A SYSTEMATIC REVIEW OF ARTIFICIAL INTELLIGENCE APPLICATIONS IN HIGHER EDUCATION: LOCATING THE ROLE OF EDUCATORS

[*1]Ismu Iskandar,[2]Yuliana Renyaan,[3]Ressa Uli Patrissia
[4]Rivani Adistia Dewi

[1]Universitas Negeri Makassar, Makassar, Indonesia
[2]Master of Management, Postgraduate Program
Universitas Sangga Buana YPKP, Bandung, Indonesia
[3]Doctoral Program in Communication Science
Postgraduate Program, Universitas Sahid, Jakarta, Indonesia
[4]Mathematics Education, Faculty of Mathematics and Natural Sciences Education
Universitas Pendidikan Indonesia, Bandung, Indonesia

Author's email:
[1]ismoe3377@gmail.com; [2]yulirenyaan85@gmail.com; [3]rpatrissia@gmail.com
[4]rivaniadistiadewi@upi.edu

**Corresponding author:ismoe3377@gmail.com*

Abstract. *Although artificial intelligence (AI) is becoming increasingly important in higher education, little research has examined these phenomena from an educational perspective. Through a comprehensive evaluation of 146 peer-reviewed empirical studies published between 2007 and 2018, this paper addresses the lack of pedagogical and ethical considerations in current AI-oriented publications. Based on accepted rules for evidence synthesis, the review used a methodical approach, including papers indexed in Scopus, Web of Science, and EBSCO Education Source. With only 6.2% of academics having an eye toward education, the statistics show a predominance of papers from Computer Science and STEM fields. Four main areas define artificial intelligence applications in higher education: intelligent tutoring systems, adaptive systems and personalisation, assessment and evaluation, and profiling and prediction. Only a tiny minority of research addressed ethical issues or instructional frameworks; most employed quantitative approaches. This assessment concludes that while artificial intelligence shows potential for improving educational processes, current research lacks significant input from teachers and remains technologically oriented. It advocates for multidisciplinary cooperation and theory-based methods to ensure that AI supports ethical norms and educational objectives.*

Keywords: *Artificial Intelligence in Education (AIEd); Educational Technology; Ethical Challenges; Higher Education; Pedagogical Challenges*

1. INTRODUCTION

Thanks to its broad applications and ability to enhance learning outcomes, artificial intelligence (AI) in education has become a transformative agent, attracting increasing attention recently. Studies, such as the Horizon Report (Educause, 2018, 2019), project a rapid increase in the adoption of artificial intelligence in higher education. Companies like Contact North (2018) contend that artificial intelligence is intimately linked to the direction higher education will take. Notably, significant expenditures by companies like Google and projects such as the German Research Centre for Artificial Intelligence (DFKI) underscore the increasing pace of AI integration in educational institutions (Popenici & Kerr, 2017).

Although artificial intelligence technology has been around for decades, its instructional uses are somewhat new. Early scholarly attempts to investigate AI's instructional possibilities were marked by the 1997 founding of the International Society for AI in Education and its related publication. Most teachers, however, have recently started to realise how effectively artificial intelligence can be used to support institutional and academic purposes throughout a student's life. To investigate these opportunities,

colleges such as the Technical University of Eindhoven are currently devoting large sums of money, including the establishment of AI research centers.

The emergence of artificial intelligence in higher education raises ethical questions and presents institutional challenges alongside its excellent prospects. Financial restrictions on organisations raise questions about the possible use of artificial intelligence to replace administrative personnel and human teachers. Automated tutoring systems, chatbots, and intelligent agents might all cause faculty anxiety about displacement. Furthermore, the extensive use of artificial intelligence in learning analytics necessitates the collection of vast amounts of sensitive data, thereby posing significant concerns for privacy and data protection (Russell & Norvig, 2010). Organisations such as the Australian Analysis & Policy Observatory and the Institute for Ethical AI in Education have responded by initiating the development of AI ethics models to guide the responsible integration of AI.

