A review of trends and applications of learning analytics in higher education in the post-pandemic era

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ABSTRACT

Learning analytics is defined as collecting, analysis, and reporting of data about learners inside a system. Users' interaction, which is a form of digital traces can be processed and identified into pattern. In comparison with subjective methods such as surveys and questionnaires, learning analytics provide deeper insight on students' behaviour and assist learning institution with data-informed decision-making regarding students' learning issues. This paper reviews on existing literature on the latest application and the trends of learning analytics in higher education over the last few years, within the period of pre and post pandemic era. As online learning was adapted rapidly during the pandemic, learning analytics became an important tool to assess students' learning. The literature review was obtained from Scopus and Web of Science databases by using Boolean search techniques with the right keywords. This study reviewed and provided a comprehensive analysis according to certain criteria of searched studies from the year 2018 to 2023. The result showed that the research trend in learning analytics was fluctuating in Scopus and gradually declining in Web of Science due to the pandemic and shifts in research interest. In this post pandemic era, Artificial Intelligence (AI) is trending upwards, and researchers are putting interest in integrating AI with learning analytics in education. As such, this paper could help educators see the trends of LA over the last few years, as well as the innovative practices recently.

Keywords
learning analytics; higher education; online learning

Introduction

The process of analysing captured data for decision making and reporting purposes is called Learning Analytics (Campbell et al., 2007). Historically, the root of Learning Analytics (LA) is strongly connected with many important fields of study. These include statistics, social-network analysis, machine learning, human-computer interaction, text mining, learning sciences, social psychology, and so forth (Mustafina et al., 2021). The application of LA is very much situated in online learning environments since the breakthrough of technology, distance education, and the development of the Learning Management System (Ye, 2022). Over the years, more universities are adopting the use of LA to understand students' academic progress, to predict future behaviours, as well as to identify potential problem as early as possible (Peña-Ayala, 2017).

In early 2020, our world was severely impacted by the COVID-19 pandemic which lasted for three years. At the initial stage, the crisis caught many education sectors cold, as teachers and students were pushed to quickly adapt to online learning, and digital resources became a lifeline for education (OECD, 2021). Even worse, not every learning institution had the capability to transition efficiently nor experience in implementing e-learning beforehand (Lasi, 2021). Learning monitoring was difficult to be done as students were almost invisible most of the time. Regardless, at such difficult times, LA became a crucial tool for higher education institutions during the pandemic era because it provided promising solutions to tackle challenges related to online learning (Celik et al., 2022).

The crisis gradually recovered, and the higher education sector confidently returned to physical learning mode as usual. Online learning is still trending and preferred by students in this post-pandemic era due to the flexibility and

convenience of online courses (Dos Santos, 2022). However, it raised one more concern, as to how is the trend and LA practices afterwards. Therefore, this study aims to identify the trends of LA in higher education over the last few years within the period of pre and post pandemic era, and what are the recent and innovative LA practices that have been done lately.

Methodology

The first objective of this research was to identify the trend of LA in higher education. Thus, the literature search was performed using the two biggest academic research databases: Scopus and Web of Science. The following terms in the search strategy were used: "*learning analytic" OR "learning analytics" AND "higher education" OR "university" OR "universities"*. From the result, the first inclusion criterion was applied: (i) the range of publication year is 2018-2023. The publication year was very important criteria in identifying the overall trends over the last 5 years.

The second objective of this research was to identify any LA practices that have been done recently. From the search results earlier, other inclusion criteria were applied: (ii) the study published in English, (iii) the document type is article, (iv) the publication year is 2022-2023. In this case, the publication year is restricted to only 2022 onwards, which highlight the post-pandemic era.

Findings and Discussion

The trend of learning analytics research in higher education

By using the mentioned search strategy in both Scopus and Web of Science, we retrieved a total of 2779 publications related to the use of LA in higher education from year 2018-2023. According to the Scopus' search report, LA were widely researched in the Computer Science (35.6%), Social Sciences (27.9%), and Engineering (11.9%) areas. As for Web of Science, the top three research areas related to LA were Educational Research (65.20%), Computer Science (35.45%), and Engineering (13.71%). Based on the data retrieved in August 2023, the following Figure 1 presents the trends of publications by years in both databases, along with the number of publications in Table 1.

