Examining the Trends of Published Literature on Post Occupancy Evaluation (POE): A Bibliometric Analysis

Wan Nor Faezah Wan Mustaffa
Adi Irfan Che Ani
Afifuddin Husairi Mat Jusoh @ Hussain
Rusnani Ali
Mohd Norazmi Nordin
Mashitah Mohd Hussai

DOI: https://doi.org/10.37178/ca-c.22.1.178

Wan Nor Faezah Wan Mustaffa, *Department of Architecture and Built Environment, Faculty of Engineering and Built Environment, The National University of Malaysia, Bangi, Selangor;*
Email: wnfaezahmustaffa@gmail.com

Adi Irfan Che Ani*, *Department of Architecture and Built Environment, Faculty of Engineering and Built Environment, The National University of Malaysia, Bangi, Selangor; School of Liberal Studies, The National University of Malaysia, Bangi, Selangor*
Email: adiirfan@ukm.edu.my

Afifuddin Husairi Mat Jusoh @ Hussain, *School of Liberal Studies, The National University of Malaysia, Bangi, Selangor*

Rusnani Ali, *Department of Mathematics, Science and Computer, Sultan Haji Ahmad Shah Polytechnic, Kuantan, Pahang*

Mohd Norazmi Nordin*, Faculty of Education, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia*

Mashitah Mohd Hussain, *Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia*

ABSTRACT

The Post-Occupancy Assessment Research (POE) program was initiated in 1979. Since then, researchers have frequently used the term POE to investigate POE in the relevant industry further. Therefore, this study aims to analyze and examine the titles of papers and articles from the Scopus Post-Occupancy Evaluation database. Various tools, including Microsoft Excel, were used for frequency analysis and Wordsift for text visualization. The standard bibliometric methodology was used to show the growth of publications and research production. Based on the search results, a total of 381 documents were retrieved. The growth rate of literature on post-occupancy evaluation has increased year by year since 1979. Most of the publications, particularly those written in English, have been published in journals and conferences. Engineers carried out the majority of the post-occupancy assessments. The majority of the terminology used in the post-occupancy evaluation represents the key research fields. The majority of POE-related research has taken place in the United States. This study presents the

evolution of the POE scientific literature and identifies areas of current research interest and future research directions.

***Keywords*:** Post-occupancy evaluation; Bibliometric analysis; Scopus; Citation analysis

Introduction

Post-Occupancy Evaluation' (also known as POE) is a systematic assessment of building performance. In architecture, engineering, and construction (AEC), this strategy is commonly employed. Recognizing the importance of POE in improving building performance by linking human actions to building design and creating a new urban layout[1], several POE studies have taken place in different sectors[2]. Mainly in the residential sector[3], education[4], commercial, healthcare, open space, etc. The studies meet specific requirements, such as design, energy consumption, maintenance, and user satisfaction[5].

The approach of POE is quite different from other conventional surveys that use the direct and uninterrupted experiences of building occupants to determine how a building performs for its intended purpose. By focusing on building occupants and their needs, they will participate in the assessment process and become more involved. Therefore, POE can serve as a process or analysis to decide whether the architectural design results achieve the expected values for the building occupants and use the occupants as a benchmark[6]. When you use occupants as the benchmark for evaluation, the scope for improving building performance is immense. The occupants of a building have helpful information about the knowledge of the building and the criteria for building performance, which promotes occupant satisfaction[7]. Therefore, POE is a necessary test for occupants of occupied buildings[8], and POE reports are helpful in all building sectors. Healthcare, offices, commercial and residential buildings are no exception. Building failure can impact maintenance costs, occupancy, and business results. But to improve building performance very well, the applicable POE indicator must match the POE method, and the type of building must be specific

Following[9], the methodological model POE describes three phases of research: process planning, conducting studies, and application. Each stage in typical POE activities has three levels of effort: indicative, investigative, and diagnostic[10]. The indicative level is the most superficial first level identified and contributes to a general assessment or awareness of building performance issues. The second level of research provides a deeper understanding of the causes and consequences of surveys and stakeholder interviews related to building outcomes. The POE diagnostic community gathers sophisticated data and analysis, physical measurements, surveys, and stakeholder interviews in the third level. All the information obtained indirectly leads to a new awareness of building efficiency. The methodology used is vital at each stage of the POE process to capture the assessment and be useful for future studies.

