A Scientometric Analysis of Education 4.0 and Massive Open Online Courses in Citespace

Jiyun Chen(✉)

Faculty of Humanities and Social Sciences, Jinling Institute of Technology, Nanjing 211169, China
chenjiyun@jit.edu.cn

Abstract. In the era of globalization, education is available without the time and location limits. Massive Open Online Courses, one of the most popular forms of education, have been introduced for a decade. Utilizing CiteSpace, this research investigated the intellectual base and milestones in the era of Education 4.0, focusing on 4553 documents retrieved from the Web of Science between 2014 and 2022. The findings indicated that tracking strategies for the entire learning process, evaluating the learning effects, and forecasting students' learning behaviors, as well as the influencing variables from consumers' post-consumption perspectives, are high-profile research topics or domains. The main progress has been made by elucidating the field's intellectual structure through recently explored and broadened datasets.

Keywords: Scientometric Analysis · Education 4.0 · MOOCs · CiteSpace

1 Introduction

Education 4.0 represents an innovation through the learning processes and resource implementation (Lasi et al. 2014). Its purpose for reconstructing the design and implementation of today's teaching-learning process for optimizing the effects based on closely integrated innovative technologies under a collaborative and dynamic environment in the education domain (World Economic Forum, 2020). Meanwhile, Massive Open Online Courses (MOOCs) have prevailed for over a decade (Breslow et al. 2013), and their predominant advantages include offering a broad audience through unlimited access to low-cost and dynamic online education (Liyanagunawardena et al. 2013). The emergence of MOOCs echoed the need for lifelong learning under a dynamic environment within a cyber-physical system from a practical perspective.

Using statistical and machine learning methods like Citespace, analyses of bibliographic databases can reveal information about the influence of significant scholarly works and discipline evolution processes within a specific field. Previous literature on Education 4.0 or MOOCs was conducted in isolated investigations. It is essential to identify significant research to understand how these integrated fields promoted mutually and evolved over the years. The present study aims to comprehensively synthesize research themes related to Education 4.0 and MOOCs in higher education domains.

R. B. B. M. Hussain et al. (Eds.): ICHSSR 2023, ASSEHR 765, pp. 1563–1570, 2023.
https://doi.org/10.2991/978-2-38476-092-3_201

2 Education 4.0 and MOOCs

Education 4.0, with its distinctive features marked as dynamic, innovative, and self-directed, is introduced and applied in the higher education sector to promote sustainable and open-access education that produces innovation for achieving the Sustainable Development Goals (SDGs) of the United Nations (Butt et al. 2020). It is generally accepted in academia that Education 4.0 has evolved to the fourth stage, from Education 1.0 to the present Education 4.0 (Chaka, 2022). Global adoption of MOOCs has occurred in parallel with the improvement and innovation of information technology, especially in high education (Meet et al. 2022) [7]. Additionally, MOOCs are seen as an effective medium for promoting lifelong learning, one of the United Nations' Sustainable Development Goals (SDGs) specified for member countries to fulfill by 2030 (Meet and Kala, 2021) [8].

3 Methods

3.1 Data Collection

Bibliographic records were retrieved from the Web of Science Core Collection, incorporating Social Sciences Citation Index (SSCI) and Science Citation Index Expanded (SCIE). After a series of topic search queries and filtering out less representative record types such as proceedings papers and notes, the 4553 bibliographic records of the types of Articles or Reviews in English are used in the subsequent analysis.

