**CHAPTER (F)**

**BIBLIOMETRIC ANALYSIS FOR REVIEWING PUBLISHED STUDIES IN THE BUILT ENVIRONMENT**

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**SUMMARY**

*Literature review is generally one of the key steps in conducting a scientific research. The overwhelming amount of literature may require significant effort to sort out, screen, and analyse before generating useful information and achieving research objectives in any scholarly work within a given domain. As the text-mining-featured analysis tools (e.g., VosViewer) become available for visualizing and analysing secondary data sources (e.g., literature), the bibliometric analysis is becoming one of the widely adopted methods in reviewing literature, especially for a large amount of secondary sources. In this chapter, bibliometric analysis is firstly defined. The rationale for adopting them when conducting literature review is described. The existing software tools for conducting the text-mining-based analysis (e.g., VosViewer, Gephi, etc.) are introduced. Using two cases in the subject of built environment, the detailed workflow of conducting the science mapping approach involving bibliometric analysis is also described. The network analysis using one of the bibliometric analysis tools (i.e., VosViewer) is showcased. Finally, the general guidance of conducting a bibliometric analysis is summarised, with recommendations provided and common mistakes described.*

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1. **Introduction**

Literature review is considered crucial in synthesising past research findings as well as in introducing new concepts, theories or paradigms. In any of these, the aim is to sustain a degree of professional judgement and expertise (Rousseau, 2012). Traditionally, the manual-based literature review has been widely adopted, primarily to unveil the trend of a given research domain. The manual review is usually based on a limited sample of literature. For example, the sample could be from influential or mainstream academic journals which further aid the researcher in buttressing their own point of view. A potential limitation of the manual review is its subjectivity as mentioned by Song et al. (2016) and Hosseini et al. (2018). The number of academic publications is on the increase of a phenomenon that is critical to determine any rapid paradigm shift within well-established models and bodies of theories. It is less feasible today to remain current given the breadth and depth of research knowledge and the ever expanding conduits to disseminate new findings through open-access (Aria and Cuccurullo, 2017). Therefore, bibliometric analysis is being widely adopted to assist the literature review process by offering a less subjective, more reliable, and time-saving approach to uncover the mainstream research keywords and other citation-related metrics within a defined research domain. For example, in a review-based study, bibiometric analysis can assist in achieving three general research questions, namely: (1) within a defined domain, what are the current mainstream topics? (2) what are the notable gaps or limitations from existing studies? and (3) what are the recommended or plausible areas dictating future research directions? Examples of adopting bibliometric analysis and which address the three research questions can be found in some existing literature within the built environment research domain, such as off-site construction (Jin et al., 2018), infrastructure management (Jiang et al., 2019), and sustainable transport (Zhao et al., 2020).

This chapter aims to introduce the methodology of conducting a review-based study utilising secondary data. The secondary data is derived from academic publications, including journal articles and conference proceedings. The concept of bibliometrics is firstly defined as well as the widely used database of literature (e.g., Scopus), followed by the commonly adopted bibliometric analysis tools such as *VOSViewer* (van Eck and Waltman, 2010). In describing the general workflow of the science mapping approach, the chapter also recommends an in-depth discussion beyond the bibliometric analysis by incorporating researchers’ own knowledge or expertise in the selected research domain. It is suggested that as an aid to synthesis of information, the bibliometric analysis enables researchers to pre-define research objectives, but should not be treated as the research aim. Principally, the bibliometric analysis is a tool to assist researchers to derive the answers to the research questions through unveiling mainstream keywords or topics within the pre-defined domain. Researchers are suggested to move a step forward from the network analysis of the citation data (e.g., keyword, document, etc.) by demystifying the selected research domain. Moving from general to the specifics, the chapter also includes two examples of how to conduct the science mapping approach to demonstrate the workflow of bibliometric analysis. The chapter also proffers the rationale of conducting bibliometric analysis, the fundamental steps to follow, including examples of how the bibliometric analysis may well assist in providing clarity to the definitions of the research objectives particularly in literature review-based studies. The two showcases that characterise this chapter can also be adopted for other research domains in the built environment and beyond.