Evaluating the building during its life cycle ensures that the building is still in the most efficient position. This guideline considers the word POE to be an appropriate means of providing high-quality feedback on building efficiency during operation. Its goal is to determine how long structures have been tested after being finished and occupied to meet the design intent.[11-13]. It is also a tool and framework used by service providers to systematically diagnose and assess critical building performance issues[14].

Research in POE began in 1979, and the idea was born in the United States with the emergence of problems such as building syndrome[15]. Since then, this term has been widely used among researchers further to investigate the method's development in the relevant industry. Many previous studies in the field of POE have contributed to building performance evaluation. Nevertheless, [16]found that practitioners still lack a

basic understanding of how to conduct a POE to obtain optimal building performance. . With technological development, new approaches in POE research have also emerged. The recent methodology shows that the outcome of the POE process has started to adapt to building data modelling (BIM) to provide user input on building outcomes[8]. Not surprisingly, researchers in developed countries are still exploring the use of POE to build understanding, with positive and negative implications for current and future trends in building design[17].

Objective

Because POE has been studied for nearly four decades, an overview of the field study is essential to gather valuable data or understand the underlying development trends. Therefore, this study aims to analyze the scientific literature published in POE using bibliometric analysis. Bibliometric analysis usually involves using mathematical and statistical tools to analyze the quantity and quality of printed materials and to observe trends or patterns of particular research papers[18]. Visual representation of bibliometric data also allows academic subjects to study quickly and comprehensively[19].

The first section shows how to perform a bibliometric analysis, while the second section outlines the approach applied. In the third section, the outcomes of critical bibliometric metrics were discussed. The final section summarizes the findings, addresses future study directions, and identifies some limitations.

Methods

This study gathered all data from the Scopus database from 1979 to September 2020 to locate previously published documents regarding the POE. Scopus was chosen because it covers more information than equivalent databases like Web of Science (WoS) and is easier to index on the bibliometric data[9]. The collected datasets, such as access mode, year, author name, affiliation type, document type, source type subject area, language, country, and keywords, provided some analytical results. For this review, we focused on all documents from POE based on the title of the text. We used the following terms: post-occupancy evaluation," OR "post occupancy evaluation," OR "POE," OR "postoccupancy evaluation."

This query generated a total of 1955 documents. After manually examining the data, the documents that did not meet the environmental criteria were excluded. After cleaning the data, 381 articles were compiled and reviewed for future research. This study utilized a bibliometric method to examine the database's output to determine POE research and publication trends. This strategy collects the necessary data since it allows the researcher to identify current trends in POE studies. Fig. 1 shows the steps of bibliometric analysis in studying the trends in the published literature of POE research.

