Bioedukasi
Jurnal Biologi dan Pembelajarannya
Vol. 23 No 2, June 2025, page 156-162
e-ISSN: 2580-0094; p-ISSN:1693-3931
DOI: 10.19184/bioedu.v23i2.53702
bioedukasi.jurnal.unej.ac.id/index.php/BIO

The Effect of E-Module for Scientific Writing Assisted by AI (Artificial Intelligence) Software on Digital Literacy and Critical Thinking Skills of Biology Education Undergraduate Students

Ivan Ramadhani Putra[1], Hadi Suwono[2], Munzil[3]
[1]Biology Education, State University of Malang, Indonesia
[2,3] Chemistry Education, State University of Malang, Indonesia

Article Info
Article history:
Received May 19, 2025
Revised June 13, 2025
Accepted June 21, 2025

Keywords: (A-Z)
Critical Thinking
Digital Literacy
E-module

ABSTRACT
This study aims to analyze the effect of an AI-assisted e-module for scientific writing on the digital literacy and critical thinking skills of Biology Education undergraduate students. The research was driven by a preliminary study showing that students' digital literacy was moderate, while their critical thinking skills were still low. Using a quantitative approach, the study employed a quasi-experimental nonrandomized control-group pretest-posttest design. The participants were fifth-semester Biology Education students at Malang State University, consisting of two classes (59 students in total). The experimental class (31 students) used the AI-assisted e-module, while the control class (28 students) used PowerPoint during technobiology courses. Data collection involved pretest and posttest instruments: a digital literacy questionnaire with six indicators (e.g., source selection, evaluation, and production of original work), and descriptive questions on critical thinking with five indicators (e.g., application, evaluation, and synthesis). Independent sample t-test results showed that the AI-assisted e-module significantly improved students' digital literacy and critical thinking skills. This was evidenced by the higher post-test scores in the experimental group compared to the control group.

Corresponding Author:
Hadi Suwono,
Biology Education, State University of Malang
Jalan Semarang 5, Sumbersari, Kec. Lowokwaru, Malang 65145, Indonesia
Email: hadi.suwono.fmipa@um.ac.id

1. INTRODUCTION

Writing scientific papers is one of the demands that must be fulfilled by students. This demand is based on the development of science that continues to move quickly and requires rapid dissemination. In addition, Director General of Higher Education Circular Letter Number 152/E/T/2012 explicitly requires students to compile scientific papers as part of their academic process. From an academic perspective, writing scientific papers aims to develop and disseminate knowledge by reporting the latest findings. Thus, the ability to write and publish scientific papers is an essential skill for students in the academic world (Fauziya, 2020).

The process of writing scientific papers requires complex stages, from finding ideas to publication (Farid, 2017). Students need qualified tools to improve the quality of their writing to comply with applicable academic standards (Fauziya, 2020). One solution that can be used is the utilisation of artificial intelligence (AI) in the scientific writing process. The development of AI technology has brought significant changes in various aspects of life, including education. In the academic world, the use of AI in writing scientific papers can provide convenience, but also poses its own challenges. Although AI can assist in writing academic essays, answering exam questions, and drafting contracts automatically (Zhai, 2022), its uncontrolled use can lead to academic ethics problems, such as decreased creativity and critical reasoning of students (Maulana et al., 2023). Therefore, it is important for students to understand the potential and limitations of the use of AI in academia and adhere to applicable academic ethics.

Chatbots or conversational AI, such as ChatGPT, Copilot, and Gemini, have become increasingly popular tools in academic writing (Bubaš et al., 2023). Several studies have shown that chatbots can help students in brainstorming, outlining, and editing academic writing (Henry, 2023). However, the use of AI also exerts a broader influence on students' critical thinking abilities and digital literacy. Several studies have shown that students tend

to rely on AI in writing their academic papers, raising concerns among academics regarding students' academic integrity and critical thinking skills (Huang & Tan, 2023). As a solution to this problem, clear guidelines are needed for the use of AI in academic writing. One form of guidance that can be applied is through the development of e-modules that contain ethical and technical guidelines in utilising AI for academic purposes. E-modules are systematically designed teaching materials in digital form that can be accessed anytime and anywhere. The advantages of e-modules lie in their flexibility in improving learning effectiveness and their ability to present interesting content through various multimedia features (Triyono, 2021).

