Jurnal Penelitian dan Pembelajaran IPA JPPI
Vol.11, No.1, 2025, p. 98-112 p-ISSN 2477-1422 e-ISSN 2477-2038

# Artificial Intelligence Research in Biology Learning: A Systematic Review

(Received 20 October 2024; Revised 31 May 2025; Accepted 31 May 2025)

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**DOI: 10.30870/jppi.v11i1.23075**

## Abstract

This study aimed to investigate the trends in artificial intelligence publication, author contributions, active countries, and key information in articles. A systematic review used in this study. The research parameters include the publication period from 2018 to 2023, English-language articles, article accessibility, and the application of artificial intelligence in biology learning. The results of the study show fluctuations in interest in artificial intelligence research in biology learning. In addition, the various contributions from the authors reflect the diversity of views and analytical approaches. The results also reveal that the analyzed documents originate from multiple countries. Furthermore, widely used artificial intelligence applications include learning personalization, interactive material development, student performance evaluation, intelligent tutoring, big data analysis, and collaborative learning. The conclusion is that artificial intelligence has been applied in various countries, demonstrating its potential to enhance the learning experience and improve the effectiveness of the learning process. The study's recommendation is that further research is needed to develop the use of artificial intelligence in supporting student-focused learning models that empower 21st-century competencies, especially in rural areas, to minimize the learning quality gap in Indonesia.

Keywords: Artificial Intelligence, Automatic Scoring, Biology Education, Collaborative Learning, Interactive Material

## INTRODUCTION

Today's learning cannot be separated from the use of artificial intelligence. Artificial intelligence supports collaborative learning and provides students with a more meaningful learning experience (Beltran et al., 2018; Blaser, 2019; Al Yakin et al., 2025). Through artificial intelligence, students can find and understand important information from the subject matter and offer solutions to the problems (Thirugnanasambandam et al., 2022). Various forms of artificial intelligence continue to develop and significantly contribute to the development of the learning process (Maganathan et al., 2020; Omarova et al., 2021; Tariq et al., 2021; Begum et al., 2023).

However, using artificial intelligence in learning has not been fully optimised. Although artificial intelligence has become part of the development of educational technology, the learning process has not fully utilised its potential (Cao et al., 2022; Lu, 2022; Santos et al., 2022). Teachers still act as instructors and primary sources of information in learning (Hudha et al., 2018; Onah et al., 2020; Salsabila et al., 2020; Tan et al., 2023), while learning objectives have not provided 21st-century skills called 4C (Robberts & van Ryneveld, 2019; Jaedun et al., 2022; Frerejean et al., 2023). Student participation in the learning process is also still less active (Abella-García et al., 2019; Hettiarachchi, 2019; Huang et al., 2020), and student learning motivation tends to be low (Jahnke et al., 2022; Chang-Tik & Song, 2023). Artificial intelligence is needed to create a more interactive, inclusive, and motivating learning experience for students (Chang-Tik & Song, 2023; Sundar & Liao, 2023).

This research is essential because there are still minimal reports on using artificial intelligence in biology learning. Therefore, it is necessary to explore research trends, author contributions and their countries of origin, and essential information from research results to provide a comprehensive picture of the potential and implications of using artificial intelligence in biology learning.

## METHOD

This study used a systematic review with methods adopted from (Ahmad & Junaini, 2020; Usman & Hartati, 2024). With the same approach, this study aims to understand the research topic comprehensively. The steps of systematic review include formulating research questions, searching for relevant literature, evaluating and selecting articles based

on inclusion criteria, in-depth analysis of selected papers, and compiling a comprehensive summary. The purpose of this study is to contribute to the overall context of science. Research questions include publication trends, authors, author countries of origin, and essential information. The next step is to search for research with the keyword "artificial intelligence" in the Scopus database. The data found were then analyzed, with the process of selecting and evaluating research including searching the Scopus database, with inclusion criteria: 1) publication period between 2018 and 2023, 2) focus on biology learning, and 3) involving all levels of education, from elementary school to high school. The details are illustrated in Figure 1, including keywords and screening steps.