3.2 Visualization Analysis

CiteSpace is employed for data analysis and visualization based on sets of bibliographic records retrieved from the collected paper. It supports several bibliometric studies, while this study focuses on the following analyses between 2014 and 2022:

- Annual publication analysis with article fitting curve;
- Reference co-citation analysis

4 Results

4.1 Publication years and Journals

Overall, publication trends in Education 4.0 and MOOCs research revealed an increasing trend (Fig. 1). The research output increased from 3 in 2014 to 1333 in 2022. In this figure, the vertical axis on the left is devoted to the number of publications per year, while the vertical axis on the right represents the accumulated number of publications that contributed to studying Education 4.0 and MOOCs. The horizontal bottom axis is devoted to the publication year. Moreover, the trend line of publications per year is demonstrated in blue. The equation is obtained by fitting curve analysis, which indicates that the polynomial fitting (red dashed line) is of optimal prediction effect, with $R^2 = 0.9985$. Hair et al. (2018) state that the R^2 above 0.75 shows substantial predictive power.

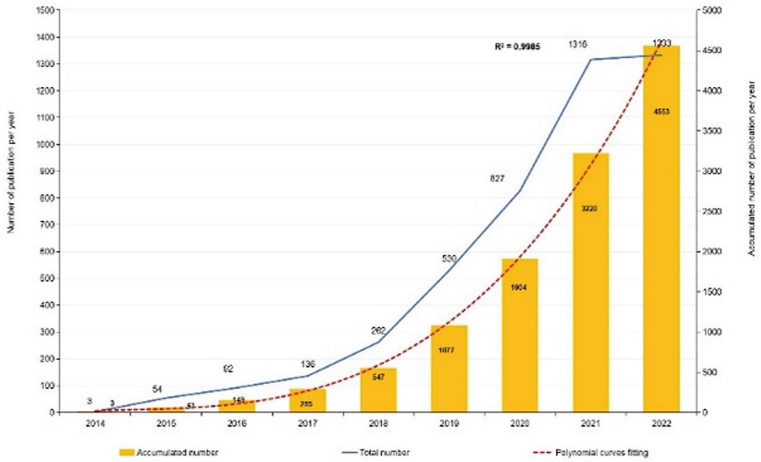

Fig. 1. The distribution of the bibliographic records

4.2 Co-citation Analysis

Landscape View

The following landscape view (Fig. 2) shows the overview of a network based on reference co-citation. In addition, Table 1 lists 5 major clusters by size since large clusters are more likely to be produced by the citation patterns of a significant publication, making them more representative than small clusters (Chen et al. 2012).

Cluster Interpretation

In this section, the study will be focused on the top 3 clusters since they are more representative than small clusters (Chen et al. 2012).

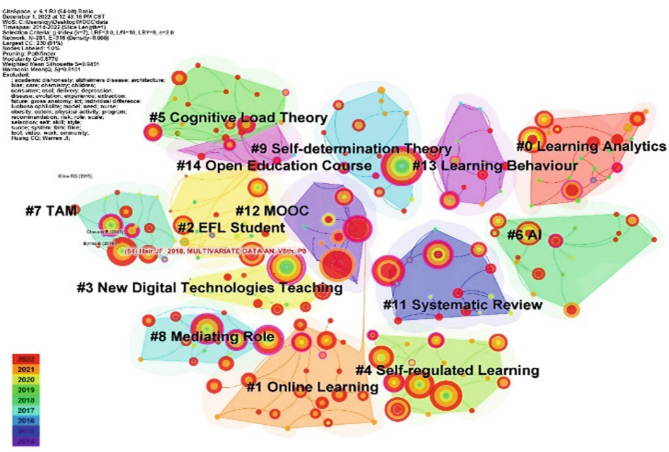

Fig. 2. A Landscape View of the Major Clusters

Table 1. Lists of 5 Major Clusters by Co-citations

Cluster ID	Size	Silhouette	Label (LLR)
0	23	0.923	Learning Analytics
1	21	0.964	Online Learning
2	18	1	EFL Student
3	18	0.977	New Digital Technologies Teaching
4	17	0.935	Self-regulated Learning

Cluster #0 Learning Analytics is the largest cluster, containing 23 members and a silhouette value of 0. 923. The most representative citing paper in this cluster is by Baneres et al. (2019). This study established a novel adaptive prediction model trained for each course using solely student grades. It contributes to identifying at-risk students and implementing the intervention strategy.

