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# A REVIEW OF THE IGLC CONFERENCE´S MAIN TOPICS

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**ABSTRACT**

On 1990´s, the Toyota Production System (TPS) started a new era for world industry, when releases the concept of Lean Thinking, transposed for construction by Lauri Koskela (1992) with eleven principles. In a scenario of floating demand, this concept is related to productivity, combining philosophy, system and tools. The Lean Thinking overcome Ford´s mass production system providing few amounts of pieces, requiring less space, resources and inventory of raw material on productive process. In this context, International Group for Lean Construction (IGLC) is the best and more respectful congress of lean construction, that disclose papers, in different approaches. Besides the subject importance, it was not founded a comprehensive bibliometric study of all IGLC´s papers, since the first edition. So, the objective of this paper is to identify the main topics, the main countries and the most important authors of IGLC Conferences. This work uses bibliometric technics on the 1.557 IGLC papers, from 1996 to 2018, highlighting authors, country and key words. The data bibliometric treatment is presented by descriptive statistics, obtained with Microsoft Excel tables and graphics illustrated and quantitative and qualitative analysis. As a main result, it created a tag cloud, identifying the most relevant topics of lean construction research.



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## INTRODUCTION

Lean construction is a construction management philosophy that is growing in North America countries and England, that optimize, confers quality, reduction of waste and consumer's satisfaction (BLAMPIED; TOMMELEIN, 2016). Lean construction´s researchers appear for the academic world in International Group for Lean Construction (IGLC), with its conferences. Since 1996, important research fields and papers are released on IGLC for scientific community. Nowadays, is serves as a reference, directing post-graduation studies and bringing news in each edition. In this terms, IGLC works like an important radar for current lean construction studies. However, in 23 years of conference achievement and with 1.557 papers published, there is no way to know which the trends of lean construction topics or approaches are.

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So, in these way, researchers can study obsolete topics, that moves the research away of the lean principles. In this question lies the problem of this study: What are the main themes focused, from 2014 to 2018, with the main countries and authors who stand out in the IGLC? This subject has academic, scientific and educational relevance. The paper´s objective is identifying the main topics of IGLC researches, from 2014 to 2018, determining the authors, its countries and key words. It uses the bibliographic method, an historical and bibliometric researches, of 23 editions.

## MATERIALS AND METHODS

This paper intends to make a bibliometric analysis of 23 years of IGLC publications. Defined as research technic, its goal is analyzing size, growing and bibliographic distribution of knowledge field (PILKINGTON; MEREDITH, 2009). The bibliometric analysis has extensive applications in several

areas and aims to broaden research performance and evaluate its trends, determining characteristics of publications, such as authorship, sources of research, themes, geographic origin, among others (SMALL, 2003). It was made a survey of the papers from 1996 to 2018, removing all the information that could have relevance to the search: name of the authors; keywords; title, city and country of the conference; and year. After the process of capturing the information, the research shows 1,557 papers. From these, a filter was applied based on the number of publications per author, where it was evidenced that the 39 authors with more publications as author or co-author represent a total 1,268 papers or 80% of all who were published (Figure 1). The data were obtained manually by a research group, which performed the following steps to collect the information, are these: entry in the IGLC site, selection of the article, article download, a superficial reading of the relevant information and the inclusion in a worksheet in Excel. The group was separated into two teams, one worked with the classification, separation and quantification of the frequency of publications of each author and the second team worked with the number of repetitions of the keywords. The research strategy followed table 1: After measurement, the process of treatment of the data collected was given in single or diversified function applications. The transformation of complex analysis tables into easy-to-understand visual information, such as: graphs, figures and quantitative data is made. For this, the following programs were used: Excel, Word, Power BI and Word Art.

