Learning Analytics: A Systematic Literature Review

Seyyed Kazem Banihashem[1], Khadijeh Aliabadi[1, *], Saeid Pourroostaei Ardakani[2], Ali Delaver[3] and Mohammadreza Nili Ahmadabadi[1]

[1]Department of Educational Technology, Faculty of Psychology & Educational Sciences, Allameh Tabataba'i University, Tehran, Iran
[2]PhD in Computer Sciences, Assistant Professor of Educational Technology, Faculty of Psychology and Educational Sciences, Allameh Tabataba'i University, Tehran, Iran
[3]Professor of Assessment and Measurement, Faculty of Psychology and Educational Sciences, Allameh Tabataba'i University, Tehran, Iran

Corresponding author: Khadijeh Aliabadi, Associate Professor of Educational Technology, Department of Educational Technology, Faculty of Psychology & Educational Sciences, Allameh Tabataba'i University, Tehran, Iran. E-mail: aliabadikh@yahoo.com

Abstract

Context: Learning analytics is considered as the third wave in educational technology and it is a new and promising field of study. This study was conducted to clarify benefits and challenges of learning analytics in education.
Methods: Cooper's systematic literature review was used as the research method. This method has five steps as follows: a) formulation of the problem, b) collection of data, c) evaluation of the appropriateness of the data, d) analysis and interpretation of relevant data, and e) organization and presentation of the results. Based on the study selection process, 36 articles were finally selected to be analyzed.
Results: The results showed that ethics and privacy were one of the most important challenges of learning analytics in education along with the lack of attention to theoretical foundations and scope and quality of data. The results also showed that learning analytics could bring remarkable benefits for education, such as increased engagement of students, improvement of learning outcomes, identification of students at risk, providing real - time feedback, and personalization of learning.
Conclusions: Based on the results, it can be concluded that learning analytics offer new insights in education, however, there are ethical, educational, and technical issues in the use of learning analytics in education.

Keywords: Learning, Technology, Education

1. Background

Data is one of the key factors that could play an important role in the future of education (1). Siemens and Long (2) believed that the most important factor in the future of education, especially in higher education, is what we cannot see and touch, and it is big data and analytics. Big data is radically large datasets that are beyond human's ability to analyze and it is computed by a machine to uncover patterns, trends, and associations, specifically about human behavior and interactions (3). Data is critical for educational institutions. Data helps provide better outcomes for students by supporting educators. Data can provide information on why students fail to graduate, why a student drops out of a course, and why a student cannot understand a concept or skill (4). Cooper (5) stated that "analytics is the process of developing actionable insights through problem definition and the application of statistical models and analysis against existing and/or simulated future data" (p. 3). Therefore, it can be said that analytics is the process of discovering and interpreting data to reach ac-

tionable insights. Since 2008, the concept of analytics in education has been seriously considered with a focus on understanding and optimizing learning. Since 2010, the concept of Learning Analytics (LA) has been isolated from the field of analytics and has emerged as an independent area (6).

Learning analytics, as a new field of study, is considered as an interdisciplinary field between learning technology, pedagogy, machine learning, business intelligence, artificial intelligence, and statistics (7-9). Learning analytics seek to use educational data to improve learning, teaching, and learning environments (10). At the beginning, learning analytics was defined as follows: "Using intelligent data, learner - centered data generation and analysis models to explore information and social interactions, predict learning, and provide recommendations for learning" (11). However, the most popular definition of learning analytics was presented by the Society for Learning Analytics Research (SOLAR) at First Learning Analytics and Knowledge Conference in 2011 (LAK-11). Learning analytics is "the

measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (2). Thus, it can be said that learning analytics is based on the data - driven approach to education and its main purpose is to enhance and optimize learning and its environment. Learning analytics is becoming a phenomenon with a wide application in different parts of education from preschool to postgraduate level (12). Fiaidhi (13) claimed that learning analytics is the third wave of developments in educational technology. The first wave begun with the emergence of learning management system (LMS) in 1991. In the second wave, social networks (also called web 2.0) appeared and influenced education. In the third wave, learning analytics were used to optimize and enhance learning and teaching. Today, different universities use learning analytics. For example, Purdue University uses learning analytics to identify students, who are at risk of failure (14). Higher education experts in the United States predict that over the next few years, learning analytics will be widely used in online education to identify student behavior patterns, improve students learning, and improve retention rates in higher education (15). Siemens (16) believed that learning analytics has the potential to impact existing educational models and provide new insights to what is used in teaching and learning. However, in order to reach its potential in education, it is needed to deeply understand what potential it has in education and secondly, the challenges of learning analytics faced in education.