Optimising the use of e-modules in AI-assisted scientific writing is expected to assist students in comprehending academic regulations and ethics while also enhancing their 21st-century competencies, particularly in digital literacy and critical thinking. Digital literacy includes the capability to comprehend and utilize information from various formats effectively (Pangrazio et al., 2020). Gilster in Pangrazio et al. (2020) emphasises that digital literacy is more than just technical skills, but also includes a critical thinking process in evaluating information found through digital media. The results of research conducted by Kaya & Korucuk (2022) on 688 students at universities in Eastern Anatolia showed that average digital literacy level of students remained at a low level. Research by Sumadi et al. (2023) on 108 biology education students also showed that only 50.93% of students had digital literacy in the moderate category, while 37.96% were classified as weak.

In addition to digital literacy, critical thinking is also an essential skill in higher education and is part of Students in the 21st century are required to possess essential skills. One of these is critical thinking, which encompasses the capability to evaluate, analyse and synthesise information to generate deep insights (Greenstein, 2012). Critical thinking includes the ability to evaluate ideas in depth, develop logical arguments, and analyse and synthesise information effectively (Oikonomidis & Sofianopoulou, 2023). However, previous research shows that many university students do not have adequate critical thinking skills, so intervention through appropriate training programmes is required (Pnevmatikos et al., 2023; Suciati et al., 2022). This is evidenced by the research of Pnevmatikos et al. (2023) at the University in Northwestern Greece on 243 socio-science students showed that 53.9% to 66.3% of students did not have adequate conceptualisation of critical thinking, and their understanding of critical thinking was not aligned with academic standards. Similar findings were also found in a study by Suciati et al. (2022) on 107 biology education students from two different campuses, which revealed that students' capacity for critical thinking were still at the beginner level, with an average score of 30 out of 100. Inconsistency in answers and oversimplification without clear implications were the main factors for the low score. According to Pnevmatikos et al. (2023) showed that many students have inadequate conceptualisation of critical thinking, resulting in the low quality of their academic writing.

Findings from the initial study indicate that the average percentage of digital literacy scores using the measurement of 6 indicators from Greenstein (2012) shows that students' digital literacy is at a moderate level. However, there is one indicator of student digital literacy that is still classified as low, namely the indicator "considers source, message effect", and there is one indicator that is classified as good, namely the indicator "finds". Meanwhile, The mean percentage score of critical thinking abilities using the measurement of 5 indicators from Greenstein (2012) showed that students' critical thinking skills were at a low level. However, there is one indicator of student digital literacy that has been classified as moderate, namely the "synthesize" indicator. According to research from (Putri et al., 2023), the implementation of e-modules has the potential to enhance the digital literacy skills of its users. Research from (Fakhri et al., 2024) also states that training in utilizing Artificial Intelligence for writing scientific papers can improve digital literacy. In addition, according to research from Khasanah & Indah (2024) that e-modules can develop students' capacity for critical reasoning. Research by Hendra et al. (2023) also stated that writing scientific papers can enhance learners' ability to think critically.

Through the information above, it is evident that students' digital literacy tends to be in the moderate category and students' critical thinking skills tend to fall within the lower classification. Therefore, students' digital literacy and critical thinking skills in scientific writing assisted by AI (Artificial Intelligence) software still need to be improved. Based on this background, this study aims to determine the effect of e-module for scientific writing assisted by AI (Artificial Intelligence) software on digital literacy and critical thinking skills of Biology Education undergraduate students. This research is expected to provide insight into how AI technology can be integrated in the learning process optimally and ethically, and contribute to improving the quality of higher education in the digital era.

