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Artificial intelligence in biology and learning biology: A literature review

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ABSTRACT

Artificial Intelligence (AI) had been developed in various fields of human life. The use of AI brought the world towards a digital transformation that had not been imagined before. One form of AI development in the fields of biology and biology education brought the development of science in both fields far beyond expectations. The use of AI in the fields of biology and biology education had utilized many new methods and discoveries that are beneficial to humans. The purpose of this study was to determine the application of AI in biology and biology learning. The literature review method was used to analyze and synthesize research results from a new perspective. The results of the analysis of various pieces of our literature found various uses of AI. In the field of biology, including AI in the field of biology used for biological data analysis, genetic data analysis, investigation of complex biological phenomena (synthetic biology and system biology), bioinformatics, disease detection, and diagnosis. AI had been utilized in various fields of biological sciences such as medical, agriculture, animal husbandry, and industry for product development and automation in the production process utilizing IoT. There were 24 types of AI utilization in education, especially biology learning, which can be grouped into six groups: personalized and tutoring learning (teaching assistance/tutor), evaluation and assessment, teaching media, enriching learning, virtual classes, and learning aids.

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INTRODUCTION

The development of information and communication technology has significantly enhanced the convenience of human life. Developments in the field of ICT have led to a new technology called Artificial Intelligence (AI). AI is the ability of machines to adapt to new and emerging situations, solve problems, answer questions, make plans, and perform intelligent functions that are usually associated with human abilities (Owan et al., 2023). It represents a swiftly advancing discipline, encompassing the development of intelligent robots capable of replicating human thought processes and actions. AI finds application in areas such as medical diagnosis, driverless cars, and education (Wardat et al., 2023). In general, AI refers to the ability of machines to simulate the intelligence of higher organisms (Bhardwaj et al., 2022).

AI has become a recent trend in the world that has penetrated various aspects of human life, including the education subject. Advances in the field of AI have significantly made human work

easier, especially for instructors and teachers (Chen et al., 2020). The presence of AI has transformed the traditional learning pattern to digital learning based on digital computation and data analysis. The use of AI in education has consistently expanded and grow by 47% in the 2018-2022 period in the United States (Ahmad et al., 2023). The presence of AI has changed the paradigm of education, especially higher education, especially with the development of Intelligence Tutorial System (ITS), Teaching Course Content, Evaluation and Assessment, Adaptive Systems, and Personalized which seems to have reduced the role of the teacher (Zawacki-Richter et al., 2019).

The utilization of AI in education has raised both positive and negative, especially concerning ethical issues (Reiss, 2021). AI brings numerous advantages to education but there is still a debate about ethical issues related to AI. The utilization of AI in education has the potential to violate academic ethics such as data privacy, data bias, security, social impact, transparency and accountability, and safety (Reiss, 2021; Remian, 2019; Elliott & Soifer, 2022).

In the field of biology, AI can be applied for for various task, including biological knowledge discovery and assembly, behavioral ecology observation, predicting gene appearance, prediction, evolution, and infectious disease control (Hassoun et al., 2021), (Reiss, 2021). The application of AI in education, especially biology learning, is mainly to assist in learning assessment, providing teaching assistance, utilizing teaching media, enhancing the learning process, facilitating virtual classes, and serving as learning tools (Al Braiki et al., 2020; González-Calatayud et al., 2021; Timms, 2016; Zawacki-Richter et al., 2019). Additionally, the use of AI in biology learning also has the potential to improve student comprehension (Nguyen et al., 2023).

One type of AI application that is widely used in education, particularly in the field of biology, is ChatGPT. This technology can serve various purpose, including search for information, answer specific questions, ask questions about any topic; engage in open conversations and discussions; write and edit reports and essays; code software; provide tutoring by explaining code; provide sample data for databases and analysis; and complete mathematical calculations and statistical analysis, and translate text into other languages (Halaweh, 2023). In the fields of biology and biological education, ChatGPT can be utilized to simplify and accelerate highly complex and challenging tasks (Agathokleous et al., 2023).