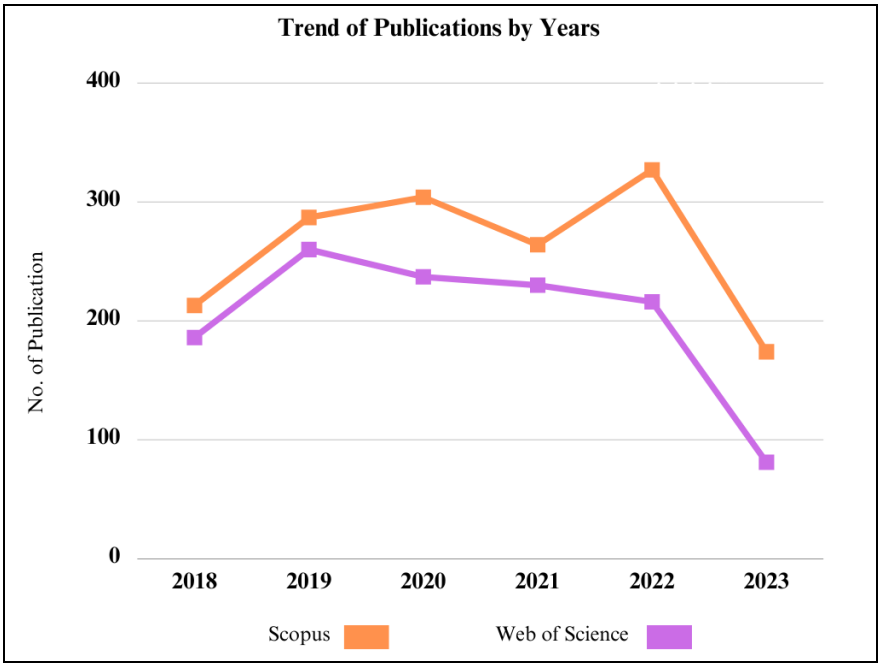

Figure 1. Trend of publications by years for Scopus and Web of Science database

Table 1. Distribution of publications by years

Year	Number of Publications	
	Scopus	Web of Science
2018	213	186
2019	287	260
2020	304	237
2021	264	230
2022	327	216
2023	174	81
Total	**1569**	**1210**
	2779	

Prior to the pandemic, Lee et al. (2020) found that the number of publications related to LA in Scopus alone has increased at a fast pace from 2011 to 2019. However, the current study found that there was a fluctuation in the trend, especially in the Scopus database as shown in Figure 1. Similarly, the trend showed a gradual decline in the Web of Science since 2020 (Figure 1). Although education is one of the most affected areas and widely researched during the pandemic, most of the educational research during 2020-2021 was focused at eliminating the uncertainties and the challenges in online learning (Polat, 2022). Nevertheless, the available research at that period has proven that LA was a useful tool in tackling online learning challenges faced by higher education (Celik, 2022).

Learning analytics practice in post pandemic era

LA continues to be an excellent approach, which serves many benefits for higher education institutes. Universities especially, have played a leading role in practicing the concept of LA. Peña-Ayala (2017) summarised a dozen LA techniques that have been used in the context of higher education. Accordingly, Table 2 below overviews some of the recent studies published in 2022-2023 (798 papers) that utilise LA in higher education.

Table 2. Overview of recent LA studies

No.	Author, Year	Objectives	Technique
1	Zamecnik et al. (2023)	To examine team cohesion in learning environments using a learning analytics approach.	Clustering
2	Talebinamvar & Zarrabi (2022)	To discover student's writing profiles by using keystroke logging data, and the writing quality of English as a Foreign Language (EFL) students.	Clustering
3	Gonzalez-Nucamendi et al. (2022)	To identify the impact of the students' profile dimensions on their academic performance using predictive models based on Multiple Intelligence (MI) and self-regulated learning and affective strategies (SRLAS)	Clustering and prediction
4	Ifenthaler et al. (2023)	To investigate students' engagement with self-assessments and how it relates to their performance in the final exam and self-reported self-testing strategies.	Clustering and process mining

No.	Author, Year	Objectives	Technique
5	Zhidkikh et al. (2023)	To propose and explore a learning analytics method of combining aptitude and event measures to evaluate student's self-regulation skills.	Clustering and process mining
6	Martins et al. (2023)	To develop early prediction models to detect students who are at risk of dropping out or not finishing their study in due time.	Prediction
7	Waheed et al. (2022)	To predict students who are at risk of failing in a self-paced online course.	Prediction
8	Kustitskaya et al. (2022)	To develop predictive model for detecting at-risk students at early stages by current learning performance and learning behavior indicators.	Prediction
9	West et al. (2022)	Using learning analytics and student perceptions to explore student interactions in an online construction management course.	Relationship mining
10	Zhang et al. (2023)	To design and implement Teaching and Learning Analytic (TLA) tool to support the teaching and learning process in a face-to-face, undergraduate-level course in China.	Social network analysis, lag sequential analysis, and process mining

Based on articles listed above, LA offers many promising approaches with solid evidence especially in understanding students' behaviour and predicting academic progress. Be that as it may, LA does have its own challenges that require special attention by fellow researchers and practitioners. Past studies concluded that LA has difficulty with data tracking and collection, the analysis, its connection with learning sciences, optimization for learning environment, as well as concerns regarding ethics and user privacy (Avella et al., 2016). Therefore, these challenges must be considered prior to the research.