Still a broad and multidisciplinary discipline, artificial intelligence encompasses computer science, neurology, philosophy, cognitive psychology, and other related fields. On a single definition of artificial intelligence, nevertheless, there is little agreement. For instance, whereas Popenici and Kerr (2017) define machine learning—a fundamental branch of artificial intelligence—as the capacity of software to detect and adapt to patterns, Baker and Smith (2019) characterize AI as technologies that replicate human cognitive processes, such as problem-solving and learning. Such conceptual differences raise questions for teachers trying to assess whether artificial intelligence is relevant for education and learning.

Generally speaking, artificial intelligence applications in higher education can be categorized into three main areas: learner-facing tools, teacher-facing tools, and system-facing technologies (Baker & Smith, 2019). Tools addressing learners include sophisticated tutoring systems and adaptable learning environments customizing education. By utilizing automated evaluation and feedback systems, teacher-facing technologies aim to reduce the instructional burden. For example, system-facing artificial intelligence forecasts student attrition or matches courses to labor market needs, therefore supporting institutional decision-making.

Academic debate still lags significantly, even as artificial intelligence becomes increasingly prevalent in higher education. While teachers make a disproportionately small contribution, researchers from computer science and STEM fields predominate in the present literature (Zawacki-Richter et al., 2019). As such, most studies focus on the performance of technology and the correctness of algorithms, often overlooking important pedagogical viewpoints and educational philosophies. This disciplinary discrepancy limits the applicability of current research to instructional and learning settings. One noticeable gap in the present research is the lack of consideration of pedagogical and ethical implications. Of the 146 examined papers, only a small number address ethical issues, such as data privacy, algorithmic bias, or job consequences (Li, 2007; Welham, 2008). Likewise, few researchers anchor their investigations in accepted educational ideas or frameworks. This lack of theoretical involvement raises questions about the shallow incorporation of artificial intelligence systems in educational environments, particularly when their instructional influence remains unknown.

Given these shortcomings, this study aims to provide a thorough, systematic evaluation of studies on the use of artificial intelligence in higher education. It aims to grasp the present conception of artificial intelligence, the publication of research, and the range of practical applications of AI across many educational environments. The assessment, especially, underlines the significance of including pedagogical views and instructional perspectives in AI-related conversations.

The primary objective of this study is to synthesize the findings of peer-reviewed papers published between 2007 and 2018 that examine the use of artificial intelligence in higher education. The evaluation points out methodological techniques, subject areas of application, and publishing trends. Moreover, it assesses how closely current studies take ethical considerations, educational strategies, and teacher viewpoints. For

institutional leaders, legislators, and teachers, this study is very valuable. It provides a basis for more pedagogically informed and morally grounded AI integration by mapping current advancements and identifying research needs. Ultimately, this paper advocates for a fair debate that balances both technical innovation and academic integrity in shaping the direction of artificial intelligence in higher education.

2. LITERATURE REVIEW

Driven by rapid developments in machine learning, natural language processing, and intelligent systems, artificial intelligence in education (AIEd) has emerged as a vital area of study over the past two decades. From intelligent tutoring systems and adaptive learning environments to predictive analytics and institutional decision-support tools, researchers have investigated a broad spectrum of applications in higher education (Luckin et al., 2016; Popenici & Kerr, 2017). These advances have enabled universities to utilize artificial intelligence to enhance administrative processes and instructional methods. Researchers have closely examined how artificial intelligence profiles and predicts a student's life. Delen (2011) has examined how institutional data, such as demographics, financial assistance, and academic records, can be used to train machine learning models with high accuracy in predicting student dropout rates. In a similar vein, Kardan et al. (2013) have created neural network models to forecast course choice behaviour, thereby enabling institutions to maximize their course offerings. These studies demonstrate how artificial intelligence can help allocate resources more effectively and identify at-risk children.