2. Methods

To address the research problem, the researcher conducted a systematic literature review suggested by Cooper (17). For synthesizing the literature, the following procedure should be followed; problem formulation, data collection, data evaluation, data analysis and interpretation, and results in presentation and organization.

Learning analytics, as a new field of study, still has gaps between its theory and practice. In order to embrace learning analytics in education, the benefits and challenges in education, specifically from an educational view, need to be identified. In this way, one can address how effectively learning analytics can be used in educational settings. Thus, the research questions were as follows:

RQ1. What are the benefits of learning analytics in education?

RQ2. What are the challenges of learning analytics in education?

The answer to these questions will help educators to properly incorporate learning analytics in education and

learning environments.

The purpose of data collection was to find research studies and review articles, which were published in journals to identify benefits and challenges of learning analytics in education. The search was conducted in August 2017. In order to collect and identify relevant studies, a search strategy was defined. The search strategy was as follows: a) only scholarly and review articles, b) articles that were published in English language, c) articles that were published in 2011to 2017, d) articles that had full text. The keywords were "learning analytics" OR "LA" AND "benefits of learning analytics" OR "LA benefits" OR ", "learning analytics benefits", AND "learning analytics challenges" OR "LA challenges" OR "challenges of learning analytics". Based on the search strategy, these keywords must be mentioned in the document title. The databases selected for literature review were as follows: Scopus, ProQuest, Sage, Emerald Insight, PubMed, Springer, and Science Direct. Therefore, based on the information mentioned above, inclusion and exclusion criteria were as follow (Table 1).

Table 1. Inclusion and Exclusion Criteria

Include	Exclude
Only research and review articles	Articles that had no clear and related results
Date from 2011 to 2017	Book chapters and short papers from workshops
Full text available	Other databases were excluded
Published in English language	Article that was written in other languages
Databases: Scopus, ProQuest, Sage, Emerald Insight, PubMed, Springer, and Science Direct	

The review was done on databases based on inclusion and exclusion criteria; 247 articles were found. Of these, 18 articles focused on issues related to learning analytics benefits and 24 articles focused on learning analytics challenges. The remaining articles were excluded from this review because they could not be used to address the questions of the study. Data evaluation and analysis process were based on reading abstracts and results of the study. After reading abstracts and results, the appropriateness of studies was determined based on the articles' relevancy. Only articles that were directly related to learning analytics benefits and challenges and helped answer the questions were included. The process of the systematic literature review is presented in Figure 1.

Table 2 provides characteristics of included studies for learning analytics benefits, and Table 3 provides characteristics of included studies for learning analytics challenges.
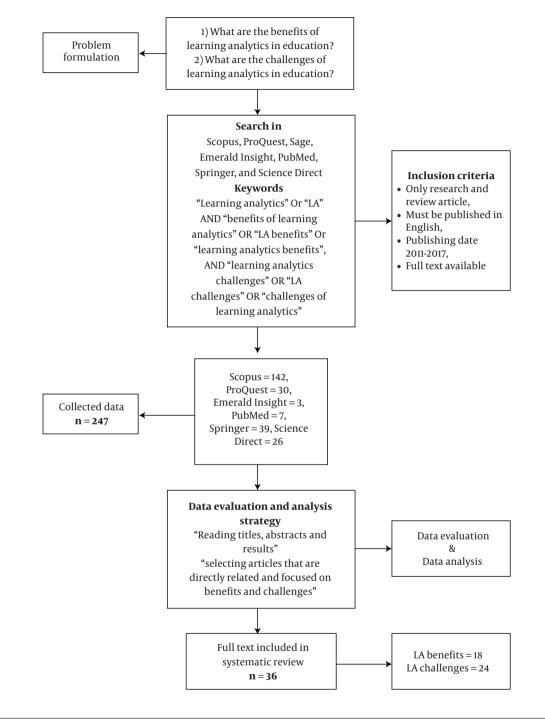
Figure 1. Flow Diagram of the Systematic Literature Review Process

3. Results

In this section, findings were presented based on analysis of published case studies. Non - statistical methods were used to evaluate and interpret findings of the collected studies.