The rise of AI-driven learning analytics

The pandemic has reshaped our educational approach with many new pedagogies and continuous advancement of educational technologies. Meanwhile, Artificial Intelligence (AI) has gained more attention than ever with rapid increase in publications and collaboration by many parties (Maslej et al., 2023). Within the educational research area, Artificial Intelligence in Education (AIEd) is one of the fields of scientific research that leverage AI-related technologies to improve learning. AI education began with the use of computers and computer-related systems, then moved to online and web-based platforms; the impact of AI on education sector can be seen in administration, instruction and learning at educational institutions (Singh & Hiran, 2022).

In that regard, Ouyang et al. (2023) used an integrated approach to combine AI performance prediction model with LA approaches, aims to improve student learning effects in a collaborative learning context. In an online engineering course, an AI model based on the genetic programming was utilized to predict students' academic performance. Multiple LA approaches, such as social network analysis, content analysis, lag sequential analysis, and thematic analysis, were then used to project the results and generate feedback to students and course instructor. To understand the effect of with and without the integrated approach towards students learning, Ouyang et al. (2023) conducted a quasi-experimental study. It is found that student engagement was increased, collaborative learning performances were improved, and students were satisfied with their learning. This research has developed a pathway for future advancement of AI-driven learning analytics.

Similarly, Darvishi et al. (2022) incorporated AI and LA to address some of the common concerns associated with peer assessment system, such as lack of quality feedback and accuracy in assigning grade by the peer student-assessors. Hence, a systematic approach for development, deployment and evaluation of AI and LA approaches in a

peer assessment system was carried out. The improved system utilises Natural Language Processing (NLP) as the AI component in the while the LA machine learning approach, specifically spot-checking algorithm and active learning were used as well. It helped course instructors to efficiently use their time in reviewing controversial case based on the human-driven and data-driven metrics.

Conclusion

This study provides insight into the trend of LA over the years and reviewed the innovative practices that have been done recently. In the findings, both Scopus and Web of Science showed that the trend of publication is fluctuating and declining respectively. Regardless of the trend, LA alone has been widely researched and has already proven to be a reliable tool for higher education in many ways. In this post-pandemic era, the LA practice continues to be present and more advanced than before, as researchers have introduced some ways to incorporate AI and LA in education. The AI-driven learning analytic is at such a different level that needs to be further studied.

Limitations and Future Studies

The limitation of this research is that it highlights the application of LA in higher education only. Therefore, the findings of this research should not be generalized to any other education level. Future studies could further explore the application of LA in different education level.

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References

Avella, J., Kebritchi, M., Nunn, S., & Kanai, T. (2016). Learning Analytics Methods, Benefits, and Challenges in Higher Education: A Systematic Literature Review. Online Learning Journal, 20, 1–17.

Campbell, J. P., Deblois, P. B., & Oblinger, D. G. (2007). "Academic Analytics: A New Tool for a New Era."

Celik, I., Gedrimiene, E., Silvola, A., & Muukkonen, H. (2022). Response of learning analytics to the online education challenges during pandemic: Opportunities and key examples in higher education. Policy Futures in Education, 21(4), 387. https://doi.org/10.1177/14782103221078401

Darvishi, A., Khosravi, H., Sadiq, S., & Gašević, D. (2022). Incorporating AI and learning analytics to build trustworthy peer assessment systems. British Journal of Educational Technology, 53(4), 844–875. https://doi.org/https://doi.org/10.1111/bjet.13233

Dos Santos, L. M. (2022). Online learning after the COVID-19 pandemic: Learners' motivations. Frontiers in Education, 7, 879091. https://doi.org/10.3389/FEDUC.2022.879091/BIBTEX

Gonzalez-Nucamendi, A., Noguez, J., Neri, L., Robledo-Rella, V., García-Castelán, R. M. G., & Escobar-Castillejos, D. (2022). Learning Analytics to Determine Profile Dimensions of Students Associated with Their Academic Performance. Applied Sciences (Switzerland), 12(20). https://doi.org/10.3390/app122010560

Ifenthaler, D., Schumacher, C., & Kuzilek, J. (2023). Investigating students' use of self-assessments in higher education using learning analytics. Journal of Computer Assisted Learning, 39(1), 255–268. https://doi.org/10.1111/JCAL.12744