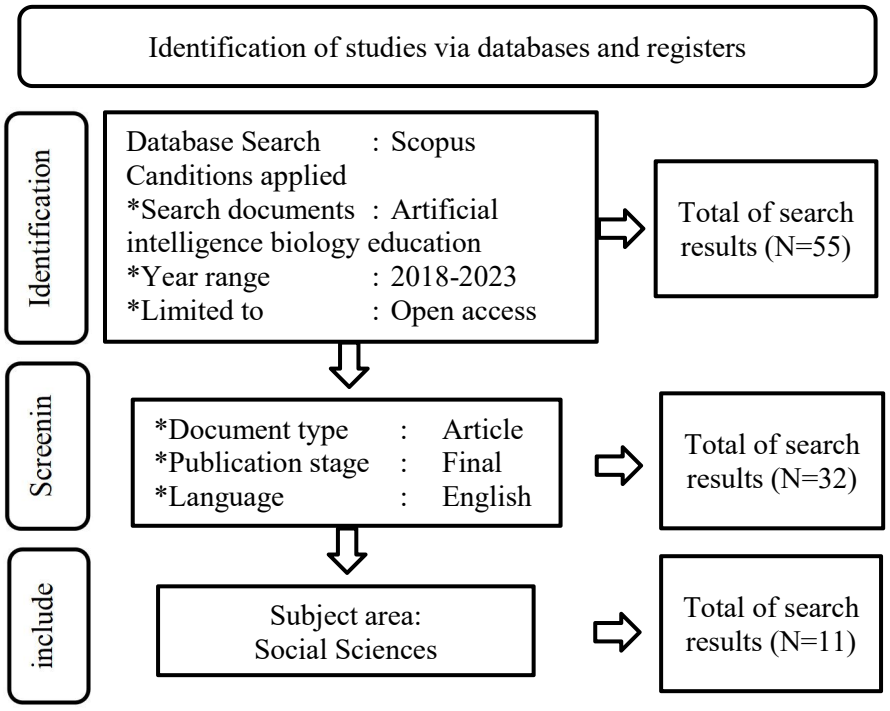


Figure 1. Review process for study selection

**RESULTS AND DISCUSSION**

The discussion is divided into four sections according to the main research questions. This division is to provide a comprehensive overview of the diversity and breadth of the literature on artificial intelligence research in biology learning. The analysis provides in-depth insight into research and literature development dynamics in artificial intelligence in biology learning. The first discussion discusses publication trends by analyzing the number and distribution of research documents by year of publication. The data shows variations in research

documents over the past few years. In 2023 and 2022, a significant number was recorded, with four research documents each. However, no research documents were listed in some years, such as 2021 and 2019. In 2020, there were three documents, while in 2018, there was only 1 document. Further details can be seen in Figure 2.

