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Bibliometric Overview and Visualization Analysis for Interior Design Research based on CiteSpace

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Abstract

Interior design is a fascinating and rapidly growing interdisciplinary field of study. To be continuously updated in the interior design body of knowledge, this article aims to determine the disciplinary distributions, landmark articles, research hotspots, and emerging trends in interior design by integrating the knowledge map analysis and scientific mapping of the bibliometric method. In line with scientometric analysis, results were presented in three parts. The first part presented the co-authorship networks of organisations, authors, and countries. The second part presented three types of co-citation networks, which are the journal co-citation network, reference co-citation network and author's co-citation network identified the discipline leaders. Following that, the third part presented keyword networks of co-occurrence, cluster, and bursting citation. Subsequently, the results demonstrated that interior design research acknowledged the diversification and intersection of research topics, although the scholars and research institutions appeared to be lacking in cooperation. The research hotspots included the indoor environment, user experience, colour wheel, emotional state, and learning style. Future research frontiers include space, stress, quality, and human-centred design.

Discipline: Interior Design, Scientometric.

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1 Introduction

Currently, the interior environment in which individuals spend approximately 95% of their time has attracted much attention in the architectural environment (Spence, 2020). The level of behaviours, physiological comfort, performance, emotions, psychological health, and well-being of

occupants is influenced by the design elements in the interior space. With the growing interest in interior design development, more interior design articles have been published. Despite the importance of articles for gaining a thorough understanding of research subjects, the articles are not adequate in keeping abreast with the high pace of scientific publications. This challenge could be solved by applying science mapping tools and bibliometric analysis, which use advanced text-mining technologies to collect a full grasp of knowledge structure and patterns.

Bibliometrics employ statistical and visualisation methods to study a particular discipline's knowledge structure and evolution (Moed et al., 1995). Following the fast pace of scientific publishing in interior design, bibliometric studies and regular scientific mapping were required to be updated with the newest discoveries, identify emerging areas, and identify the gaps to encourage sustainable development in the field. This article conducted a bibliometric analysis to address the above research gap. It was designed quantitatively to describe using CiteSpace software and determine the global state and emerging trends. A comprehensive bibliometric analysis and substantial discussion were presented to achieve the following three objectives:

To summarise the significant research workforces in interior design at the individual, institute, and country levels with basic statistics and advanced analytics.

To reveal the landmark articles, distinguish the thematic patterns, and explore the knowledge structure from multiple perspectives, including the co-citation analysis of journals, documents, and authors.

To present the research hotspots and frontiers in interior design from various angles.

This article could serve as a point of reference for new researchers in the area to promptly gain an understanding of the knowledge base of interior design and its evolution, emerging themes, and research gaps. In addition, new researchers and readers who are interested in this area could use the references and authoritative sources mentioned in this article to learn further about their themes of interest.

2 Data and Methods

The following parts are covered in this section: (1) research method selection, (2) data collection procedure, and (3) path of parameters.

2.1 Research Method

Traditional literature review methods rely on researchers who personally acquire, extensively read, and manually summarise the literature (Li et al., 2022). Each researcher also has limited time and energy. Various perspectives and cognitive styles among researchers examining the same literature within the same data may result in different results. The use of network analysis and graph theory to visualise scientific knowledge is a new area of bibliometric methods. CiteSpace is one of the free software Java-based scientific visualisation tools created by Dr. Chen Chaomei of Drexel University in Philadelphia, Pennsylvania. It is a visual analytic system that tracks the

intellectual structure and identifies critical evidence based on relevant scientific disciplines (Chen, 2006).

2.2 Data Collection

Currently, various online bibliographic data store scientific works and documents with their citations. The WoS has been acknowledged as the most comprehensive and authoritative logical literature indexing tool for gathering critical scientific and technology research data. It is frequently considered an ideal data source for bibliometrics research (Van Leeuwen, 2006). Based on the criteria employed in other bibliometrics research, most data for this article mainly originated from Social Science Citation Index (SSCI), Science Citation Index Expanded (SCI-E), and Arts & Humanities Citation Index (A & HCI) of Web of Science Core Collection (WOSCC) databases. The data relating to interior design was collected for as long a duration as possible, considering that the accurate time of interior design articles in WOS was not known. An original topic search for "interior design" led to the publication of 1,506 articles from 1967 to 2022. The decrease in the dataset to 1,366 articles was made after the filtration of less representative record categories, including meeting abstracts, design works, editorial material, papers, book reviews, letters, and news items. The data was retrieved on March 4, 2022, using the retrieval strategies: "Topic = Interior Design, AND Time span = All Years, AND Document Type = article, AND Language = English."

