



# Development of Android-Based E-Modules in Biology Learning on Water Environmental Pollution to Enhance Science Literacy

Tuti Liana<sup>1\*</sup>, Djufri<sup>2</sup>, Ali Sarong<sup>2</sup>, Sofyan A<sup>2</sup>

<sup>1</sup> Doctoral Program of Education, Faculty of Teacher Training and Education, Universitas Syiah Kuala, Syiah Kuala, Banda Aceh, Indonesia.

<sup>2</sup> Department of Biology Education, Faculty of Teacher Training and Education, Universitas Syiah Kuala, Syiah Kuala, Banda Aceh, Indonesia.

Received: June 13, 2024

Revised: July 10, 2024

Accepted: September 25, 2024

Published: September 30, 2024

Corresponding Author:

Tuti Liana

[tutiliana.liana85@gmail.com](mailto:tutiliana.liana85@gmail.com)

DOI: [10.29303/jppipa.v10i9.8097](https://doi.org/10.29303/jppipa.v10i9.8097)

© 2024 The Authors. This open access article is distributed under a (CC-BY License)



**Abstract:** Water environmental pollution has become an urgent global concern, requiring in-depth understanding and appropriate solutions to address its adverse impacts. In the educational context, it is important for students to have a strong science literacy to be able to understand and participate in environmental protection efforts. One of the proposed approaches to improving students' understanding of water environmental pollution is to use Android-based E-modules in biology learning. This method of research uses a systematic literature review (SLR). The SLR method is carried out in three stages so that it can obtain a combination of literature study appropriate and accurate to the research problem to be raised. The results of the Systematic Literature Review (SLR) conducted to evaluate the effectiveness of developing Android-based E-modules in improving student science literacy in the context of biological learning about water pollution. Through a systematic approach, the study analyses a variety of relevant literary studies to draw strong conclusions about the potential of e-modules in facilitating a deeper understanding of scientific concepts related to water environmental pollution to enhance student involvement in science learning and literacy.

**Keywords:** Android based e-module; Biology learning; Science literacy; Water environmental pollution

## Introduction

Pollution of the aquatic environment is one of the serious global environmental problems faced by humans. Such pollution can be caused by a variety of factors, including industrial waste, domestic waste, agriculture, and other human activities. Water pollution is a complex problem that involves various factors and activities and affects various water bodies for various benefits (Schweitzer & Noblet, 2018). The impact of pollution on the aquatic environment can damage aquatic ecosystems, threaten the sustainability of water resources, and endanger the health of humans and animals that depend on the water. Water pollution has a significant impact on human health, with diarrheal

diseases caused by poor water quality (Lin et al., 2022; Rathi et al., 2021).

Water environmental pollution is directly linked to Point 6 of the SDGs, which emphasises the importance of "Clean Water and Affordable Sanitation." Sustainable Development Goal No. 6 (SDG 6) has committed all countries in the world to achieve ambitious water supply and sanitation targets by 2030 to meet universal basic human and environmental needs (Jagannathan, 2021). This pollution not only threatens the availability of safe, clean water but also impacts human health and socio-economic development. By reducing pollution in the water environment, we not only support universal access to clean water but also strengthen efforts towards sustainable development. SDG 6 for water and sanitation faces challenges and potential obstacles in

### How to Cite:

Liana, T., Djufri, Sarong, A., & Sofyan A. (2024). Development of Android-Based E-Modules in Biology Learning on Water Environmental Pollution to Enhance Science Literacy. *Jurnal Penelitian Pendidikan IPA*, 10(9), 644–654. <https://doi.org/10.29303/jppipa.v10i9.8097>

local governance, highlighting the need for gradual prioritization and implementation (Herrera, 2019).

In the context of education, science literacy is key to understanding environmental problems such as water pollution. Science literacy includes not only understanding scientific concepts but also data analysis, problem-solving, and understanding the impact of human actions on the environment (Martinah et al., 2022). However, in the process of learning biology in schools, a slight lack of resources and innovative teaching methods can be an obstacle to improving students' science literacy, especially in the context of environmental issues (Agpriani & Syofyan, 2020; Irsan, 2021).

According to the Organisation for Economic Co-operation and Development (OECD), science literacy is based on three main competencies: explaining scientific phenomena or issues scientifically; designing and evaluating scientific investigations; and interpreting evidence and data scientifically (OECD, 2019). However, Indonesia currently has a low level of science literacy, as seen from various international surveys. An OECD survey through the PISA programme in 2018 showed that students' literacy skills in Indonesia ranked 70th out of 78 participating countries, while UNICEF data ranked Indonesia 60th out of 61 countries in terms of science literacy levels (Nugroho, 2019; OECD, 2020). One of the factors causing the low science literacy skills of Indonesian students is the limited selection of teaching materials in presenting material effectively (Kimianti & Prasetyo, 2019).

Research conducted by Fuadi et al. (2020) states that the factors causing low student literacy ability are related to the results of PISA (the Programme for International Student Assessment), such as improper selection of textbooks, misconceptions, learning that is not in accordance with daily or contextual problems, low habits of reading science books, and a learning climate that is not conducive. Thus, learning solutions are needed that can train students' science literacy skills (Kembara et al., 2020; Yusmar & Fadilah, 2023).