## RESULTS

Considering the authors who had their papers published in the IGLC, it has been that of the 1,557 papers presented in the period, 39 authors, individually or combined, appear in 1,268 papers, corresponding to 81.43%. This percentage points to a sufficient number of authors for conclusions, taking into account the 20-80 disposition of Pareto (MOORE, 2011). Of these 39 authors, Koskela led in the author versus article ranking, appearing in 116 of them. It has its name as an author in 7.45% of the published papers, followed by Ballard, with 6.80% and Tommelein with 5.45%. The first has operations in England, and the two others in the United States. In this ranking Brazil is represented by Formoso who, appearing in 83 papers published in the period, is author in 5.33% of the total papers. These four authors represent 25% of the published papers together and, with 10 more authors (Alarcón, from Chile; Tzortzopoulos Fazenda, from Brazil, Howell, from the United States, Alves, from Brazil, Pasquire, from England, Hamzeh, from Lebanon, Barros Neto, from Brazil, Seppänen, from Finland, Lædre, from Norway, and Sacks from Israel), make up a representativeness of 51.18% of the papers. They add together 797 studies. Table 1 shows the distribution of 39 authors who make up 81.43% (1,268) of the 1,557 papers published in the IGLC (1996-2018), highlighting as group 1, for this study, the 14 authors represent 51.19% of these papers, and as group 2 the other 25 authors who add up to 30.25 %. It is observed that in Group 1 the United States, Brazil and England represent mostpapers published (75%), with emphasis on the United States followed by Brazil. This reinforces that in England publications are prevalent on an author (Koskela), and that despite having the highest percentage production (7.48%) Of the 1268 papers focused on, in the United States and Brazil, research on the subject is more widespread, with more authors (Figure 2). In relation to group 2, Brazil and Norway are highlighted in relation to the number of authors on Lean Construction. These are followed by the United States, Germany and England, reinforcing the fact that in England the relevant production on the subject is Lauri Koskela and few authors dedicate themselves to the subject.

| Step | Descriptive | Result |
|---|---|---|
| 1 | Identification and processing of data from the 23 IGLC editions | Spreadsheet with 1557 papers, containing by authors columns, keyword, abstract. |
| 2 | Identification of 40% of the authors who wrote 80% of the papers | 39 authors are responsible for 80% of publications |
| 3 | For the 39 authors, a correlation was made involving the number of papers written accumulated (accumulated freq.) and then two groups were generated. | Group 1-14 authors who most wrote in the IGLC (1996-2018), comprising 51.19% of the 1268 papers that contemned Pareto<br>Group 2-25 authors who wrote in the IGLC (1996-2018), totaling 30.25% of the 81.43% of the total of the papers published at the time in analysis. |
| 4 | Analysis of groups 1 and 2, simultaneously, for the identification of the most relevant countries in relation to the highlighted number of published papers, and the quantity of researchers producing research in Lean's sprain. | It was identified that Brazil and the United States stand out as countries of relevant and important researches published in the IGLC. |
| 5 | Analysis of the number of publications of the 9 Brazilian authors and of the 7 American authors, who are within the 39 authors who contemplate Pareto, in order to identify whether they produced more in the years that the IGLC was in their country or not. | Brazilian and American authors produce significantly over the years, within the studied in the IGLC, not only stimulated by an event in their country.<br>The research line of these authors can be considered the most relevant for conclusions. |
| 6 | Analysis, among the 16 Brazilian and American authors, attending the prevalence, which were responsible for most of the publications in the last 5 years. | The study identified the authors Glenn Ballard (USA), PatríciaTzortzopoulosFazenda (Brazil), Iris D. Tommelein (USA), Carlos Torres Formoso (Brazil) |
| 7 | The key words used by the 4 authors identified in step 6 were identified. | Number of Words / frequency<br>1 / 12<br>1 / 9<br>2 / 8<br>1 / 7<br>3 / 6<br>2 / 5<br>5 / 4<br>11 / 3<br>39 / 2<br>185 / 1 |
| 8 | Prevalence analysis of the keywords identified in step 7, except for the word that has a simple frequency equal to 1 | 16 words, which represent 51.10% of the accumulated frequencies. (Problem response) |

**Figure 1. Research strategy**

Brazil again stood out, which denotes that, besides having three authors (Carlos Formoso, Thais Alves and Barros Neto) who dedicate themselves to writing quantity on the subject and led Brazil to prominence in Group 1, also presents five authors who, containing from 15 to 24 Publications each in the IGLC from 1996 to 2018, lead Brazil to prominence in group 2. From the results of Brazil, we note a global highlight, on other countries and in the IGLC, about the number of researches presented (Figure 3). Also, with regard to group 2, United States maintains a prominent position among the three best quantities of papers published by the group, which in a global ranking of research on Lean, measured by the IGLC, it stands and position superior to England and Paired with Brazil.