Table 2. Characteristics of Included Studies for Learning Analytics Benefits

Authors	Year	Type of Research	Method	Participants and Tools
Adejo & Connolly (12)	2017	Research	Survey	Students at the University of the West of Scotland
Arnold & Pistilli (14)	2012	Review	Review	Course Signal App
Conde & Hernandez-Garcia (18)	2015	Review	Review	
Dietz-Uhler & Hurn (19)	2013	Review	Review	
Dinu, Papuc, Gheorghiu, Dascalu, Moldoveanu, & Moldoveanu (20)	2017	Review	Review	Biometric data for LA
Freitas, Gibson, Du Plessis, Halloran, Williams, Ambrose, & Dunwell (21)	2014	Research	Qualitative	Documents of LA
Greller & Drachsler (22)	2012	Research	Qualitative	Documents in LA
Ifenthaler (23)	2017	Research	Survey	The initial dataset consisted of 176 responses
Lawson, Beer, Rossi Moore & Fleming (24)	2016	Research	Case Study	Central Queensland University
Lu, Huang, Huang & Yang (25)	2017	Research	Experimental	A set of 102 freshmen students with an average age of 19
Mah (26)	2016	Review	Integrative review	
Nunn, Avella, Kanai & Kebritchi (15)	2016	Review	Systematic literature review	Documents in LA
Papamitsiou & Economides (27)	2014	Review	Systematic qualitative review	Empirical studies in LA and EDM
Prinsloo, Slade & Galpin (28)	2012	Review	Review	Open University, and University of South Africa (Unisa)
Reyes (29)	2015	Review	Review	
Serrano-Laguna, Torrente, Moreno-Ger, Fernandez-Manjon (30)	2014	Research	Intervention	Video games were assessed
Siemens (8)	2013	Review	Review	
Stewart (31)	2017	Review	Theoretical review	

3.1. RQ1. What are the benefits of learning analytics in education?

In order to address this research question, 18 studies were finally selected and analyzed. The interpretation of the results are as follows:

Advantages of learning analytics in all types of education from traditional education to blended education and e-learning have been emphasized (12). Serrano-Laguna and Fernandez-Manjon (30) reported that learning analytics application in serious games could increase the effectiveness of these games in the class. Lu, Huang, Huang, and Yang (25) pointed out that learning analytics can be applied to enhance engagement of students and outcome of learning in a MOOCs collaborative environment. Ifenthaler (23) presented a matrix of learning analytics benefits and indicated that learning analytics could help understand learning habits of students, obtain real-time feedback and real-time insight, make efficient interventions, modify content to be aligned with students' desire, increase student engagement, student success modeling, and promote student success. Dinu et al. (20) addressed learning analytics benefits in predicting students' per-

formance, personalization of learning, increase retention rate, improvement eLearning, and boost cost efficiency. Arnold and Pistilli (14) focused on real-time feedback potential of learning analytics. Freitas et al. (21) reported that learning analytics could improve learning design, prevent students drop out, provide warning signals, and enrich personalized learning environments. Some studies shifted their attention on identification of at-risk students, student retention, and student success (19, 24, 26, 28, 29). Papamitsiou and Economides (27) mentioned performance prediction, self-awareness, and self-reflection, drop out prediction, feedback improvement, sources recommendation, and assessment services as objectives of learning analytics, while they were also considered as benefits of learning analytics. Conde and Hernandez-Garcia (18) stated that learning analytics helped teachers, students, and institutional leaders to make evidence-based decisions. Nunn, Avella, Kanai, and Kebritchi (15) addressed learning analytics benefits in a) identifying target course, b) curriculum improvement, c) student learning outcome, behavior, and process, d) personalized learning, e) improved instructor performance, f) post-educational employment,