To effectively to utilize AI in biological learning, it must be supported by basic knowledge about the working principles of AI and its utilization in learning. There is necesarry for studies that can provide perspectives related to the use of AI in biology and especially biology education as well as various ethical and safety issues in the use of AI for education. Studies on the utilization of AI in biology and biology learning have not been conducted by many researchers in Indonesia. Therefore, this study aims to describe the role of AI in biology and education in general and biology education specifically. The results of this study are expected to provide a real contribution to education stakeholders in Indonesia in the utilization of AI to support learning as well as challenges and ethical issues related to the utilization of AI in learning.

METHOD

This research employed the literature review method, a systematic, explicit, and reproducible method for identifying, evaluating, and synthesizing research works and thoughts that have been

produced by researchers and practitioners. Identification, evaluation, and synthesis of research works and the results of thoughts that had been produced by researchers and practitioners. The literature review aimed to analyze and synthesize existing knowledge related to the topic under research. Related to the topic under study to find empty spaces for research to be carried out (Ulhaq & Rahmayanti, 2020).

The literature review technique used in this study includes several stages: determining the research problem, searching for literature, reading and reviewing the contents of the literature, synthesizing the results of the literature, and rewriting the results of the literature review into new ideas. The *Litmaps* application was employed to facilitate the discovery of relevant literature align with the research theme. (https://app.litmaps.com/) and https://typeset.io/.

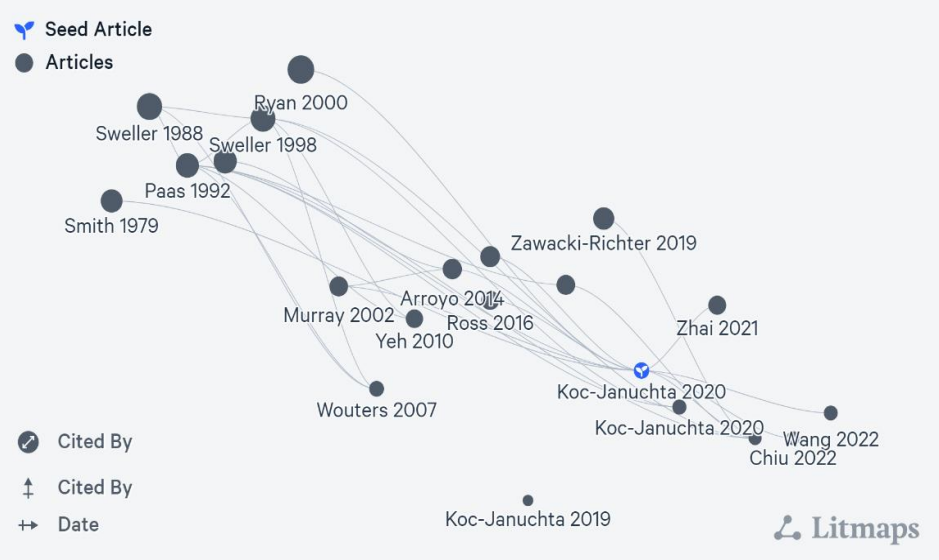


Figure 1. Literature map of AI in education

RESULTS AND DISCUSSION

1. Artificial Intelligence in Biology

The implementation of AI in the field of biology has diverse applied in various fields such as medical, industry, agriculture, and animal husbandry. The use of AI in biology is primary involved the studying of molecular interaction networks and cell behavior (Fages, 2020). The development of AI for biologists can be a solution to solving various research problems such as investigating and integrating complex mechanisms at various scales (from genes, cells, organisms, populations, and ecosystems), and developing theoretical engines to understand biological and ecological systems at very large scales, all of which would be very limited without integration of AI (Hassoun et al., 2021).

The application of AI in various fields of human life (i.e. Figure 1) can be used for various purposes .In the medical field, AI can be used to detect and diagnose diseas. In agriculture, AI can be used to carry out various agricultural activities such as identifying plant diseases, watering with IoT systems and harvesting processes using autonomous robots that are programmed using AI. Within the industrial field, AI can be used to develop medicines with accuracy and minimal side effects (Bhardwaj et al., 2022).