1. **Definition of bibliometric analysis**

In many cases, bibliometrics may be interchangeably used with other terminologies such as scientometrics and informetrics, which share the same theories, methods, technologies, and application, but differ relative to subject specialisms (Yang and Yuan, 2017). Specifically, bibliometrics refers to an effectual library and documentation science; invariably, scientometrics seeks focus on the science of science, and informetrics focuses on information science (Brookes, 1990; Wang, 1998; Qiu et al., 2017). The three terminologies differ in the degrees of utilisation and recognition, but offer a convergent point for the general principles enshrined in citation of secondary sources (Yang and Yuan, 2017). More detailed descriptions of the three terms can be found in Hood and Wilson (2001). According to Hood and Wilson (2001), the three terms considerably overlap with bibliometrics having a longer history and being stably used. Bibliometrics is the most frequently used terminology commanding the highest degree of increase among the three. However, in order to avoid confusion, it is recommended by Yang and Yuan (2017) that the term “bibliometrics” should be adopted as a general terminology for scientometrics and informetrics. For this reason, in the follow-up sections of this chapter, bibliometric is adopted as a generalised terminology to represent the feature of the bibliometric method akin to text-mining-based algorithms and the derivatives of search patterns from various data sources. It is further posited by Aria and Cuccurullo (2017) that the use of bibliometrics is gradually extending to all disciplines. For example, bibliometric analysis is now found in a variety of subjects, such as pharmacy (Burghardt et al., 2020), engineering (Xu et al., 2018; Vilutiene et al., 2019), and management theories (He et al., 2017). In the field of built environment, multiple bibliometric analysis-based studies have found a place in academic publications, for example, off-site construction and volumetric-modular assembly (Hosseini et al., 2018), digital construction and Building Information Modelling (Zhao, 2017), and construction waste management (Jin et al., 2019). These extant literature sources adapt a review-based approach to bibliometric analysis which enumerate the frequency of citation-based evaluations as well as those which corroborate the most cited author, linked institution, allied journal, as well as the frequency of author-generated keywords and host-country. These metrics are extrapolated from a sample of constitutive literature using constructs integral to pre-defined research domains, such as off-site construction.

1. **Secondary data source for conducting bibliometric analysis**

In conducting the bibliometric analysis of academic literature, Scopus (Elsevier) and Web of Science (WOS, Claravite Analytics)are the two commonly suggested databases to search the secondary data. These databases are suggested because they carry the bibliometric analysis functions which project traffic flow on a number of ‘reads’ and ‘downloads’ as well as consistent past reports on author-publication rates (Burghardt et al., 2020) within a given discipline such as built environment. It is believed that Scopus covers more journals and more recent publications than other digital sources such as WOS (Aghaei Chadegani et al., 2013). Nevertheless, other databases are equally gaining in popularity such as Google Scholar. It is therefore not uncommon to utilise all these search engines to have a more comprehensive coverage of literature.

Within any of these databases, different types of literature sources can be found, including journal articles, conference proceedings, and book chapters. Researchers can opt to include or exclude the types of literature sources relative to the research endeavour. Butler and Visser (2006) postulated that conference papers, although generally in larger quantities, do not often provide as a good medium for comparative bibliometric analyses and have little to offer in this aspect compared to journal articles. Researchers in bibliometric analyses such as Xu et al. (2018) and Chen et al. (2019) are good reference points whose findings exclude conference proceedings. However, conference proceedings could be considered depending on the scenarios of the review. For example, there may be more educational studies in built environment published in conference proceedings. In the review of Building Information Modelling education in the built environment higher education, Wang et al. (2020) included both journal articles and conference proceedings.