Cluster #1 Online Learning comprised 21 members with a silhouette value of 0. 964. The most representative citing paper in this cluster is by Shanshan and Wenfei (2022). This research investigated the impact of quality elements on continuance intention based on the Expectation Confirmation Model, Task Technology Fit, flow theory, and variable trust through the quantitative analysis of the Partial Least Square Structural Equation Model. The outstanding cited reference includes work by Dai et al. (2020). This research again conducted a quantitative analysis in the context of Chinese university students, revealing that students' confirmation, satisfaction, attitude, and curiosity can positively affect continuance intention.

Cluster #2 EFL Student comprised 18 members with a silhouette value of 1. The most representative citing paper in this cluster is by Yildiz Durak (2018). The study found that students' preparation for flipped learning and related indications are essential determinants of engagement, attitude, programming self-efficacy, and interaction intensity in programming lessons using the flipped classroom approach.

Citation Bursts

Major milestones can be identified from the references with strong citation bursts. The following discussions will focus on the 6 articles with the strongest burst in the group that ended simultaneously from 2014 to 2022 (Table 2).

From 2016 to 2017, the strongest burst is associated with the paper by Reich (2015), which proposed that researchers, course designers, and other stakeholders should advance the field from three perspectives: research participation for learning research, course surveys for cross-context comparisons, and better multidisciplinary experimental design of post hoc assessment.

Adam et al.s' (2015) article, sustained over a two-year period, led to citation bursts beginning in 2017. This study examined the efficacy of MOOCs that provided integrated nutrition and cooking instruction for enhancing eating habits and meal composition among course participants. The popularity of eating healthy and homemade food

Table 2. Top 6 References with the Strongest Bursts Ended Simultaneously

References	Strength	Begin	End	2014-2022
Reich (2015)	9.11	2016	2017	
Adam et al. (2015)	6.16	2017	2018	
Liyanagunawardena and Williams (2014)	14.19	2015	2019	
Breslow et al. (2013)	15.49	2015	2020	
de Barba et al. (2016)	6.28	2020	2022	
Sailer et al.(2017)	6.28	2020	2022	

has increased people's propensity to choose home-cooked meals, which has stimulated interest in this specific research topic.

Among citation bursts that ended in 2019, the strongest burst was led by Liyanagunawardena and Williams (2014), with a strength value of 14.19. The paper comprehensively analyzed the literature on MOOCs using peer-reviewed articles retrieved from journals, database searches, web searches, and citations from well-known sources.

The next highly impactful article is by Breslow et al. (2013) from cluster #12. From 2015 to 2020, it experienced the strongest citation value of 15.49. Conducted by a research team from the Massachusetts Institute of Technology and Harvard University, this research demonstrates a robust citation burst over five. A team of multidisciplinary researchers from MIT and Harvard University conducted an initial study of the data generated by MIT's first MOOCs, "Circuits and Electronics" (6.002x), with the research sample comprising undergraduate students in the Department of Electric Engineering and Computer Science.

Two citation bursts with the same strength value of 6.28 ended in 2022, implying a promising future research trend. Paying particular attention to those students who completed the online course, de Barba et al. (2016) investigated the mechanism of how students' motivation and participation affect their performance. Similar topics are presented by Sailer et al. (2017), who analyzed the motivational effects of gamification from an educational psychology perspective. The findings indicate that gamification alone is ineffective; however, various game design components can produce different motivational effects.

5 Conclusion and Future Research

The results indicated that academic interests had increased substantially as annual publications exhibited polynomial growth between 2014 and 2022. Predictably, this research area will demonstrate strong sustainability as a prevalent academic issue.

Notwithstanding the rapid development, MOOCs suffer a low retention rate (Reparaz et al. 2020). The convenience of the online learning system enables students even easier to abandon the course if they are unsatisfied with it (Alraimi et al. 2015). Multiple factors, including social (Davis Mersey et al. 2010), personal (Chen et al. 2020), and course-related (Jiang et al. 2016), can influence students' learning commitment and course completion.