Path of Parameters

The methodology employed in this article was similar to the methods employed in the previously published bibliometrics studies. Knowledge maps of the interior design research articles were visualised and analysed using CiteSpace. The main analysis steps are as follows:

A project with default properties, such as "interior design" was developed, followed by the addition of 1,335 journal articles with total entries and cited references in plain text format into CiteSpace for "interior design" projects. Following that, the parameters were set, which included seven aspects: 1) Time Slicing; 2) Term Source; 3) Node Type; 4) Selection Standards; 5) Pruning; 6) Connections; 7) Visualisation. In the third step, the three primary pathways as a response to the research objections were analysed using CiteSpace. In the final step, the most critical networks and data and the visualisation analysis findings were observed from the interior design research.

3 Results and Discussion

The intellectual landscape could be described as networks of collaborating authors, co-citation references, and co-emerging keywords (Chen et al., 2014). The co-authorship networks of authors, organisations, and nations in the interior design were mapped to present the social structure. This was followed by the co-citation networks of journals, references, and authors to display the intellectual structure in interior design. The keyword networks of the keywords co-occurrence map, clusters of knowledge map, and stronger citation bursts were then mapped to identify the research hotspots and research frontiers.

3.1 Cooperation Analysis of Interior Design

Cooperation analysis provides references for assessing academic influence and finding scholars and institutions of concern (Hu et al., 2019). This section presents the co-authorship networks of the author, institution, and country from the micro, medium, and macro viewpoints.

3.1.1 Author's Co-authorship Analysis

The author's co-authorship analysis provides references for scholars to analyse and read related publications in interior design. Analyzing the structural characteristics of communication authors and their cooperative network could determine the core author group and its collaborative relationship (Hu et al., 2019). Figure 1 illustrates the academic collaboration network among authors. The overall network comprised a few isolated sub-networks, as illustrated in Figure 1. This factor indicated the author's preference to work in small groups with little communication. Notably, Debajyoti Pati, Shabboo Valipoor, Sherry Ahrentzen, and Nichole Campbell formed the largest sub-network, with 20 nodes and four small, decentralised subnets. Furthermore, the second largest sub-network included 14 researchers, such as Demetri Terzopoulos, Lapfai Yu, Dieter Schmalstieg, and others. The third team comprised Jason Meneely, Namkyu Park, Margaret Portillo, Beth Mcgee, and Candy Carmelgilfilen among others. Based on the author's authorship network viewpoint, the interior design field is characterised by a vast dispersion and a low concentration. The communication and cooperation between authors were insufficient, and the research authors had not formed an effective cooperation network.