2. RESEARCH METHOD

Research for this study was undertaken at the State University of Malang. Participants in this study were 5th semester students of S1 Biology Education at State University of Malang, which has a population of 2 classes consisting of 59 students (28 control class students and 31 experimental class students) who took Technobiology courses and will compile a paper. Research data were collected through digital literacy questionnaire instruments and critical thinking skills tests. The digital literacy questionnaire aims to measure students' digital literacy using six indicators, namely finds, uses multiple sources, selects, evaluates, considers sources, message effects, and uses to produce original work. Meanwhile, the critical thinking skills test aims to measure students' abilities using five

indicators, namely apply, evaluate, uses data to develop critical insights, analyse, and synthesize (Greenstein, 2012).

This study employs a quantitative approach and utilizes a quasi-experimental design with a non-randomized control group pretest-posttest framework which aims to determine the cause-and-effect relationship between one variable and another (Leedy & Ormrod, 2021). This research design involves two classes namely the experimental class and the control class. The experimental group received treatment through the use of a e-module scientific writing assisted by AI software, while the control group used Power Point.

Before the research instrument was used in the field, the digital literacy instrument and students' critical thinking skills were tested, which included expert validation tests and validation tests using Pearson correlation using IBM SPSS 27 statistical software calculations, then calculated using validity and reliability tests. Field trials were conducted to measure digital literacy using a questionnaire in the form of 12 statements and students' critical thinking skills using a test instrument consisting 10 description questions. Next, a preliminary test was conducted, specifically the test of normality (Shapiro-Wilk) and the test of homogeneity (Levene's Test of Equality of Error Variance), this test was carried out to determine whether the collected data followed a normal distribution and proved homogeneous or not. After the data was normally distributed and proved homogeneous, a t-test for independent samples was performed to assess whether the use of e-module scientific writing assisted by AI software had an effect on digital literacy and critical thinking skills of Biology Education undergraduate students.

3. RESULT AND DISCUSSION

Findings from study regarding the application of e-module scientific writing assisted by AI (Artificial Intelligence) software on digital literacy and critical thinking skills of biology education undergraduate students are presented in the form of tables and bar charts which are then described. This data was taken According to the pretest and posttest score results of digital literacy questionnaires and critical thinking skills questions that had been carried out in experimental and control classes. Table 1 below displays the average score per indicator taken from the pretest and posttest of the control class and experimental class.

Table 1. Average PreTest and PostTest Scores of Control and Experimental Classes Per-Indicator

Dependent Variable	Indicators	Control Class Pre-test Score	Control Class Post-test Score	Experimental Class Pre-test Score	Experimental Class Post-test Score
Digital Literacy	Finds	59	66	59	86
	Uses multiple sources	51	66	52	83
	Selects	55	63	55	80
	Evaluates	54	62	55	82
	Considers source, message effect	45	58	50	79
	Uses to produce original work	55	63	53	82
	Average	53,250	63,036	57,387	87,419
	Standard Deviation	1,538	7,300	1,462	9,542
Critical Thinking Skills	Apply	37	63	38	69
	Evaluates	37	64	39	73
	Uses data to develop critical insights	38	67	42	80
	Analyse	42	65	41	78
	Synthesize	41	64	35	81
	Average	39,250	64,821	39,194	76,677
	Standard Deviation	4,394	14,213	4,061	10,937

Based on the table above, it can be seen that the digital literacy post-test score found the highest value in the "finds" indicator in the experimental class, namely 86, this is also supported by evidence that students in the experimental class were able to find information through AI software which was then included in scientific papers in the form of papers that they compiled. Meanwhile, the critical thinking skills post-test score found the highest value on the "synthesize" indicator in the experimental class, namely 81, this is also supported by evidence that students in the experimental class were able to make information through AI software into a single unit which was then used as the final conclusion in scientific work in the form of papers they compiled.