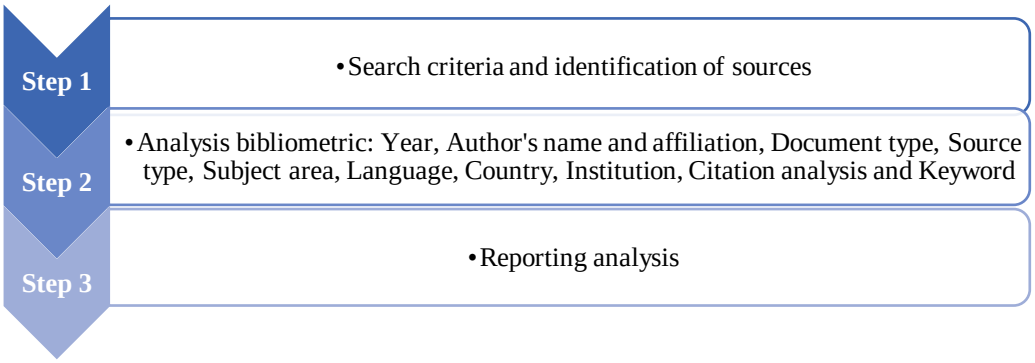


Fig. 1: Steps involved in the bibliometric analysis of POE researc

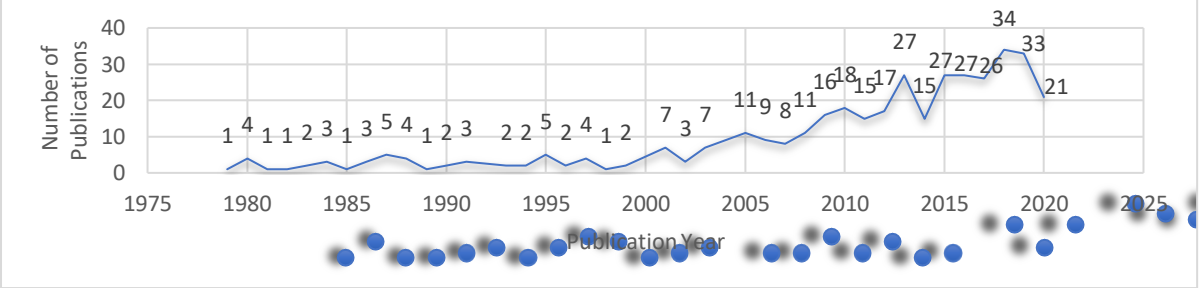
Results and Discussion

The year of publishing, the type of articles, the variety of sources, the languages used, the topic areas covered, the country's productivity and affiliation, and keywords were all evaluated. The majority of the findings were made public as a total and as a percentage. A different analysis is performed on the title of the article section.

Year Publication

In this first analysis, research productivity is examined based on the number of documents published per year. Based on 381 articles, the first publication on POE was in 1979 by and Beck WC with their paper entitled "Postoccupancy evaluation of a surgical suite." This document describes a successful design of a surgical suite that should include user analysis at all levels. The growth of the publication was somewhat slow until 2009. In the first 30 years (before 2010), fewer POE publications have less than 15 documents published per year. It is worth noting that the number of publications fluctuates throughout the year until 2017. Fig. 2 shows the number of publications on POE since 1979. Based on the evolution of the number of publications on POE, this is no longer the favorite topic of academia.

Fig. 2: The annual trends of POE Publication



Document and Source Types

In POE publications, documents for published records were evaluated based on their document type and source type. Papers based on the originality of the papers, such as conferences, journal articles, or book chapters, are examples of document types. On the other hand, source document types include a journal, conference paper, book chapter, book series, or journal[20, 21]. Table 1 summarises the publications in the domain POE by document type. In total, the POE generates nine kinds of documents. The number of document types such as notes, books, editorials, erratum, and letters is limited (all less than five)

Table 1

Document type of POE publication

Document Type	Total Publication	Percentage (%)
Article	219	57.48
Conference Paper	107	28.08
Book Chapter	25	6.56
Review	23	6.04
Note	3	0.79
Book	1	0.26
Editorial	1	0.26
Erratum	1	0.26
Letter	1	0.26
Total	381	100

There were also five other types of articles identified that emerged from POE research. The majority of papers (242 publications) were published in journals, followed by conference proceedings (92), books (22), book series (15), and professional journals (10). Table 2 summarizes the findings.

Table 2

POE publication on the source type

Source type	Total Publication	Percentage (%)
Journal	242	63.52
Conference Proceeding	92	24.15
Book	22	5.77
Book Series	15	3.94
Trade Journal	10	2.62
Total	381	100

Subject Area

This study also organized the published documents by topic. Most post occupancy evaluation studies are from engineering, natural sciences, environmental sciences, energy, and computer sciences. Figure 3 below illustrates the other topics that have been addressed in research on post-occupancy evaluation.