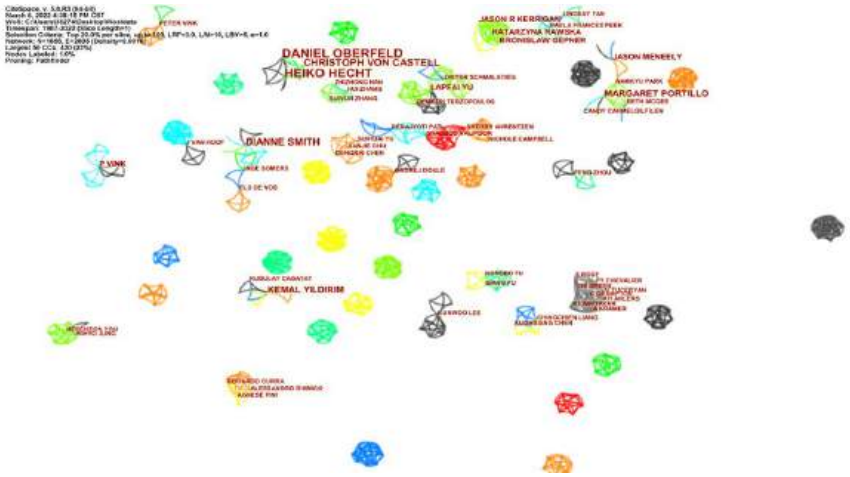

Figure 1: Map of the author's co-authorship network

3.1.2 Institution's Co-authorship Analysis

The institution's co-authorship network map could indicate the significant contribution, collaboration among the institutions, and distribution of research power in the interior design field. Figure 2 presents the academic collaborations in interior design research among institutions. The number of articles distributed by institutions was reflected in the size of nodes, while institutional cooperation was denoted through the strength of the links and the space between the nodes. Based on Figure 2, the institution's co-authorship network was supported by three significant distributed sub-networks and occasional institutions. The largest sub-network included

49 institutions. The distribution of nodes in the largest sub-network revealed that the majority of the 49 nodes were comparatively decentralised. In terms of the number of ties, most of them collaborated extensively. However, based on the strength of the links, the cooperation degree among most nodes was generally insufficient. Furthermore, universities dominated the research institutes, with 554 universities among the 842 institutions comprising the institution's co-authorship network and occupying a share of 65.79%. In conclusion, interdisciplinary cross-regional cooperation between institutions was poor, which was not beneficial for sharing research data and developing the research system. Therefore, communication and collaboration between various linked research institutions should be strengthened in the future.

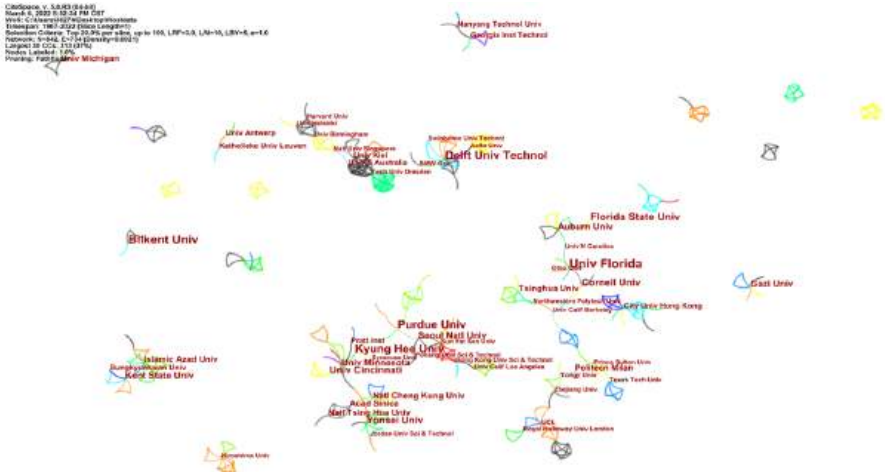

Figure 2: The map of the institution's co-authorship network

3.1.3 Nation's Co-authorship Analysis

Figure 3 presents the nation's co-authorship network, which presents the cooperation trend between different countries and the influence of the countries in the interior design field. The line thickness and space between the nodes indicate international cooperation. The purple rings around the nodes represent strong betweenness centrality, indicating that these nodes served as a connecting point between the different parts. The purple circle thickened upon the increase in the node betweenness centrality, implying its importance in communicating with other nodes. A nation's co-authorship network with 20 nodes and 24 lines is presented in Figure 3. The 20 countries were spread across five continents, including 10 countries in Europe (England, Germany, Italy, Netherlands, Sweden, Poland, Spain, Croatia, Austria, and Romania), six in Asia (P.R. China, South Korea, Turkey, Japan, China Taiwan, and Israel), two in North America (the USA and Canada), one in Africa (Egypt), and one in Oceania (Australia). The USA, Germany, England, South Korea, and Turkey were among the five purple-ringed nodes, which also played critical roles in collaborating with 20 countries on interior design research. The 14 countries that constituted the country's co-authorship network accounted for 70% of the total 20 countries. The dense links of the 14 countries indicated their close cooperation, with Austria and Canada having a strong connection with Germany. Notably, increased international exchanges have boosted scholarly communication in recent years.