The average of the pre-test and post-test scores of digital literacy and critical thinking skills of students needs to be known to determine the comparison of the influence given by the dependent variable on the independent variable. Based on the data above, it can be seen that the average pre-test and post-test scores of digital literacy and critical thinking skills of the control class and experimental class have increased. In the pretest data, the average value of digital literacy in both classes is 53.250 and 57.387, while the average value of critical thinking skills in both classes is 39.250 and 39.194, respectively. In this experiment, a score of 100 is considered a perfect score. By using the e-module, in the digital literacy post-test, the experimental group obtained an average score of 87.419, while the control group obtained a score of 63.036, while in the critical thinking skills post-test,

the experimental group obtained an average score of 76.677, while the control group obtained a score of 64.821. Based on these findings, the experimental group obtained a better posttest score than the control group. In addition, the highest increase in student digital literacy was found in the experimental group, which reached 30.032. While the highest increase in students' critical thinking skills was also found in the experimental group, reaching 37.483. This shows that the increase in the average score of the experimental group is higher than the average score of the control group.

The presentation of hypothesis testing of research results begins with prerequisite tests which include normality and homogeneity tests. This test was conducted after the data of pretest scores and posttest scores of experimental and control class students were collected. The Shapiro-Wilk test at the 5% significance level was conducted to determine whether the research data were normally distributed. Based on the results of the normality test that has been carried out, a significance value of 0.343 has been obtained in the digital literacy pre-test of the control class; 0.072 in the digital literacy post-test of the control class; 0.200 in the digital literacy pre-test of the experimental class; 0.105 in the digital literacy post-test of the experimental class; 0.056 in the critical thinking skills pre-test of the control class; 0.132 critical thinking skills post-test control class; 0.343 critical thinking skills pre-test experimental class; and 0.505 critical thinking skills post-test experimental class, using a significant level ($\alpha = 0.05$), which means that the overall significance value obtained in the Shapiro Wilk normality test is more than 0.05. So it can be that the sample is taken from a normally distributed population.

The Levene test, which is set at a significance level of 0.05, is used to determine whether the research data from the control group and the experimental group are homogeneous. According to the homogeneity test results that have been conducted, the obtained significance value is 0.378 has been obtained on the pre-test digital literacy data; 0.104 on the post-test digital literacy data; 0.489 on the pre-test critical thinking skills data; and 0.064 on the post-test critical thinking skills data using a significant level ($\alpha = 0.05$), which means that the overall significance value obtained in the Levene homogeneity test is more than 0.05. So it is stated that all variances are homogeneous. So it can be stated that all variances are homogeneous.

The data followed a normal distribution and exhibited homogeneity variance after undergoing the prerequisite test. Therefore, the independent sample t-test can be used to continue hypothesis testing. Table 2 displays the evaluation of statistical findings from the independent sample t-test.

Table 2. Independent Sample T-Test Hypothesis Test Results

Dependent Variable	Test	F	Sig. (2-tailed)
Digital Literacy	Pre-test	0,791	0,056
	Post-test	2,727	<0,001
Critical Thinking Skills	Pre-test	0,486	0,959
	Post-test	3,555	<0,001

The initial ability of students can be known through the acquisition of pre-test scores that have been done by students. Table 4 shows that the results of the independent sample t-test test found a significance value (2-tailed) of digital literacy pre-test data and critical thinking skills of 0.056 and 0.959, respectively, from the independent sample t-test test of digital literacy data and critical thinking skills of control classes and experimental classes at a significant level ($\alpha = 0.05$). So it can be said that the pre-test data of digital literacy and critical thinking skills are not different. Therefore, both classes can be declared to have the same or equal initial ability.

After both classes were treated, further analysis showed that the independent sample t-test test on the post-test data of digital literacy and critical thinking skills which both had <0.001, from the independent sample t-test test of digital literacy data and critical thinking skills of the control class and experimental class at a significant level ($\alpha = 0.05$). Thus, it can be concluded that the data from the post-test of digital literacy and critical thinking skills are significantly different. Therefore, it can be concluded that the e-module scientific writing assisted by AI (Artificial Intelligence) software has an effect on digital literacy and critical thinking skills of Biology Education undergraduate students.

