ACCESSIBILITY AND UNIVERSAL DESIGN IN THE BUILT ENVIRONMENT: A BIBLIOMETRIC ANALYSIS

Zuraihana Ahmad Zawawi[1]*, Hikmah Kamarudin[2],
Mohd Khazli Aswad Khalid[3], & Mohamad Rachmadian Narotama[4]
*Corresponding Author

[1,2]*College of Built Environment, Universiti Teknologi MARA,*
40450 Shah Alam, Selangor, Malaysia
[3]*Department of Built Environment & Technology, College of Built Environment,*
Universiti Teknologi MARA, Perak Branch, Seri Iskandar Campus,
32610 Seri Iskandar, Perak, Malaysia
[4]*Centre for Transportation and Logistics Studies, Universitas Gadjah Mada, Jl.*
Kemuning Blok M-3, Sekip, Mlati, Sleman, 55284 Yogyakarta, Indonesia

*zuraihana@uitm.edu.my, hikmah@uitm.edu.my,
khazliaswad@uitm.edu.my, & m.r.narotama@ugm.ac.id

ABSTRACT

Accessibility and the adaptations of universal design in the built environment is an important aspect that affects the quality of life of building users. Thus, this paper aims to study the research evolution on accessibility and universal design in the built environment so that the current and future paradigm can be determined. To achieve the objective, a dataset of documents from Web of Science (WoS), within two decades; from year 2003 until 2023. Based on the keywords used, the study has retrieved a total number of 64 documents for further analysis using various tools. Microsoft Excel was used to conduct the frequency analysis and VOSviewer for data visualization. This study reports the result using standard bibliometric indicators such as the growth of publications, country contribution, preferred journals, top authors, most occurrence keywords, and top cited articles. The findings showed an increasing trend of new research in accessibility and universal design within the field of built environment, with notable contributions from countries such as Australia, Malaysia and the United States of America. The study contributed to a better understanding of the field and is expected

PENERBIT PRESS
UNIVERSITI TEKNOLOGI MARA

to help researchers to identify research areas and appropriate journals for publishing research related to accessibility and universal design in the built environment.

Keywords: *Accessibility, Bibliometric Analysis, Built Environment, Universal Design*

INTRODUCTION

Accessibility and universal design are important components that can help to achieve the quality of life of building users, especially in the built environment. The purpose of accessibility is to make spaces can be usable by as many people as possible, regardless of their abilities. This can be achieved by removing physical barriers and making it accessible. The universal design further extends this principle by proposing solutions that aimed to make life easier for everyone through its practical design concept.

As awareness of inclusive environments are growing among society, accessibility and universal design have become interesting research topics, especially in the field of the built environment. This paper aims to provide a quantitative analysis of the evolving of this research topic, with focus on scientific output for nearly two decades (2003 till 2023).

Previously, in a bibliometric analysis in accessibility by Shi et al. (2020), they have identified 6 themes in wide range of accessibility-related research: Transport Network Performance Assessment, Demand Modelling, Vulnerability, Social Equity, Travel Behaviour and Autonomous Vehicles. However, this paper only focused on the accessibility and universal design in the built environment with the aid of bibliometric analysis technique.

LITERATURE REVIEW

The application of accessibility and universal design in built environment can give hope to people with disabilities and diverse users by focusing on making space more inclusive for everyone. It aims to create environments that are both practical and fair for all users.

Accessibility

Accessibility is defined as the freedom or ability of people to achieve their basic needs in order to sustain their quality of life (Abdul Rahim, 2015). Inaccessible environments can create barriers that often hinder the full and effective participation of people with disabilities in a society.

Accessibility in the built environment involves the design, construction, management and maintenance of buildings that comply with relevant code standards, guidelines and regulations. Initially, many accessible design components may been designed with disabilities in mind, but the vast majority of accessible improvements to products, fixtures and environments actually end up providing better access to everyone.