Table 3. Characteristics of Included Studies for Learning Analytics Challenges

Authors	Year	Type of Research	Method	Participants and Tools
Chatti et al. (32)	2014	Review	Review	
Dawson, Gasevic, Siemens & Joksimovic (33)	2016	Review	Systematic Review	Data related to LA
Drachsler & Greller (34)	2016	Review	Review	
Ferguson (6)	2012	Review	Review	
Gasevic, Dawson & Jovanovic (35)	2016	Review	Review	
Gasevic, Dawson & Siemens (36)	2015	Review	Review	
Gasevic, Dawson, Rogers & Gasevic (37)	2016	Research	Correlational design	4134 undergraduate students
Gursoy, Inan, Nergiz & Saygin (38)	2017	Research	Experimental study	Students at Adana Science and Technology University
Ifenthaler & Tracey (39)	2016	Review	Review	
Knight, Shum & Littleton (40)	2014	Review	Literature examining	
Koh, Shibani, Tan & Hong (41)	2016	Research	Intervention	A total of 272 students participated in the program
Lockyer, Heathcote & Dawson (42)	2013	Review	Review	
Macfadyen & Dawson (43)	2012	Research	Qualitative	
Marzouk et al. (44)	2016	Research	Design based research	Students at Simon Frazer University
Nunn, Avella, Kanai & Kebritchi (15)	2016	Review	Systematic literature review	Documents in LA
Pardo & Siemens (45)	2014	Review	Review	
Rubel & Jones (46)	2016	Review	Review	
Siemens (8)	2013	Review	Review	
Slade & Prinsloo (47)	2013	Review	Review	
Stewart (31)	2017	Review	Theoretical review	
West, Huijser & Heath (48)	2016	Research	Mixed-method design	22 institutional leaders, 353 academic staff, 23 academic level staff
Willis, Slade & Prinsloo (49)	2016	Research	Qualitative	
Wintrup (50)	2017	Review	Review	
Wise, Vytasek, Hausknecht & Zhao (51)	2016	Review	Literature review	

g) learning analytics practitioners and research community. Siemens (8) believed that one of the main reasons why learning analytics is obtaining attention in education is due to deeper understanding of teaching, learning, intelligent content, personalized learning, and adaptive learning. Stewart (31) stated that the potential benefits of learning analytics will help educational institutions shift from speculative decision making within course instruction to a more data - informed and evidenced - based foundation of decision making and understanding how students learn. Reyes (29) pointed out that learning analytics could help identify knowledge gaps, curriculum modification, improve teaching strategy, and take appropriate measures for targeted learners and monitoring students' activities. Dietz - Uhler and Hurn (19) focused on the advantages that faculties could benefit from. They indicated that learning analytics improved accountability and fac-

ulty could use learning analytics to predict students' performance. Greller and Drachslrer (22) suggested that faculty members could be informed about the shortage of knowledge in their students by learning analytics.

As indicated, learning analytics could bring remarkable benefits for education. In the following table, benefits of learning analytics in education were classified based on the stakeholders of education and learning analytics. Some of these benefits are in common (Table 4).

3.2. RQ2. What are the challenges of learning analytics in education?

Challenges of learning analytics can be addressed in two aspects: technical and educational. Examples of technical challenges include how data is tracked, how data is collected, and how data is evaluated. However, in this paper, technical challenges were not discussed. These challenges refer to technical issues in terms of using learning

Table 4. Benefits of Learning Analytics for Stakeholders

Stakeholders	Benefits
Learners	Enhance engagement of students
	Improve learning outcomes
	Personalization of learning
	Increase in students adaptivity
	Enrich personalized learning environments
	Increase self - reflection and self-awareness
Teachers	Assessment services
	Make efficient interventions
	Get a real - time feedback
	Get a real - time insight
	Understand students learning habits
	Modify content for students' desire
	Monitoring students' activities
	Get a deeper understand of teaching and learning
	Predicting student performance
	Provide warning signal
	Improve teaching strategy
	Improve instructor performance
	Sources recommendation
Institutions	Improve educational decision making
	Increase student success
	Student success modeling
	Monitoring students' activities
	Boost cost efficiency
	Increase retention rate
	Make evidence - based decisions
	Prevent student drop out
	Identify students at risk
	Curriculum improvement
	Improve accountability
Researchers	Increase efficiency of education and serious games
	Identify knowledge gaps
Course designers	Identifying target course
	Improve learning design
Parents	Monitoring students' activities

analytics in education. According to a systematic literature review, three main educational challenges for this area are as follows, ethics and privacy, scope and quality of data, and theoretical and educational foundations.
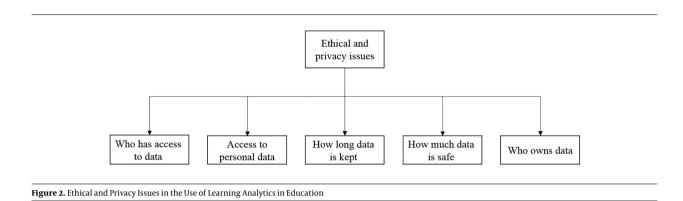
3.3. Ethic and Privacy