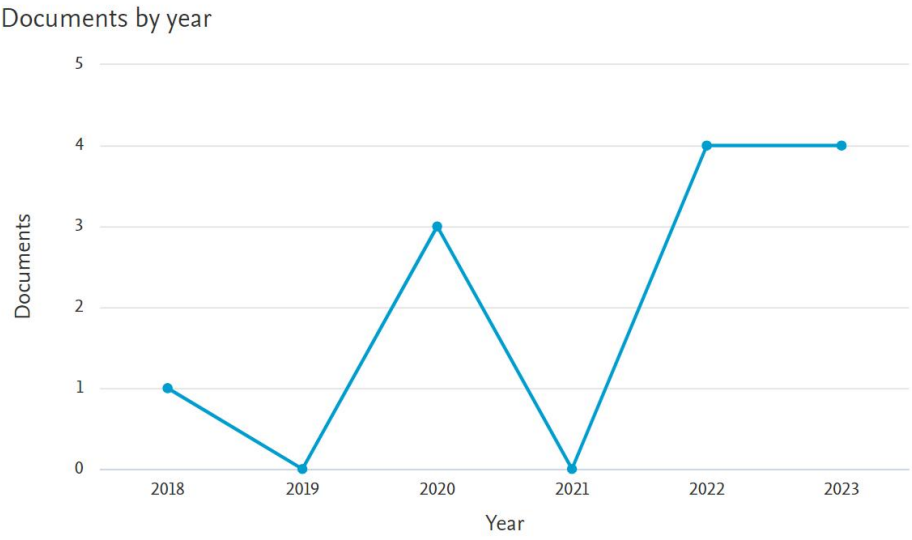


Figure 2. Document by year

Intelligence research in biology learning experiences fluctuations in research interest. Several factors, such as one can cause this) developments in technology or learning methods, 2) products in education that influence research focus, and 3) production of scientific literature in artificial intelligence and biology learning.

Trends in research interest related to intelligence in biology learning have fluctuated, as reflected in the development of related documents. Advances in technology or learning methods may increase the number of records described in relevant reference documents (Boyer et al., 2017; Siddique et al., 2019; Gupta et al., 2023). Furthermore, developments in education have a significant impact on research focus.

Several authors who have contributed to the literature on the use of artificial intelligence in biology learning include Koć-Januchta, M.M. with two documents (Koć-Januchta et al., 2020; Koć-Januchta et al., 2022), Schönborn, K.J. with two documents (Koć-Januchta et al., 2020, Koć-Januchta et al., 2022), Tibell, L.A.E. with two documents (Koć-Januchta et al., 2020; Koć-Januchta et al., 2022), Bernacki, L. with one documents (Metcalf et al., 2023), Bernacki, M.L. with one document

(Metcalf et al., 2023), Bertolini, R. with one document (Bertolini et al., 2023), Cazier, J.B. with one document (Johnston et al., 2022), and Chinnadurai, M. with one document (Manikandan & Chinnadurai, 2020). More details can be seen in Figure 3.

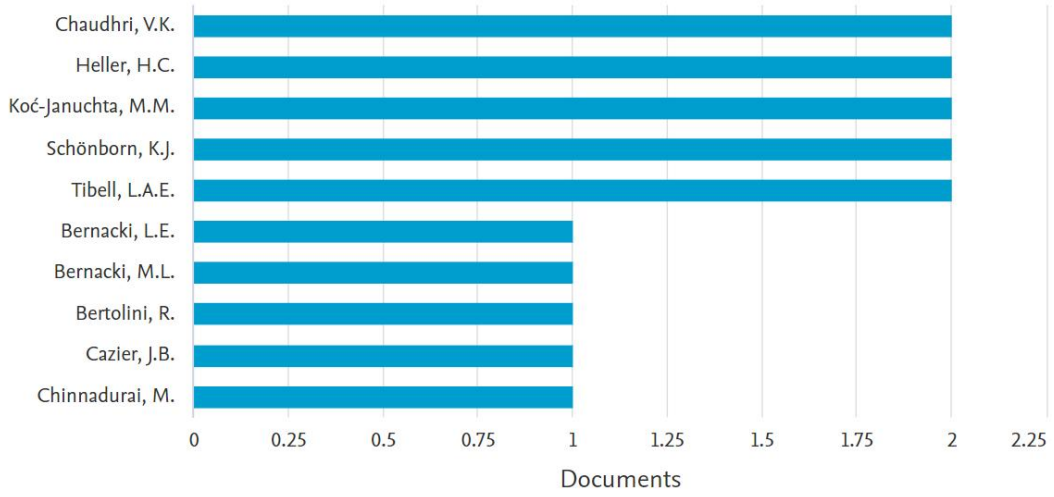


Figure 3. Document by author

The diverse contributions of these authors reflect the diversity of views and approaches in artificial intelligence research in the field of biological learning. Each author brings a unique perspective, contributing to our understanding of how artificial intelligence can be applied to biology learning (Ma et al., 2018; Alam et al., 2019; Ostafe et al., 2020; Jebril & Abu Al-Haija, 2021).