There is a handful number of literature on the accessibility and the assessment of accessibility in different types of built environment. However, Yau and Lau (2016) argued that the literature on building accessibility generally suggested that our built environment is far from being disability-inclusive

Universal Design

The term Universal Design (UD) was first introduced by an architect named Ronald L. Mace in 1985 which described the universal design as the concept of designing products and the built environment to serve the needs of people regardless of their age, ability, or status in life. Besides, universal design means the design of products, environments, programs and services to be enjoyed by all individuals, to the greatest extent possible, without the need for renovation or specialized design (Abdul Rahim, 2016; Mace, 1985).

Later, The Centre of Universal Design (1997), has created a list of principles that would be used to define universal design, called The Seven Principles of Universal Design. Table 1 listed the principles of universal design and its description.

Table 1. The Key Principles of Universal Design

UD Principles	Description
Equitable Use	The design is useful and marketable to people with diverse abilities
Flexibility in Use	The design accommodates a wide range of individual preferences and abilities
Simple and Intuitive Use	Use of the is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level
Perceptible Information	The design can communicate its necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities
Tolerance for Error	The design minimizes hazards and the adverse consequences of accident or unintended actions
Low Physical Effort	The design can be used efficiently and comfortably and with a minimum fatigue
Size and Space for Approach and Use	Appropriate size and space are provided for approach, reach, manipulation, and use regardless of user's body size, posture or mobility

Source: (Abdul Rahim, 2016; Kamarudin et al., 2013; Kurniawan, 2010; The Centre of Universal Design, 1997)

These descriptions on universal design principles translate that the designers are not only involved in consideration for usability, but must also incorporate other considerations such as economic, engineering, cultural, gender, and environmental concerns in design phase (Kurniawan, 2010). To solve complex design problems, it is necessary to engage all the competence, creativity, the innovation capacity that the arts of architecture, engineering, design, which can express the design to the greatest extent possible.

METHODOLOGY

This study used bibliometric analytic approaches to achieve its research goals. Bibliometric analysis is an effective method to quantitatively assess academic publications using statistical techniques, consisting of citation analysis and content analysis (Shi et al., 2020; Zhong et al., 2016).

The VOSviewer software was used to construct and evaluate networks of diverse things (documents, authors, sources, and references) connected

by citation, co-citation, co-authorship, or co-occurrence relationships, as well as to create, visualise, and explore bibliographic maps (Van Eck & Waltman, 2021).

The purpose of this paper is to answer the following questions:
1) How was research on accessibility and universal design in the built environment evolved between 2003 and 2023?
2) What are the main contributors (countries, journals, authors) to this research?
3) What is the top-cited articles and most frequently occurring keywords in this area?
4) What are the preferred journals for publishing research related to accessibility and universal design in the built environment?