Ethics and privacy are one of the most important challenges that learning analytics is faced with (32). The question is whether learning analytics have access to personal data of individuals. If this is the case, it is important to determine who sees this information and to what extent this information is secure (46). Studies have been conducted by learning analytics researchers to solve this challenge (35, 39, 45-47, 49, 50). Ifenthaler and Tracey (39) attempted to determine the relationship between ethics and privacy in learning analytics and design. They emphasized that if learning analytics wants to be used in education, it needs to solve its ethical and privacy challenges in instructional design. Wintrup (50) stated that in learning analytics, ethics and student engagement are correlated and student's engagement could be increased when students have no ethical and privacy issues. West, Huijser, and Heath (48) underlined putting an ethical lens on learning analytics and pointed out that by increasing the importance and application of learning analytics in education, considerations about ethical and privacy issues would be increased as well. Figure 2 shows ethical and privacy issues.

3.4. Scope and Quality of Data

Siemens (8) stated that the most important challenges in learning analytics are not technical. He believed that one of the greatest challenges of learning analytics is knowing the scope and quality of data. As Macfadyen and Dawson (43) stated, numbers are not enough, which means the quality of data is important for learning analytics to improve learning and predict students' success. Siemens (8) indicated that one of the questions in learning analytics is how much data should be collected and how much data should have variety. These questions refer to the scope of data. Quality of data indicates what type of data has value of learning and how much reliable prediction we could have by analyzing these data. Useful data should be extracted from a large set of data. Data that can be pedagogically interpreted and can give us true learning results should be discriminated from other data (7). Gasevic, Dawson, Rogers, and Gasevic (37) pointed out that learning analytics cannot fit one size to all. Learning analytic models should not be general and collect general data. It should focus on a specific scope of specific data with high quality that could give true insights in learning and teaching.

3.5. Theoretical and Educational Foundation

One of the key challenges in learning analytics is the lack of attention to learning and teaching theories (41). Knight, Shum, and Littleton (40) stated that learning analytics should be based on pedagogical and epistemological

Figure 2. Ethical and Privacy Issues in the Use of Learning Analytics in Education

assumptions. They emphasized that pedagogical and epistemological assumptions determine the kind of learning analytics regarding the method that should be used. Wise, Vytasek, Hausknecht, and Zhao (51) pointed out that integrating learning analytics as a part of teaching and learning process has not been explored. By a perfect combination of pedagogical and technical aspect in learning analytics, the proper use of learning analytics in education could be garanteed. Stewart (31) pointed out that there is a gap between theory and practice in learning analytics. He addressed this gap within learning theory. By reviewing empirical studies in learning analytics, it can be realized that learning analytics tools have not been developed based on educational strategies (33, 36). Learning analytics researchers believe that this field needs to collect, measure, analyze, report, and interpret data within learning research (31, 33, 36, 40, 41). Learning analytics researchers also believe that learning analytics has not made a strong connection with learning science (6, 15, 44). Lockyer, Heathcote, and Dowson (42) highlighted the importance of aligning learning analytics with learning design. These researchers considered the role of learning design as a contextual framework to broad scale applicability of learning analytics in education. This means that, basically, learning analytics occurs in a learning context and it needs to be a part of a learning and teaching pedagogy. Gasevic, Dawson, Rogers, and Gasevic (37) pointed out that instructional conditions should be considered in learning analytics. They said that learning analytics would not provide a reliable academic prediction if it doesn't pay attention to instructional conditions. Gasevic, Dawson, and Siemens (36) stated that we must not forget that learning analytics is about learning. Siemens (8) indicated that learning necessarily has a social process and it cannot be entirely reduced to algorithms. Align, Knight, Shum, and Littleton (40) emphasized that learning analytics must be careful not to be trapped in a technological and mechanical determinism.

Therefore, paying attention to the theoretical, pedagogical, and educational foundations in learning analytics is critical. Addressing these challenges would help apply learning analytics in education effectively. Figure 3, presents a conceptual map of theoretical and educational foundation issues in the use of learning analytics in education.