Their capacity to replicate one-on-one education has generated considerable interest in intelligent tutoring systems (ITS). To provide customized feedback and direction, Huang and Chen (2016) have proposed a multi-model architecture for ITS, incorporating student models, domain knowledge, and diagnostic algorithms. Studies by Ray and Belden (2007) and Weston-Sementelli et al. (2018) have also demonstrated its potential benefits in areas such as psychology, particularly in writing and reading comprehension. These results validate the instructional worth of ITS in large-scale learning contexts. Much research has also focused on the assessment and evaluation capabilities of artificial intelligence. For instance, many educational environments have explored the use of automated essay scoring (AES) systems. According to Gierl et al. (2014), in medical education, AES tools like Light SIDE may achieve grading accuracy comparable to that of human raters. Using instantaneous feedback, McNamara et al. (2015) examined how such systems may support formative evaluation. Particularly in courses with large enrollments, this study has demonstrated how artificial intelligence can simplify evaluation processes.

Furthermore, the use of artificial intelligence for administrative and institutional purposes is well-documented. Amigud et al. (2017) have developed AI-based methods to assess academic integrity through analysis of student writing patterns. Using AI-driven learning analytics, Samarakou et al. (2015) have developed diagnostic systems that track student development and provide targeted support. At higher education institutions, these systems have enabled data-informed decision-making on both the organizational and personal levels. By adjusting the material based on student behavior and preferences, adaptive systems have enabled the provision of tailored learning experiences. Research by Kose and Arslan (2016) and Lo et al. (2012) has demonstrated the capability of innovative e-learning systems to adapt the course of teaching dynamically. Researchers such as Dodigovic (2007) and Vlugter et al. (2009) have demonstrated in language learning environments how artificial intelligence can aid vocabulary acquisition and reading comprehension through customized feedback systems. These systems have given differentiated instruction scalable solutions.

Studies have also examined how artificial intelligence can enhance group learning. Using intelligent agents, Adamson et al. (2014) employed academically successful speaking strategies to facilitate peer interaction. To facilitate group writing, Calvo et al. (2011) have combined automated feedback systems. These results suggest that in

virtual learning settings, artificial intelligence may enhance group cohesiveness and interaction. Still, much research in this field has concentrated more on technological feasibility than on long-term educational influence. From a teacher-support standpoint, several systems have been developed to alleviate teaching responsibilities and facilitate informed decision-making. Intelligent assistants developed by Casamayor et al. (2009) notify teachers to track student development and spot group disputes. Chou et al. (2011) have developed ITS tools that enable instructors to focus on higher-order instructional activities while automatically providing guidance. Although few have studied their impact on teacher satisfaction or pedagogy, these systems have enabled the use of mixed teaching strategies.

Although artificial intelligence (AI) research has produced insightful analyses in many different fields, it has disproportionately focused on technological advancements at the cost of educational theory. According to Zawacki-Richter et al. (2019), only a small proportion of articles feature academics from education faculties; most publications originate from writers in computer science and STEM fields. Much research, therefore, lacks connection with instructional design ideas, reflective teaching approaches, or learning theories. Moreover, ethical issues in artificial intelligence still go understudied. Studies addressing issues of data privacy, algorithmic bias, or the possible displacement of teachers (Li, 2007; Welham, 2008) are few in count. Although specific projects, such as the Institute for Ethical AI in Education, have emerged, the broader literature has not adequately addressed the hazards and obligations associated with using artificial intelligence in educational settings. The lack of ethical debate narrows the range of present studies.

A further important flaw in current studies is the dearth of longitudinal or impact-oriented research. Most empirical research has consisted of pilot studies or short-term trials devoid of institutional change or evaluation of continuous learning results. For instance, whereas ITS and adaptive systems offer promise, little research has assessed their long-term efficacy or fit to student development objectives (Steenbergen-Hu & Cooper, 2014). This restriction complicates our understanding of how artificial intelligence facilitates comprehensive, enduring learning. The current systematic review presents an educator-centered study of artificial intelligence applications in higher education, aiming to close several existing gaps. It aims to strike a mix between educational and ethical issues and technical viewpoints. This study provides a comprehensive foundation for further research by outlining the terrain of AIEd study and highlighting marginalized voices. It calls for more education researchers' participation in the development and application of artificial intelligence, consistent with responsible innovation and meaningful learning.