This research shows that various authors have focused on specific aspects, such as personalization of learning, development of interactive materials, automatic assessment, intelligent tutor assistance, use of big data for learning analysis, and collaborative learning. This diversity provides a rich and comprehensive picture of the various ways artificial intelligence can help improve learning experiences and effectiveness (Rusu et al., 2014; Parvez & Khan, 2023).

Contributions from authors from various countries represent artificial intelligence research in biology learning. In this literature, contributing countries include the United States with seven documents, Germany with two documents, India with two documents, Sweden with two papers, Australia with one copy, Brazil with one record, Hong Kong with one document, Norway with one document, Portugal with one document, and the United Kingdom with

one paper. More details can be seen in Figure 4.

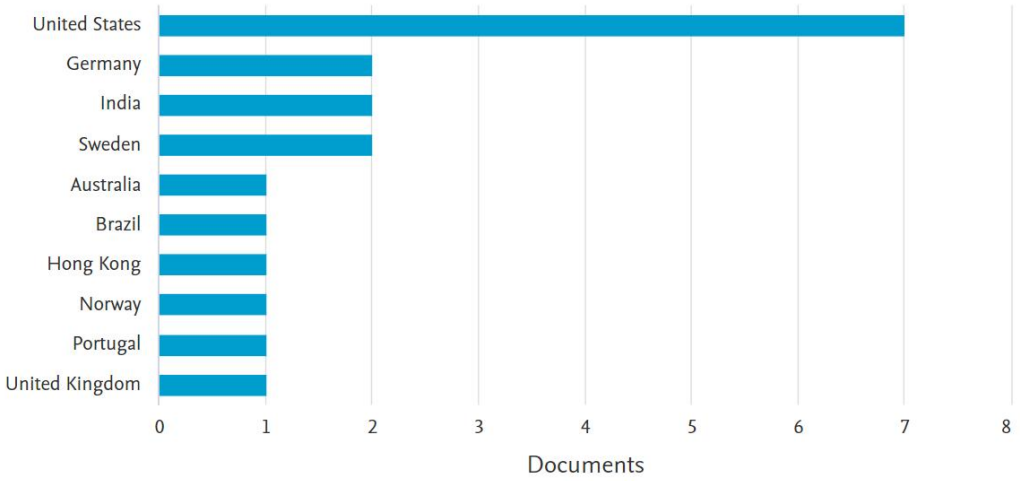


Figure 4. Document by coutry

This reflects the diversity of artificial intelligence research in the context of biology learning in various parts of the world. This emphasis reflects the diversity of artificial intelligence research in the context of biology learning conducted in various parts of the world. Authors from different countries bring their unique perspectives to using artificial intelligence in the context of biology learning. This diversity indicates that using artificial intelligence in biology learning is not just a local phenomenon but has become a global research focus. Thus, the results of this research provide a comprehensive picture of the trends and contributions of artificial intelligence research in the field of biology learning internationally. Important information in the article, such as concepts or significant findings that can contribute to further understanding and development can be seen in Table 1.

Table 1. Important information related to research results

| Autor | Important information |
|---|---|
| Hubbard and Couch, (2018) | Using clickers or audience response systems is an effective active learning strategy. Clicker helps teachers activate the classroom learning process by allowing each student to provide real-time feedback. This allows for the identification and correction of misunderstandings by both students and teachers. This learning strategy has been proven to encourage student participation, including those with low academic abilities, positively impacting student exam performance. |
| Manikandan and Chinnadurai, (2020) | The TensorFlow platform is an artificial intelligence engine used as a Big Data analysis tool to evaluate student performance in the context of educational science and predict |