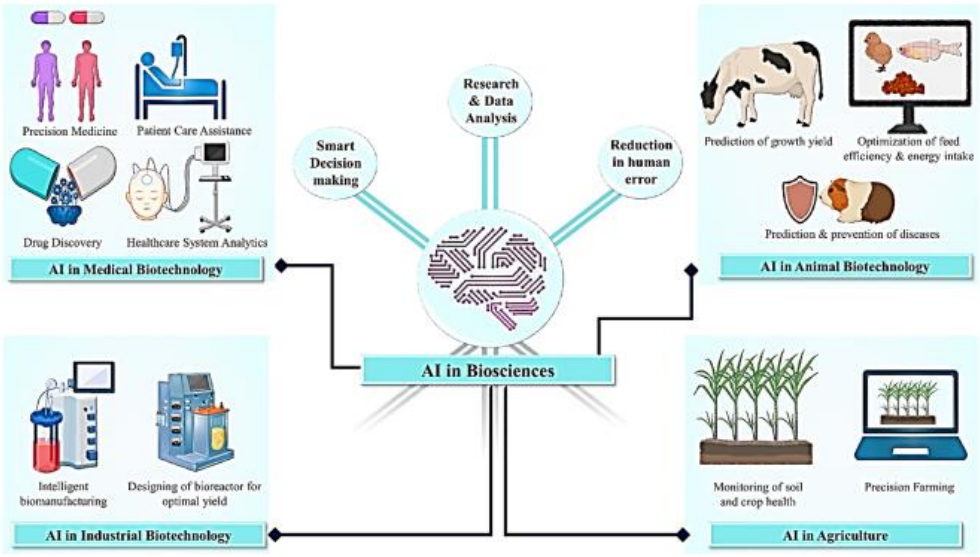


Figure 2. Utilization of AI in Biology
(Source: Bhardwaj et al., 2022)

Figure 2 shows the illustration of diverse application of AI in the field of biology, one example is in the field of agriculture. The utilization of AI in this field can be done through IoT technology. Through this technology, farmers enable to monitor various nutritional needs of plants using AI-based sensors. This technology allows for the controlling and monitoring plant nutrition at any time.

2. Artificial Intelligence in Biology Education

The utilization of AI in biology learning share similarities with the use of AI in education in general, the difference is only in the field of study is specific focus on biology learning. Owan et al., (2023) identified 24 benefits of using AI in education, including Personalized learning, Intelligent tutoring systems (ITS), Automated grading, Predictive analytics, Natural language processing, Intelligent content, Virtual assistants, Automated transcription and translation, Learning management systems (LMS), Automated essay scoring (AES) software, Learning analytics tools, Computer-based testing (CBT) platforms, Gamification tools, Virtual reality (VR) and augmented reality (AR), Formative assessment tools, Online polling tools, Interactive whiteboards, Video conferencing tools, Digital portfolios, Data visualization tools, Social media platforms, Plagiarism detection, Classroom response systems, and Digital assessment tools.

Table 1. Application of AI in Education

No.	Utilization of AI	References
1.	Teaching assistance (tutor)	(Zawacki-Richter et al., 2019); (du Boulay, 2019)
2.	Learning evaluation and assessment	(González-Calatayud et al., 2021); (Al Braiki et al., 2020); (Nasution, 2023); (Owan et al., 2023)
3.	Teaching media	(Remian, 2019); (Koć-Januchta et al., 2020)
4.	Enriching learning	(Veselinovska, 2014); (Yang & Wang, 2012)
5.	Virtual classroom	(Kim et al., 2018); (Dhanalakshmi et al., 2021)
6.	Learning aids	(Sahu, 2015)

Based on its application, various types of AI services can be grouped into six categories, namely teaching assistance (i.e ITS, virtual assistants, personalized learning), learning evaluation (i.e automated grading, AES, CBT), teaching media (i.e VR and AR), virtual classroom (i.e LMS),

enriching learning (i.e interactive whiteboard), games (i.e gamification tools), and learning aids (i.e online polling tools). Here are some utilizations of AI in education and related references.

Table 1 shows the diverse application of AI in education in general. The most widely employed utilization of AI, based on identified references, is for learning evaluation activities. AI in education is versatile and can be employed for various learning purposes. The utilization of AI in education is tailored to the needs and solutions offered through AI technology. Tabel 2 shows the various types of AI technology used in education, especially in biology learning.