Teacher addiction can only use print media to teach; students are not interested in biology. This is indicated by the fact that few students have source books. Students' disinterest in printed books is also due to the fact that the supporting images in the book are not attractive, so students are too lazy to read them (Sureni et al., 2023). In addition, the display given by the teacher about the books and modules used cannot attract students' interest in reading and has no connection with science problems in everyday life. As a result, students are unable to relate the science knowledge they learn to real-world problems (Permanasari, 2016).

The studies of Shofiyah et al. (2020) and Hartono et al. (2023) provide a solid foundation for developing more effective learning strategies for improving students' science literacy through the use of digital media such as animation and video, as well as self-accessible teaching material modules, offering solutions to current learning challenges. The integration of these technologies not only makes learning more engaging and interactive but also helps students understand scientific concepts better. In addition, a focus on contextual learning that is connected to everyday life can increase students' motivation to learn and see the relevance of learning material to the real world, which in turn can improve their overall science literacy.

The integration of Information Technology (IT) into educational environments is increasingly important, but educators' acceptance of these technologies significantly impacts their implementation in schools. The Technology Acceptance Model (TAM) highlights subjective norms and computer self-efficacy as key factors influencing teachers' intentions to use e-learning technology, emphasizing perceived ease of use. While TAM explains teachers' digital technology use well, external variables and important notions may challenge common assumptions (Scherer et al., 2019). Additionally, teachers' acceptance of IT is multifaceted, with perceived usefulness, ease of use, job relevance, and self-efficacy playing crucial roles. TAM, supplemented by subjective norms and attitudes toward technology, offers a comprehensive understanding of the factors influencing teachers' adoption and utilization of technology in education (Granić & Marangunić, 2019).

Educational technology acceptance is a critical factor in the integration of new tools and platforms into teaching and learning processes. The perceived usefulness and ease of use of such technologies are central to their acceptance and subsequent adoption by educators and learners. Perceived usefulness and perceived ease of use positively mediate the association between ICT support and ICT use among teachers (Eze et al., 2021). There is a positive relationship between perceived ease of use and the use of technology among students, leading to a satisfactory level of technology usage (Ubaidillah et al., 2020).

Educational technology has become an integral part of the biology learning process, playing an increasingly important role in providing interactive, well-rounded, and student-oriented learning resources. Through the use of technology such as e-modules, simulations, and interactive software, biology learning becomes more interesting and affordable for students. E-Module is an example of a multimedia, animation, and interactivity application that enriches students' learning experiences (Haka et al., 2021; Sureni et al., 2023). They can also be

tailored to the needs of each individual student, enabling more effective differentiation of learning.

In addition, educational technology allows access to broader and more up-to-date information, connecting students with resources such as scientific journals, genetic databases, and educational videos that can deepen their understanding of complex biological concepts. With the development of information and communication technology, one type of learning medium using a mobile device called mobile learning was made, both in the form of e-modules, interactive games, learning videos, and others (Husein & Yuliani, 2023). E-modules are systematically created digital teaching materials presented in electronic form. This teaching material can improve student learning outcomes because it is packaged attractively (Pramana et al., 2020).

The rapid development of mobile device technology is what provides opportunities for the development of mobile learning media (Surahman & Surjono, 2017). This will increase attention to the learning material, make learning persuasive, and encourage motivation. The development of Android-based e-modules offers the potential to overcome these barriers by providing an interactive platform that allows students to learn in a more engaging way. Solutions to train science literacy skills can be through teaching materials or media as learning resources so as to encourage students to learn that is relevant to the applicable curriculum (Criollo-C et al., 2021).

The availability of teaching materials in schools is very important as a support for the quality of education in the 21<sup>st</sup> century. 21<sup>st</sup> century teaching materials are marked by a transformation in terms of presentation from conventional to electronic, such as e-modules. Android-based e-modules make it easier for students in education and can be used for independent learning that can be done anytime and anywhere (Helleve et al., 2020; Hermawan et al., 2022; Matsun et al., 2021). In addition, e-modules can also add flipbook features so that they are more practical, efficient, and interactive (Yusmar & Fadilah, 2023). Android-based E-Module makes it easy for teachers to provide in-depth understanding and develop enhanced learning materials for students based on advanced technology in training students' science literacy skills (Chen & Tsai, 2021; Sidiq & Najuah, 2020).

In addition, android-based E-modules are easily accessible (Asrial et al., 2019; Sanova et al., 2022). Mobile-assisted android-based e-modules can contribute to supporting independent learning and training critical thinking concepts (Cahyani & Jayanta, 2021; Nurrijal, 2022). The presence of Android-based e-modules can be an effective and fun alternative learning resource. To make it easier for students to absorb the material

presented, lecturers need to prepare teaching materials that are in accordance with the progress of the industrial revolution era 4.0, namely: learning that can be delivered through the concept of e-learning in the form of digital electronics in the form of android-based e-modules (Bahreini et al., 2016; Hidayati, 2020).

