,259 |
| EMJ—Engineering Management Journal | 1 | 1042-9247 | 0,232 | 0,369 |
| International Journal of Continuing Engineering Education and Life-Long Learning | 6 | 1560-4624 | 0,220 | 0,529 |
| Business: Theory and Practice | 2 | 1648-0627 | 0,211 | 0,423 |
| Dyna (S pain) | 1 | 0012-7361 | 0,207 | 0,208 |
| Metalurgia International | 2 | 1582-2214 | 0,206 | 0,327 |
| Journal of Electrical and Electronics Engineering | 1 | 1844-6035 | 0,204 | 0,229 |
| World Transactions on Engineering and Technology Education | 3 | 1446-2257 | 0,189 | 0,096 |
| European Journal of Scientific Research | 5 | 1450-202X | 0,150 | 0,699 |
| International Journal of Construction Management | 1 | 1562-3599 | 0,136 | 0,131 |
| Jurnal Teknologi (Sciences and Engineering) | 1 | 0127-9696 | 0,132 | 0,137 |
| Periodica Polytechnica, Social and Management Sciences | 1 | 1416-3837 | 0,131 | 0,817 |
| World Academy of Science, Engineering and Technology | 2 | 2010-376X | 0,125 | 0,252 |
| Technics Technologies Education Management | 2 | 1840-1503 | 0,123 | 0,320 |
| Journal of Information Systems Education | 1 | 1055-3096 | 0,105 | 0,044 |