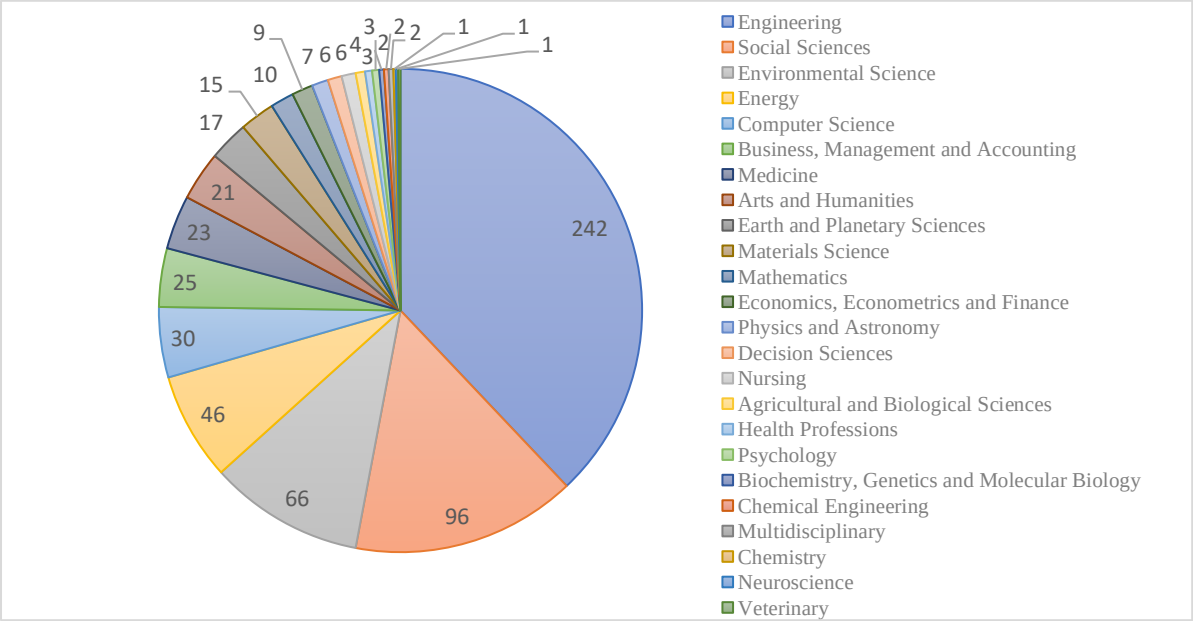


Fig. 3: POE publication on the subject area

Languages

Table 3 demonstrates that most of the documents discovered (almost 90%) were published in English, with 369 totals. Turkish, Chinese, Japanese, French, Italian, and Portuguese translations were also available for some publications. Two publications were published in dual languages.

Table 3

Languages used for POE publication

Language	Total publication	Percentage (%)
English	369	96.34
Chinese	4	1.04
Turkish	4	1.04
Japanese	3	0.78
French	1	0.26
Italian	1	0.26
Portuguese	1	0.26
Total	383	100

Author name and affiliation

The analysis results show that during 1979-2020, 159 authors were involved in 381 publications in the study POE. From the details, Hassanain, M.A., was the most prolific author with ten publications, and Sanni-Anibire, M.O., with five articles. Fig. 4 shows the top 10 authors who contributed the most POE and affiliation documents. Saudi Arabia has two top authors.

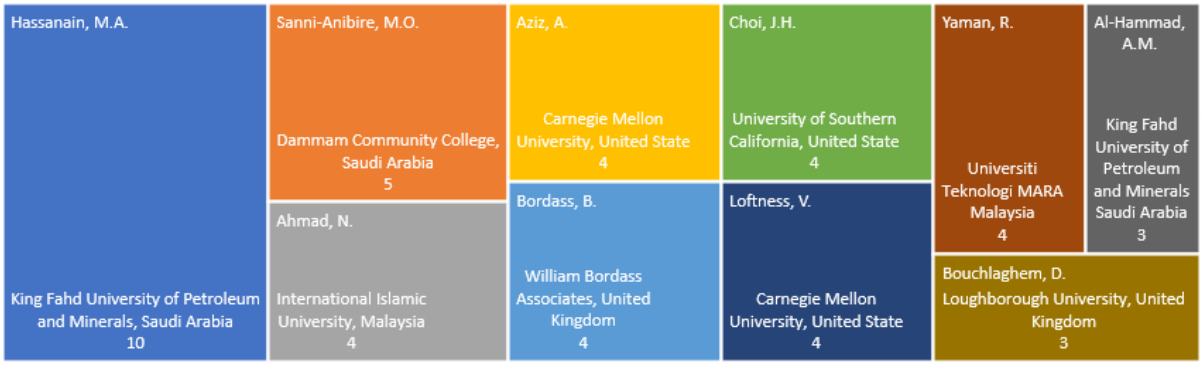


Fig. 4: Top 10 author name and affiliation

Productive Country

This paper also examined the dissemination of the work based on the origin of the author. Most studies were from the United States (86), followed by the United Kingdom. (69), China (28), Canada (20), and Malaysia (18). The summary is shown in figure 5.