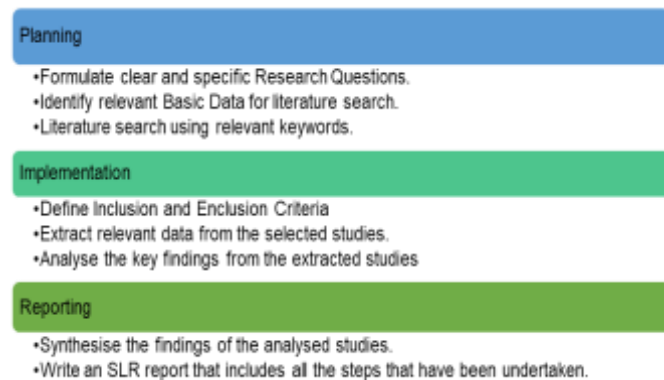
In biology learning, an understanding of water environmental pollution is an important part of the desired science literacy in the SDGs (Nur Azizah & Syafiuddin, 2022). Android-based E-Modules can help students understand the negative impacts of pollution, promote awareness of the importance of maintaining water quality, and encourage concrete actions to support SDGs goals related to clean water and affordable sanitation. Thus, the development of this e-module not only improves students' science literacy but is also a real step in achieving sustainable development goals related to clean water and affordable sanitation (Fadil et al., 2023).

This research aims to conduct a systematic literature review (SLR) on the development of an Android-based e-module in biology learning on water environmental pollution material to improve science literacy. In this study, we will explore various related journals that have been conducted previously and analyze the suitability and effectiveness of using android-based e-modules in biology learning. Through this SLR, it is expected to find empirical evidence that supports the use of Android-based e-modules as an effective tool for increasing students' science literacy.

## Method

The method used in this research is the SLR (Systematic Literature Review) method. This SLR method is carried out with 3 stages so as to obtain a combination of appropriate and accurate literature studies on the research issues to be raised. The stages carried out are planning, implementation, and reporting. While the object raised in this research is the feasibility as well as the advantages and disadvantages of mobile learning media developed by previous research. The process of conducting a systematic review is characterized by a rigorous and replicable methodology, which involves a comprehensive search for all relevant literature, including both published and unpublished work, and a systematic integration and critique of the evidence. The best practice guide for conducting and reporting narrative reviews, meta-analyses, and meta-syntheses emphasizes the importance of synthesizing studies to draw broad theoretical conclusions, linking theory to evidence and evidence to theory (Siddaway et al., 2019). Systematic reviews in educational research are a diverse and

effective method for analyzing literature, with aggregative and configurative approaches offering distinct advantages (Newman & Gough, 2020). The Systematic Literature Review (SLR) stages in the research can be seen in Figure 1.



**Figure 1.** Systematic literature review (SLR) stages

The reliability of literature reviews, especially in fields such as conservation biology where findings can influence policy or practice, is of paramount importance. Systematic reviews overcome biases such as publication bias, selection bias and vote counting through a rigorous methodology that maximises transparency, objectivity and repeatability. Lessons from systematic reviews can be applied to traditional reviews to improve their reliability, especially when a full systematic review is not possible (Haddaway et al., 2015). A systematic literature review aims to identify, analyse and interpret evidence relating to a specific research question in a scientifically rigorous manner (Wohlin et al., 2012).

#### Research Questions (RQ)

The formulation of research questions is used to determine the scope so that there is a clear focus regarding the research. Research questions were developed in response to the needs of the selected topic, namely:

- RQ 1 : How can the validity of Android-based E-Modules improve students' science literacy in understanding water environment pollution material?
- RQ 2 : How is the development and implementation of Android-based E-modules in biology learning, especially in the context of water environment pollution, going to improve students' science literacy?
- RQ3 : How is teacher acceptance of Android-based E-Module in biology learning to improve students' science literacy?

#### Research Process

This stage involved searching for journals on Google Scholar (<https://scholar.google.com/>), ScienceDirect (<https://www.elsevier.com/products/sciencedirect/journals>), and Taylor and Francis Online (<https://www.tandfonline.com/>). The data obtained was saved in the form of \*CSV and \*RIS, which were then stored in Mendeley Reference Manager. The data was visualised with the help of the online application <https://www.researchrabbit.ai/> to obtain data relevant to the research questions. These databases were selected based on their availability in academic institutions and have been considered in other similar studies. Literature from articles generated from the keyword search was reviewed for backward search. A forward search was conducted by reviewing additional sources generated from references cited in the selected studies. No further studies were found during the process.

#### Inclusion and Exclusion Criteria

At This stage the researcher decides on the criteria for finding data, whether or not the data is suitable as a source of research data. The following are the criteria used to find this data.

The data sought has a publication range in 2017-2024. Data obtained from Google Scholar <https://scholar.google.co.id/>, ScienceDirect <https://www.elsevier.com/products/sciencedirect/journals>, Taylor and Francis Online <https://www.tandfonline.com/>.

Data used in the form of journals related to Android-based E-Module, the development of Android-based E-Module can improve students' science literacy in understanding the material of water environmental pollution. The order of inclusion and exclusion carried out in this systematic literature review (SLR) is presented in Figure 2.