The experimental class was given material about writing scientific papers in the form of an e-module which contained content that could train each indicator in digital literacy from finding, using multiple sources, selects, evaluates, considers sources, message effects, to uses to produce original work. There are many explanations in the e-module that are coherent, concise, and easy to understand to add insight into student digitalisation in writing scientific papers. In addition, the e-module is also accompanied by support in the form of videos, scientific references, and external website links to provide support in improving students' digital literacy. This is evidenced by the results of scientific work in the form of papers from experimental class students which have more references, complexity, and quality, compared to the control class. Therefore, the indicator 'uses multiple sources' of digital literacy showed a significant increase among students in the experimental class, which contributed to improvements in other digital literacy indicators. This notable increase is likely influenced by the interactive features of the AI-assisted e-module, which not only provided access to a wider range of references but also encouraged students to critically evaluate and compare information from multiple digital sources. The integration

of AI tools within the e-module, such as real-time suggestions, keyword-based search assistance, and content analysis support, may have played a key role in guiding students to consult various credible sources before constructing their scientific writing. Additionally, the AI's ability to offer feedback and recommendations likely fostered a habit of information triangulation, prompting students to cross-check and validate data across several platforms. As a result, students became more engaged in the research process and demonstrated greater initiative in selecting and using diverse sources, which in turn positively impacted the development of other digital literacy skills such as evaluating content credibility, understanding the impact of messages, and producing original work.

In addition, the material about writing scientific papers in the e-module contains content to train each indicator in critical thinking skills from applying, evaluating, using data to develop critical insights, analysing, to synthesising. There are evaluation exercises and group assignments in the e-module to provide training for students' critical thinking skills. This is evidenced by the outcomes of academic work presented through the papers from experimental class students who are more in-depth and thorough in their discussion and final conclusions, in contrast with the control class. Therefore, a considerable increase was recorded in the *"synthesize"* indicator of critical thinking skills among students in the experimental class. This improvement may be attributed to several factors related to the design and implementation of the AI-assisted e-module. One possible reason is the presence of structured tasks and scaffolded writing steps within the e-module, which gradually guided students to combine information from various sources and formulate original arguments. In addition, the integration of Artificial Intelligence played a key role by offering real-time feedback, generating alternative perspectives, and suggesting relevant content that encouraged students to think beyond surface-level understanding. The interactive nature of the AI-assisted tools may have stimulated higher-order thinking by challenging students to analyze, compare, and integrate ideas critically. As a result, students were better equipped to synthesize knowledge, which not only enhanced this particular indicator but also had a positive cascading effect on other aspects of critical thinking, such as evaluation, application, and analysis. This suggests that the synergy between e-module features and AI interaction contributed significantly to fostering deeper cognitive engagement and more independent, reflective thinking processes.

The e-module treated in the experimental class has the features of self instruction, self contained, stand alone, adaptability, and user-friendliness so that enable it to provide comfort and convenience for students in the experimental class in exploring the material for writing scientific papers in biology education assisted by AI (Artificial Intelligence) software. While the control class is only given material for writing scientific papers on biological education assisted by AI (Artificial Intelligence) software in the form of Power Point.

The e-module applied to the experimental class positively influenced students' digital literacy and critical thinking skills in writing AI-assisted scientific papers within the Technobiology course. This effect is attributed to the e-module's design as a self instructional, self contained, stand alone, adaptive, and user friendly learning resource. Such characteristics stimulate the development of 21st-century skills, particularly digital literacy and critical thinking. Pratiwi & Indana (2022) emphasized that e-modules provide guidance for online learning, offer access to videos and relevant articles, and include interactive quizzes, features that help strengthen digital literacy. Similarly, research by Putri et al. (2023) and Rachmawati et al. (2024) affirmed the effectiveness of e-modules in enhancing digital literacy. In addition, Astuti et al. (2022) and Imam et al. (2024) stated that e-modules oriented toward biological content are well-suited to developing students' critical thinking skills, a claim further supported by Mahmudah et al. (2022). The structure of the e-module encourages active student engagement in preparing scientific papers. However, during implementation, certain limitations were observed, such as varying levels of student engagement with the module, technical challenges in using AI software, and the need for additional guidance for students unfamiliar with digital platforms. These factors may have influenced the overall effectiveness and should be considered in future research.