Bibliometric analysis for this study was performed using the Web of Science (WoS) database in May 2024. Figure 1 which adapted from Zakaria et al., (2021) illustrates the search strategy by adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. This study targeted the accessibility and universal design in the built environment related research from 2003 until 2023. The search string included keywords "accessibility" AND "universal design" AND "built environment" in the topic field. The total number of 85 matching records were identified, of which 21 were excluded during screening. The excluded documents are not truly relevant in targeted field and further manual extraction was conducted and final relevant records of 64 were identified to be included for bibliometric analysis.
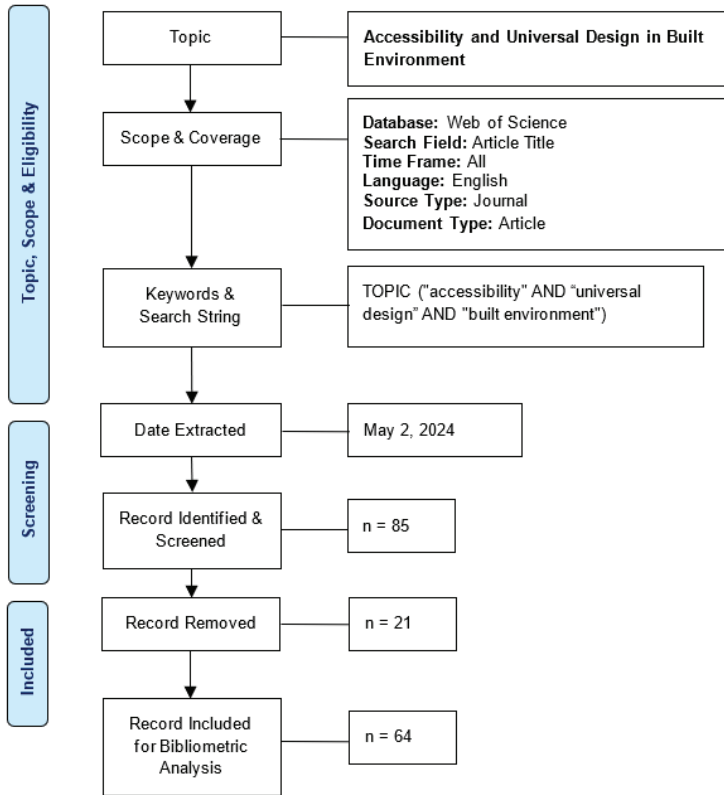
Figure 1: Flow Diagram of the Search Strategy
Source: Adapted from Zakaria et al. (2021)

RESULT

A total final number of 64 documents were identified from the WoS database. This study targeted the accessibility and universal design in the built environment related research from 2003 until 2023. In search of documents which met this topic theme, it was found that there were many documents from other themes in accessibility-related study that were irrelevant included in the initial counting. Manual screening needs to be conducted to exclude about one-quarter of them. It was also found that no relevant documents was available for several years. Therefore, the final number of articles that can be analysed was not as much as expected.

Document and Source Type

The document type could be either from journal articles, review articles, proceeding papers or early access articles. Table 2 summarizes the total number of publications depending on the type of document. Journal articles accounted for more than half (33, 51.6%) of the total documents published, followed by proceeding paper (27, 42.2%), review articles (3, 4.69%), and early access articles (1, 1.56%).

Table 2. Document and Source Type

Document Type	Total Publications	Percentage (%)
Journal Article	33	51.6
Proceeding Paper	27	42.2
Review Article	3	4.69
Early Access	1	1.56
Total	64	100.00

Source: Author

Growth of Publications

Examination of the documents based on year of publication help the researcher to observe the growth patterns and popularity of the subject over time (Ahmi & Mohamad, 2019). By referring to Table 3 and Figure 2, the highest productivity was recorded in 2016, with as total of 11 documents, and in 2009 and 2005, recorded only one publication in this relevant field. However, in year 2015, 2010, 2008, 2007, 2006, 2004 and 2003, there was no relevant publication recorded.

Table 3. Year of Publications

Year	Total Publications	Percentage (%)	Cumulative Percent (%)
2023	2	3.13	3.13
2022	5	7.82	10.95
2021	9	14.06	25.01
2020	3	4.69	29.70
2019	8	12.50	42.20
2018	9	14.06	56.26
2017	2	3.13	59.39

2016	11	17.19	76.58
2015	0	0	76.58
2014	3	4.69	81.27
2013	4	6.25	87.52
2012	4	6.25	93.77
2011	2	3.13	96.90
2010	0	0	96.90
2009	1	1.56	98.46
2008	0	0	98.46
2007	0	0	98.46
2006	0	0	98.46
2005	1	1.56	100
2004	0	0	100
2003	0	0	100

Source: Author

Figure 2 also illustrates the fluctuations in number of documents recorded from 2003 till 2023. However, it still show a slight improvement and is expected to continue to increase in the coming years.
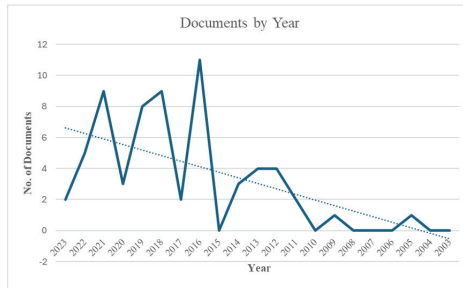

Figure 2. Documents by Year

Language of Documents

From the total retrieved documents, there were only two languages identified which are English and Icelandic. Table 4 shows that most of the documents were published in English (98.44%), and the remaining was in Icelandic language (1.56%).

