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RESEARCH TRENDS ON MULTIMODAL ASSESSMENT IN SCIENCES LEARNING: BIBLIOMETRICS ANALYSIS

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Abstract

This study aims to conduct a bibliometric analysis to obtain the current emerging trends in multimodal assessment (MMA) for science learning namely the annual development, contributions of countries, organizations, and co-occurrence of keywords on MMA. The data was extracted from Scopus for the timespan of 1981-2022 and screened to result in 158 documents that met the criteria. Data were analysed by Microsoft Excel, VOSviewer, and Bibliometrics. The productivity and reputation of MMA in science learning increased over time, although there was a gap in the period (1982-1990). Additionally, the citation number of MMA in science learning has not shown a satisfactory level. Institutions in the USA outperformed the number of publications. Most authors publish papers through intra-collaboration countries The trending topic of the field is artificial intelligence. Therefore, MMA-related research is directed at the integration of digital technologies.

Keywords: Assessment, Bibliometrics, Chemistry, Multimodality.

1. Introduction

Science learning is one of important subject [1-6]. It is closely related to multimodality; instructors and students use pictures and writing to explain physical phenomena [7]. Developing knowledge and practical encompass activities with representational forms to depict models and represent concepts [8]. Multimodality is essential in responding to challenges related to the broader range of "new" texts and resources, digital and mobile technology [9]. The assessment constructions used should accommodate the various ways students express their understanding. Assessment ought to be approached as a process of reasoning from evidence generated by students as part of the assignment. It likewise influences students' perspectives in seeing or judging themselves as learners [10]. Presently, multimodal assessment (MMA) is considered part of science learning because it relates to the need for digital visualization, animations, simulations, and interactive models to represent scientific knowledge and processes in the classroom [11]. It can be alternative completion to the weaknesses arising from a unimodal assessment (writing) that are less able to develop students' abilities to share, criticize and build knowledge following the academic environment in tertiary education [12].

Previous studies have shown that there are several challenges regarding the implementation of MMA. Students' engagement in multimodal is limited to the superficial aspects of technology [9]. Device preparation is crucial because it relates to the consumption of additional resources from the organization [13]. The quantification rapidity of student responses based on reasoning quality also needs to be considered in a written assessment [14] related to the assessment technique criteria and composition [15]. Besides that, it will be required to recognize the modalities group that proposes the outstanding synergistic merit because some modalities combinations overlap in diagnostic power. In contrast, others reveal a significant complementarity [7].

Therefore, the challenges in constructing MMA provide opportunities for further studies. It is in line with growing attention to multimodal practices developing for all generations in both formal and informal social contexts. To get clarity on the future role of MMA in science learning, it is crucial to obtain a better understanding of the comprehensive picture and emerging trends of MMA-related research in science learning. However, based on the literature, there is no report on the bibliometric analysis of MMA.

Bibliometric analysis is an admirable and conscientious method for finding out and analysing large volumes of scientific data. It is a quantitative methodology to recognize the literature's volume and growth pattern or definite emerging research. The novelty of this study is helping create an exhaustive database of MMA in science learning and analysing the relationships and structural models for the research fields. Furthermore, this study aims to conduct a bibliometric analysis to obtain the current emerging trends in MMA for science learning namely the annual development, contributions of countries, organizations, and co-occurrence of keywords on MMA.

2. Methodology

The study's data was collected using the Scopus database on 20 January 2023. Scopus covers many documents [16], has consistency in journal indexing, and transferable scope, and is arduous to manipulate citation counting. The data exploration use subject-related search, including title, abstract, and keywords. The publication first appeared in 1981. The topic search used Boolean Logic and it selected 167 documents. Among the total publications, the five main document types were article (n = 82, 51.3%), conference paper (n = 28, 17.5%), conference review (n = 23, 14.4%), book chapter (n = 12, 7.5%), and review (n = 11, 6.9%). The rest documents, like the book, data paper, and short survey, were less than 3%. Moreover, the data paper and short survey were excluded since the content did not match the study of science learning. In consequence, the records exported and analysed were 158. The steps of article retrieval and analysis are shown in Fig. 1.