Explicit selection criteria were applied for inclusion and exclusion of relevant studies to maintain transparency of the process (Figure 2). This SLR focused on analysing Android-based E-modules in biology learning (3030 articles), water environmental pollution (2030 articles), and Science Literacy (1339 articles) authors added keywords and found, resulting in 6,676 exclusions. All these articles were published by Google Scholar, ScienceDirect, Taylor and Francis from 2017-2024. This is because articles in the last 7 years contain the latest information and are more developed than previous studies. There were 1140 articles that met these criteria. Furthermore, the author used the original article criteria, the result was 1085 articles, so 55 articles were excluded. In the final stage, the author re-examined the existing articles, ensuring the suitability of the article

with the theme to be elaborated and based on this, the author obtained 20 articles that met the specified criteria. This meant there were 35 articles that did not fulfil the criteria and were excluded.

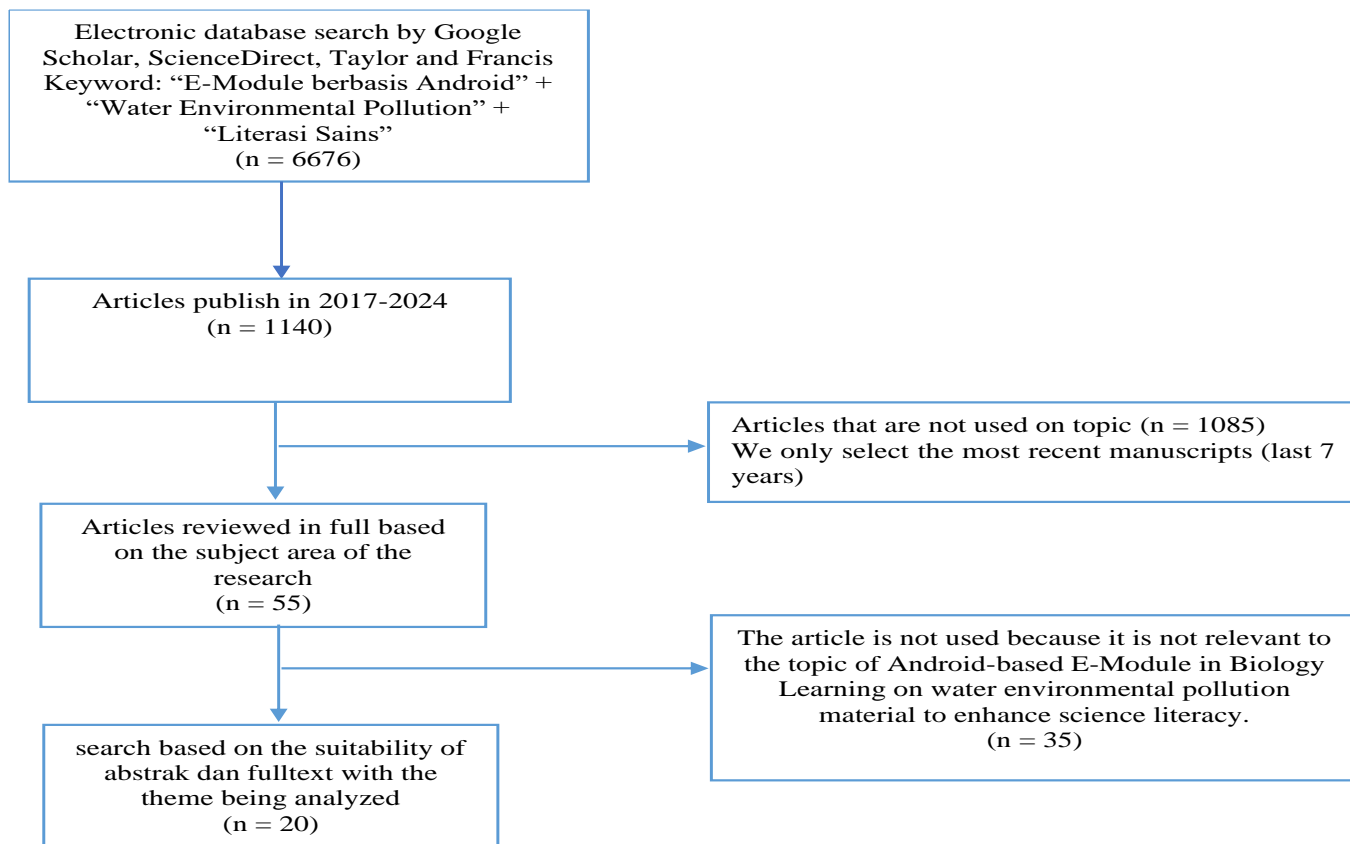


Figure 2. Review process for study selection

## Result and Discussion

The results of the data search were 20 journals that were taken in accordance with the inclusion and exclusion criteria and had discussions related to 'the development of android-based e-modules in biology learning on water environmental pollution material to

improve science literacy. After conducting a quality assessment of the 20 journals that have been analysed into the good category classification, it can proceed to the next stage, namely data extraction. Data extraction is done by analysing information according to the title, the effectiveness of the Android-based E-module and the results of the research.

Table 1. Literature Review Synthesis Results

Author/Year	Title	Journal	Result
Lailatul Fitriyah, Eva Ari Wahyuni, Irsad Rosidi, Nur Qomaria, Badrud Tamam (2023)	Android-based Module Development on Plant Structure and Function Material	Jurnal Natural Science Educational Research Vol 6 (1) 2023	Android-based E-Module media is very good to use for students in the chapter on plant structure and function. Making Android-based module media requires paid software, so not all schools can make this Android-based module media.
Muhammad Maulana Husaen, Hadma Yuliani (2023)	Sytematic Literature Review: Feasibility of Mobile Learning Media as a Support for MIPA Learning in Indonesia	Lambda: Jurnal Pendidikan MIPA dan Aplikasinya Lembaga "Bale Literasi" Vol 3 (2) 2023	Mobile learning media allows learners to be actively involved in learning. Various interactive features, such as quizzes, simulations, and learning videos, can increase learners' interest and motivation in learning MIPA concepts.