Table 4. Language Used for Publications

Language	Total Publications	Percentage (%)
English	63	98.44
Icelandic	1	1.56
Total	5	100.00

Source: Author

Preferred Journal

Table 5 lists the top 15 publishing journals on accessibility and universal design research. Studies in Health Technology and Informatics ranked first with 15 publications, followed by Universal Design 2016 "Learning from The Past, Designing for The Future" (9 publications) in second place.

Table 5. Top 15 Publishing Journals on Accessibility and Universal Design Research

Source Title	Total Publication	Percentage (%)
Studies in Health Technology and Informatics	15	23.44
Universal Design 2016 "Learning From The Past, Designing For The Future"	9	14.06
Transforming Our World Through Design Diversity and Education	6	9.38
Journal of Housing and The Built Environment	4	6.25
Procedia Social and Behavioural Sciences	4	6.25
Assistive Technology Research Series	3	4.69
Universal Design 2014 "Three Days of Creativity and Diversity"	3	4.69
ARCHNET IJAR International Journal of Architectural Research	2	3.13
Building and Environment	2	3.13
Disability and Health Journal	2	3.13

Disability and Rehabilitation	2	3.13
Disability Society	2	3.13
Scandinavian Journal of Disability Research	2	3.13
Sustainability	2	3.13
12th International Technology Education and Development Conference	1	1.56

Source: Author

Keyword Analysis

Table 6 shows the top 15 most occurrence author keywords which was universal design. It had the greatest number of occurrence (33, 29.2%), followed by accessibility (29, 25.7%) and built environment (10, 8.8%). The keywords which counted less than 10 times were inclusive design, disability, usability, access, sustainability, architecture, design, barriers, education, design for all, inclusiveness and people.

Table 6. Top 15 Author Keywords

Author Keywords	Cluster (Color)	Occurrences	Percentage (%)
universal design	Dark Blue	33	29.2
accessibility	Dark Blue	29	25.7
built environment	Dark Blue	10	8.8
inclusive design	Light Blue	6	5.3
disability	Light Blue	5	4.4
usability	Purple	5	4.4
access	Purple	4	3.5
sustainability	Purple	4	3.5
architecture	Dark Green	3	2.7
design	Dark Green	3	2.7
barriers	Dark Green	2	1.8
education	Dark Green	2	1.8
design for all	Yellow Green	2	1.8
inclusiveness	Yellow Green	3	2.7
people	Yellow	2	1.8

Source: Author

The keywords were further analysed using VOSviewer software to generate network visualization map of the author keywords. It used blue-green-yellow shades to show the most keywords used in different years. Figure 3 illustrates the visualization map of the author keywords; it is in circle and in the same colour cluster. This indicates the most occurrence keywords within the same year. From the diagram, we can see the initial keywords used in this research area are in purple colour (usability, access and sustainability), and the latest used keywords are in yellow green (design for all and inclusiveness) and yellow colour (people and users).
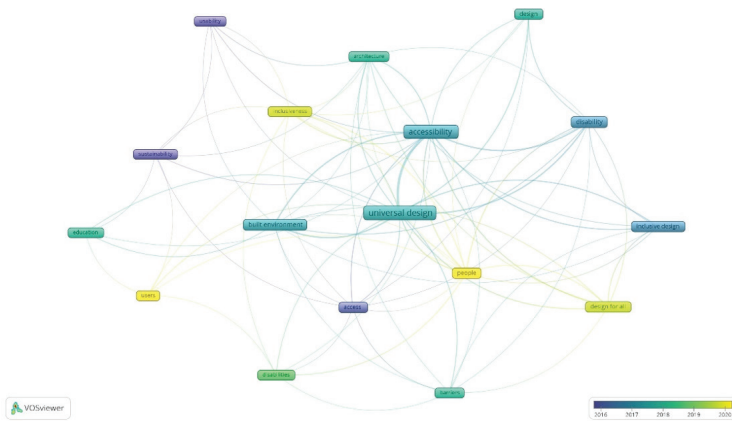