3. RESEARCH METHODS

3.1 Research Design

Grounded on accepted rules for evidence synthesis, the research used a methodical review approach. To ensure methodological openness and replicability, the strategy employed the frameworks proposed by Gough, Oliver, and Thomas (2017) as well as those of Petticrew and Roberts (2006). Through peer-reviewed empirical research published between 2007 and 2018, the review aimed to explore the landscape of Artificial Intelligence (AI) applications in higher education. With a quantitative descriptive approach, the study enables researchers to map trends, disciplinary contributions, research techniques, and types of AI applications across the chosen corpus. Particularly regarding the conceptualisation and ethical issues of artificial intelligence, the evaluation also included qualitative aspects to code and analyse theme patterns within the papers.

3.2 Data Collection

Data collection began with the development of a comprehensive search plan targeting peer-reviewed journal publications on the use of artificial intelligence in education. The first search phrase included "higher education" and "student learning," with keywords

such as "artificial intelligence." "machine learning," "intelligent tutor," and "neural network." In November 2018, three central databases were searched: EBSCO Education Source, Web of Science, and Scopus. The first search yielded 2,656 documents in total.

The pool was reduced to 1,549 papers after duplication removal and the application of predetermined inclusion and exclusion rules. Considered were only research indexed in the three chosen databases, targeted on higher education environments, and published in English or Spanish between 2007 and 2018. We rejected non-empirical materials, including theoretical studies, literature reviews, and grey literature. Three independent coders reviewed titles and abstracts first and then conducted a thorough search for suitable papers. Cohen's kappa coefficient was used to evaluate inter-rater reliability, yielding a median κ value of 0.79, indicating substantial agreement across coders (Bakeman & Gottman, 1997; Fleiss, 1981). One hundred forty-six papers, in all, satisfied all inclusion criteria and were kept for final synthesis.

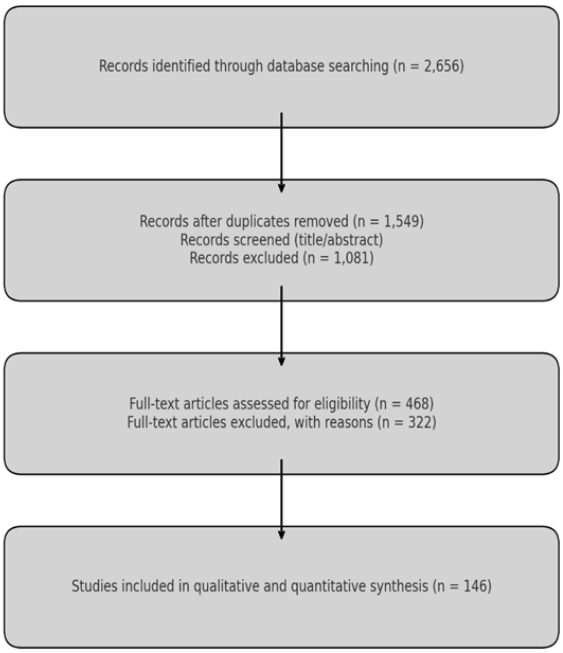

Figure 1. PRISMA Diagram

3.3 Data Analysis

The EPPI Reviewer program imported the data from the 146 included studies for methodical categorization and analysis. To record data on multiple levels, including year of publication, journal name, country of the first author, academic affiliation, research technique, and type of artificial intelligence application, a systematic coding system was developed. Every research study was also evaluated for its creative framing of artificial intelligence and whether it addressed ethical issues, such as privacy, prejudice, or job consequences. Descriptive statistics, including frequency distributions and cross-tabulations, were generated through a quantitative analysis conducted using R statistical software and the tidy package (Wickham & Grolemund, 2016). These numbers supported the geographical distribution of publications, the predominance of specific fields (e.g., computer science and STEM), and the predominance of quantitative rather than qualitative approaches. Four main areas—profile and prediction, intelligent tutoring systems, assessment and evaluation, and adaptive systems and personalization—were used to classify the artificial intelligence applications using qualitative analysis. Iterative coding produced sub-categories within these more general categories from an inductive perspective. This mixed-methods approach made it possible to synthesize the corpus of current research comprehensively and allowed the study to identify not only important

gaps in the literature but also trends.