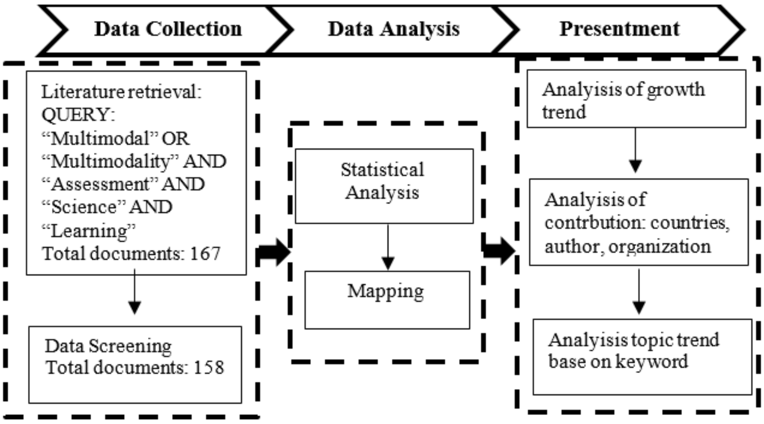

Fig. 1. The research flow of bibliometric analysis of MMA in science learning.

Three research tools are applied to analyse data; Microsoft Excel, VOSviewer, and Bibliometrics. Microsoft Excel was employed to help simplify statistical analysis and graphing, such as compiling the annual numbers of articles, type of research, and the most prolific authors. VOSviewer was utilized to cluster publications and to analyse the resulting clustering solutions. At the same time, Bibliometrics is used to elaborate a more descriptive visual analysis of relevant data. It was handy to figure out the link between the terms, authors, and countries. Detailed information for the VOSviewer is explained elsewhere [17].

3. Result and Discussion

The annual developments of the research field in the period 1981-2022 are revealed in Fig 2. The blue area represents the annual number of total publications (TP), and the yellow represents the mean entire citation per year (MTCY). It can be seen that the publications in the first 25 years are flat, with just one publication every year; there was even a long hiatus between 1982-1990. Starting in 2010, it was exponential growth in the number of publications on the topic, and it reached a maximum number in 2022 with 26 documents. Immersion of MMA in science learning concurrent with the first phase of digital technology development in education (the 1980s). Teachers did not have sufficient technical knowledge of computers [18], and this also explains the vacuum of research on this topic for several periods.

While MTCY shows yearly fluctuations, in the early research stage, the number of citations is deficient. The concept of MMA in science learning is not mature. Consequently, no papers had significant influence in some years. In 2007, MTCY reached the highest value (3.18), indicating that the documents published in the period had a high impact, triggering the establishment of the field of MMA. The development trends of the study can also be explored from the national perspective. Documents issued by authors from multi-countries are computed in the output of all relevant countries. The distribution of production papers by the top 10 most productive countries is presented in Table 1. In the collection data period, academics from 31 countries redounded papers related to MMA in science learning. Out of 158 documents, the USA has the highest number of publications on the topic. It is directly proportional to the number of the corresponding author. Other countries experienced a similar pattern; the more the number of related authors, the greater the number of country productivity levels in publications.

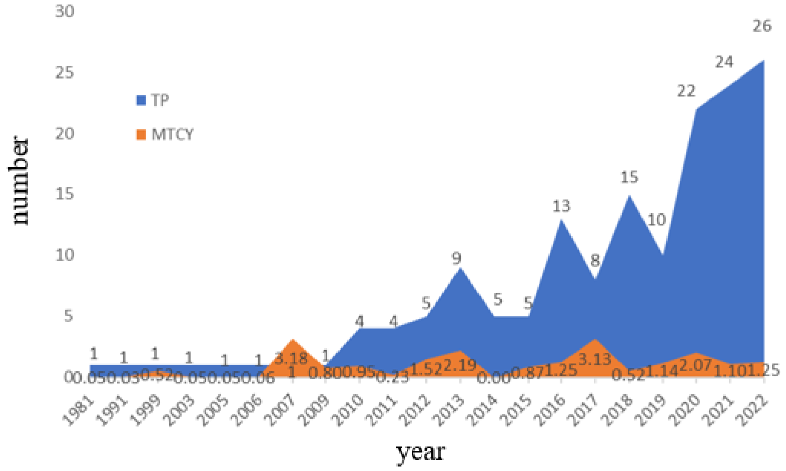

Fig. 2. Annual scientific production.