1. **Decisions to conduct bibliometric analysis**

After knowing the concept and data sources related to literature review, it is also vital to decide when it is and when not to adopt bibliometric analysis. Generally, bibliometric analysis, by its name and features, is applicable to a relative larger sample of literature. The definition of “relatively larger”, although not related to a standard quantified sample size of literature, the datum point is that the sample size should be large enough. This should ensure that any derived pattern analysis or quantitative summary of frequency or citation-related metrics, such as what is the most frequently studied author keyword, are outcomes of large sample frames. For a smaller sample of literature, other review methods other than bibliometric analysis might be more appropriate, including the manual review involving purely qualitative discussions. The valid sample size (for example, more than 50 documents found within the defined scope) would determine whether it is wise to conduct the bibliometric analysis. The sample size of literature would be determined by the defined scope of the study. Generally, a wider scope would result in a larger sample of literature. Below is an example of how the same topic in a given discipline could be defined from a wider scope to a more narrowed-down scope:

* review of safety management;
* review of construction safety management;
* review of construction safety climate;
* review of organizational safety culture in construction;
* review of virtual reality for construction safety.

It can be seen from the example above that a domain (e.g., safety in the built environment) could be defined in a broader or a narrower scope. There is no recommendation or preference to select a broader or a narrower scope, but depending on the researchers’ aim and objectives of the study. It is not uncommon to adopt multiple keywords to define the scope, for example, virtual reality applied in construction safety management.

While it is critical to define the review scope within the domain, it is possible to have the same study starting from a broader scope to recruit a larger size of literature sample, and then emphasizing a specific topic generated from the originally broader scope. The rationale of starting from a larger sample of literature is that a bigger picture is obtained before moving to the focused scope. Furthermore, sometimes a certain pattern or highlight from the larger literature sample could be identified as new findings of the research. For example, Jin et al. (2019b) started from the two main keywords related to Building Information Modelling and building performance analysis. After the bibliometric analysis of the initial literature sample, the keyword of interoperability was identified as the focal point. This also creates the opportunity of linking bibliometric analysis with other review methods such as content analysis. Therefore, adopting bibliometric analysis does not exclude other review methods to form a comprehensive review of the pre-defined study scope such as in the example of Jin et al. (2019b).

1. **Software tools for conducting bibliometric analysis**

There are several widely used software tools that have been developed to assist bibliometric analysis, including but not limited to VOSViewer (van Eck and Waltman, 2010), CiteSpace (Chen, 2016), and Gephi (Bastian et al., 2009). The weblinks of several software tools for bibliometric analysis are listed in Table 1.

Table 1. Introductions of several software tools for visualizing bibliometric networks (adapted from van Eck and Waltman, 2014)

|  |  |  |
| --- | --- | --- |
| **Software tool** | **URL** | **Main description** |
| CitNetExplorer | https://www.citnetexplorer.nl/ | A software tool for visualizing and analysing citation networks of scientific publications; allowing citation networks to be imported directly from the Web of Science database |
| CiteSpace | <http://cluster.cis.drexel.edu/> ~cchen/citespace/ | A freely available Java application for visualizing and analysing trends and patterns in scientific literature |
| Gephi | https://gephi.org/ | A visualization and exploration software for all kinds of graphs and networks; open-source and free |
| Pajek | http://mrvar.fdv.uni-lj.si/pajek/ | Analysis and visualization of very large networks |
| Sci2 | https://sci2.cns.iu.edu/user/index.php | A modular toolset specifically designed for the study of science; supporting the temporal, geospatial, topical, and network analysis and visualization of scholarly datasets at the micro (individual), meso (local), and macro (global) levels |
| VOSViewer | https://www.vosviewer.com/ | A software tool for constructing and visualizing bibliometric networks, including journals, researchers, or individual publications which can be constructed based on citation, bibliographic coupling, co-citation, or co-authorship relations; offering text mining functionality that can be used to construct and visualize co-occurrence networks of important terms extracted from a body of scientific literature |

