RESEARCH TRENDS IN GREEN BUILDINGS AND BUILDING INFORMANTION MODELING

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RESUMO:
A conexão entre Green Building e Building Information Modeling (BIM) tem sido apontada como uma das formas para se fomentar a sustentabilidade na construção civil. No entanto, as pesquisas sobre a integração entre Green Building e BIM ainda estão em estágios iniciais e muitos profissionais não utilizam o BIM para desenvolver projetos de edificações verdes. Este artigo investiga as tendências nas pesquisas sobre Green Building e Building Information Modeling. Baseado na análise de registros bibliográficos recuperados do banco de dados da Web of Science, avalia o crescimento do número de publicações, os principais países de origem, periódicos e áreas de conhecimento, os artigos mais influentes e os tópicos mais frequentes. Este estudo fornece um ponto de partida para acadêmicos e profissionais que planejam usar o BIM para desenvolver projetos de edificações verdes.

PALAVRAS-CHAVES: Green Building, Building Information Modeling, Tendências de pesquisa.

ABSTRACT:
The connection between Green Building and Building Information Modeling has been identified as one of the ways to promote sustainability in civil construction. However, Green Building and Building Information Modeling integration research are still in nascent stages and many professionals still do not use BIM to develop Green Building projects. This article investigates research trends in Green Building and Building Information Modeling. Based on analysis of bibliographic records retrieved from the Web of Science database, it evaluates the growth in the number of publications, the main countries of origin, journals and areas of knowledge, the most influential article and the most frequent topics. This study provides a starting point for academics and practitioners who to plan to use BIM for Green Building projects.

KEYWORDS: Green Building, Building Information Modeling, Research trends.

INTRODUCTION

Green Building theme has attracted the attention of civil construction professionals (UDOMSAP, 2020; AHMAD, AIBINU and STEPHAN, 2019; WUNI, 2019). Green Buildings consume less resources than conventional buildings (RAMESHWA, 2020; ZHAO, 2019) and offer users better comfort conditions (GENG et al., 2019). Despite being an important measure to deal with energy and environment problems in the construction sector, the Green Buildings adoption is still a challenge. Green Buildings could be more expensive than conventional buildings (CHEGUT, EICHHOLTZ and KOK, 2019) and there is a lack government incentive (PHAM, KIM and LUU, 2020), regulations (AZEEM, NAEEM and WAHEE, 2020) and, especially, integrated tools to consider multiple Green Building aspects (CHANG and HSIEH, 2020).
Recent studies suggest that Building Information Modeling (BIM) is critical in advancing Green Building design (CHANG and HSIEH, 2020; ANSAH, 2019). As source of information generated and maintained throughout the building life cycle (SARAIREH, MOH'D and HARON, 2020), BIM allows for the integrated development of projects (for example, gain solar, ventilation, and energy), which can facilitate the practice of more sustainable buildings (ZICHI et al., 2020; EBRAHIM and WAYAL, 2019). However, Green Building and BIM integration research are still in nascent stages (AHSAH, 2019; ISMAIL, 2019; LU et al., 2017) and many professionals do not use BIM to develop projects (FGV, 2018).

1. PURPOSE

To investigate the trends in Green Building and Building Information Modeling research.

2. METHODS

Data source and search strategy

The Web of Science (WoS) database was consulted on April 21, 2020 to retrieve bibliometric records of documents related to Green Building and Building Information Modeling. The search expression ((("Green building*")OR("Sustainable building*"))AND((BIM)OR("Building Information Management")OR("Building Information Model*")))OR("Green BIM") was applied to gather all the publications with those terms in their titles, abstracts, or keywords. These search terms were used in systematic literature reviews on Green Building (UDOMSAP and HALLINGER, 2020; ZHAO et al., 2019; WUNI, SHEN and OSEI-KYEI, 2019; DARKO, ZHANG and CHAN, 2017; OLAWUMI, CHAN and WONG, 2017)) and Building Information Modelling (ZHAO, 2019; He et al. 2017; Li et al., 2017; OLAWUMI, CHAN and WONG, 2017). Were retrieved the articles published from 1990, year that the concept of Green Building arose (ZUO and ZHAO, 2014), until 2019.