When discussing collaboration between countries, most papers published by US scholars just embraced domestic colleagues (intra-collaboration country), indicated by the SCP ratio which is much higher than the MCP. China and Australia have almost equal publications, followed by Germany. When the citation number per article counts publication productivity of the country, the USA ranked first, followed by Australia, UK, and Norway. Table 1 also shows that there is no correlation between citation quantity and the number of country productivity, corresponding author, and collaboration. The number of citations from the UK and Norway outperformed China and Germany, even though both countries had fewer publications and corresponding authors. Interestingly, Norway, which does not have publication collaboration inter-countries (MCP = 0), has a relatively large number of citations. There are many factors relating to the number of citations: quality and visibility of papers; novelty, interest, and characteristics of the topics; methodology; and journal impact [19]. Totally 233 research institutes have contributed to publishing articles related to MMA in science learning. As presented in Table 2, Arizona State University and the University of Miami settle in the first and two places in the rank, with 9 and 6 documents, respectively. Among organizations, 8% published more than two papers, 5% published two papers, and the rest (87%) published only one. It represents that MMA in science learning is widespread across organizations and has no agglomeration trends.

Table 1. Production distribution of documents by countries.

Country	Total Publications	Corresponding author	SCP	MCP	Total Citation
US	130	40	36	4	731
China	29	14	13	1	44
Australia	28	8	7	1	123
Germany	23	5	2	3	25
UK	17	4	3	1	54
Canada	12	4	4	0	21
Sweden	8	0	0	0	0
Switzerland	8	3	1	2	11
France	7	1	1	0	8
Norway	6	3	3	0	54

SCP: single country publications
MCP: multiple country publication

Table 2. Top 10 productive research organizations in the field of MMA in science learning.

Affiliation	%
Arizona State University	5.70
University of Miami	3.80
North Carolina State University	3.16
University of California	3.16
Tsinghua University	2.53
The University of California San Francisco	2.53
Auburn University	1.90
Australian Catholic University	1.90
Bilkent University	1.90
Chinese Academy of Medical Sciences, Peking Union Medical College	1.90

Compared to the cooperation network of countries, the density of organizational collaboration is higher, which is identified by a few clusters. Figure 3 presents the networking within institutions represented by departments or research centres of the institutions. Among the four clusters, bilateral and multilateral cooperation are characterized by collaboration spanning two or more clusters. School of Education, Deakin University, and Linnaeus University are most active in collaborating with other institutions.

This section examines in detail the actual content of the papers related to MMA in science learning. It is intended to elucidate the development paths and the research focus on the topic. Accordingly, it is crucial to scrutinize the frequencies and evolution of keywords. Firstly, the keyword with similar meanings such as "multimodal" and "multimodality", "school child" and "student", "young adult", and "adolescent" are merged. Afterward, visualization tools are applied to draw keyword networking and topic trend.

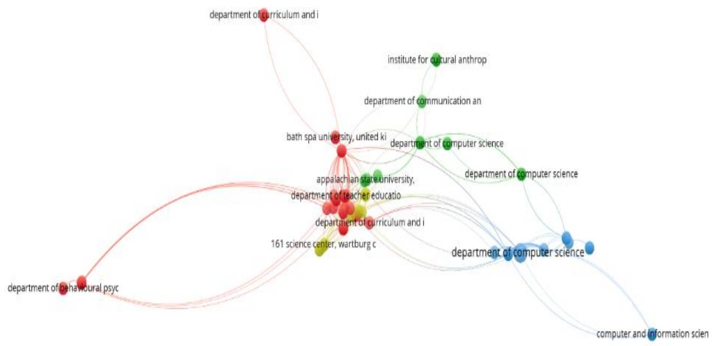

Fig. 3. Networking between institutions.