It is seen in Table 1 that these software tools are typically freely downloadable for use in visualizing and analysing the network (e.g., citation) from scientific publications, despite the variability in the strength and suitability of each tool. This chapter does not aim to recommend any specific tool as preference to another, but describes the main features of a few widely used tools (e.g., VOSViewer and CiteSpace). It is the researchers’ decision to adopt any tool for the bibliometric analysis, although some generally comparative descriptions can be found from user experience. For example, compared to Pajek, Gephi focuses less on network analysis and more on network visualization with extensive visualization capabilities (van Eck and Waltman, 2014). CiteSpace provides a dynamic visualizations to show how bibliometric networks evolve over time, and offers both graph-based and timeline-based visualizations (van Eck and Waltman, 2014). It also allows co-citation cluster analysis to generate research themes. This timeline-based visualization feature has been widely adopted in the review of academic publications in the built environment, for example, in the domain of off-site construction (Hosseini et al., 2018) and in the topic of sustainable transport (Zhao et al., 2020). According to van Eck and Waltman (2014), VOSViewer offers an easy-to-use option highlighting visualization of distance-based visualization with less functionality for analysing networks. It is also practical to adopt more than one tool to conduct the bibliometric analysis of networks from a selected sample of literature, including the journal or document sources, authors or scholars, institutions, keywords, and countries or regions.

1. **Workflow of conducting bibliometric analysis**

Science mapping is the workflow involving bibliometric analysis. Aria and Cuccurullo (2017) proposed the three-step science mapping mechanism, namely data collection, data analysis, and data visualization. The workflow of the science mapping approach can be further generalised from the review of other literature review-based studies (Jin et al., 2018; Xu et al., 2018; Zhao et al., 2020). Fig.1 illustrates the typical workflow.

Fig.1. Typical workflow of conducting the bibliometric analysis in the science mapping approach (adapted from Jin et al., 2019a).

According to the workflow described in Fig.1, bibliometric is part of science mapping, defined by literature search and screening, bibliometric study, and the further discussion. The first step of searching and screening literature from the database (e.g., WOS, or Scopus) is by using predefined keywords. The screening process might undergo one or more steps to finalise the literature sample that falls into the defined scope of study. An illustration is included in the next section and it reveals a specific example. After the literature sample is finalised, the bibliometric analysis can be applied by adopting one of the software tools listed in Table 1. A further in-depth discussion is recommended beyond the bibliometric analysis, with the three general research questions to be addressed, corresponding to the mainstream topics or patterns from the literature sample, the limitations or gaps from these existing studies, and the recommended future directions. The last step should be coherent with the bibliometric analysis, but also moves a step forward from it. For example, the bibliometric analysis provides the quantitative measurement of the most highly cited scholars, journals, keywords, or institutions within the given domain. As a step forward, the further discussion could be more qualitative by offering insights for readers to understand what the quantitative measurements reflect and what could be performed in the future work to fill the existing gaps.

1. **Cases demonstrating bibliometric analysis in built environment**

Following the workflow described in Fig.1 and the general principles of conducting bibliometric analysis in reviewing the defined topic in a given domain, this section aims to extend the generalisation by demonstrating two cases in the built environment. Although the software tool adopted to conduct the bibliometric analysis is VOSViewer as the showcase, the option of software tools should not be limited to those presented in Table 1.

* 1. **Case One: Building Information Modelling and off-site construction**

Following the review work conducted by Zhao (2017) who focused on Building Information Modelling (BIM) and Hosseini et al. (2018) targeting off-site construction (OSC), the review work in this case aims to extend these two studies by investigating the existing literature on adopting BIM for OSC, or BIM linked to OSC. Therefore, the scope of the review-based study is defined as BIM crossing over OSC, examples of existing studies could be but are not limited to: case studies of applying BIM to assist the early stage cross-disciplinary coordination in OSC projects; BIM in the life cycle assessment of OSC projects from design and construction to facility management; and investigating the effects of BIM on OSC project delivery and productivity. Scopus is used as the database for the initial literature search. Other databases such as WOS can also be adopted.