Figure 3. VOSviewer Network Visualization Map Overlay of the Author Keywords

Source: Author

Geographical Distribution of Publications – Most Influential Countries

Researchers from 28 countries have contributed to the publication of screened documents. The top 15 countries that contributed to the publications are listed in Table 7. The most influential country was Australia and Malaysia, which ranked first with a total of 7 publications each country (10.9%), followed by the United State of America (9.4%) and Sweden (7.8%).

Table 7. Top 15 Countries Contributed to the Publications

Country	Total Publications	Percentage (%)
Australia	7	10.9
Malaysia	7	10.9
USA	6	9.4
Sweden	5	7.8
Canada	4	6.3
Norway	4	6.3
Turkey	4	6.3
Belgium	3	4.7
England	3	4.7
India	3	4.7
Italy	3	4.7
South Africa	3	4.7
Brazil	2	3.1
Finland	2	3.1
New Zealand	2	3.1

Source: Author

Authorship

The 15 most productive authors, which only consider the first author with more than 5 citations, are listed in Table 8. The most productive author recorded in this study area was Rob Imrie, ranked first with 4 publications and 79 citations. Valerie Watchorn ranked second with 4 publications and 49 citations. Followed by Asiah Abdul Rahim, with 3 publications and 14 citations.

Table 8. Top 15 Most Productive Authors (First Author) With More Than 5 Citations

Author's Name	No. of Documents	No. of Citations
Imrie, Rob	4	79
Watchorn, Valerie	3	49
Abdul Rahim, Asiah	3	14
Ang, Susan	2	43
Hitch, Danielle	2	43
Tucker, Richard	2	28

Abd Samad, Nur Amirah	2	5
Egilson, Snaefridur Thora	2	5
Jonasdottir, Sigrun Kristin	2	5
Marin-Nicholas, Jose	2	5
Calder, Allyson	2	36
Bashiti, Alaa	2	9
Baibarac, Corelia	2	9
Flood, Nuala	2	9
Byrne, Aimee	2	9
Byrne, Niall	2	9

Source: Author

Co-authorship

Mapping with the VOSviewer software to present co-authorship showed the authors, which have common publications in this research area, is shown in Figure 4. Only four of the authors are also listed in the top 15 most productive authors which are Baibarac, Corelia; Flood, Nuala; Byrne, Aimee; and Byrne, Niall.

Figure 4. VOSviewer Visualization Overlay of Co-authorship

Citation Analysis

The 15 top cited articles in the field of accessibility and universal design in built environment are listed in Table 9. Imrie, R. owns the highest

number of citations article titled "Universalism, Universal Design and Equitable Access to the Built Environment" from year 2012. It received a total of 112 citations and was the most impactful article based on the citations per year (9.3).