Data analysis

To identify the research trends on Green Building and Building Information Modeling were used the co-word analysis method, which is the only approach to construct a similarity measure using the actual content of documents (NÁJERA-SÁNCHEZ, 2020). Other methods (based on citations or co-authorships, for example) identify indirect relationships between documents (ZUPIC and ČATER, 2015). As Xu et al. (2020), Özdağoğlu et al. (2020) and Grzybowska e Awasthi (2020), were analysis of keywords used by the authors. Keywords are used to express the theme of the academic documents, and the clustering analysis of these co-occurrence keywords can reveal the knowledge structure and hotspots in this research field (SHI and MIAO, 2019).

Using VOSviewer software (www.vosviewer.com) were produced keywords map, in which strongly related terms are located close to each other and the weaker the relationship is between terms, the bigger the distance is between them. Thus, keywords maps provide overviews for identifying the structure of a topic (VAN ECK and WALTMAN, 2010). Each keyword was represented by a rectangle, where the size of its label indicates the number of publications, where the term appears in keywords. The keywords that often co-occur are strongly related to each other and are assigned automatically to the same cluster. On the contrary, keywords with a low co-occurrence or no-occurrences at all, are assigned to different clusters. Therefore, a cluster that is made up of keywords of the same colors represents a research theme in which one or more research topics can be identified.

3. RESULTS

Were identified 124 articles in Green Building and Building Information Modeling research. In last years the number of publications has grown exponentially (Figure 1a). Construction Building Technology was the most common subject area (Figure 1b). USA was the country with the largest number of publications, but recently Malaysia and Brazil have stood out (Figure 1c). The Automation in Construction journal (impact factor 2018 equal 4.313) was the most productive source, however lately the periodic Architectural Engineering and Design Management (impact factor 2018 equal 2.130) has published more articles on the theme. Azhar et al. (2011) was the pioneer and most cited publication (Figure 1e). They demonstrated the use of BIM for sustainable design and the Leadership in Energy & Environmental Design (LEED®) certification process.