Keyword search between BIM and OSC in Scopus is shown below.

**TITLE-ABS-KEY** ( BIM OR "Building Information Modelling" OR "Building Information Modeling" ) AND **TITLE-ABS-KEY** ( "Off-site construction" OR "off site construction" OR "prefabricated construction" OR "industrialized building" OR "panelized construction" OR "modular construction" OR "tilt up construction" OR "offsite construction" OR "precast construction" )

The reason of using “OR” relationship for BIM and OSC is that both terms could be presented in various phrases. There are a variety of different terminologies to express OSC, for instance, modular construction. The “AND” relationship is used between the two major types of terms, meaning that in either the title, abstract, or keyword list, only publications with both terms mentioned will be selected in the automatic search of literature. Up to the Mid-February of 2020, it is found from Scopus that a total of 142 documents were found. It can be seen that BIM crossing over OSC results in a much smaller literature sample compared to literature on BIM solely or OSC. Totally 58 out of the whole initial sample were journal articles, with the majority of the rest literature coming from conference papers. Researchers initially have to decide either to include the whole sample regardless of document type, or to include journal articles only. Assuming the decision is to include only the 58 journal articles: initially, the selected 58 journal articles can be saved in a single CSV file including the key information metrics such as author, citation count, abstract, author keywords, and others. Scopus also enables the export of literature information into other reference management tools such as Endnote seamlessly possible. Indeed, similar procedures can be performed if WOS is adopted as the database instead of using Scopus, although the different coding format in WOS should be noticed. Specifically, the format of *TITLE-ABS-KEY* shown in Scopus will be different in WOS, which mainly allows the search of the *Topic* and *Title* of documents.

Researchers now need to read through the downloaded CSV file, especially the title, abstract, and keyword list of each document, in order to perform the filtering and screening sub-steps illustrated in Fig.1. When the literature sample is larger (e.g., over 1,000 documents), it is essential that the manual screening is performed between individual researchers. A comparison of the results is then made until the final agreement is reached. It is common to exclude more documents after the manual reading and screening. In this case, a few initially selected documents are also excluded due to falling out of the pre-defined scope, for example, studies only focusing on a technical aspect of BIM but without the focus in OSC, and studies focusing on OSC but not emphasizing the role of BIM. After the literature sample is finalised, the literature information contained in the CSV file could then be loaded into VOSViewer to conduct the networking analysis based on visualisation and citation-related metrics. The networking and citation analysis can be Author Keywords suggested by Oraee et al. (2017) and Hosseini et al. (2018), or other options including the journals, authors, institutions, and countries.

In this study, it is found that due to the relative small sample size of literature, the visualisation of keyword network could not demonstrate the links between keywords, or the closeness of clusters of keywords being co-studied in the same articles. The relatively small sample size (e.g., less than 60 documents in this case) motivates other review methods, such as content analysis conducted in Jin et al. (2019b), and the qualitative analysis based on manual review. The alternative approach is to enlarge the sample size by including other types of literature such as conference proceedings and to restart the process of bibliometric analysis.

* 1. **Case Two: BIM and Geographic Information System (GIS)**

In this example, BIM is co-studied with the other digital tool named Geographic Information System (GIS) in the built environment. Following the consistent procedure according to Fig.1 and using Scopus as the database, the following keywords related to BIM and GIS are input to generate the initial literature sample.