4. RESULTS AND DISCUSSION

4.1 Findings

The systematic review identified 2,656 records overall, from which 146 peer-reviewed empirical papers met all inclusion criteria. With the United States (29%), China (7.5%), Taiwan (6.8%), and Turkey (6.2%) accounting for 50% of the articles, these studies covered 38 nations. The published article's yearly trend showed a consistent climb over time; from 2016 to 2018, a notable surge was observed. Forming a loop between empirical testing and theoretical improvement, this graphic illustrates the conversion of psychological theory into practical applications.

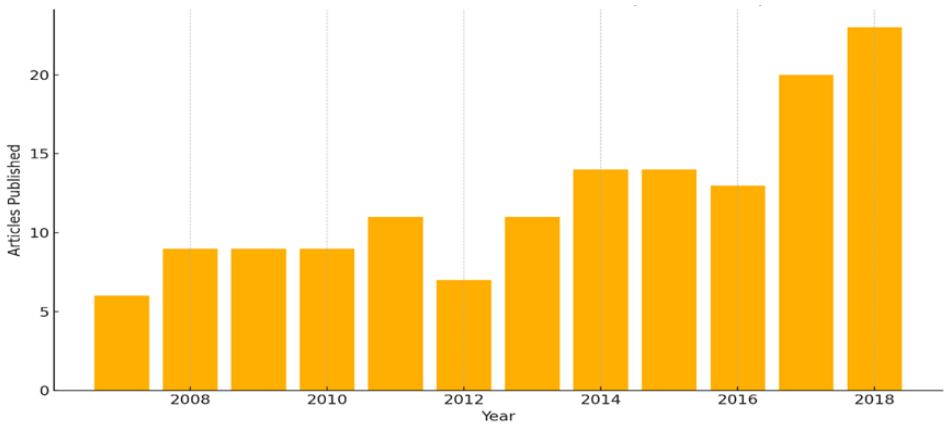

Figure 2. Number of Included Articles Per Year (2007–2018)

Only 6.2% came from Education departments; the initial authors' disciplinary affiliation indicated that Computer Science supplied the most significant number of publications (41.8%), followed by STEM subjects (19.9%), while only. Table 1 lists the most prominent connections of authors.

Table 1. First Author Affiliation Distribution (n = 146)

Affiliation	Frequency	Percentage
Computer Science	61	41.8%
STEM	29	19.9%
Arts, Humanities & Social Science	14	9.6%
Education	9	6.2%
Psychology	8	5.5%
Information Science	8	5.5%
Business & Law	6	4.1%
Others/ Unspecified	11	7.5%

Methodologically speaking, only 0.7% of the research utilized qualitative techniques, 73.3% of the studies used quantitative methods, and 20.5% were theoretical or descriptive. In 5.5% of the studies, mixed approaches were used. Four broad categories emerged among the applications of artificial intelligence:

- Profiling and Prediction (58 studies)
- Assessment and Evaluation (36 studies)
- Intelligent Tutoring Systems (29 studies)
- Adaptive Systems and Personalisation (27 studies)

Table 2: Distribution of AI Application Domains

AI Application Domain	Number of Studies
Profiling and Prediction	58

Assessment and Evaluation	36
Intelligent Tutoring Systems	29
Adaptive Systems and Personalisation	27

Machine learning techniques, such as ANN, SVM, Decision Trees, and Naïve Bayes, were widely used in the profiling and prediction areas. In forecasting student performance, dropout risk, or admission results, these methods often beat conventional logistic regression.

4.2 Interpretation

The findings of this comprehensive study demonstrate that, particularly after 2015, the area of artificial intelligence in higher education has seen significant expansion. Although the academic focus remains in technical fields, the growing number of published papers reflects an increased interest in study. The limited participation of education-oriented researchers highlights a gap between pedagogical innovation and the evolution of artificial intelligence.