Additionally, the most utilized research method in related topics is quantitative analysis, particularly Structure Equation Modelling (SEM), based on data collected from the survey, interviews, and web-based platforms. One possible explanation is that, compared to conventional qualitative literature analysis (Chen et al. 2014), the quantitative analysis method is directed by a computational methodology, allowing access to a considerably broader and more diverse range of relevant topics (Rasheed et al. 2019).

Finally, the review article bears important academic significance and practical value. Due to the rapid evolution at an exponential pace, an updated synthesized review of the empirical research should be applied to better track intellectual fronts and emerging trends in related fields.

Further study should continuously focus on conducting updated research to discover the development of the relevant field. Given that there are more conceptual and theoretical academic articles than the ones describing actual, in-the-field implementations, it is necessary to conduct further study on the practical difficulties of Education 4.0 and MOOCs in the university sector.

Acknowledgments. This work was supported by the Jiangsu University Philosophy and Social Science Fund Project, China (Grant Number 2022SJYB0613).

References

1. Lasi, H., Fettke, P., Kemper, H.-G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business & Information Systems Engineering*, *6*(4), 239–242. https://doi.org/https://doi.org/10.1007/s12599-014-0334-4
2. World Economic Forum. (2020). *Schools of the Future Defining New Models of Education for the Fourth Industrial Revolution*. World Economic Forum. https://www.weforum.org/
3. Breslow, L., E, P. D., Deboer, J., S, S. G., D, H. A., & T, S. D. (2013). Studying Learning in the Worldwide Classroom Research into edX's First MOOC. *Research & Practice in Assessment*, *8*, 1325.
4. Liyanagunawardena, T. R., Adams, A. A., & Williams, S. A. (2013). MOOCs: A systematic study of the published literature 2008–2012. *The International Review of Research in Open and Distributed Learning*, *14*(3), 202. https://doi.org/10.19173/irrodl.v14i3.1455
5. Butt, R., Siddiqui, H., Soomro, R. A., & Asad, M. M. (2020). Integration of Industrial Revolution 4.0 and IOTs in academia: a state-of-the-art review on the concept of Education 4.0 in Pakistan. *Interactive Technology and Smart Education*, *17*(4), 337–354. https://doi.org/10.1108/itse-02-2020-0022
6. Chaka, C. (2022). Is Education 4.0 a Sufficient Innovative, and Disruptive Educational Trend to Promote Sustainable Open Education for Higher Education Institutions? A Review of Literature Trends. *Frontiers in Education*, *7:824976*. https://doi.org/10.3389/feduc.2022.824976