**TITLE-ABS-KEY** (BIM OR "building information modelling" OR "building information modeling") AND **TITLE-ABS-KEY** (GIS OR "geographic information system" OR "geographic information systems")

Continuing following the consistent workflow as described in the former case (i.e., BIM and OSC review) and Fig.1 until the literature sample is finalised, researchers can now analyse the author keyword in VOSViewer or other software tools. Fig.2 demonstrates the generated visualisation of keywords contained in the literature sample. The visualisation map in Fig.2 consists of these following elements, node with corresponding keyword texts, connection lines, and colour indicating the cluster. These elements are generated based on the in-built algorithms in VOSViewer (van Eck and Waltman, 2014) by extracting the literature information. The example shown in Fig.2 indicates that interoperability and IFC are two main frequently studied topics in linking BIM to GIS. The clusters shown in Fig.2 are determined based on a given group of keywords being co-studied in the same publication, or one keyword being cited by another in different publications. The relevance of a pair of keywords, i.e., being co-studied within the same publication, can be detected in VOSViewer and visualized through the connection line in Fig.2. The distance between any two keywords show their closeness. For example, interoperability is the keyword that is closely related to IFC, which is a data format when exchanging information between BIM and GIS. Researchers are strongly recommended to include the critical analysis of clusters or the connections between keywords, for example, why and how are interoperability, IFC, and schema mapping strongly connected in the existing studies, and what research has been performed under each cluster shown in Fig.2.



Emergency response

Multi-purpose

Geospatial model

Fig.2. Visualised mapping of author keywords in VOSViewer

It should be noticed that although VOSViewer is adopted as the showcase to demonstrate the usefulness of bibliometric analysis, the text-mining and visualization features of the bibliometric tools can be found in other software packages listed in Table 1. Besides the visualized map demonstrated in Fig.2, the quantitative measurements of author keywords can be summarised as presented in Table 2.

Table 2. Quantitative measurements of keyword generated from VOSViewer

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Keyword** | **Occurrence** | **Average publication Year** | **Average citations** | **Average normalized citations** |
| IFC | 11 | 2016 | 16.09 | 1.45 |
| CityGML | 9 | 2016 | 12.78 | 0.98 |
| Interoperability | 9 | 2015 | 29.22 | 1.31 |
| Integration | 6 | 2017 | 13.83 | 1.60 |
| 3D GIS | 3 | 2014 | 37.67 | 0.97 |
| Ontology | 3 | 2016 | 13.67 | 1.04 |
| Semantic Web | 3 | 2017 | 20.67 | 2.25 |
| Big Data | 2 | 2017 | 3.00 | 0.33 |
| Core Model | 2 | 2018 | 0.00 | 0.00 |
| Cross-Domain | 2 | 2018 | 0.00 | 0.00 |
| Data Model | 2 | 2014 | 49.00 | 1.32 |
| Emergency Response | 2 | 2015 | 25.00 | 1.28 |
| Flood Damage Assessment | 2 | 2016 | 15.50 | 1.71 |
| Framework | 2 | 2016 | 13.50 | 1.49 |
| Geospatial Model | 2 | 2018 | 0.00 | 0.00 |
| Indoor | 2 | 2014 | 49.00 | 1.32 |
| Information | 2 | 2016 | 16.00 | 1.90 |
| Multi-Purpose | 2 | 2018 | 0.00 | 0.00 |
| Schema Mapping | 2 | 2016 | 24.50 | 2.34 |
| Visualization | 2 | 2015 | 16.50 | 1.39 |

A variety of quantitative measurements are shown in Table 2, including the occurrence which shows the popularity or the frequency of being studied, the average publication year which depicts the regency of the keyword, and the citation-related indicators which measure the influence of the given keyword. There is a total citation number for any given keyword listed in Table 2, and also for any given journal, author, institution, or country. Average citation is automatically calculated in the software tool by dividing the total citation by the number of documents. The normalised citation, or average normalised citation is the measurement that corrects the biasness that older documents or keywords gain more time to receive citations. It is calculated by dividing the total citations (or the average citation of the given keyword in this case) by the average number of citation of this keyword gained in the same year. Generally, the normalised or average normalised citation can be considered as the unbiased measurement of the influence of a given keyword, linked-journal, author, institution, or country of source within the defined domain. More detailed descriptions of these quantitative indicators can be found in Jin et al. (2019a). Overall, it should be noticed that the bibliometric analysis is not the last step of the science mapping methodology according to the workflow described in Fig.1. Researchers in this study of BIM linked to GIS are suggested to move a step forward to perform the in-depth discussion, especially when addressing the three research questions related to the mainstream topics in the defined scope, gaps or limitations, and the future research directions. Researchers would need to have their own understanding, reflection, and critical thinking from the bibliometric outputs to address the three generalised research questions akin to the specifically defined scope (e.g., BIM integration with GIS in this case).