Table 9. Top 15 Most Cited Articles

Authors	Title	Year	Citations	Citations Per Year
Imrie, R.	Universalism, Universal Design and Equitable Access to the Built Environment	2012	112	9.3
Egilson, S.T., Jonasdottir, S.K.	Universal Design: A Guide for Equality and Social Participation	2021	73	24.3
Lid, I.M., Solvang, P.K	(Dis)ability and the Experience of Accessibility in the Urban Environment	2016	53	6.6
Heylighen, A., Van der Linden, V., Steenwinkel, I.	Ten Questions Concerning Inclusive Design of the Built Environment	2017	50	7.1
Hamraie, A.	Universal Design and the Problem of "Post Disability" Ideology	2016	42	5.3
Calder, A., Sole, G., Mulligan, H.	The Accessibility of Fitness Centres for People with Disabilities: A Systematic Review	2018	36	6
Li, Y., Hsu, J.A., Fernie, G.	Aging and the Use of Pedestrian Facilities in Winter – The Need for Improved Design and Better Technology	2013	31	2.8
Yiing, C.F., Yaacob, N.M., Hussein, H.	Achieving Sustainable Development: Accessibility of Green Buildings in Malaysia	2013	26	2.4
Zallio, M., Clarkson, P.J.	Inclusion, Diversity, Equity and Accessibility in the Built Environment: A Study of Architectural Design Practice	2021	23	7.6
Watchorn, V., Hitch, D., Grant, C., Tucker, R., Aedy, K., Ang, S., Frawley, P.	An Integrated Literature Review of the Current Discourse Around Universal Design in the Built Environment – Is Occupation the Missing Link?	2021	22	7.3
Hitch, D., Larkin, H., Watchorn, V., Ang, S.	Community Mobility in the Context of Universal Design: Inter-professional Collaboration and Education	2012	21	1.8
Kadir, S.A., Jamaludin, M.	Applicability of Malaysian Standards and Universal Design in Public Buildings in Putrajaya	2012	19	1.6
Evcil, A. N.	Raising Awareness About Accessibility	2012	15	1.3

Ormerod, M.G., Newton, R.A.	Moving Beyond Accessibility: The Principles of Universal (Inclusive) Design as A Dimension in nD Modelling of the Built Environment	2005	13	0.7
Meshur, H. F. A.	Accessibility For People With Disabilities in Urban Spaces: A Case Study of Ankara, Turkey	2013	11	0.92

DISCUSSION

From the 64 documents which were analysed, majority of the document types were from journal articles and proceeding paper which accounts for 51.6% and 42.2% respectively. In terms of publication language, English is undeniably the most preferred (98.44%) since it is the universal language worldwide.

The Evolvement of Research on Accessibility and Universal Design in the Built Environment

The low number of relevant publications recorded for this study topic may indicate that this field are relatively less popular compared to any other research field in the built environment. The use of articles only from WoS database for this study was also the reasons why a small number of publications can be retrieved.

Main Contributors (Countries, Journals, Authors)

Researchers from Australia and Malaysia have the same numbers of total publication, which ranked first and second in top 15 countries, contributed to the publications. Meanwhile, Valerie Watchorn and Asiah Abdul Rahim were the most productive authors for this research field which produced three documents respectively. Finally, the top journals which contributed to the publication of research for this topic were the Studies in Health Technology and Informatics with 15 publications. The Universal Design 2016 "Learning from the Past, Designing for the Future" ranked second with 9 publications.

Top-cited Articles and Most Occurring Keywords

In addition, universal design, accessibility, and built environment were the most occurrent keywords recorded since the search string was based on these keywords. The other keywords which rank slightly below these keywords are "inclusive design", "disability" and "usability".

The first rank of most cited article was also rank first of most productive authors. The article titled "Universalism, Universal Design and Equitable Access to the Built Environment" by Rob Imrie in 2012, currently have a total of 112 citations. This article had almost all the keywords for this research topic. In addition, the second most cited article "Universal Design: A Guide for Equality and Social Participation" by Snaefridur Thora Egilson who also listed at eighth rank of the most productive authors.

Most Preferred Journals

From the list of top publishing journals on accessibility and universal design research, the Universal Design is a journal series that published every two years, which currently recorded in 2014 and 2016, may be the best platform for the researchers to publish their articles. The other journals which used any of the keywords of "universal design", built environment" and "disability" were also the most preferred journals to be chosen by the researchers.