| | |
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| | future developments. TensorFlow can classify and predict student performance in the realm of educational science. In addition, this platform can help students choose their future study major and plan their career development based on evaluating academic and non-academic performance factors while in high school. |
| Pence, (2020) | Artificial intelligence influences the learning process in the classroom. However, these technologies can cause students to experience isolation, potentially hindering the development of social skills necessary for the world of work. |
| Koć-Januchta et al. (2020) | The application of artificial intelligence (AI) to support science learning is an integral part of the digital education revolution. Using AI books increases student learning motivation and retention, encouraging students to be more active in searching for and understanding material or concepts through visual representations. |
| Jain et al. (2022) | The modern learning process cannot be separated from using artificial intelligence technology. Artificial intelligence is a critical element in implementing learning. So, skill in operating technology is an essential aspect. Furthermore, the learning curriculum must constantly be updated and adapted to technological developments to ensure its relevance and effectiveness. |
| Johnston et al. (2022) | A hands-on computing approach that utilizes virtual machines can create a collaborative and efficient learning environment. Virtual machines encourage students to be able to work in teams, thereby increasing students' skills and confidence in the learning process. |
| Rabelo et al. (2022) | The Intelligent Personal Assistants (IPA) application can be an alternative for students, especially students with special needs, such as blind people. IPAs such as ForAlexa offer two types of forms: Questions and Answers (Q&A) and Random Quotes. Both states allow the user to design the intent or activity generated by a verbal request from the user, although with slightly different functions. The Q&A form is used to structure the answers that Alexa will develop in response to a greeting or question. At the same time, Random-Quote extends the interaction between Alexa and the user by considering the question asked in the first form. |
| Koć-Januchta et al. (2022) | The AI-enriched digital biology textbook, which integrates a knowledge base of 5000 concepts and algorithms, offers the ability to ask questions and receive answers. This increases student involvement in the meaningful learning process. Furthermore, the existence of AI-enriched digital biology textbooks can provide support for a more profound learning process. |
| Henrich et al. (2023) | Student responses to using artificial intelligence in implementing the learning process are excellent.<br>This is because artificial intelligence can help students find solutions and understand other materials during learning. One of these artificial intelligence is using computer-based applications to analyze animal behaviour outside the school |

| | |
|---|---|
| | laboratory. |
| Gibson et al. (2023) | The theory of artificial intelligence in the learning process plays a role in collecting, combining and disseminating information and utilizing it at three levels of the learning process, namely micro, meso and macro. At the micro level, this theory is a core learning mechanism that highlights fundamental aspects of the teaching and learning process—the meso level is a social environment for learning teams focusing on joint problem-solving. Meanwhile, the macro level operates as an interdisciplinary and cross-cultural space where groups interact and work together to build knowledge. |
| Metcalf et al. (2023) | Digital textbook platforms have great potential to enhance active learning. Features such as self-explanation, summary, and elaboration can encourage student engagement in education. However, to maximize their effectiveness, these features must be improved to promote productive engagement in learning strategies further. In addition, more explicit instructions also need to be implemented to organize learning practices more effectively. |

Artificial intelligence in biology learning involves several applications that can improve student learning experiences and the effectiveness of the learning process. Some of them include: 1) personalization of learning, namely providing learning experiences for students and increasing understanding of biological concepts. 2) development of interactive materials, such as virtual models, that help increase understanding of biological concepts. 3) Evaluation of student performance, namely providing feedback to students and teachers from the learning process. 4) Smart tutors who can guide students during the learning process. 5) Big data, namely for learning analysis or identifying patterns and trends in student understanding. 6) Collaborative learning supports the collaborative learning process and encourages interaction between students to understand biological concepts.

## CONCLUSION

Research on artificial intelligence in biology learning is increasingly being conducted in various countries. Various applications of artificial intelligence have been applied in the context of education. Artificial intelligence can improve students' learning experiences and the effectiveness of the learning process. Further research is needed on the use of artificial intelligence to support student-focused learning models, which aim to empower 21st-century competencies, particularly in rural areas, thereby minimizing the learning quality gap in Indonesia.

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