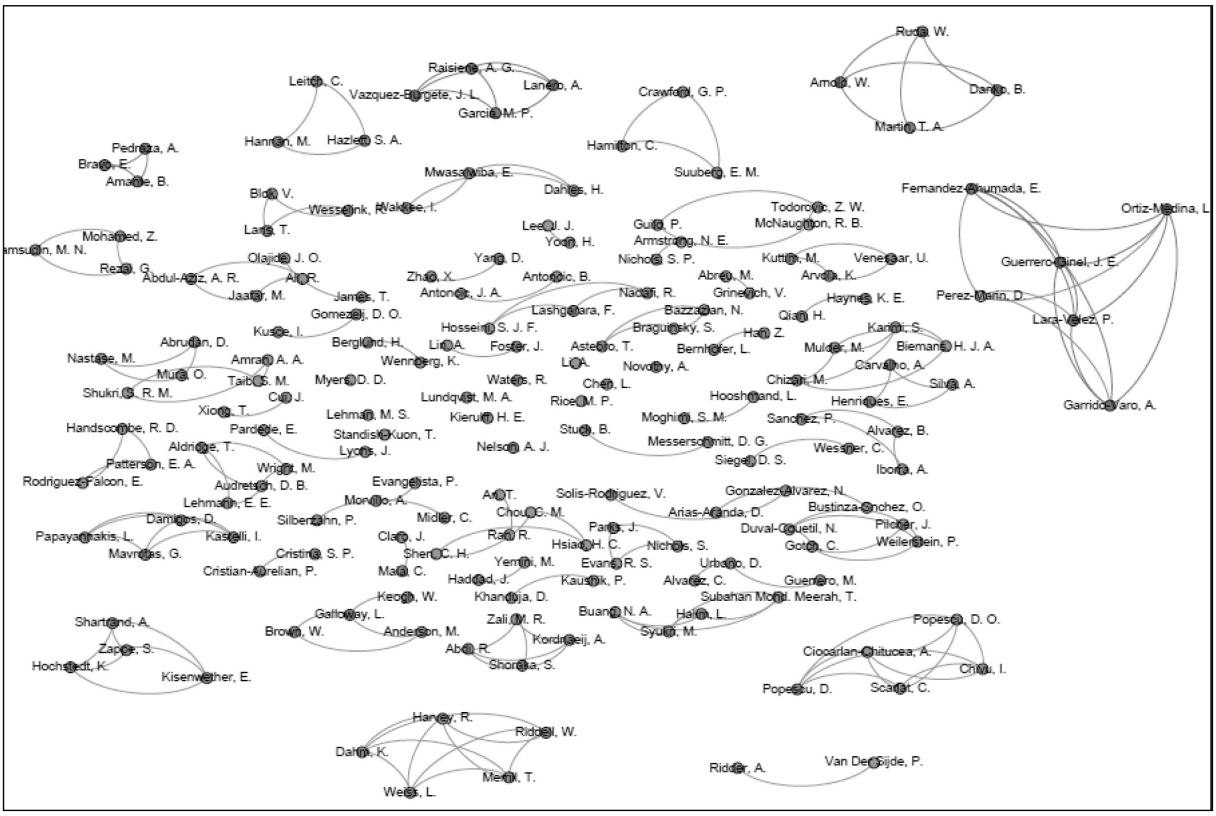


**Fig. 4.** Relations among researchers—Network Graph.

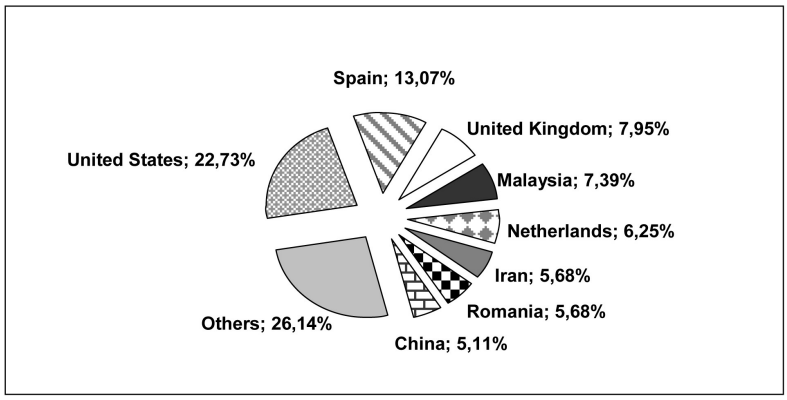


**Fig. 5.** Distribution of authors by Country Affiliation

### *4.4 Identifying the largest production cycles (Chronology of production)*

In order to enable the observation of the evolution of scientific production in Entrepreneurship, quantitative data on the distribution records of published articles is consolidated in Fig. 6, grouped by year of publication.

The scatter plot (Fig. 7) shows the number of citations of published papers, seeking to indicate, in terms of citations, the most relevant publications; moreover, it is possible to identify that the works with the largest number of citations were published in 2002, 2009, 2011 and 2012.

## 5. Selection of references for the composition of starting core (Sc)

Based on *Webibliomining* model, the following rules were adapted to the present work.

### *5.1 Selecting 10% of older articles from different authors*

The purpose of this rule is to identify different lines of thinking in the initial discussions; uncovering the requirement: identification of the first authors to write about the subject. Applying this rule, the following results were obtained: [22, 40, 45–49].