Table 2 presented the various forms of AI technology used in supporting the biology education or learning process. In general, the use of AI in learning in Table 2 focuses on AI as a teaching medium, as an assessment tool, and as a tutor. In the context of education in Indonesia, AI is applied as a method and tool to facilitate student learning (Mambu et al., 2023; Astagisa & Aldiansyah, 2022).

Table 2. Types of AI Technology in Biology Education and Learning

No.	AI Technology Models	Utilization of AI	Types	Authors
1.	Adaptive modeling	Teaching media	Educational Game	(Thomas & Young, 2010)
2.	Experience point data modeling	Teaching media	Digital Game	(Moon et al., 2011)
3.	Interactive book	Enriching learning	Digital Book	(Koć-Januchta et al., 2020)
4.	Smart classroom	Virtual classroom	Virtual Classroom	(Kim et al., 2018)
5.	Virtual laboratory	Teaching media	Virtual Laboratory	(Munawar et al., 2018)

Figure 3 shows that AI systems for education generally consist of teaching content, data, and intelligent algorithms, which can be divided into two parts: system models (including learner models, teaching models, and knowledge models) and intelligent technologies (Kim et al., 2018). The utilization of AI in learning can improve learning activities and the quality of learning used by teachers (Huang et al., 2021).

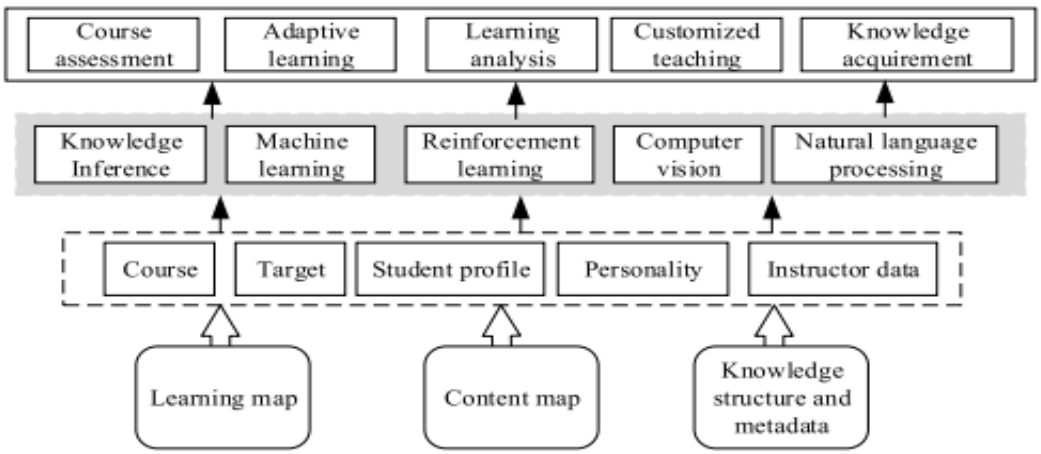


Figure 3. Structure of AI for Education
(Source: Chen et al., 2020)

3. Artificial Intelligence Challenges in Biology Education and Learning

The development of AI in education will focus on the Internet of Things, swarm intelligence, deep learning, and neuroscience, as well as the assessment of the influence of AI in education (Zhai

et al., 2021). The challenges associated with implementing AI in education relate to techniques, the roles of teachers and students, and social-ethical issues (Zhai et al., 2021). The application of AI in education should pay attention to various aspects including emphasizing fairness, addressing ethical and security issue arising from data collection, use, and dissemination, as well as considering the using, and disseminating data; paying attention to the readiness of teachers in the use of AI, changes in learning styles especially self-learning, and more attention needs to be paid to communication between students (Huang et al., 2021).

CONCLUSION

Based on the results of the literature review, it is known that some of the roles of AI in the field of biology are utilized for biological data analysis, genetic data analysis, investigation of complex biological phenomena (synthetic biology and biological systems), bioinformatics, disease detection, and diagnosis. The utilization of AI in biology learning includes teaching assistance (ITS), learning evaluation and assessment, teaching media, enriching learning, virtual classes, and learning aids. AI has payed a pivotal role in supporting teachers, enhancing the learning process to be more meaningful and contextualized.

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