4. CONCLUSION

This study employs a quantitative approach to examine the effect of an AI-assisted e-module for scientific writing on the digital literacy and critical thinking skills of Biology Education undergraduate students. The findings indicate that the implementation of the e-module in guiding students to write academic articles, particularly in technobiology courses, significantly enhanced both digital literacy and critical thinking. This is supported by hypothesis testing results and a substantial increase in the mean scores from the pretest to the posttest in the experimental group that utilized the e-module as a learning medium. Given these promising outcomes, further research is suggested to explore the long-term impact of AI-assisted e-modules across different biology-related courses and educational levels. It is also recommended to investigate students' perceptions and engagement levels when using such digital tools to gain deeper insights into their learning experiences.

5. ACKNOWLEDGEMENT

The author expresses sincere gratitude to everyone who has contributed their support and assistance in the research process, especially the Department of Biology which has provided facilities for research.

6. REFERENCES

Astuti, N., Kaspul, K., & Riefani, M. K. (2022). Validitas Modul Elektronik "Pembelahan Sel" Berbasis Keterampilan Berpikir Kritis. *Jurnal Eksakta Pendidikan (JEP)*, *6*(1), 94–102. https://doi.org/10.24036/jep/vol6-iss1/667

Bubaš, G., Čižmešija, A., & Kovačić, A. (2023). Development of an Assessment Scale for Measurement of Usability and User Experience Characteristics of Bing Chat Conversational AI. *Future Internet*, *16*(1), 4. https://doi.org/10.3390/fi16010004

Fakhri, M. M., Rifqie, D. M., Asriadi, Ismail, A., Isma, A., & Fadhilatunisa, D. (2024). Peningkatan Literasi Digital dan Menulis Artikel Ilmiah Guru dengan Memanfaatkan Artificial Intelligence. *Jurnal Sipakatau*, *1*(2), 30–39. https://doi.org/10.61220/sipakatau

Farid, M. (2017). Menulis Artikel Ilmiah: Proses Menemukan Ide Hingga Publikasi. *Seminar Penulisan Artikel Ilmiah, Perhimpunan Pelajar Indonesia (PPI) NPUST, NPUST Campus, Pingtung*, 1–9.

Fauziya, D. S. (2020). Penilaian Artikel Ilmiah Mahasiswa Berdasarkan Instrumen Evaluasi Arjuna. *Diglosia: Jurnal Pendidikan Kebahasaan, Dan Kesusastraan Indonesia*, *4*(2), 232–240.

Greenstein, L. (2012). *Assessing 21st Century Skills: A Guide to Evaluating Mastery and Authentic Learning*. CORWIN a Sage Company.

Hendra, H., Aditya Candra, A., & Ekaputra, F. (2023). Meningkatkan Keterampilan Berpikir Kritis Mahasiswa Melalui Kegiatan Pendampingan Penulisan Gagasan Pada Artikel. *Estungkara: Jurnal Pengabdian Pendidikan Sejarah*, *2*(1), 24–32. https://doi.org/10.22437/est.v2i1.24577

Henry, E. S. (2023). Hey ChatGPT! Write Me an Article about Your Effects on Academic Writing. *Anthropology Now*, *15*(1), 79–83. https://doi.org/10.1080/19428200.2023.2230097

Huang, J., & Tan, M. (2023). The role of ChatGPT in scientific communication: writing better scientific review articles. In *Am J Cancer Res* (Vol. 13, Issue 4). www.ajcr.us/

Imam, Moh., Zaini, M., & Suyidno, S. (2024). Analisis Validitas dan Daya Tarik E-Modul Biologi Untuk Melatihkan Kemampuan Berpikir Kritis. *Jurnal Penelitian Sains Dan Pendidikan (JPSP)*, *4*(1), 70–83. https://doi.org/10.23971/jpsp.v4i1.7999

Kaya, H. İ., & Korucuk, M. (2022). Examination of Digital Literacy Levels of University Students. *Dinamika Ilmu*, 167–186. https://doi.org/10.21093/di.v22i1.4523

Khasanah, U., & Indah, N. K. (2024). Pengembangan E-Modul Berbasis Problem Based Learning pada Materi Keanearagaman Hayati untuk Melatih Berpikir Kritis Peserta Didik. *BioEdu: Berkala Ilmiah Pendidikan Biologi*, *13*(3), 699–704.