Norway shows that it has actors acting and that are publishing in the IGLC, in a relationship of more authors without highlighting the number of publications per author, as in Group 1. Germany emerges as a highlight in group 2, even without appearing in Group 1, which may denote to be a new line of research in the country that is instigating authors to research and publish in this direction "Lean". and Finland, and Chile do not show up as potential in research on Lean. By the percentage ratios in figure 2 and 3, a global representativeness analysis of the countries is highlighted in these graphs for the induction of Lean research ranking. It is considered by country to highlight the percentage product indicating the presence in an "E" chart in the other, with the result as shown in Table 2.

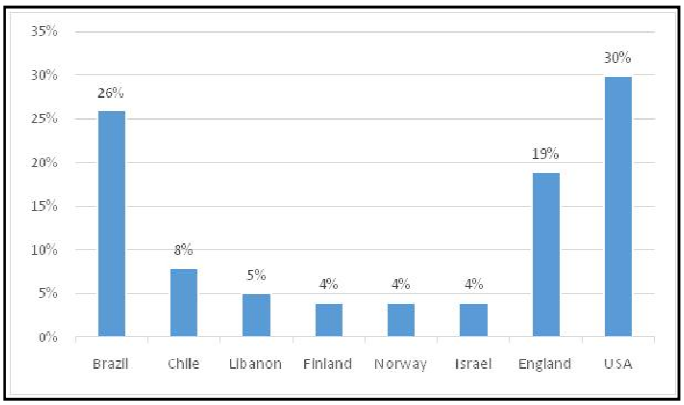


**Figure 2. Percentage representation countries versus publication – Group 1**

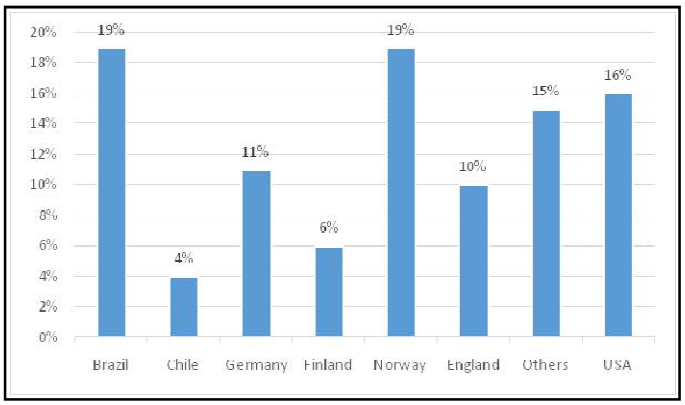


**Figure 3. Percentage representation countries versus publication – Group 2**

**Table 1. Authors, Countries and Frequencies that add Up 81.43% of the total articles of the 23 editions**

| | Authors | Acting | Freq. | % | Acum. Freq. | % Acum. |
|---|---|---|---|---|---|---|
| GROUP 1 | LauriKoskela | ENGLAND | 116 | 7,45 | 116 | 7,45 |
| | Glenn Ballard | USA | 106 | 6,81 | 222 | 14,26 |
| | Iris D. Tommelein | USA | 85 | 5,46 | 307 | 19,72 |
| | Carlos Torres Formoso | BRAZIL | 83 | 5,33 | 390 | 25,05 |
| | Luis Fernando Alarcón | CHILE | 65 | 4,17 | 455 | 29,22 |
| | PatriciaTzortzopoulos Fazenda | BRAZIL | 54 | 3,47 | 509 | 32,69 |
| | Gregory A. Howell | USA | 52 | 3,34 | 561 | 36,03 |
| | Thais da C. L. Alves | BRAZIL | 39 | 2,50 | 600 | 38,54 |
| | Christine L. Pasquire | ENGLAND | 38 | 2,44 | 638 | 40,98 |
| | Farook R. Hamzeh | LIBANON | 37 | 2,38 | 675 | 43,35 |
| | José de Paula Barros Neto | BRAZIL | 33 | 2,12 | 708 | 45,47 |
| | OlliSeppänen | FINLAND | 31 | 1,99 | 739 | 47,46 |
| | OlaLædre | NORWAY | 29 | 1,86 | 768 | 49,33 |
| | Rafael Sacks | ISRAEL | 29 | 1,86 | 797 | **51,19** |
| GROUP 2 | Vicente A. González | N. ZELAND | 28 | 1,80 | 825 | 52,99 |
| | John A. Rooke | ENGLAND | 24 | 1,54 | 849 | 54,53 |
| | Luiz Fernando MählmannHeineck | BRAZIL | 24 | 1,54 | 873 | 56,07 |
| | Tariq SamiAbdelhamid | EGYPT | 24 | 1,54 | 897 | 57,61 |
| | Bo TerjeKalsaas | NORWAY | 23 | 1,48 | 920 | 59,09 |
| | Fritz Gehbauer | GERMANY | 23 | 1,48 | 943 | 60,57 |