4.3 Comparison

The present research aligns with that of Bartolomé et al. (2018) and Misiejuk and Wasson (2017), who also identified a significant frequency of quantitative and technical methods, in contrast to earlier conclusions in the field of educational technology. Unlike conventional academic research, which emphasises learning theories and student-centred outcomes, most AI-based studies have focused on system performance, classification accuracy, and scalability.

4.4 Limitations

This review has specific restrictions despite being quite extensive. It includes only English or Spanish publications indexed in three databases, therefore omitting grey literature and non-indexed research. Moreover, even if inter-rater accuracy was outstanding, the subjectivity of qualitative coding might have brought bias. Another issue is the predominance of short-term and small-scale assessments, given comparatively few long-term impact studies.

CONCLUSION

Through an analysis of 146 peer-reviewed empirical papers published between 2007 and 2018, this systematic review examines the application of artificial intelligence (AI) in higher education. The results show that, with a notable underrepresentation of educational researchers, most studies in Computer Science and STEM fields originate from artificial intelligence uses, including profiling and prediction, assessment and evaluation, intelligent tutoring systems, and adaptive learning systems. While instructional frameworks and ethical issues remain mostly unmet, quantitative approaches dominate the field of research. The study highlights a growing interest in artificial intelligence in higher education, as well as a lack of theoretical rigour and teacher participation. The study demonstrates how the area has progressed technologically, but not equally, in educational philosophy and practice, thereby addressing the main research question. The gap between artificial intelligence innovation and pedagogical integration hinders the efficient use of these technologies in real-world educational environments. The review emphasises that, under the guidance of knowledgeable instructional viewpoints and ethical considerations, AI technologies have the potential to enhance academic quality; otherwise, this is not the case.

Long-term consequences of artificial intelligence applications on student learning, instructional efficacy, and institutional change will be investigated in future studies. Academics will require longitudinal research to assess if artificial intelligence systems maintain their educational effect over time. The research will also examine ways to deliberately incorporate educational conceptions in the assessment and creation of AI-

based tools. A deeper study will also be necessary to address ethical concerns, such as data privacy, algorithmic fairness, and educator agency. Researchers will likely create multidisciplinary models that strike a compromise between ethical and teaching obligations and technical innovation. More cooperation among educators, data scientists, and legislators will be integral to future projects aimed at ensuring that artificial intelligence promotes inclusive, fair, and efficient learning environments.

REFERENCES

Adamson, D., Dyke, G., Jang, H., & Rosé, C. P. (2014). Towards an agile approach to adapting dynamic collaboration support to student needs. International Journal of Artificial Intelligence in Education, 24(1), 92–124.

Amigud, A., Arnedo-Moreno, J., Daradoumis, T., & Guerrero-Roldan, A.-E. (2017). Plagiarism detection: Machine learning versus conventional methods. Journal of Educational Technology & Society, 20(3), 123–135.

Bakeman, R., & Gottman, J. M. (1997). Observing interaction: An introduction to sequential analysis. Cambridge University Press.

Baker, T., & Smith, L. (2019). Educ-AI-tion Rebooted? Exploring the future of artificial intelligence in schools and colleges. Nesta.

Bartolomé, A. R., Castañeda, L., & Adell, J. (2018). Personalisation in educational technology: The absence of underlying pedagogies. International Journal of Educational Technology in Higher Education, 15(14), 1–15.

Calvo, R. A., O'Rourke, S. T., Jones, J., Yacef, K., & Reimann, P. (2011). Collaborative writing support tools on the cloud. IEEE Transactions on Learning Technologies, 4(1), 88–97.

Casamayor, A., Amandi, A., & Campo, M. (2009). Intelligent assistance for teachers in collaborative e-learning environments. Computers & Education, 53(4), 1147–1154.

Chou, C.-Y., Huang, Y.-M., & Lin, C.-H. (2011). The effectiveness of using procedural scaffoldings in a multimedia supported learning system. Educational Technology & Society, 14(2), 118–129.

Contact North. (2018). Artificial Intelligence in Higher Education. Retrieved from https://teachonline.ca

Delen, D. (2011). Predicting student attrition with data mining methods. Journal of College Student Retention: Research, Theory & Practice, 13(1), 17–35.