Leedy, P. D., & Ormrod, J. E. (2021). *Practical Research* (12th edition). Pearson Education Limited.

Mahmudah, S., Kirana, T., & Rahayu, Y. S. (2022). Profile of Students' Critical Thinking Ability: Implementation of E-Modul Based On Problem-Based Learning. *IJORER : International Journal of Recent Educational Research*, *3*(4), 478–488. https://doi.org/10.46245/ijorer.v3i4.231

Maulana, M. J., Darmawan, C., & Rahmat, R. (2023). Penggunaan Chatgpt dalam Pendidikan Berdasarkan Perspektif Etika Akademik. *Bhineka Tunggal Ika: Kajian Teori Dan Praktik Pendidikan PKn*, *10*(1), 58–66. https://doi.org/10.36706/jbti.v10i1.21090

Oikonomidis, I., & Sofianopoulou, C. (2023). Critical thinking skills in the Greek lyceum: Their promotion within the first class's informatics textbook. *Pedagogical Research*, *8*(4), em0167. https://doi.org/10.29333/pr/13387

Pangrazio, L., Godhe, A. L., & Ledesma, A. G. L. (2020). What is digital literacy? A comparative review of publications across three language contexts. *E-Learning and Digital Media*, *17*(6), 442–459. https://doi.org/10.1177/2042753020946291

Pnevmatikos, D., Christodoulou, P., Georgiadou, T., & Lithoxoidou, A. (2023). Undergraduate Students' Conceptualization of Critical Thinking and Their Ideas for Critical Thinking Acquisition. *Education Sciences*, *13*(4), 416. https://doi.org/10.3390/educsci13040416

Pratiwi, M. K., & Indana, S. (2022). Pengembangan e-module berbasis QR-CODE untuk melatihkan kemampuan literasi digital siswa pada materi perubahan lingkungan. *Bioedu: Berkala Ilmiah Pendidikan Biologi*, *11*(2), 457–468.

Putri, L., Permana, I., & Holiyani, I. (2023a). Upaya Meningkatkan Literasi Digital Peserta Didik Melalui Penggunaan E-Modul Berbasis Flipbook pada Materi Keanekaragaman Hayati. *Report of Biological Education*, *4*(2), 85–98.

Putri, L., Permana, I., & Holiyani, I. (2023b). Upaya meningkatkan literasi digital peserta didik melalui penggunaan e-module berbasis flipbook pada materi keanekaragaman hayati. *Report of Biological Education*, *4*(2), 85–98.

Rachmawati, R. N., Rohman, F., & Novianti, V. (2024). Development of E-module toward Mangrove Species Diversity Based on Local Potential of Pulau Dua Nature Reserve Serang Banten to Improve Students' Digital Literacy. *Bioedukasi: Jurnal Biologi Dan Pembelajaran*, *22*(1), 129–139.

Suciati, R., Susilo, H., Lestari, U., & Gofur, A. (2022). Critical thinking skills: Profile and mastering concepts of undergraduate students. *International Journal of Evaluation and Research in Education (IJERE)*, *11*(3), 1250. https://doi.org/10.11591/ijere.v11i3.22409

Sumadi, S. W., Nurhayati, B., & Faisal. (2023). Analisis Keterampilan Literasi Digital Mahasiswa Pendidikan Biologi FKIP UNTAD. *In Prosiding Seminar Nasional Biologi: Inovasi Sains & Pembelajarannya* , *11*(1), 190–197.

Triyono, S. (2021). *Dinamika Penyusunan E-Modul*. Adanu Abimata.

Zhai, X. (2022). *ChatGPT: Artificial Intelligence for Education*. AI4STEM Education Center University of Georgia.