Kustitskaya, T. A., Kytmanov, A. A., & Noskov, M. V. (2022). Early Student-at-Risk Detection by Current Learning Performance and Learning Behavior Indicators. Cybernetics and Information Technologies, 22(1), 117–133. https://doi.org/10.2478/CAIT-2022-0008

Lasi, M. bin A. (2021). Online Distance Learning Perception and Readiness During Covid-19 Outbreak: A Research Review. International Journal of Academic Research in Progressive Education and Development, 10(1). https://doi.org/10.6007/ijarped/v10-i1/8593

Lee, L.-K., S Cheung, S. K., & Kwok, L.-F. (2020). Learning analytics: current trends and innovative practices Learning analytics. Journal of Computers in Education, 7(1), 1–6. https://doi.org/10.1007/s40692-020-00155-8

Martins, M. V., Baptista, L., Machado, J., & Realinho, V. (2023). Multi-Class Phased Prediction of Academic Performance and Dropout in Higher Education. Applied Sciences, 13(8), 4702. https://doi.org/10.3390/app13084702

Maslej, N., Fattorini, L., Brynjolfsson, E., Etchemendy, J., Ligett, K., Lyons, T., Manyika, J., Ngo, H., Niebles, J. C., Parli, V., Shoham, Y., Wald, R., Clark, J., & Perrault, R. (2023). The AI Index 2023 Annual Report.

Mustafina, J., Galiullin, L., Alloghani, M., & Khanova, A. (2021). Learning Analytics: Challenges and Perspectives. INTED2021 Proceedings, 1, 3163–3166. https://doi.org/10.21125/inted.2021.0665

OECD. (2021). The State of School Education: One Year into the COVID Pandemic. https://doi.org/10.1787/201dde84-en

Ouyang, F., Wu, M., Zheng, L., Zhang, L., & Jiao, P. (2023). Integration of artificial intelligence performance prediction and learning analytics to improve student learning in online engineering course. International Journal of Educational Technology in Higher Education, 20(1), 4. https://doi.org/10.1186/s41239-022-00372-4

Peña-Ayala, A. (2017). Learning Analytics: Fundaments, Applications, and Trends: A View of the Current State of the Art to Enhance e-Learning (Vol. 94). https://doi.org/10.1007/978-3-319-52977-6

Polat, M. (2022). Exploring Educational Research during the COVID-19 Pandemic: 2020-2021. FIRE: Forum for International Research in Education, 7(2), 86–104. https://doi.org/10.32865/FIRE202172276

Singh, S. V., & Hiran, K. K. (2022). The Impact of AI on Teaching and Learning in Higher Education Technology. Journal of Higher Education Theory and Practice, 22(13). https://doi.org/10.33423/jhetp.v22i13.5514

Talebinamvar, M., & Zarrabi, F. (2022). Clustering students' writing behaviors using keystroke logging: a learning analytic approach in EFL writing. Language Testing in Asia, 12. https://doi.org/10.1186/s40468-021-00150-5

Waheed, H., Hassan, S. U., Nawaz, R., Aljohani, N. R., Chen, G., & Gasevic, D. (2023). Early prediction of learners at risk in self-paced education: A neural network approach. Expert Systems with Applications, 213, 118868. https://doi.org/10.1016/J.ESWA.2022.118868

West, P., Paige, F., Asce, A. M., Lee, ; Walter, Watts, N., & Scales, G. (2022). Using Learning Analytics and Student Perceptions to Explore Student Interactions in an Online Construction Management Course. Journal of Civil Engineering Education, 148(4). https://doi.org/10.1061/(ASCE)EI.2643-9115.0000066

Ye, D. (2022). The History and Development of Learning Analytics in Learning, Design, & Technology Field The Pre-Digital Era Impact of the Philosophy of Behaviorism. TechTrends, 66(4), 607–615. https://doi.org/10.1007/s11528-022-00720-1

Zamecnik, A., Kovanovíc, V., Joksimovíc, S., Grossmann, G., Ladjal, D., Marshall, R., & Pardo, A. (2023). Using online learner trace data to understand the cohesion of teams in higher education. Journal of Computer Assisted Learning. https://doi.org/10.1111/JCAL.12829

Zhang, L. Y., Wu, M., & Ouyang, F. (2023). The design and implementation of a teaching and learning analytics tool in a face-to-face, small-sized course in China's higher education. Education And Information Technologies. https://doi.org/10.1007/s10639-023-11940-0

Zhidkikh, D., Saarela, M., & Karkkainen, T. (2023). Measuring self-regulated learning in a junior high school mathematics classroom: Combining aptitude and event measures in digital learning materials. Journal of Computer Assisted Learning. https://doi.org/10.1111/jcal.12842