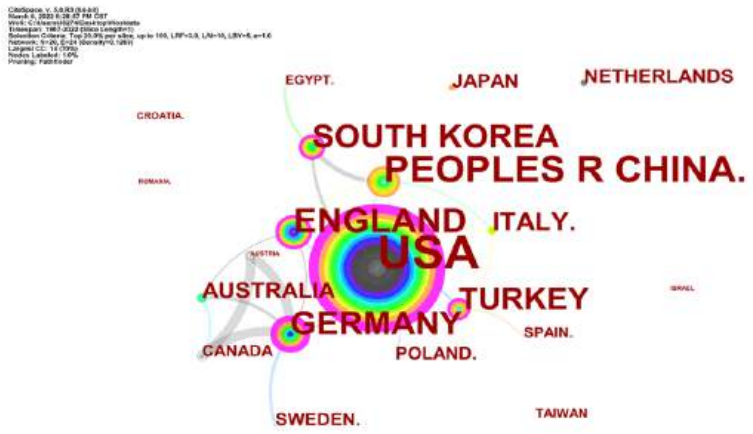

Figure 3: The map of the nation's co-authorship network

3.2 Co-citation Analysis of Interior Design

Co-citation is a refined expression of a study topic in scholarly articles, which could identify the internal associations of knowledge among disciplines to some degree (Hu et al., 2019). The co-citation networks could indicate the knowledge base, structure, and evolutionary process of the study topics and the literature contributing to evolution. The co-citation networks of cited journals, authors, and references are presented in this section.

3.2.1 Journal Co-citation Analysis

The journal co-citation analysis is the essential type of all co-citation network analysis (Tang et al., 2018). It presents the relevance of various journals, which helps examine an academic area structure where scholarly publications are the dominant mode of communication (Hu et al., 2011). CiteSpace was used to create Figure 4, in which the node refers to the journal, while the links represent the co-citation relationship between the journals. Figure 4 illustrates a journal co-citation network with 914 linkages and 440 nodes, with the most prominent sub-network that comprised 402 nodes occupying 91% of the total nodes. Notably, J Interior Des (Journal of Interior Design), Thesis (Thesis Eleven), Build Environ (Building and Environment), Environ Behav (Environment and Behaviour), and J Environ Psychol (Journal of Environmental Psychology) are prominent journals in the interior design domain. A vital node with a betweenness centrality of higher than 0.1 was represented with purple rings, indicating the importance of the journal. The journal co-citation network was concentrated on the node corresponding to Design Studies, with the highest centrality of 0.30. As the bridge between various journals and a disciplined leader in interior design, the Journal of Design Studies exhibited excellent information control capabilities. The findings also demonstrated the characteristics of interior research's multidisciplinary solid nature. There was no single subject area that adequately reflected the study of interior design with a wide range of disciplines.

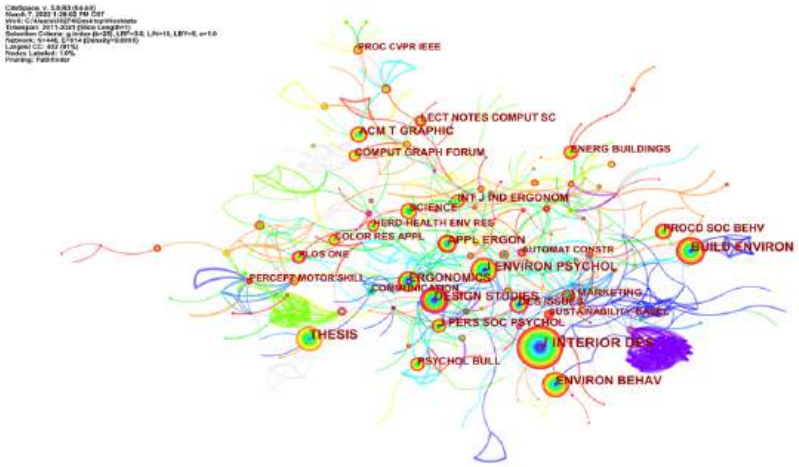

Figure 4: Map of the journal co-citation network

3.2.2 Reference Co-citation Analysis

The reference co-citation analysis assisted the research in discovering widely cited and essential research documents and learning the intellectual foundations (Liao et al., 2018). Figure 5 illustrates the interior design reference co-citation network, in which the nodes represent different cited documents. As seen in Figure 5, the separate sub-networks reflect different specialties or themes. The largest sub-network is reflected through its most central node (AL-Ayash A, 2016) following the average size of nodes in every subnetwork. The focus was placed on the performance, perception, and emotion research of interior design. In addition, Fu Q (2017), Wang K (2018), and Ma R (2016) constituted the second large sub-network in Figure 5, which focused on interior design 3D technology. Wang K et al. (2018) represented 3D scenes based on orthogonal top-down views using semantically rich image-based representations. The third sub-network in Figure 5 was represented by Al horr Yousef (2016), Getuli V (2017), and Schieweck A, 2015). Getuli V et al. (2017) proposed a design and validation procedure for submitting a construction site layout and safety plan based on health and safety building information modeling, which established the minimal requirements and mandatory helpful material.