| | Mike Kagioglou | ENGLAND | 22 | 1,41 | 965 | 61,98 |
| | JardarLohne | NORWAY | 21 | 1,35 | 986 | 63,33 |
| | SvenBertelsen | DENMARK | 21 | 1,35 | 1007 | 64,68 |
| | Yong-Woo Kim | USA | 21 | 1,35 | 1028 | 66,02 |
| | Zofia K. Rybkowski | USA | 21 | 1,35 | 1049 | 67,37 |
| | Paz Arroyo | CHILE | 18 | 1,16 | 1067 | 68,53 |
| | ShervinHaghsheno | GERMANY | 17 | 1,09 | 1084 | 69,62 |
| | Dayana Bastos Costa | BRAZIL | 17 | 1,09 | 1101 | 70,71 |
| | Patricia André Tillmann | BRAZIL | 17 | 1,09 | 1118 | 71,80 |
| | Ariovaldo Denis Granja | BRAZIL | 16 | 1,03 | 1134 | 72,83 |
| | Bhargav A. Dave | FINLAND | 16 | 1,03 | 1150 | 73,86 |
| | Cynthia C. Y. Tsao | USA | 16 | 1,03 | 1166 | 74,89 |
| | TrondBølviken | NORWAY | 16 | 1,03 | 1182 | 75,92 |
| | Flávio Augusto Picchi | BRAZIL | 15 | 0,96 | 1197 | 76,88 |
| | Fredrik Svalestuen | NORWAY | 15 | 0,96 | 1212 | 77,84 |
| | KristenParrish | USA | 15 | 0,96 | 1227 | 78,81 |
| | Ergo Pikas | FINLAND | 14 | 0,90 | 1241 | 79,70 |
| | Janosch Dlouhy | GERMANY | 14 | 0,90 | 1255 | 80,60 |
| | Frode Drevland | NORWAY | 13 | 0,83 | 1268 | 81,44 |

Table 2 shows that Brazil is having the greatest representation in both groups, followed by the United States. From the results, it is inferred that there should be lines of research in this regard, since by quantity of papers published by author, and by number of authors writing on the topic, table 1 is assembled. Table 3 shows whether the performance of Brazil and the United States, identified in Table 4, is directly related to the production of papers due to the IGLC event being or not in the country. It is considered that in Brazil the IGLC winds were in Guarujá 1998, in Gramado 2002 in Fortaleza 2013. And that in the USA were in Berkeley in 1999, Virginia in 2003, East Lansing in 2007, San Diego in 2012 and Boston in 2016. As observed in table 3, and since the authors of Brazil and the United States published more in the IGLC when the congress was in other countries than in their own country, it reinforces the idea that these authors are active and maintain a constancy of studies about the subject. It is noticed that they remain updated and present in IGLC, according to table 4, thus being a good indication of trends and study on Lean Construction at the present time. For a better quality of the results of the study trends on Lean Construction, on IGLC and at the present time, Table 4 and 5 are generated.