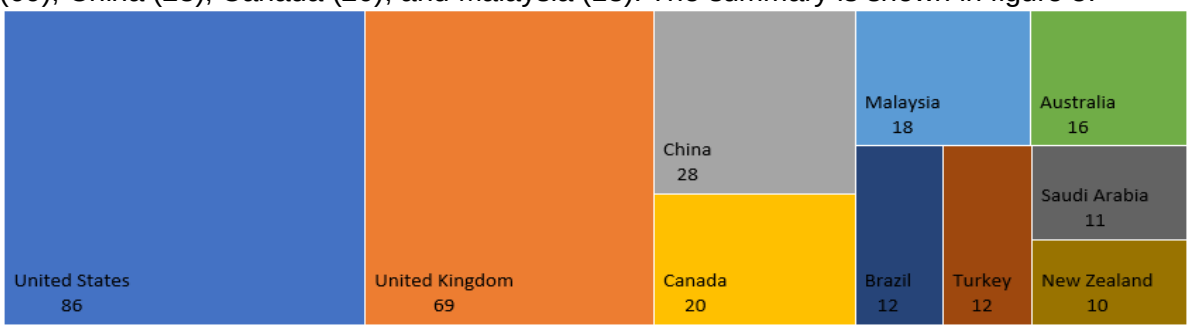


Fig. 5: Top 10 of POE publication by country

Productive Institution

The study also identified the most productive domain POE of organizations using the author's affiliation. The results show that 160 institutions publish POE studies. The top 10 organizations contributing to research on POE are tabulated in Figure 6. Regarding the total number of publications and percentage, King Fahd University of Petroleum and Minerals from Saudi Arabia is the most prolific institution with ten publications, followed by the University of Reading, United Kingdom, Universiti Teknologi MARA, Malaysia with eight publications each. Georgia Institute of Technology, United States, and Victoria University of Wellington (New Zealand) are ranked fourth and fifth with six publications. In addition, three of the most prolific top 10 institutions are from the United Kingdom and the United States, and two are from Malaysia.

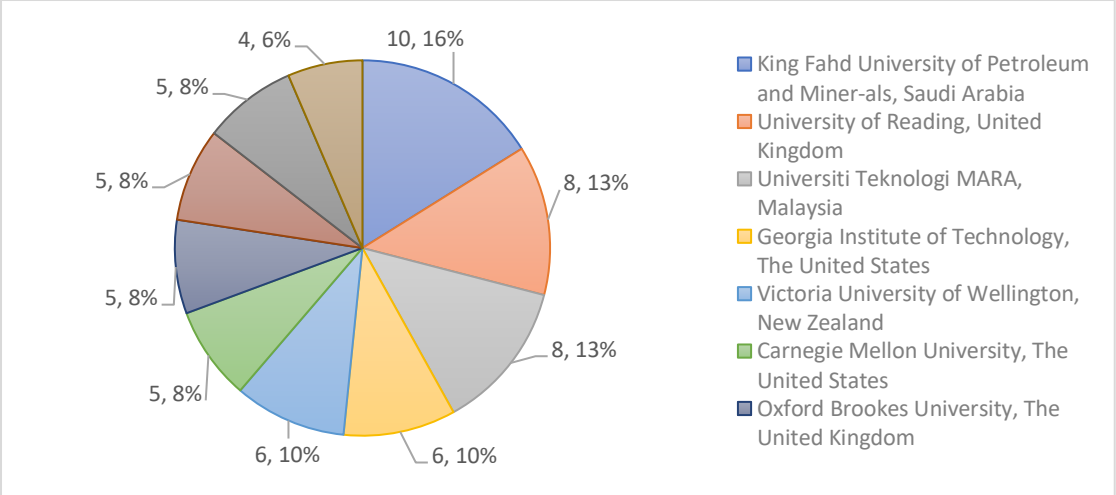


Fig. 6: Productive institution on POE publication

Keywords

This study also analyzes the keywords used to categorize some specific areas covered in the survey POE. Table 4 contains a summary of the top ten terms utilized in the POE research.

Table 4

Top 10 keywords used in POE publication

Keywords	Total	Percentage (%)
Post Occupancy Evaluation	165	43.31
Post-occupancy Evaluation	92	24.15
Surveys	71	18.64
Sustainable Development	54	14.17
Buildings	46	12.07
Postoccupancy Evaluation (POE)	46	12.07
Architectural Design	35	9.19
Energy Utilization	33	8.66
Energy Efficiency	32	8.40
Housing	31	8.14

For keyword analysis, this study first created the word cloud for the author's keywords using WordSift (https://wordsift.org). With the maximum number of 100 words and scaling √n, the result of the word cloud is shown in Fig.6. The figure shows the 100 most used words (or parts of keywords) from the published article on POE. The size of each word represents the total number of occurrences of the keywords. In addition to the keyword used to search the document's title, the word cloud also shows other emerging keywords such as design, evaluation, performance, interior, energy, building, quality, occupancy, management, hospital, and construction. Additional keywords are relatively small, but it is a fact that the words have been used to fit the theme of POE. It is essential to highlight that all the words generated in Fig. 7 are the trending words used in POE research. Thus, we can predict that future research on POE will focus on these keywords.