4. Discussion and Conclusion

In this systematic literature review, learning analytics was considered from an educational perspective. Thus, it was not focused on technical aspect where data mining, algorithmic processing, data collection, and data analysis are important. From an educational perspective, successful introduction of educational innovations is never just a matter of providing access to new tools, no matter how much they are useful (52). In other words, explanation of new innovations and new technologies in education should be passed through the filter of the theoretical foundations of education. Thus, it is very important for learning analytics to understand the basis of learning and teaching. Moreover, in this study, the researchers discussed about the importance of ethics and privacy and scope and quality of data. It is a human right to be respected in terms of privacy, and ethical considerations are the first thing that should be respected in education. Perhaps this is why learning analytics care about ethics and privacy in education. In addition, the scope and quality of data is a matter of importance in learning analytics. Learning analytics need to determine the scope and the quality of data in education. Without it, the reliability of data could not be determined. This research also discussed about the benefits of learning analytics in education. Based on the frequency of repetition, it seems that identifying at - risk students is the most important benefit of learning analytics in education. However, it cannot be denied that learning analytics
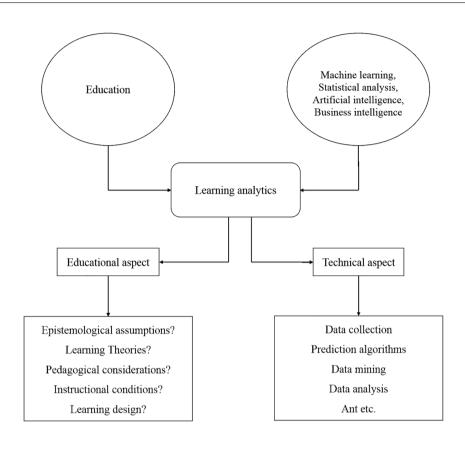
Figure 3. Conceptual Map of Theoretical and Educational Foundation Issues in Learning Analytics

have brought noticeable benefits for education stakeholders in a number of ways.

This study faced some limitations. First, the researcher limited the literature review to specific keywords and databases. Therefore, this literature may not include all related articles published in other databases. Second, some papers had an English title, however, the entire text was written in other languages. These papers were excluded. Third, the researcher had difficulties to access the full text of some papers.

In conclusion, data is going to play an important role in the future of education and learning analytics as a new and promising field of study is expected to be used widely in education in the near future. Thus, it is a matter of emergency to deeply understand what learning analytics is and how it could be widely used in the educational settings.

Supplementary Material

Supplementary material(s) is available here [To read supplementary materials, please refer to the journal website and open PDF/HTML].

Acknowledgments

Footnotes

References

1. Banihashem SK, Aliabadi K. Connectivism: Implications for Distance Education. *Interdiscipl J Virt Learn Med Sci*. 2017;**8**(3). doi: 10.5812/ijvlms.10030.

2. Siemens G, Long P. Penetrating the fog: Analytics in learning and education. *Educause Review*. 2011;**46**(5):30.

3. Chen M, Mao S, Liu Y. Big Data: A Survey. *Mobile Network Appl.* 2014;**19**(2):171–209. doi: 10.1007/s11036-013-0489-0.

4. Reid-Martinez K, Mathews M. Big data in education: Harnessing data for better educational outcomes. *Cent Digit Educ.* 2015;**100**:33.

5. Cooper A. What is analytics? Definition and essential characteristics. *CETIS Analytics Series*. 2012;**1**(5):1–10.

6. Ferguson R. Learning analytics: drivers, developments and challenges. *Int J Tech Enhanced Learn (IJTEL)*. 2012;**4**(5/6):304. doi: 10.1504/ijtel.2012.051816.

7. Guenaga M, Garaizar P. From Analysis to Improvement: Challenges and Opportunities for Learning Analytics. *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje*. 2016;**11**(3):146–7. doi: 10.1109/rita.2016.2589481.

8. Siemens G. Learning Analytics. *Am Behav Sci.* 2013;**57**(10):1380–400. doi: 10.1177/0002764213498851.

9. Chatti MA, Dyckhoff AL, Schroeder U, Thus H. A reference model for learning analytics. *Int J Tech Enhanced Learn (IJTEL)*. 2012;**4**(5/6):318. doi: 10.1504/ijtel.2012.051815.

10. Clow D. An overview of learning analytics. *Teach High Educ.* 2013;**18**(6):683–95. doi: 10.1080/13562517.2013.827653.

11. Siemens G. *What Are Learning Analytics?* 2010.

12. Adejo O, Connolly T. Learning Analytics in a Shared-Network Educational Environment: Ethical Issues and Countermeasures. *Learn.* 2017;**8**(4).