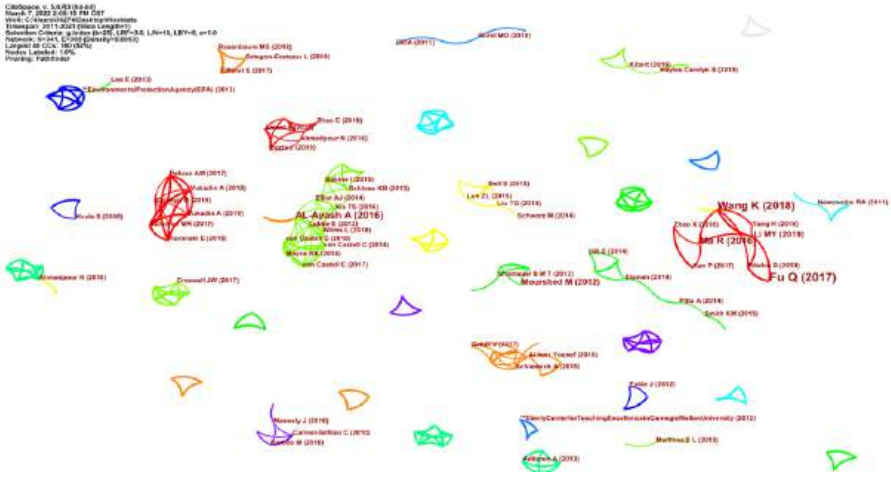

Figure 5: Map of the reference co-citation network

3.2.3 Author Co-citation Analysis

The co-citation analysis of the author may gain the administration of frequently cited authors in a specific domain, determine prominent scholars in this domain, and comprehend the research themes of the same authors within a particular area and the administration of their subjects (Chen & Liu, 2020). Figure 6 was created using CiteSpace, where the nodes represent authors, while a link was formed when two authors were referenced in the same article. Figure 6 presents an author's co-citation network with 486 nodes and 1,147 lines. Notably, the most significant node corresponded to Ulrich Rs and was co-cited with Evans Gw and other authors (Heerw Ange J, Agnes T, Taylor Rp, and others). All these statements focused on the performance, perception, and emotion research of interior design. Merrell P represents the second significant node, including the co-citation link between Fisher M and other authors (Wang K, Ma R, and Li My among others). The focus was placed on the 3D technology of interior design. These sentences were connected by red lines, which is the latest research trend. Another significant node was STAMPS AE, which was co-cited with Meerwein G, Nasar Jl, Portillo M, Huber A, and other authors (Aries Mbc, Ulrich R, Appleton J, and others). As a link between numerous components and a disciplined leader in interior design, Stamps Ae was surrounded by a purple circle, implying its substantial impact on the advancement of interior design research.