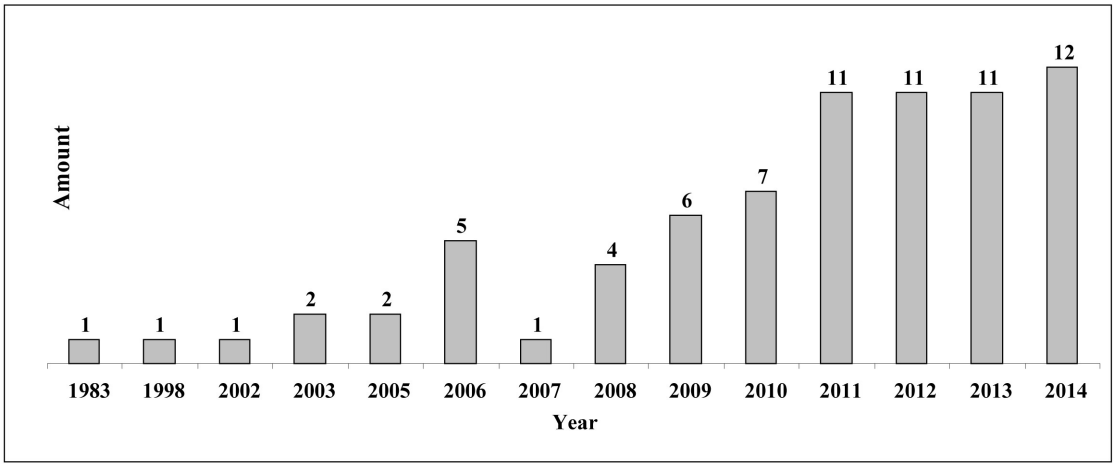


**Fig. 6.** Distribution of papers by year.

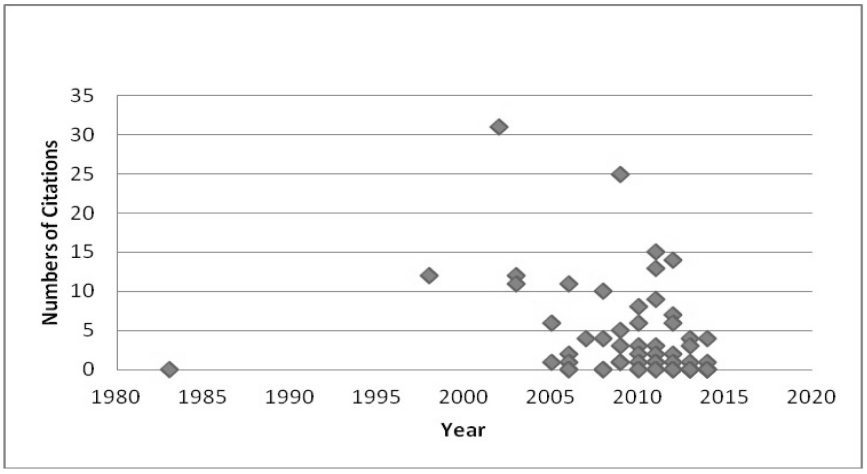


**Fig. 7.** Scatter plot—numbers of citations by year.

### *5.2 Selecting 15% of newer articles from different authors*

The purpose of this rule is to cover different trends in the most recent discussions; uncovering the requirement: identification of the latter authors to write on the subject. The percentage value assigned to the newer works tries to ensure a greater emphasis on them. As a result of the application of this rule, the following works were obtained: [1, 3, 7, 18, 21, 26, 28, 34, 50–52].

### *5.3 Selecting 15% of articles with highest citations*

The purpose of this rule is to select articles with highest number of citations. Applying this rule, the following results were obtained: [33, 36, 40, 45–46, 49, 53–57].

### *5.4 Merging the rules*

The *Starting Core* with 25 articles is obtained by merging the three previous rules: [1, 3, 7, 18, 21–22, 26, 28, 33–34, 36, 40, 45–57].

## 6. Conclusion

Entrepreneurship plays an increasingly important role in knowledge-based economic development. Previous works on the topic consider that discovering entrepreneurial opportunities constitutes an important entrepreneurial skill, a source of competitive advantage and an important content area in entrepreneurship education in engineering.

Based on the reviewed literature with a *Webibliomining* model, this study provides an initial and useful core of references that includes old and new articles, and the ones with the highest number of citations on Entrepreneurship Education in engineering. The boundaries established in *Webibliomining* model (percentage) are flexible and can be adapted in accordance with the sample.

The definition of the starting core is presented as a fast and useful tool, for future works, to reveal ideas or criteria to be used in a building process of a model that can be able to evaluate the influence of entrepreneurship education in engineering courses.

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**Glauco Barbosa da Silva**, B.Sc. in Eletronics Engineering at Brazilian Naval College; MBA Information Systems at Universidade Federal de Lavras(UFLA); M.Sc. in Operations Research at Universidade Federal do Rio de Janeiro(COPPE-UFRJ); MBA in Software Project Management at Pontiícia Universidade Católica do Rio de Janeiro (PUC-Rio). Currently, He is a Doctoral student in Decision Support Systems at Universidade Federal Fluminense (UFF), Brazil. His research interest areas include Multicriteria Decision Aid, Data Mining, Software Engineering and Entrepreneurship Education.

**Helder Gomes Costa**, Senior Professor at the Fluminense Federal University (UFF) in Brazil. He received his PhD degree in mechanical engineering from PUC-Rio. His research interests include Decision Analysis, Multi Criteria Decision Aid, Organizational Performance, Entrepreneurship Education, Sustainability and Production Planning and Control.

**Marta Duarte de Barros**, Doctoral student in Decision Support Systems at Federal Fluminense University (UFF), Brazil. Her research interests include Decision Analysis, Multi Criteria Aid, Sustainability, Entrepreneurship and Entrepreneurship Education.