13. Fiaidhi J. The Next Step for Learning Analytics. *IT Prof.* 2014;**16**(5):4–8. doi: 10.1109/mitp.2014.78.

14. Arnold KE, Pistilli MD, editors. Course signals at Purdue: Using learning analytics to increase student success. *Proceedings of the 2nd international conference on learning analytics and knowledge*. ACM; 2012.

15. Avella JT, Kebritchi M, Nunn SG, Kanai T. Learning Analytics Methods, Benefits, and Challenges in Higher Education: A Systematic Literature Review. *Online Learn.* 2016;**20**(2):13–29.

16. Siemens G, editor. Learning analytics: envisioning a research discipline and a domain of practice. *Proceedings of the 2nd international conference on learning analytics and knowledge*. ACM; 2012. 4 p.

17. Cooper HM. Organizing knowledge syntheses: A taxonomy of literature reviews. *Knowl Soc.* 1988;**1**(1):104–26. doi: 10.1007/bf03177550.

18. Conde MA, Hernandez-Garcia A. Learning analytics for educational decision making. *Comput Hum Behav.* 2015;**47**:1–3. doi: 10.1016/j.chb.2014.12.034.

19. Dietz-Uhler B, Hurn JE. Using learning analytics to predict (and improve) student success: A faculty perspective. *J Interact Online Learn.* 2013;**12**(1):17–26.

20. Dinu VE, Papuc D, Gheorghiu A, Dascalu M-I, Moldoveanu A, Moldoveanu F. Biometric data in learning analytics: A survey on existing applications. *The International Scientific Conference eLearning and Software for Education; 2017: " Carol I" National Defence University*. 2017.

21. de Freitas S, Gibson D, Du Plessis C, Halloran P, Williams E, Ambrose M, et al. Foundations of dynamic learning analytics: Using university student data to increase retention. *Br J Educ Tech.* 2015;**46**(6):1175–88. doi: 10.1111/bjet.12212.

22. Greller W, Drachsler H. Translating learning into numbers: A generic framework for learning analytics. *J Edu Tech Soc.* 2012;**15**(3):42.

23. Ifenthaler D. Are Higher Education Institutions Prepared for Learning Analytics? *TechTrends*. 2016;**61**(4):366–71. doi: 10.1007/s11528-016-0154-0.

24. Lawson C, Beer C, Rossi D, Moore T, Fleming J. Identification of 'at risk' students using learning analytics: the ethical dilemmas of intervention strategies in a higher education institution. *Edu Tech Res Dev.* 2016;**64**(5):957–68. doi: 10.1007/s11423-016-9459-0.

25. Lu OHT, Huang JCH, Huang AYQ, Yang SJH. Applying learning analytics for improving students engagement and learning outcomes in an MOOCs enabled collaborative programming course. *Interact Learn Environ.* 2017;**25**(2):220–34. doi: 10.1080/10494820.2016.1278391.

26. Mah D-K. Learning Analytics and Digital Badges: Potential Impact on Student Retention in Higher Education. *Tech Knowl Learn.* 2016;**21**(3):285–305. doi: 10.1007/s10758-016-9286-8.

27. Papamitsiou Z, Economides AA. Learning analytics and educational data mining in practice: A systematic literature review of empirical evidence. *J Edu Tech Soc.* 2014;**17**(4):49.

28. Prinsloo P, Slade S, Galpin F, editors. Learning analytics. *Proceedings of the 2nd International Conference on Learning Analytics and Knowledge*. ACM; 2012. 130 p.

29. Reyes JA. The skinny on big data in education: Learning analytics simplified. *TechTrends*. 2015;**59**(2):75–80. doi: 10.1007/s11528-015-0842-1.

30. Serrano-Laguna A, Fernandez-Manjon B, editors. Applying learning analytics to simplify serious games deployment in the classroom. *Global Engineering Education Conference (EDUCON)*. IEEE; 2014. p. 872–7.

31. Stewart C. Learning Analytics: Shifting from theory to practice. *J Empower Teach Excel.* 2017;**1**(1):10.

32. Chatti MA, Lukarov V, Thüs H, Muslim A, Yousef AMF, Wahid U, et al. Learning analytics: challenges and future research directions. *E-learn Educ (Eleed) J.* 2014;**10**(1).

33. Dawson S, Gasevic D, Siemens G, Joksimovic S, editors. Current state and future trends. *Proceedings of the fourth international conference on learning analytics and knowledge*. ACM; 2014. p. 231–40.