7. Meet, R. K., Kala, D., & Al-Adwan, A. S. (2022). Exploring factors affecting the adoption of MOOC in Generation Z using extended UTAUT2 model. *Education and Information Technologies*, *27*, 10261–10283. https://doi.org/10.1007/s10639-022-11052-1
8. Meet, R. K., & Kala, D. (2021). Trends and Future Prospects in MOOC Researches: A Systematic Literature Review 2013–2020. *Contemporary Educational Technology*, *13*(3), ep312. https://doi.org/10.30935/cedtech/10986
9. Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2018). *Multivariate data analysis*. Cengage Learning Emea. Copyright.
10. Chen, C., Hu, Z., Liu, S., & Tseng, H. (2012). Emerging trends in regenerative medicine: a scientometric analysis in CiteSpace. *Expert Opinion on Biological Therapy*, *12*(5), 593–608. https://doi.org/https://doi.org/10.1517/14712598.2012.674507
11. Baneres, D., Rodriguez, M. E., & Serra, M. (2019). An Early Feedback Prediction System for Learners At-Risk Within a First-Year Higher Education Course. *IEEE Transactions on Learning Technologies*, *12*(2), 249–263. https://doi.org/https://doi.org/10.1109/tlt.2019.2912167
12. Shanshan, S., & Wenfei, L. (2022). Understanding the impact of quality elements on MOOCs continuance intention. *Education and Information Technologies*, *27*, 10949–10976. https://doi.org/https://doi.org/10.1007/s10639-022-11063-y
13. Dai, H. M., Teo, T., Rappa, N. A., & Huang, F. (2020). Explaining Chinese university students' continuance learning intention in the MOOC setting: A modified expectation confirmation model perspective. *Computers & Education*, *150*, 103850. https://doi.org/https://doi.org/10.1016/j.compedu.2020.103850
14. Yildiz Durak, H. (2018). Flipped learning readiness in teaching programming in middle schools: Modelling its relation to various variables. *Journal of Computer Assisted Learning*, *34*(6), 939–959. https://doi.org/https://doi.org/10.1111/jcal.12302
15. Reich, J. (2015). Rebooting MOOC Research. *Science*, *347*(6217), 34–35. https://doi.org/https://doi.org/10.1126/science.1261627
16. Adam, M., Young-Wolff, K. C., Konar, E., & Winkleby, M. (2015). Massive open online nutrition and cooking course for improved eating behaviors and meal composition. *International Journal of Behavioral Nutrition and Physical Activity*, *12*(1). https://doi.org/10.1186/s12966-015-0305-2
17. Liyanagunawardena, T. R., & Williams, S. A. (2014). Massive Open Online Courses on Health and Medicine: Review. *Journal of Medical Internet Research*, *16*(8), e191. https://doi.org/https://doi.org/10.2196/jmir.3439
18. de Barba, P. G., Kennedy, G. E., & Ainley, M. D. (2016). The role of students' motivation and participation in predicting performance in a MOOC. *Journal of Computer Assisted Learning*, *32*(3), 218–231. https://doi.org/https://doi.org/10.1111/jcal.12130
19. Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human Behavior*, *69*(69), 371–380. https://doi.org/https://doi.org/10.1016/j.chb.2016.12.033
20. Reparaz, C., Aznárez-Sanado, M., & Mendoza, G. (2020). Self-regulation of learning and MOOC retention. *Computers in Human Behavior*, *111*, 106423. https://doi.org/https://doi.org/10.1016/j.chb.2020.106423
21. Alraimi, K. M., Zo, H., & Ciganek, A. P. (2015). Understanding the MOOCs continuance: The role of openness and reputation. *Computers & Education*, *80*, 28–38. https://doi.org/https://doi.org/10.1016/j.compedu.2014.08.006
22. Davis Mersey, R., Malthouse, E. C., & Calder, B. J. (2010). Engagement with Online Media. *Journal of Media Business Studies*, *7*(2), 39–56. https://doi.org/https://doi.org/10.1080/16522354.2010.11073506

23. Chen, C., Sonnert, G., Sadler, P. M., & Malan, D. J. (2020). Computational thinking and assignment resubmission predict persistence in a computer science MOOC. *Journal of Computer Assisted Learning*, *36*(5), 581–594. https://doi.org/https://doi.org/10.1111/jcal.12427
24. Jiang, Q., ZHAO, LI, & ZHAO. (2016). Empirical Research on the Specification of Design Quality in the Context of Low Completion Rate of MOOCs. *E-Education Research*, *37*(01), 51–58.
25. Chen, C., Dubin, R., & Kim, M. C. (2014). Orphan drugs and rare diseases: a scientometric review (2000 – 2014). *Expert Opinion on Orphan Drugs*, *2*(7), 709–724. https://doi.org/https://doi.org/10.1517/21678707.2014.920251
26. Rasheed, R. A., Kamsin, A., Abdullah, N. A., Zakari, A., & Haruna, K. (2019). A Systematic Mapping Study of the Empirical MOOC Literature. *IEEE Access*, *7*, 124809–124827. https://doi.org/https://doi.org/10.1109/access.2019.2938561