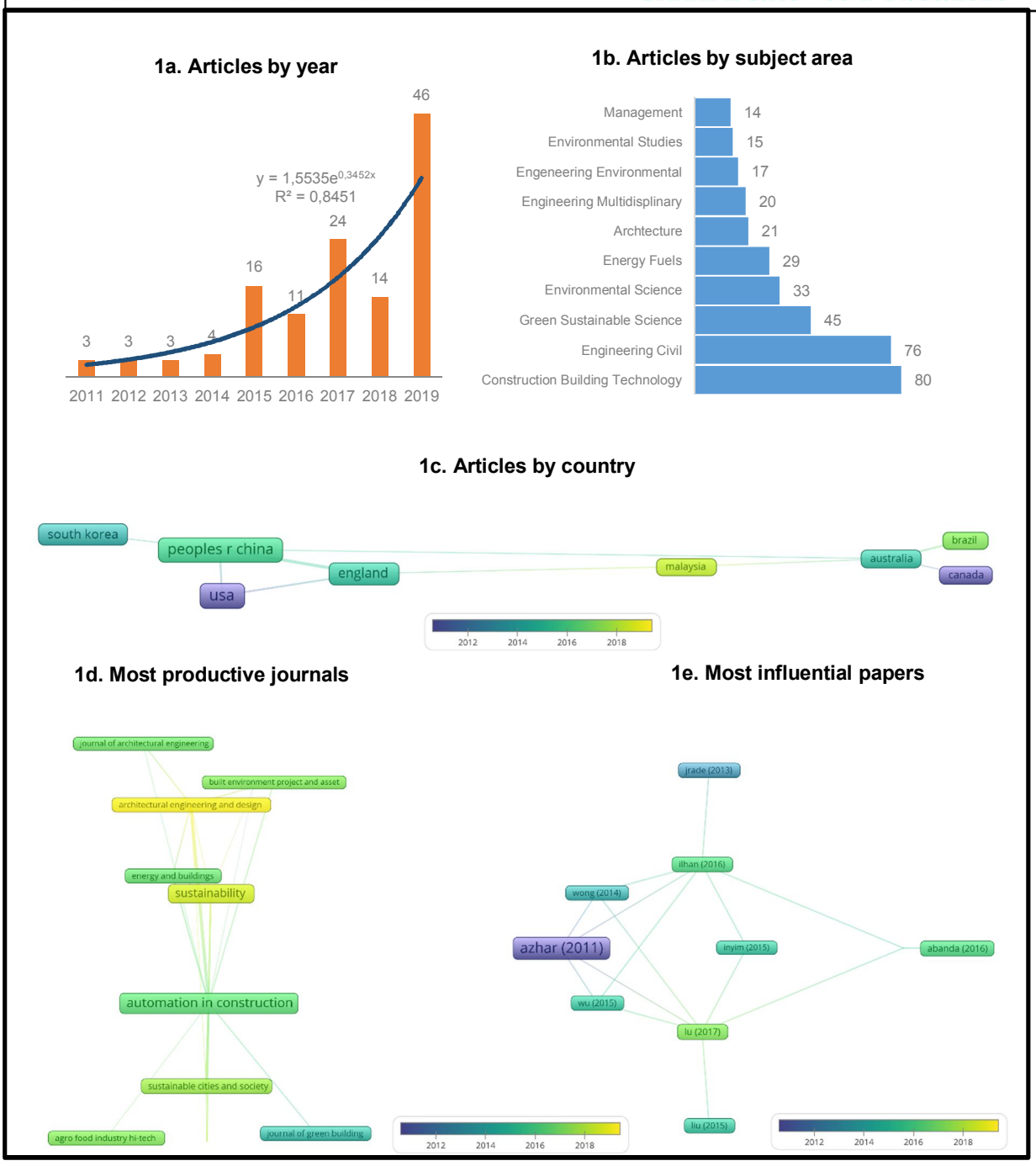

Figure 1: Dashboard in Green Building and Building Information Modeling research publications
Notes: Only countries that published at least five articles (1c), journals that published at least three articles (1d) and articles that were cited at least thirty times were plotted (1e)

Of the 124 publications, 404 keywords were extracted. Prior to doing the analysis, the keywords were standardized in line with Choi et al. (2011). Were used a unique keyword, e.g., building and buildings. Abbreviations were avoided. When both the original word and the abbreviated form(s) appeared in the keyword list, they were consolidated into the original word, e.g., Building Information Modeling, BIM. Synonyms were unified. When there were two or more synonyms in the list, they were exchanged for the most general keyword, e.g., the Sustainable Building and Green Building. After the refinement produced a database with 394 different terms. Figure 2 represent the co-word networks of 10 keywords, which appear at least five documents.