CONCLUSION

This study adopted the bibliometric analysis technique to discover research trends and popular issues, thus, it helps to provide more reliable research directions in the future. This study reported the result using standard bibliometric indicators such as the growth of publications, country contribution, preferred journals, top authors, most occurrence keywords, and top cited articles. The findings indicate that between 2003 and 2023, the research on accessibility and universal design within the field of built environment began to emerge. However, the fluctuations in number of documents recorded by year may also show that the interest in research publications for this topic is still relatively low. Nevertheless, these findings gasve a clear picture that researcher have more rooms and opportunities to

explore and produce more articles in the area of accessibility and universal design. The study contributed to a better understanding of the field and is expected to help researchers and educators to identify research areas, developments, quality scientific literature, and appropriate journals to publish their own findings in the area of accessibility and universal design in the built environment. Furthermore, there are opportunities to further investigate the emerging trends and unexplored areas within the field of universal design and the importance of applying universal design principles in a broader context as future research recommendation.

ACKNOWLEDGEMENT

FUNDING

AUTHOR CONTRIBUTIONS

All authors contributed to the conceptualization of the study. All authors also have read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare there is no conflict of interest.

REFERENCES

Abdul Rahim, A. (2015). Universal Design, Accessibility & Social Responsibility in the Built Environment. *Seminar Hari Tandas Sedunia 2015 Peringkat Kebangsaan* .

Abdul Rahim, A. (2016). *Application of Universal Design.* Access Audit In The Built Environment 2016.

Ahmi, A., & Mohamad, R. (2019). Bibliometric analysis of global scientific literature on web accessibility. *International Journal of Recent Technology and Engineering, 7*(6), 250–258.

Kamarudin, H., Muhamad Ariff, N. R., Wan Ismail, W. Z., Bakri, A. F., & Ithnin, Z. (2014). Malaysian scenario on access and facilities for persons with disabilities: A literature review. *MATEC Web of Conferences*, 15, 1–7. https://doi.org/10.1051/matecconf/20141501019.

Kurniawan, H. (2010). Universal Mosque Design. *The 3rd International Conference for Universal Design in HAMAMATSU*, 30, 10.

Mace, R. L. (1985). *Ronald L. Mace Papers* 1974-1998. Retrieved from: https://www.lib.ncsu.edu/findingaids/mc00260/summary.

Shi, Y., Blainey, S., Sun, C., & Jing, P. (2020). A literature review on accessibility using bibliometric analysis techniques. *Journal of Transport Geography, 87*(5501120011), 0–21. https://doi.org/10.1016/j.jtrangeo.2020.102810.

The Centre of Universal Design, N. C. S. U. (1997). *The principles of Universal Design.* North Carolina State University. http://www.ncsu.edu/.

Van Eck, N. J., & Waltman, L. (2021). *Manual VOSviewer.* Univeristeit Leiden, January, 54.

Yau, Y., & Lau, W. K. (2016). Property management, disability awareness and inclusive built environment. *Property Management, 34*(5), 434–447. https://doi.org/10.1108/PM-09-2015-0044.

Zakaria, R., Ahmi, A., Ahmad, A. H., & Othman, Z. (2021). Worldwide

melatonin research: a bibliometric analysis of the published literature between 2015 and 2019. *Chronobiology International, 38*(1), 27–37. https://doi.org/10.1080/07420528.2020.1838534.

Zakaria, R., Ahmi, A., Ahmad, A. H., Othman, Z., Azman, K. F., Ab Aziz, C. B., Ismail, C. A. N., & Shafin, N. (2021). Visualising and mapping a decade of literature on honey research: a bibliometric analysis from 2011 to 2020. *Journal of Apicultural Research, 60*(3), 359–368. https://doi.org/10.1080/00218839.2021.1898789.

Zhong, S., Geng, Y., Liu, W., Gao, C., & Chen, W. (2016). A bibliometric review on natural resource accounting during 1995–2014. *Journal of Cleaner Production*, 139, 122–132. https://doi.org/10.1016/j.jclepro.2016.08.039.