1. **Summary**

This chapter introduced bibliometric analysis as one research method to form part of the science mapping methodology and extent to which this tool can assist in the review of secondary sources such as academic publications. The chapter starts from the generalised concept and steps of conducting bibliometric analysis. The general guide of conducting the bibliometric analysis is provided, including the secondary data source, and the commonly adopted software tools based on the text-mining and visualisation features. Informed judgement considered suitable to conducting the bibliometric analysis is given. Examples include cases with limited literature sample size (e.g., less than 50 documents identified). The size of the available literature sample is directly related to the defined topic from a broader to a narrower scope.

 Some further recommendations are provided herein: firstly, bibliometric analysis does not exclude other research methods in conducting review of secondary database. Indeed there is a possibility of linking bibliometric analysis with other review methods such as content analysis. The review scope of the studied topic could vary depending on the aim. It is not uncommon that within the same study, the review starts from a wider scope with a larger literature sample and then narrows down to a focal point; secondly, not dissimilar to other review methods, researchers in bibliometric analysis also need to decide the keyword and database for the literature search, and also to decide the type of literature (e.g., conference proceedings) to be included. The selection of keywords reflects the review scope, which, together with literature type, determine the literature sample size; thirdly, bibliometric analysis is one of the methods or steps involved in assisting the literature review, but it cannot replace the further in-depth discussion. The further discussion aims to address three general research questions, namely: (1) what are the mainstream research keywords or topics within the pre-defined scope? (2) what are the limitations or gaps from these existing studies? and (3) what are the recommended future research directions? It is key to maintain the coherence of the discussion linked to the prior step of bibliometric analysis. To demonstrate these main recommendations, two examples of conducting the science mapping approach are showcased. The first example of literature review defines the scope focusing on BIM applied in off-site construction. Limited literature sample is found if only journal articles are included to conduct the bibliometric analysis. It is therefore suggested to adopt other review methods such as content analysis, or alternatively to include other document types (e.g., conference proceedings). The second showcase demonstrates the review of BIM working with GIS in the built environment. Author keyword is studied adopting the bibliometric analysis through visualisation and quantitative measurements, such as frequency to measure the popularity of a given keyword, and the citation-related indicators to measure the influence of the studied keyword.

Finally, several misperceptions or mistakes should be avoided in conducting a bibliometric analysis. (1) First mistake is treating the bibliometric analysis as the aim rather than the methodology. The aim should not be simply to generate some eye-catching visualisation maps. Instead, bibliometric analysis is a method or an approach to achieve the pre-defined research objectives. It should not be treated as the research aim. In another word, the bibliometric analysis is a tool to assist the research goal or to answer research questions through unveiling mainstream research keywords or topics in the pre-defined domain. Researchers are suggested to move a step forward from the network analysis of the citation data (e.g., keyword, document, etc.) by demystifying the selected research domain; (2) second mistake is applying the bibliometric analysis in a field or domain that the researcher is not familiar with. The researchers should have their own critical thinking to interpret the visualisation maps of keywords and to further address research questions related to the limitations of existing studies and the recommended future research directions; and (3) a third mistake is perceiving the bibliometric analysis as a full automatic method in screening the literature sample. The science mapping workflow descried in this chapter does not allow the bespoken Artificial Intelligence to automatically filter and screen the initially selected literature from the database. Before conducting the bibliometric analysis, manually reading the abstract, title, or author keywords is still needed to exclude further documents which do not fall into the defined scope of the researcher.

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