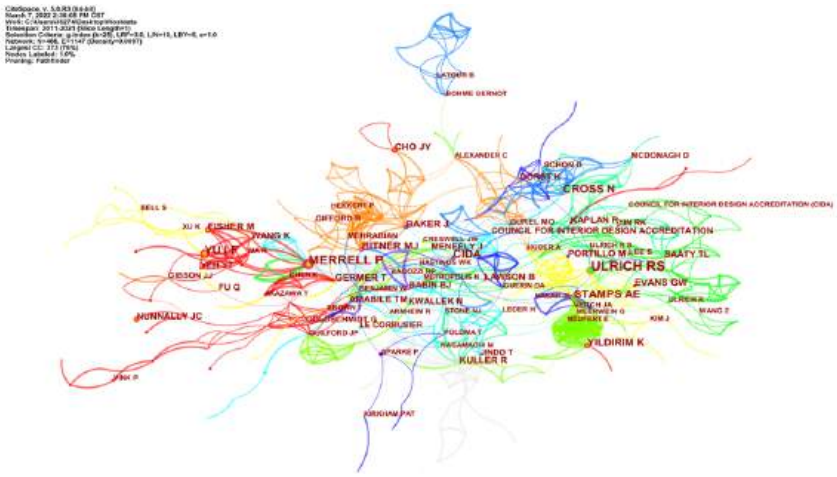

Figure 6: The map of the author's co-citation network

3.3 Co-word Analysis of Interior Design

A keyword knowledge map of co-occurrence is able to reveal study hotspots, while stronger burst keywords are able to show the study frontier (Yu et al., 2017). This section presents the co-occurrence keywords, cluster keywords, and the result of keywords citation bursts produced with CiteSpace.

3.3.1 Research Hotspots

The co-occurrence network of the keywords presents the research trends and hotspots in a particular discipline or journal (Li et al., 2016). The nodes represented the keywords, while the size of the nodes was corresponding to the co-occurrence frequencies, as shown in Figure 7. High-frequency keywords that could reflect interior design include the environment, performance,

education, model, impact, perception, behaviour, health, quality, architecture, and 3d technology among others.

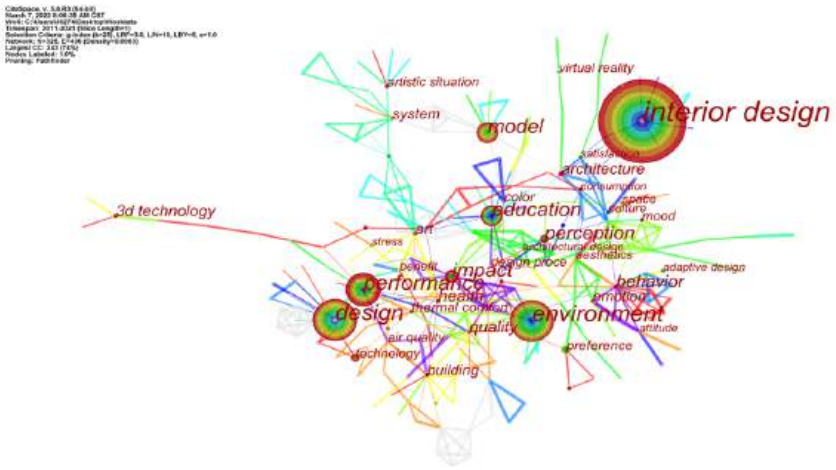

Figure 7: The map of the keyword co-occurrence network

The research hotspots in this field could be extracted through the clustering analysis of high-frequency co-occurrence keywords. Figure 8 presents CiteSpace clustering keywords distributed at different points in time, followed by merging the clustering keywords into a visual map. The categories of related research popular topics included the #0 indoor environment, #1 user experience, #2 colour wheel, #3 emotional state, #4 learning style, and so on. This article mainly focuses on the top categories, which are elaborated as follows:

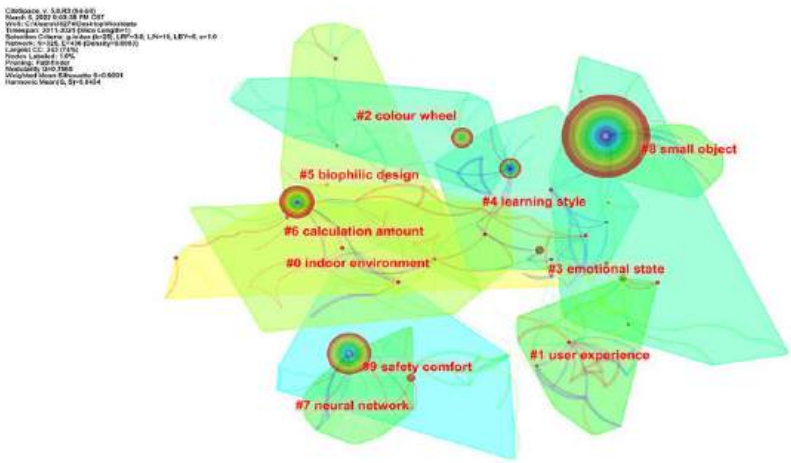

Figure 8: The map of the keyword cluster network

Labeled by the indoor environment, cluster #0 was the largest cluster. The keywords included air quality, performance, affordance, post-occupancy evaluation noise, energy, and management among others. Mujan et al. (2019) established a connection between the factors influencing health and productivity in residential and commercial indoor environments. Cluster #1 and Cluster #3 were labeled by the user experience and emotional state, respectively. The keywords emotion, behaviour, service, preference, satisfaction, and mood among others were present in these two clusters. Interior forms were reviewed by Banaei et al. (2020) based on the grouping of distinct photos of built living rooms and their emotional influence. Labeled by the colour wheel, Cluster #2 was the third-largest cluster, which comprised colour, model, aesthetics, prediction, neural network, and others. Cha et al. (2020) found that individuals in a white colour virtual world

showed considerably higher performance on an assignment, whereas the red colour showed an unpleasant and tense emotion. Cluster #4 was labeled by learning style and was the fifth-largest cluster. Several keywords, such as education, blended learning, personality, built pedagogy, and politics, were present in this cluster. Movahedi (2019) determined the optimal educational environment design that promotes creativity based on cognitive education. Cardellino and Woolner (2020) created a theoretical framework that includes academic and organisational practices, material space, student milieu, and staff culture to investigate the dynamics of space, teaching, and learning.

3.3.2 Research Frontiers

The keyword emergence analysis could illustrate the research frontier in related fields by reflecting the sudden rapid growth in the attention towards the research topic in an area within a certain period (Wang et al., 2022). High-frequency burst keywords are beneficial for understanding the evolution and development trend of interior design over time. The top 10 burst keywords over the last 10 years, including their strength and period, are presented in Figure 9. Notably, "space", "stress", "quality", and "human-centred design" have been the four main frontiers of interior design research in recent years. With a burst strength of 2.39 in 2017-2018, "preference" showed the strongest citation burst. The second strongest citation burst was "stress" (2.37), followed by "space" (2.15), and "culture" (2.13). At various stages, it could be seen that significant differences were present between the focus of the study and popular topics.

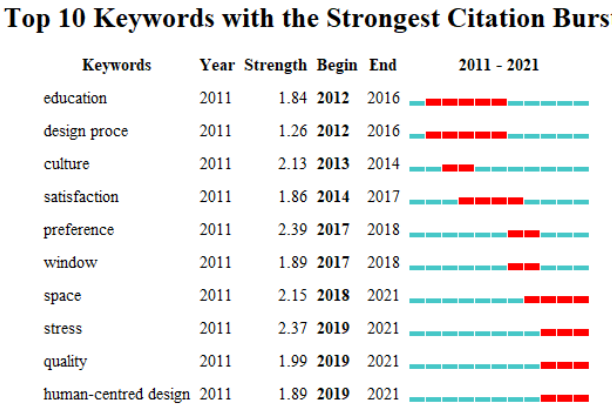

Figure 9: Keywords with the strongest citation burst

4 Conclusion

Interior design has been gaining extensive attention from scholars and practitioners. This article employed the knowledge map analysis and science mapping tools of CiteSpace to perform an analysis of the performance and visualisation of the knowledge structure. The discipline distribution was explored at different levels, while the journals and references with significant contributions were identified, and the top keywords for the sustainable development of interior design were detected.

First, the interior design field social structure was determined following the co-authorship networks analysis of the author, institutions, and country. Second, the interior design field intellectual structure was identified based on the co-citation networks analysis of journals, references, and authors. Third, the interior design field conceptual structure was presented based on the keyword network analysis of co-occurring, cluster, and stronger citation bursts. In this case, the popular research topics included "indoor environment", "user experience", "colour wheel", "emotional state", and "learning style" among others. "Space", "stress", "quality", and "human-centred design" have become the research frontiers. Based on the above findings, the research aims to focus on multidisciplinary development that combines psychology, arts, and interior design in the subsequent Ph.D. research. The development of an emotional design framework (EDF) for interior space has been suggested by combining the research fronts and hotspots.

In summary, this article is informative for building an understanding of the research status and emerging trends in interior design. The research findings would be beneficial at multiple levels, such as practitioners, design educators, researchers, and consumers to promote sustainable development for the interior design discipline.

5 Availability of Data and Material

Data can be made available by contacting the corresponding author.

6 Acknowledgement

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