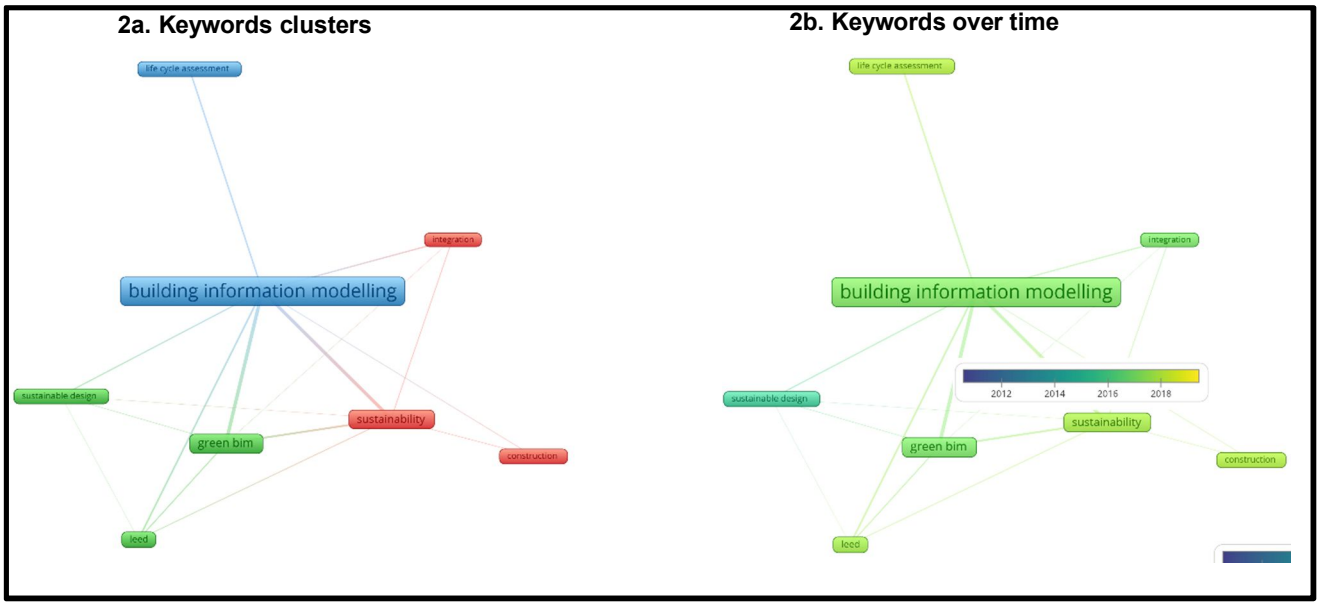

Figure 2: Co-occurrence network of keywords in publications on Green Building and Building Information Modeling

Analysis of the relationships between the most frequent keywords reveals three well-defined groups (Figure 2a). On the right, the red cluster seems to defend integration with BIM to promote the constructions sustainability. This is clearer in the green cluster, on the left. In line with Azhar et al. (2011), BIM is used for sustainable design and the LEED® certification process. LEED® is the most widely adopted sustainable building rating system in the United States and many other countries (PHAN et al., 2020). BIM facilitate meeting the requirements to obtain LEED certification because provides a framework to calculate the credits that building could potentially earn at the conceptual stage (KANG, 2020; JALAEI and JALAEI, 2020).

At the top, the blue cluster includes the emerging themes in Green Building and Building Information Modeling research (Figure 2b). Life Cycle Assessment (LCA) is globally recognized as one of the most complete methods for the environmental impact assessment of buildings (NAJJAR et al., 2019. BIM and LCA can to carried out in the early and detailed building design stages for calculate environmental impacts (REZAEI, BULLE and LESAGE, 2019). It helps determine the best building assembly options from an environmental perspective - a process that could guide building designers in the environmental assessments of their designs, making it possible to select more sustainable materials for each assembly and thus reduce the environmental impacts of the building. However, BIM and Life Cicle Assessment tools are currently not fully interoperable (SANTOS et al., 2020; JALAEI, ZOGHI and KHOSHAND, 2019).

4. CONCLUSIONS

This study showed that there is an increasing trend of Green Building and Building Information Modeling research in last year. USA had the leading position in global research in this field, but Malaysia and Brazil have stood out in last years. Despite the use of BIM for sustainable design and LEED are among the popular topics, as BIM and Life Cicle Assessment tools are currently not fully interoperable, this theme will be able to direct the research in the next few years. This study enriches the knowledge by presents a landscape in Green Building and Building Information Modeling research. Furthermore, informative to academics and practitioners who to plan to use BIM for Green Building projects.

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