Author/Year	Title	Journal	Result
Uswatun Karimah, Titin Sunarti, Munasir (2023)	Digital Era for Quality Education: Effectiveness of Discovery Learning with Android to Increase Scientific Literacy	IJORER : International Journal of Recent Educational Research 4 (6) 2023	The application of the discovery learning model integrated with Android is feasible and can be used to improve students' science literacy. Discovery learning is the model chosen during the learning process, and Android is the learning media. Science literacy is a person's ability to understand and make decisions about a problem related to natural conditions and changes that occur in nature due to human activities.
Winda Purnama Sari, Destri Ratna Ma'rifah (2020)	Development of Android-based Mobile Learning LKPD with PBL to Improve Critical Thinking on Environmental Material	JPB: Jurnal Pendidikan Biologi 11(2) 2020	The PBL approach, which encourages learners to actively participate in solving real problems, can be enhanced by using Android-based learning media. learners can access resources, conduct research, and collaborate in solving environmental problems through their Android devices.
Suardini Khairunnisa, Gufon Amirullah, Mimin Ninawati (2019)	Development of Learning Android Media-Based Mobile Learning Applications in Courses Basic Concepts of Natural Sciences	The Journal of Innovation in Elementary Education 4 (2) 2019	This media is suitable and relevant for the Basic Concepts of Natural Science course, because it uses Android-based mobile learning applications, so that it can help students understand the concepts of basic natural science concepts in a more interactive and interesting way.
Nofita Uma'iyah, Sri Wahyuni, Ulin Nuha (2023)	Development of E-Modules Based On Mobile Learning Applications to Improve Students' Critical Thinking Skills in Science Subject	JPPS (Jurnal Penelitian Pendidikan Sains) Vol 12 (3) 2023	E-modules based on mobile learning applications are also considered to have been effective and feasible to use as teaching materials during science learning in junior high school because they have used e-modules based on mobile learning applications. develop e-modules based on mobile learning applications to improve students' critical thinking skills.
Farida et al. (2018)	Developing android-based science instructional media to improve scientific literacy of junior high school students	Journal of Physics: Conference Series (2018)	Android-based science learning media has the following characteristics: attractive visualization, easy to use, flexible, and practical. They developed android-based science learning media worthy of teaching in terms of material evaluation, media evaluation aspects, and based on student trial results and product effectiveness to improve scientific literacy. The results showed that Android-based science learning media is used appropriately and effectively for teaching.
Listianingsih et al. (2021)	Android-Based Comics: An Alternative Media to Improve Scientific Literacy	Jurnal Penelitian dan Pembelajaran IPA Vol 7 (1) 2021	Android-based comics can improve students' scientific literacy. Based on the validation results, the comic can be said to be valid, and student responses are positive. The selection of digital comics can increase students' interest and learning outcomes because the side of comic images can visualize the situation between these numbers, so it is expected to help students understand and provide reasons for learning material.
Leilana Octaviana, Ismail, Hafidha Asni Akmalia (2023)	The Development of Biology E-Module Based on Unity of Sciences and Science Literacy as Teaching Materials	Al Kawnu: Science and Local Wisdom Journal 3 (1)	E-module included in the very decent category, in the range of 87.5% based on the readability test by the students. Thus, the results of this research show that the e-module developed can increase insight into the integration of Islamic values and train students' scientific literacy skills based on grade 11 biology material.