Fig. 7: Word cloud of the author keywords

Citation analysis

In addition to the above analysis, this study also performs a citation analysis. Table 5 below shows the 15 most cited articles (based on the number of citations) from the Scopus database. Each year from 1979-2020 is given by author, year, title, country and institution, journal and discipline, total citation, and average citation per year. The number of author citations is different from the number of articles.

Table 5

Top-15 cited publication

No	Author/ Year/ Title	Country/ Institution	Journal/ Discipline	Cites	Cites Per Year
1	[1]Predicted vs. actual energy performance of non-domestic buildings: Using post-occupancy evaluation data to reduce the performance gap.	The United Kingdom/ Loughborough University	Applied Energy/ Energy, Engineering and Environmental Science	375	46.88
2	[15]Post-occupancy evaluation: how to make buildings work better	The United States/ University of Cincinnati	Facilities/ Engineering & Social Sciences	173	6.92
3	[21] Post-occupancy evaluation: Benefits and barriers	Canada/ British Columbia Buildings Corp.	Building Research and Information/ Engineering	130	6.84

4	[12]Post-occupancy evaluation: An inevitable step toward sustainability	Israel/ Ben Gurion University of the Negev (BGU)	Advances in Building Energy Research/ Engineering	116	10.55
5	[19]Post-occupancy evaluation - Where are you?	The United Kingdom/ Eden Centre	Building Research and Information/ Engineering	114	6
6	[22]Post-occupancy evaluation and field studies of thermal comfort	The United Kingdom/ Oxford Brookes University	Building Research and Information/ Engineering	107	7.13
7	[21]Post-Occupancy Evaluation: An Overview	The United States/ Georgia Institute of Technology	Environment and Behavior/ Environmental Science	104	2.6
8	[23]Making feedback and post-occupancy evaluation routine 2: Soft Landings - Involving design and building teams in improving performance	The United Kingdom/ Darwin Consultancy	Building Research and Information/ Engineering	97	6.47
9	[24]Post-occupancy evaluation of healing gardens in a pediatric cancer centre	The United States/ San Diego State University	Landscape and Urban Planning/ Environmental Science	95	6.33
10	[25]Making feedback and post-occupancy evaluation routine 1: A portfolio of feedback techniques	The United Kingdom/ Usable Buildings Trust	Building Research and Information/ Engineering	93	6.2
11	[26]Post-occupancy evaluation of 20 office buildings as basis for future IEQ standards and guidelines	The United States/ Missouri University of Science and Technology	Energy and Buildings/ Engineering	92	11.5
12	[27]Completing the missing link in building design process: Enhancing post-occupancy evaluation method for effective feedback for building performance	Turkey/ Özyeğin University	Building and Environment/ Engineering, Environmental Science & Social Sciences	73	11.46
13	[28]Post-occupancy evaluation: Purpose, benefits, and barriers	The United Kingdom/ Queen's University Belfast	Facilities/ Engineering & Social Sciences	70	6.36
14	[29]The development of robust methods of post occupancy evaluation	The United Kingdom/ University of Plymouth, Plymouth	Facilities/ Engineering & Social Sciences	62	4.43
15	[30]Post occupancy evaluations relating to discomfort glare: A study of green buildings in Brisbane	Australia/ Queensland University of Technology	Building and Environment/ Engineering, Environmental Science & Social Sciences	59	8.43

Conclusions

This paper describes a bibliometric analysis to gain insight into the trends and contributions of the POE literature. The Scopus database was used to collect all research papers that are either "post-occupancy evaluation" OR "post occupancy evaluation" OR "POE" OR "postoccupancy evaluation." This study shows that research on this topic began in 1979 and increased in 2018 with the most prominent publication.