Dodigovic, M. (2007). Artificial intelligence and second language learning: An efficient approach to error correction. ReCALL, 19(1), 101–115.

Educause. (2018). Horizon Report: 2018 Higher Education Edition. EDUCAUSE.

Educause. (2019). Horizon Report: 2019 Higher Education Edition. EDUCAUSE.

Fleiss, J. L. (1981). Statistical methods for rates and proportions (2nd ed.). John Wiley & Sons.

Gierl, M. J., Latifi, S., Lai, H., Boulais, A. P., & Champlain, A. F. (2014). Computer-based constructed-response testing in postgraduate medical education. Teaching and Learning in Medicine, 26(3), 271–277.

Gough, D., Oliver, S., & Thomas, J. (2017). An introduction to systematic reviews (2nd ed.). SAGE Publications.

Hinojo-Lucena, F.-J., Aznar-Díaz, I., Cáceres-Reche, M.-P., & Romero-Rodríguez, J.-M. (2019). Artificial intelligence in higher education: A bibliometric study. Education Sciences, 9(1), 51.

Huang, C.-Y., & Chen, S.-C. (2016). A model of intelligent tutoring system based on cognitive diagnosis theory. Computers in Human Behavior, 63, 343–352.

Kardan, A. A., Sadeghi, H., Ghidary, S. S., & Sani, M. R. F. (2013). Prediction of student course selection in online higher education institutes using neural network. Computers & Education, 65, 1–11.

Kose, U., & Arslan, A. (2016). An intelligent system for students' academic performance prediction. Procedia Computer Science, 62, 550–556.

Li, Y. (2007). Intelligent agent-supported personalized instruction: A case study in higher education. Educational Technology & Society, 10(3), 320–330.

Lo, C.-C., Chan, Y.-H., & Yeh, S.-P. (2012). Development of an adaptive e-learning system based on learning style. Procedia - Social and Behavioral Sciences, 64, 506–515.

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). Intelligence unleashed: An argument for AI in education. Pearson.

McNamara, D. S., Crossley, S. A., Roscoe, R. D., Allen, L. K., & Dai, J. (2015). A hierarchical classification approach to automated essay scoring. Assessing Writing, 23, 35–59.

Misiejuk, K., & Wasson, B. (2017). Learning analytics in higher education—A literature review. CEUR Workshop Proceedings, 1828, 53–63.

Petticrew, M., & Roberts, H. (2006). Systematic reviews in the social sciences: A practical guide. Blackwell Publishing.

Popenici, S. A. D., & Kerr, S. (2017). Exploring the impact of artificial intelligence on teaching and learning in higher education. Research and Practice in Technology Enhanced Learning, 12(1), 22.

Russell, S., & Norvig, P. (2010). Artificial Intelligence: A Modern Approach (3rd ed.). Prentice Hall.

Samarakou, M., Fylladitakis, E. A., Früh, W.-G., Hatziapostolou, T., & Gelegenis, J. (2015). An intelligent system for performance evaluation of engineering students. IEEE Transactions on Learning Technologies, 8(3), 289–299.

Steenbergen-Hu, S., & Cooper, H. (2014). A meta-analysis of the effectiveness of intelligent tutoring systems on K–12 students' mathematical learning. Journal of Educational Psychology, 106(4), 901–918.

Vlugter, P., Knott, A., McDonald, J., & Hall, C. (2009). Affect and effectiveness in learning to write essays. International Journal of Artificial Intelligence in Education, 19(1), 1–24.

Welham, D. (2008). Implementing artificial intelligence in education: Costs and risks. Educational Technology & Society, 11(1), 295–298.

Weston-Sementelli, J. L., Allen, L. K., & McNamara, D. S. (2018). The impact of essay revising tools on students' writing. International Journal of Artificial Intelligence in Education, 28(1), 120–148.

Wickham, H., & Grolemund, G. (2016). R for data science: Import, tidy, transform, visualize, and model data. O'Reilly Media.

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? International Journal of Educational Technology in Higher Education, 16(39). https://doi.org/10.1186/s41239-019-0171-0