Author/Year	Title	Journal	Result
Ainun Diniyatushoaliha (2024)	for Students in Senior High School Effectiveness of E-Module to Improve Students' Critical Thinking Skills in High School Science Learning: Literature Study	International Journal of Science Education and Science IJESSES 1(1) (2024)	The Android-based Selvo E-Module (Volta Cell) and the HOTS-based physics e-module are effective in improving students' critical thinking skills in high school science learning with an increase in test results in the 61-65 range
Siti Nurkamilah, Rifaatul Muthmainnah (2022)	Development of Android-Based Learning Media in Distance Learning for Certified Biology Teachers	JOEAI (Journal of Education and Instruction) 5 (1) 2022	The results showed that Android-based learning media is feasible to develop; this is evidenced by obtaining an average score of 3.6 in the good category. In conclusion, android-based learning media can be an alternative learning medium that is effective, efficient, interesting, can be used anywhere and anytime, and can be used by teachers, especially biology teachers.
Halmi Pratama, Eliwatis, Najmiatul Fajar (2018)	Development of Android-based biology learning modules on regulatory system materials for high school students	Journal of Sainstek 10 (2) 2018	Based on the assessment of android based biology subject teachers in the very practical category, the average results of 87.92 were obtained and based on the assessment of students the biology learning module was categorized as very practical and obtained an average value of 86.6. The Android-based biology learning module that the researchers developed is feasible to use in the learning process.
Nuril Hidayati, Ardian Anjar Pangestuti, Trio Ageng Prayitno (2019)	Edmodo mobile: developing e-module on biology cell for online learning community	Biosfer: Jurnal Pendidikan Biologi, 12(1) (2019)	Hence, this e-module could be used in CB learning on a higher education level, although it has a similar display like other e-modules. This CB e-module contains the following aspects: 1) Use-instruction for lecturer and students. 2) content was following the lesson plan of the semester, and essential competencies to be achieved and had high accuracy. 3) it was equipped with images that helped to improve students' understanding of the CB concept. 4) it was equipped with students independent activities. 5) it was equipped with an evaluation test and key answers. 6) the developed e-module was by students thinking ability.
Dewi Jumiarni, Rendi Zulni Eka Putri, Rambat Nur Sasongko, Endang Widi Winarni, Eko Risdianto (2022)	Development of Android Based E-Module on Biotechnology Topic	Edukasi Islami: Jurnal Pendidikan Islam 11 (3) 2022	The results of this study revealed that the Android-based E-module on Biotechnology topic that has been developed is in the highly valid category according to the validator's assessment of content experts and media experts, with validation score value are 87,5% and 94,28 respectively. While the student's response assessment revealed that the media was very good with a percentage of 87,5%. Thus the electronic module developed is feasible to be implemented in class for mobile learning.
Zahrina Amalia, Dwi Yuliyanti, Fakhtur Rohman, Nurhanurawati (2022)	The development of an android-based e-module to increase student's critical thinking skills: a comprehensive needs analysis	International Journal of Educational Studies in Social Sciences Vol. 2 No. 3 (2022)	The results of observational research indicated that students' critical thinking attitudes are still very low and learning uses textbooks, and they still rarely use electronic media such as computers or androids to teach. Dealing with the pre-research conducted that teachers and students had desire that the teaching materials used in the learning process were developed so that they varied and facilitated to understand the material.

Author/Year	Title	Journal	Result
Elvara Aroyandini, Suyitno Aloysius	Increasing Students' Learning Motivation Through Android-Base Biology Educational Game with E-Module During COVID-19 Pandemic	Advances in Social Science, Education and Humanities Research, volume 541 Proceedings of the 6th International Seminar on Science Education (ISSE 2020)	The use of android base biology educational game with e-module during the COVID-19 pandemic can increase students' learning motivation better than using google form only.
Diana Iffatul Afifah, Enni Suwarsi Rahayu, Yustinus Ulung Anggraito	Development of E-Module Based Android for Teaching Material of Plantae Kingdom Topic	Journal of Biology Education Vol 7 (1) (2018)	The result of the research shows e-module worthy of teaching materials with material percentage of material 81.75% and media 88.46%. E-modules are practically used as teaching materials with a percentage of 83.05% scale test and 88.06% widescreen scale and e-modules with effectively average N-Gains of 0.61 (medium category). Based on these results, can get Android-based e module can be used as a teaching material of high school students X class of Plantae kingdom.
Lufty Hari Susanto , R. Teti Rostikawati , Rahmi Novira, Rika Sa'diyah, Istikomah Istikomah, Ilmi Zajuli Ichsan	Development of Biology Learning Media Based on Android to Improve Students Understanding	Jurnal Penelitian Pendidikan IPA, 8(2) (2022)	Media mobile learning Android-based on learning the biology of the nervous system material can improve students' understanding of concepts and almost all students respond positively. This is proven by an increase in the results of the pre-test and post-test values after using the application
Akbar Iskandar, Mansyur, Ansari Saleh Ahmar, Muliadi, & Abdul Rahman	Android-Based E-Learning Application Design in Schools	Journal of Applied Science, Engineering, Technology, and Education Vol. 5 No. 1 (2023)	using an Android-based E-Learning application, of course learning done in schools is better than those that only use conventional models or only use Whatsapp or Google Classroom. In addition, with E-Learning the learning process that is usually carried out in schools can be done without having to go to school again, students and teachers can carry out the learning process from their respective homes using smartphones and the internet.
Lucelle M. Maglinte, Leizle B. Coronica	Effectiveness of constructivist e-learning module in General Biology	Sapienza: International Journal of Interdisciplinary Studies Vol 4 (4) 2023	Constructivist e-learning modules effectively enhance student engagement, content mastery, and cognitive skill development in General Biology for high school STEM students.

Pollution of the aquatic environment is an urgent and complex issue that affects human health, aquatic ecosystems and environmental sustainability. In the context of biology education, an understanding of this issue is important to prepare future generations who are able to contribute to sustainable environmental solutions. However, in many cases, the traditional approach to teaching biology lacks the ability to capture students' interest and build a deep understanding of the impact of water pollution and how to address it.

Besides being able to be operated online, this android-based learning media is also interactive and can also be operated offline in the distance learning process. So that students can easily carry out the learning process even with minimal facilities. There are several benefits to using android-based learning media, including that it can be used as an effective and efficient learning media

because it can practically be carried everywhere, making it easier for students to find references, and attracting students because the contents of android applications can vary, such as material, images, videos, and interactive quizzes. Besides that, android-based learning media trains students' abilities or knowledge of material through interactive quizzes in android applications (Myori et al., 2019).