From this, it is identified that the two American Ballard and Tommelein and Tzortzopoulos and Formoso, generate the majority of the studies on Lean Construction, published in the IGLC, in last 5 years. Thus, according to the content on the Table 5 the key words from these four authors and the years from 2014 to 2018 are analyzed to arrive at the trends of studies on Lean Construction, verified by the analysis of the 23 editions of IGLC.

Table 6 presents the compiled result of these words, by number of incidents. It shows that 19 of the 65 tabulated words, already excluded those of frequency 1, add a cumulative frequency of incidences equal to 51.23%. There is the cloud of more relevant words used by the four authors with the highest overall frequency, of publications in the IGLC and in the last 5 years, these 19 words being the main result of the research. The most relevant study topics on Lean Construction nowadays, according to IGLC study (2014-2018), are in this table. The Figure 4 contains these words, in the form of a tag cloud, highlighted by relevance and being the answer to the research problem. It is noteworthy that lean construction has been more approached in visual management and BIM, being widely considered its relation with other denominations.

**Table 2. Percentage analysis of countries highlight in the intersetion group 1 and group 2**

| Country | Group 1 (a) | Group 2 (b) | (%) (a)*(b) |
|---|---|---|---|
| Brazil | 0,26 | 0,19 | 4,94 |
| USA | 0,3 | 0,15 | 4,5 |
| England | 0,19 | 0,1 | 1,9 |
| Norway | 0,04 | 0,19 | 0,76 |
| Chile | 0,08 | 0,04 | 0,32 |
| Finland | 0,04 | 0,06 | 0,24 |

**Table 3. Publications of authors of Brazil and usa regarding IGLC had been done in your country or others**

| Author | Country | Tot. Art. | Art. In | Art. Other countries | Art.last5years |
|---|---|---|---|---|---|
| Carlos Torres Formoso | BRAZIL | 83 | 14 | 69 | 19 |
| Patrícia Tzortzopoulos Fazenda | BRAZIL | 54 | 7 | 47 | 25 |
| Thais da C. L. Alves | BRAZIL | 39 | 3 | 36 | 13 |
| José de Paula Barros Neto | BRAZIL | 33 | 4 | 29 | 12 |
| Luiz Fernando MählmannHeineck | BRAZIL | 24 | 3 | 21 | 6 |
| Dayana Bastos Costa | BRAZIL | 17 | 0 | 17 | 13 |
| Patrícia André Tillmann | BRAZIL | 17 | 1 | 16 | 10 |
| Ariovaldo Denis Granja | BRAZIL | 16 | 3 | 13 | 3 |
| Flávio Augusto Picchi | BRAZIL | 15 | 1 | 14 | 1 |
| | | **298** | **36** | **262** | **102** |
| Glenn Ballard | USA | 106 | 20 | 86 | 26 |
| Iris D. Tommelein | USA | 85 | 15 | 70 | 23 |
| Gregory A. Howell | USA | 52 | 18 | 34 | 5 |
| Yong-Woo Kim | USA | 21 | 11 | 10 | 3 |
| Zofia K. Rybkowski | USA | 21 | 7 | 14 | 10 |
| Cynthia C. Y. Tsao | USA | 16 | 4 | 12 | 7 |
| KristenParrish | USA | 15 | 4 | 11 | 7 |
| | | **316** | **79** | **237** | **81** |