Figure 4 shows the mapping of keywords co-occurrence and four clusters, indicated by a different colour. The area of the four clusters is relatively similar. Cluster 1 included 32 keywords that mainly focus on multimodality systems and technologies that support them. Cluster 2 had 31 keywords related to gender, learning, and research methodology. Cluster 3 is a compounding 30 keyword focused on computer systems such as algorithms, machine learning, artificial intelligence, deep learning, forecasting, and image analysis. The last cluster comprised 26 keywords associated with gender, age, and cognitive aspects. From the keyword, it can be referred to that MMA in science learning covers the study of humanity and digital technology.

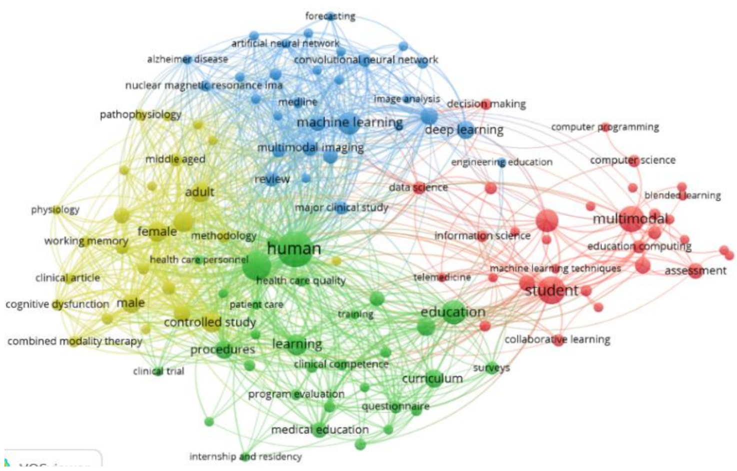

Fig. 4. Keyword co-occurrence analysis.

Trends topic of MMA in science learning changed during the period in which the field developed. Fig. 5 exhibited a trending topic based on the author's keywords along the period. Before 2011, the research focused on treatment outcome. It refers to the measurement of personality aspects or individual abilities before and after the intervention conducted by the researcher. Between 2011 – 2020, the topic trend of the field related to humanity, learning process, and methodology. Recently, the trending topics of MMA in science learning pointed to artificial intelligence and its sub-fields of study (machine learning, deep learning).

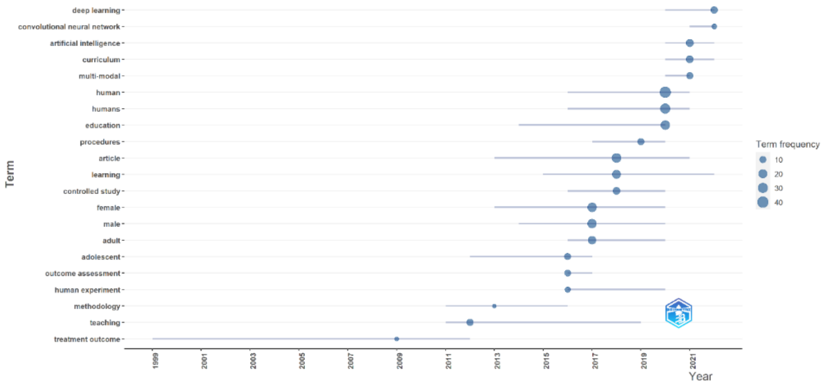

Fig. 5. Trend topics of MMA in science learning.

4. Conclusion

The starting point of research on MMA in science learning was in 1981. After that productivity and reputation of MMA in science learning increased over time. Additionally, the citation number of MMA in science learning has not shown a satisfactory level; the citation rate is low. The country's significant contribution is the US, with the highest number of corresponding authors. Furthermore, most scholars from all countries publish papers through intra- collaboration countries and have not involved co-authors from multi-countries. Besides, publications are not agglomerated within one organization but spread over them. Concerning the author's keyword, the focus of research in the field of MMA in science learning is humanity and digital technology. Recently, the trending topics in the field pointed to artificial intelligence, machine learning, and deep learning. The research finding indicated the significant key points that should be explored further in the topic are related to digital technology.