34. Drachsler H, Greller W, editors. Privacy and analytics: it's a DELICATE issue a checklist for trusted learning analytics. *Proceedings of the sixth international conference on learning analytics & knowledge*. ACM; 2016. p. 89–98.

35. Gasevic D, Dawson S, Jovanovic´ J. Ethics and privacy as enablers of learning analytics. *J Learn Anal.* 2016;**3**(1):1–4. doi: 10.18608/jla.2016.31.1.

36. Gasevic D, Dawson S, Siemens G. Let's not forget: Learning analytics are about learning. *TechTrends*. 2014;**59**(1):64–71. doi: 10.1007/s11528-014-0822-x.

37. Gasevic D, Dawson S, Rogers T, Gasevic D. Learning analytics should not promote one size fits all: The effects of instructional conditions in predicting academic success. *Internet High Educ.* 2016;**28**:68–84. doi: 10.1016/j.iheduc.2015.10.002.

38. Gursoy ME, Inan A, Nergiz ME, Saygin Y. Privacy-Preserving Learning Analytics: Challenges and Techniques. *IEEE Transactions on Learning Technologies*. 2017;**10**(1):68–81. doi: 10.1109/tlt.2016.2607747.

39. Ifenthaler D, Tracey MW. Exploring the relationship of ethics and privacy in learning analytics and design: implications for the field of educational technology. *Edu Tech Res Dev.* 2016;**64**(5):877–80. doi: 10.1007/s11423-016-9480-3.

40. Knight S, Buckingham Shum S, Littleton K. Epistemology, Assessment, Pedagogy: Where Learning Meets Analytics in the Middle Space. *J Learn Anal.* 2014;**1**(2):23–47. doi: 10.18608/jla.2014.12.3.

41. Koh E, Shibani A, Tan JP-L, Hong H, editors. A pedagogical framework for learning analytics in collaborative inquiry tasks: an example from a teamwork competency awareness program. *Proceedings of the Sixth International Conference on Learning Analytics & Knowledge*. ACM; 2016. p. 74–83.

42. Lockyer L, Heathcote E, Dawson S. Informing Pedagogical Action. *Am Behav Sci.* 2013;**57**(10):1439–59. doi: 10.1177/0002764213479367.

43. Macfadyen LP, Dawson S. Numbers are not enough. Why e-learning analytics failed to inform an institutional strategic plan. *J Edu Tech Soc.* 2012;**15**(3):149.

44. Marzouk Z, Rakovic M, Liaqat A, Vytasek J, Samadi D, Stewart-Alonso J, et al. What if learning analytics were based on learning science? *Australas J Educ Tech.* 2016;**32**(6). doi: 10.14742/ajet.3058.

45. Pardo A, Siemens G. Ethical and privacy principles for learning analytics. *Br J Educ Tech.* 2014;**45**(3):438–50. doi: 10.1111/bjet.12152.

46. Rubel A, Jones KML. Student privacy in learning analytics: An information ethics perspective. *Inform Soc.* 2016;**32**(2):143–59. doi: 10.1080/01972243.2016.1130502.

47. Slade S, Prinsloo P. Learning analytics: Ethical issues and dilemmas. *Am Behav Sci.* 2013;**57**(10):1510–29. doi: 10.1177/0002764213479366.

48. West D, Huijser H, Heath D. Putting an ethical lens on learning analytics. *Edu Tech Res Dev.* 2016;**64**(5):903–22. doi: 10.1007/s11423-016-9464-3.

49. Willis JE, Slade S, Prinsloo P. Ethical oversight of student data in learning analytics: a typology derived from a cross-continental, cross-institutional perspective. *Edu Tech Res Dev.* 2016;**64**(5):881–901. doi: 10.1007/s11423-016-9463-4.

50. Wintrup J. Higher Education's Panopticon? Learning Analytics, Ethics and Student Engagement. *High Educ Pol.* 2017;**30**(1):87–103. doi: 10.1057/s41307-016-0030-8.

51. Wise AF, Vytasek JM, Hausknecht S, Zhao Y. Developing Learning Analytics Design Knowledge in the Middle Space: The Student Tuning Model and Align Design Framework for Learning Analytics Use. *Online Learn.* 2016;**20**(2):155–82.

52. Wise AF, editor. Designing pedagogical interventions to support student use of learning analytics. *Proceedings of the Fourth International Conference on Learning Analytics And Knowledge*. ACM; 2014. p. 203–11.