**Table 4. Brazil and us authors, highlighted by number of publications, from 2014 TO 2018**

| Author | Country | Tot. Art. | Art. In coutrny | Art. Othercuntries | Aut. Last 5 years | | |
|---|---|---|---|---|---|---|---|
| Glenn Ballard | USA | 106 | 20 | 86 | 26 | | |
| PatríciaTzortzopoulos Fazenda | BRAZIL | 54 | 7 | 47 | 25 | | |
| Iris D. Tommelein | USA | 85 | 15 | 70 | 23 | | |
| Carlos Torres Formoso | BRAZIL | 83 | 14 | 69 | 19 | 93 | 50,82% |
| Thais da C. L. Alves | BRAZIL | 39 | 3 | 36 | 13 | | |
| Dayana Bastos Costa | BRAZIL | 17 | 0 | 17 | 13 | | |
| José de Paula Barros Neto | BRAZIL | 33 | 4 | 29 | 12 | | |
| Patrícia André Tillmann | BRAZIL | 17 | 1 | 16 | 10 | | |
| Zofia K. Rybkowski | USA | 21 | 7 | 14 | 10 | | |
| Cynthia C. Y. Tsao | USA | 16 | 4 | 12 | 7 | | |
| KristenParrish | USA | 15 | 4 | 11 | 7 | | |
| Luiz Fernando MählmannHeineck | BRAZIL | 24 | 3 | 21 | 6 | | |
| Gregory A. Howell | USA | 52 | 18 | 34 | 5 | | |
| Ariovaldo Denis Granja | BRAZIL | 16 | 3 | 13 | 3 | | |
| Yong-Woo Kim | USA | 21 | 11 | 10 | 3 | | |
| Flávio Augusto Picchi | BRAZIL | 15 | 1 | 14 | 1 | 90 | 49,18% |

**Table 5. Key words of the four most relevant authors (Two of brazil and two of the usa) in the last five years of IGLC (2014 to 2018)**

| Number of words | frequency |
|---|---|
| 1 | 12 |
| 1 | 9 |
| 2 | 8 |
| 1 | 7 |
| 3 | 6 |
| 2 | 5 |
| 5 | 4 |
| 11 | 3 |
| 39 | 2 |
| 185 | 1 |

**Table 6. Most of keywords quoted by the four prevalents authors in Table 4**

| Key word | Freq. | Accum. Freq. | % accumulated |
|---|---|---|---|
| Visual management | 12 | 12 | 5,91 |
| Target value design | 9 | 21 | 10,34 |
| BIM | 8 | 29 | 14,29 |
| Choosing by advantages | 8 | 37 | 18,23 |
| Production planning and control | 7 | 44 | 21,67 |
| Integratedproject delivery | 6 | 50 | 24,63 |
| Design management | 6 | 56 | 27,59 |
| Takt-time planning | 6 | 62 | 30,54 |
| Target costing | 5 | 67 | 33,00 |
| Collaboration | 5 | 72 | 35,47 |
| Value | 4 | 76 | 37,44 |
| Sharedunderstanding | 4 | 80 | 39,41 |
| Production system design | 4 | 84 | 41,38 |
| Lastplanner system | 4 | 88 | 43,35 |
| Decision-making | 4 | 92 | 45,32 |
| Workstructuring | 3 | 95 | 46,80 |
| Transparency | 3 | 98 | 48,28 |
| Sustainability | 3 | 101 | 49,75 |
| Production control | 3 | 104 | 51,23 |


**Figure 4. Cloud of tags / subjects main result of research**

**Final considerations**

Throughout the presented, it was noticed that Brazil and the United States are prominent countries next to publications in the IGLC. This prominence is given in relation to the number of publications per author as well as author number representatives of these.

The most relevant authors of each of these countries were identified, according to the methodology used and the bibliometric study, in order to discretize, by frequency and cumulative frequency, the most relevant key words. Nineteen words reached the majority in the accumulated frequency (51.23%), these being the fulfilment of the general objective launched (cloud of words presented in Figure 1). This study did not exhaust the subject, attending to the analytical explanatory objective without, however, analysing correlations of the key words among themselves. As a suggestion for future research, it is indicated that other researchers depart from the words in the cloud of the main themes treated in the IGLC on last 5 years and then correlate dependencies between them using statistical treatments. From there, the results of these new researches identify, as a collaboration for science, the biases already treated and those that could be treated, by correlation, about the result of this research.

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