The geographical distribution of the literature shows that the United States has the most publications compared to other developed countries such as the United Kingdom and China. Therefore, the majority are written in English. Our findings show that applying the concept of post-evaluation in the subject matter of papers is widely used across multi-disciplines, with the term "survey" being another buzzword used to analyze POE.

Evaluation is a general term; some researchers may use a synonymous keyword such as 'assessment,' 'appraisal,' or 'analysis.' More keywords related to evaluation may lead to more detailed search results, thus increasing the accuracy of the results.

The findings of this study enabled the researchers to address the limitations of the research and identify research gaps for future research in this area. Further analysis of the content of POE by profile and study area is possible. Other factors such as citation, test theory and component, technique and methodology, and significant contribution can split and categorize the paper material.

During the analysis, the database used and the author's search query contained several limitations. Although Scopus is among the most extensive databases, it is essential to emphasize that there are still unindexed papers or journals that other databases may have rejected. In addition, this study focused on the title of the related articles and only on POE -related topics. Additional POE -related literature was omitted that did not have a unique title.

In conclusion, regardless of the limitations, this study contributes to exploring the knowledge of published POE research literature on bibliometric indices by 2020. A complete literature review is highly advised to correctly examine this topic field and address the most critical research concerns.

Acknowledgment

The authors would like to express their gratitude to the HLP, Ministry of Higher Education, Malaysia, and Universiti Kebangsaan Malaysia for funding this research through *Geran Galakan Penyelidikan* (GGP-2019-001) and the Fundamental Research Grant Scheme (FRGS/1/2019/SS08/UKM/02/8). Endless thank you for their support in helping the authors to materialize this study.

References

1. Mustafa, F.A., *Performance assessment of buildings via post-occupancy evaluation: A case study of the building of the architecture and software engineering departments in Salahaddin University-Erbil, Iraq.* Frontiers of Architectural Research, 2017. **6**(3): p. 412-429.DOI: https://doi.org/10.1016/j.foar.2017.06.004.
2. Hay, R., et al., *Post-occupancy evaluation in architecture: experiences and perspectives from UK practice*. Building Research & Information, 2018. **46**(6): p. 698-710.DOI: https://doi.org/10.1080/09613218.2017.1314692.
3. Chiu, L.F., et al., *A socio-technical approach to post-occupancy evaluation: interactive adaptability in domestic retrofit.* Building Research & Information, 2014. **42**(5): p. 574-590.DOI: https://doi.org/10.1080/09613218.2014.912539.
4. Lawrence, R., M. Elsayed, and C. Keime, *Evaluation of environmental design strategies for university buildings.* Building Research & Information, 2019. **47**(8): p. 883-900.DOI: https://doi.org/10.1080/09613218.2019.1652551.