The use of well-organised Android-based learning media can positively and effectively influence the development of children's thinking skills (Cai, 2021). Android-based learning media can be used as a learning tool for tasks such as submitting homework, reflecting on hands-on learning experiences, and sharing ideas, but teachers must consider three main components of mobile learning such as learner and teacher readiness,



learning management, and support systems (Sophonhiranrak, 2021).

One of the main advantages of Android-based e-module development is its flexibility. E-modules can be accessed by students through their mobile devices, allowing learning outside the classroom and at any time according to individual needs. Thus, e-modules not only facilitate independent learning but also provide opportunities for students to explore learning materials in a deeper and more personalised manner.

In addition, e-modules can also provide immediate feedback to students, allowing them to track their learning progress and identify areas for improvement. With integrated evaluation and monitoring features, teachers can monitor students' progress in real-time and provide appropriate guidance according to individual needs.

## Conclusion

From the results of the Systematic Literature Review conducted, it can be concluded that the development of Android-based E-modules has received significant attention in the context of learning biology about pollution in the water environment. Such e-modules offer great potential to improve students' science literacy through innovative approaches and exciting technologies. Findings from literature studies suggest that e-modules can provide a more engaging, meaningful, and engaged learning experience for students, as well as facilitate a deeper understanding of complex scientific concepts related to pollution of the water environment. Android-based E-modules also have advantages in flexibility and accessibility, enabling learning outside the classroom and tailored to individual student needs. With integrated interactive features, simulations, and evaluations, e-modules can facilitate effective self-learning, strengthen student understanding, and provide immediate feedback to them. Thus, although the development of Android-based E-modules is promising, further research is needed to address the challenges faced and maximise the potential of e-modules in improving student science literacy in biological learning about water environmental pollution. Future research can explore more effective implementation strategies, identify factors that affect the effectiveness of e-modules, and evaluate their impact on student academic achievement and understanding of scientific concepts. By linking water environmental pollution with Point 6 of the SDGs, it can be understood that handling this pollution is not only an environmental problem but also a health problem and socio-economic development. Pollution of the aquatic environment can lead to the spread of

disease, economic losses, and social instability within the affected communities. Therefore, measures to reduce pollution of the water environment not only support efforts to improve access to safe, clean water but also support overall sustainable development. In the context of biology learning, an understanding of water environmental pollution and the efforts made to overcome it is an integral part of science literacy, as intended in Point 6 of the SDGs. Learning about water environmental pollution can help students understand the importance of maintaining water quality suitable for consumption and the negative impacts of pollution on human health and the environment.

## Acknowledgments

Thank you to Professor Dr. Djufri, M.Si; Prof. Dr. M. Ali Sarong, M.Si; and Prof. Dr. Sofyan A. Gani., M.A., who have helped guide and provide input so that it succeeds in writing this article. Then thank you to Prof. Dr. Asnawi, S.Pd., M.Ed., as Coordinator of the Programme of Doctoral Studies of FKIP USK Education.

## Author Contributions

All four authors make equal contributions to all research, data collection, data analysis and writing processes. Tuti Liana: writing original articles, reviews, and revisions of articles; Djufri: methodologies, data collection, reviews; Ali Sarong and Sofyan A: systematics of original article writing, data processing, and review of manuscripts.

## Funding

This research received no external funding.

## Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

## References

- Asrial, A., Syahrial, S., Kurniawan, D. A., Subandiyo, M., & Amalina, N. (2019). Exploring obstacles in language learning among prospective primary school teacher. *International Journal of Evaluation and Research in Education*, 8(2), 249-254. <https://doi.org/10.11591/ijere.v8i2.16700>
- Bahreini, K., Nadolski, R., & Westera, W. (2016). Towards multimodal emotion recognition in e-learning environments. *Interactive Learning Environments*, 24(3), 590-605. <https://doi.org/10.1080/10494820.2014.908927>
- Cahyani, N. L. P., & Jayanta, I. N. L. (2021). Digital Literacy-Based Learning Video on the Topic of Natural Resources and Technology for Grade IV Elementary School. *Jurnal Ilmiah Sekolah Dasar*, 5(3), 538-548. <https://doi.org/10.23887/jisd.v5i3.37918>
- Cai, P. (2021). RETRACTED: Thinking skills development in mobile learning: The case of