References

1. Ekamilasari, E.; and Pursitasari, I.D. (2021). Students' critical thinking skills and sustainability awareness in science learning for implementation education for sustainable development. *Indonesian Journal of Multidiciplinary Research*, 1(1), 121-124.
2. Homdijah, O.S.; Budiman, R.A.; Maryanti, R.; Sholihat, L.F.; and Armindony, F.F. (2022). The use of the diorama in science learning about highlands and lowlands for children with autism spectrum disorders. *Indonesian Journal of Multidiciplinary Research*, 2(2), 437-444.
3. Juhanaini, J.; Sholihat, L.F.; Maryanti, R.; Budiman, R.A.; and Armindony, F.F. (2022). Media learning patch board in science learning energy change materials for children with intellectual disabilities. *Indonesian Journal of Teaching in Science*, 2(2), 139-146.
4. Maryanti, R.; Nandiyanto, A.B.D.; Hufad, A.; and Sunardi, S. (2021). Science education for students with special needs in Indonesia: From definition, systematic review, education system, to curriculum. *Indonesian Journal of Community and Special Needs Education*, 1(1), 1-8.

5. Nursaniah, S.S.J. (2023). Analysis of science education curriculum for students with special needs in special schools: The curriculum of 2013. *Indonesian Journal of Community and Special Needs Education*, 3(1), 113-130.
6. Maryanti, R.; and Nandiyanto, A.B.D. (2021). Curriculum development in science education in vocational school. *ASEAN Journal of Science and Engineering Education*, 2(1), 151-156.
7. Smith, A.; Leeman-Munk, S.; Shelton, A.; Mott, B.; Wiebe, E.; and Lester, J. (2018). A multimodal assessment framework for integrating student writing and drawing in elementary science learning. *IEEE Transactions on Learning Technologies*, 12(1), 3-15.
8. Jones, P.; Turney, A.; Georgiou, H.; and Nielsen, W. (2020). Assessing multimodal literacies in science: Semiotic and practical insights from pre-service teacher education. *Language and Education*, 34(2), 153-172.
9. Ryan, J.; Scott, A.; and Walsh, M. (2010). Pedagogy in the multimodal classroom: An analysis of the challenges and opportunities for teachers. *Teachers and Teaching: theory and practice,* 16(4), 477-489.
10. Silseth, K.; and Gilje, Ø. (2019). Multimodal composition and assessment: A sociocultural perspective. *Assessment in Education: Principles, Policy and Practice*, 26(1), 26-42.
11. Van Rooy, W.S.; and Chan, E. (2017). Multimodal representations in senior biology assessments: A case study of NSW Australia. *International Journal of Science and Mathematics Education*, 15, 1237-1256.
12. Ross, J.; Curwood, J.S.; and Bell, A. (2020). A multimodal assessment framework for higher education. *E-learning and Digital Media*, 17(4), 290-306.
13. Gundlach, M.; Baumann, M.; and Engelmann, U.M. (2021). How multimodal examinations can increase sustainable student gain by aligning teaching and assessment. *Current Directions in Biomedical Engineering*, 7(2), 73-76.
14. Sung, S.H.; Li, C.; Chen, G.; Huang, X.; Xie, C.; Massicotte, J.; and Shen, J. (2021). How does augmented observation facilitate multimodal representational thinking? Applying deep learning to decode complex student construct. *Journal of Science Education and Technology*, 30, 210-226.
15. Curwood, J.S. (2012). Cultural shifts, multimodal representations, and assessment practices: A case study. *E-Learning and Digital Media*, 9(2), 232-244.
16. Visser, M.; Van Eck, N.J.; and Waltman, L. (2021). Large-scale comparison of bibliographic data sources: Scopus, Web of Science, Dimensions, Crossref, and Microsoft Academic. *Quantitative Science Studies*, 2(1), 20-41.
17. Al Husaeni, D.F.; and Nandiyanto, A.B.D. (2022). Bibliometric using VOSviewer with publish or perish (using google scholar data): From step-by-step processing for users to the practical examples in the analysis of digital learning articles in pre and post covid-19 pandemic. *ASEAN Journal of Science and Engineering*, 2(1), 19-46.
18. Singh, M.N. (2021). Inroad of digital technology in education: Age of digital classroom. *Higher Education for the Future*, 8(1), 20-30.
19. Tahamtan, I.; Afshar, A.S.; and Ahamdzadeh, K. (2016). Factors affecting number of citations: A comprehensive review of the literature. *Scientometrics*, 107, 1195-1225.