5. Roberts, C.J.C.C.J., et al., *Post-occupancy evaluation: a review of literature. Engineering, Construction and Architectural Management, 26(9), 2084–2106.* . 2019.DOI: https://doi.org/10.1108/ECAM-09-2018-0390.
6. Al Horr, Y., et al., *Occupant productivity and office indoor environment quality: A review of the literature.* Building and environment, 2016. **105**: p. 369-389.DOI: https://doi.org/10.1016/j.buildenv.2016.06.001.
7. Hashim, A.E., H. Aksah, and S.Y. Said, *Performance Review through Post Occupancy Audit on Refurbished Listed Public Building in Kuala Lumpur.* Journal of ASIAN Behavioural Studies, 2018. **3**(7): p. 75-84.DOI: https://doi.org/10.21834/jabs.v3i7.260.
8. Göçer, Ö., Y. Hua, and K. Göçer. *A BIM-GIS integrated pre-retrofit model for building data mapping.* Springer.DOI: https://doi.org/10.1007/s12273-016-0293-4.
9. Fabregat-Aibar, L., et al., *A bibliometric and visualization analysis of socially responsible funds.* Sustainability, 2019. **11**(9): p. 2526.DOI: https://doi.org/10.3390/su11092526.
10. Aksah, H., et al., *Sustainable Historical Government Building Assessment Via Post Occupancy Evaluation (POE), Vol 3, 45–54.* Research Journal, 2013: p. 45.
11. Khair, N., et al., *Post occupancy evaluation of physical environment in public low-cost housing.* Jurnal Teknologi, 2015. **75**(10).DOI: https://doi.org/10.11113/jt.v74.4519.
12. Leaman, A., F. Stevenson, and B. Bordass, *Building evaluation: practice and principles.* Building Research & Information, 2010. **38**(5): p. 564-577.DOI: https://doi.org/10.1080/09613218.2010.495217.
13. Preiser, W.F.E., *The evolution of post-occupancy evaluation: Toward building performance and universal design evaluation.* Learning from our buildings a state-of-the practice summary of post-occupancy evaluation, (pp. 9–22). , 2001.
14. Li, P., T.M. Froese, and G. Brager, *Post-occupancy evaluation: State-of-the-art analysis and state-of-the-practice review.* Building and Environment, 2018. **133**: p. 187-202.DOI: https://doi.org/10.1016/j.buildenv.2018.02.024.
15. Preiser, W.F.E., *Post-occupancy evaluation: how to make buildings work better.* facilities, 13(11), 19–28., 1995.DOI: https://doi.org/10.1108/02632779510097787.
16. Woon, N.B., et al., *Critical success factors for post occupancy evaluation of building performance: A literature analysis.* Jurnal Teknologi, 2015. **74**(2).DOI: https://doi.org/10.11113/jt.v74.4521.
17. Preiser, W. and J. Vischer, *Assessing building performance, 42-242.* 2006: Routledge.DOI: https://doi.org/10.4324/9780080455228.
18. Aidi Ahmi, R.M., *Bibliometric analysis of global scientific literature on web accessibility.* Nternational Journal of Recent Technology and Engineering (IJRTE), 7(6), 250–258., 2019.
19. Cobo, M.J., et al., *Science mapping software tools: Review, analysis, and cooperative study among tools.* Journal of the American Society for information Science and Technology, 2011. **62**(7): p. 1382-1402.DOI: https://doi.org/10.1002/asi.21525.
20. Sweileh, W.M., et al., *Bibliometric analysis of worldwide scientific literature in mobile-health: 2006–2016.* BMC medical informatics and decision making, 2017. **17**(1): p. 1-12.DOI: https://doi.org/10.1186/s12911-017-0476-7.
21. Zimring, C.M. and J.E. Reizenstein, *Post-occupancy evaluation: An overview.* Environment and behavior, 1980. **12**(4): p. 429-450.DOI: https://doi.org/10.1177/0013916580124002.
22. Nicol, F. and S. Roaf, *Post-occupancy evaluation and field studies of thermal comfort.* Building research & information, 2005. **33**(4): p. 338-346.DOI: https://doi.org/10.1080/09613210500161885.
23. Way, M. and B. Bordass, *Making feedback and post-occupancy evaluation routine 2: Soft landings–involving design and building teams in improving performance.* Building Research & Information, 2005. **33**(4): p. 353-360.DOI: https://doi.org/10.1080/09613210500162008.
24. Sherman, D.L., et al., *Neurofascins are required to establish axonal domains for saltatory conduction.* Neuron, 2005. **48**(5): p. 737-742.DOI: https://doi.org/10.1016/j.neuron.2005.10.019.
25. Bordass, B. and A. Leaman, *Making feedback and post-occupancy evaluation routine 1: A portfolio of feedback techniques.* Building Research & Information, 2005. **33**(4): p. 347-352.DOI: https://doi.org/10.1080/09613210500162032.
26. Choi, M.J., A. Torralba, and A.S. Willsky, *Context models and out-of-context objects.* Pattern Recognition Letters, 2012. **33**(7): p. 853-862.DOI: https://doi.org/10.1016/j.patrec.2011.12.004.
27. Göçer, Ö., Y. Hua, and K. Göçer, *Completing the missing link in building design process: Enhancing post-occupancy evaluation method for effective feedback for building performance.* Building and Environment, 2015. **89**: p. 14-27.DOI: https://doi.org/10.1016/j.buildenv.2015.02.011.
28. Hadjri, K. and C. Crozier, *Post-occupancy evaluation: purpose, benefits and barriers.* Facilities, 2009.DOI: https://doi.org/10.1108/02632770910923063.

29. Turpin-Brooks, S. and G. Viccars, *The development of robust methods of post occupancy evaluation.* Facilities, 2006.DOI: https://doi.org/10.1108/02632770610665775.
30. Hirning, M.B., et al., *Post occupancy evaluations relating to discomfort glare: A study of green buildings in Brisbane*. Building and Environment, 2013. **59**: p. 349-357.DOI: https://doi.org/10.1016/j.buildenv.2012.08.032.