- elementary school students studying environmental studies. *Thinking Skills and Creativity*, 42, 100922. <https://doi.org/10.1016/j.tsc.2021.100922>
- Chen, C.-H., & Tsai, C.-C. (2021). In-service teachers' conceptions of mobile technology-integrated instruction: Tendency towards student-centered learning. *Computers & Education*, 170, 104224. <https://doi.org/10.1016/j.compedu.2021.104224>
- Criollo-C, S., Guerrero-Arias, A., Jaramillo-Alcázar, Á., & Luján-Mora, S. (2021). Mobile Learning Technologies for Education: Benefits and Pending Issues. In *Applied Sciences* (Vol. 11, Issue 9). <https://doi.org/10.3390/app11094111>
- Eze, N. U., Obichukwu, P. U., & Kesharwani, S. (2021). Perceived Usefulness, Perceived Ease of Use in ICT Support and Use for Teachers. *IETE Journal of Education*, 62(1), 12–20. <https://doi.org/10.1080/09747338.2021.1908177>
- Fadil, C., Zawawi, Z., & Nisa, F. L. (2023). Implementasi Bela Negara (SDGs) Mewujudkan Generasi Islami. *Jiip - Jurnal Ilmiah Ilmu Pendidikan*, 6(9), 7268–7276. <https://doi.org/10.54371/jiip.v6i9.2949>
- Fuadi, H., Robbia, A. Z., Jamaluddin, & Jufri, A. W. (2020). Analisis Kemampuan Literasi Sains Peserta Didik SMA Kelas X di Kota Solok. *Jurnal Pendidikan Matematika dan Sains. Jurnal Ilmiah Profesi Pendidikan*, 5(2), 108–116. <https://doi.org/10.29303/jipp.v5i2.122>
- Granić, A., & Marangunić, N. (2019). Technology acceptance model in educational context: A systematic literature review. *British Journal of Educational Technology*, 50(5), 2572–2593. <https://doi.org/10.1111/bjet.12864>
- Haddaway, N. R., Woodcock, P., Macura, B., & Collins, A. (2015). Making literature reviews more reliable through application of lessons from systematic reviews. *Conservation Biology*, 29(6), 1596–1605. <https://doi.org/10.1111/cobi.12541>
- Hartono, A., Djulia, E., Hasruddin, & Jayanti, U. N. A. D. (2023). Biology Students' Science Literacy Level on Genetic Concepts. *Jurnal Pendidikan IPA Indonesia*, 12(1), 146–152. <https://doi.org/10.15294/jpii.v12i1.39941>
- Helleve, I., Grov Almås, A., & Bjørkelo, B. (2020). Becoming a professional digital competent teacher. *Professional Development in Education*, 46(2), 324–336. <https://doi.org/10.1080/19415257.2019.1585381>
- Hermawan, R., Munadi, S., & Safitri, M. L. O. (2022). Using of Students' Modules and Role on Learning Achievement in Covid-19 Pandemic. *Jurnal Iqra' : Kajian Ilmu Pendidikan*, 7(1), 139–155. <https://doi.org/10.25217/ji.v7i1.2191>
- Herrera, V. (2019). Reconciling global aspirations and local realities: Challenges facing the Sustainable Development Goals for water and sanitation. *World Development*, 118, 106–117. <https://doi.org/10.1016/j.worlddev.2019.02.009>
- Hidayati, R. (2020). Tingkat Pengetahuan Masyarakat Tentang Penanganan Henti Jantung di Wilayah Jakarta Utara. *NERS Jurnal Keperawatan*, 16(1), 10. <https://doi.org/10.25077/njk.16.1.10-17.2020>
- Husein, M. M., & Yuliani, H. (2023). Sytematic Literature Review: Kelayakan Media Pembelajaran Mobile Learning Sebagai Penunjang Pembelajaran MIPA Di Indonesia. *LAMBDA : Jurnal Ilmiah Pendidikan MIPA Dan Aplikasinya*, 3(2), 78–86. <https://doi.org/10.58218/lambda.v3i2.561>
- Jagannathan, N. V. (2021). *Water Supply, Sanitation, and the Environment*. Oxford University Press. <https://doi.org/10.1093/acrefore/9780199389414.013.782>
- Kembara, M. D., Hanny, R., Gantina, N., Kusumawati, I., Budimansyah, D., Sunarsi, D., & Khoiri, A. (2020). Scientific Literacy Profile Of Student Teachers On Science For All Context. *Solid State Technology*, 63, 5844–5856. Retrieved from <https://api.semanticscholar.org/CorpusID:228930979>
- Kimianti, F., & Prasetyo, Z. K. (2019). Pengembangan E-Modul IPA Berbasis Problem Based Learning Untuk Meningkatkan Literasi Sains Siswa. *Kwangsan: Jurnal Teknologi Pendidikan*, 7(2), 91. <https://doi.org/10.31800/jtp.kw.v7n2.p91--103>
- Matsun, M., Hadiati, S., & Pramuda, A. (2021). Development of Arduino-Based Electrical Practicum e-Module. *Radiasi: Jurnal Berkala Pendidikan Fisika*, 14(2), 120–126. <https://doi.org/10.37729/radiasi.v14i2.1040>
- Myori, D. E., Chaniago, K., Hidayat, R., Eliza, F., & Fadli, R. (2019). Peningkatan Kompetensi Guru dalam Penguasaan Teknologi Informasi dan Komunikasi melalui Pelatihan Pengembangan Media Pembelajaran Berbasis Android. *JTEV (Jurnal Teknik Elektro Dan Vokasional)*, 5(2), 102. <https://doi.org/10.24036/jtev.v5i2.106832>
- Newman, M., & Gough, D. (2020). *Systematic Reviews in Educational Research: Methodology, Perspectives and Application BT - Systematic Reviews in Educational Research: Methodology, Perspectives and Application*. Springer Fachmedien Wiesbaden. [https://doi.org/10.1007/978-3-658-27602-7\\_1](https://doi.org/10.1007/978-3-658-27602-7_1)
- Nugroho, F. A. S. M. (2019). Peningkatan Minat Baca dan Literasi Sains Menggunakan “Bacem Tempe” Di SMP Negeri 6 Temanggung. *Proceeding of Biology Education*, 3(1), 150–160. <https://doi.org/10.21009/pbe.3-1.18>

- Nur-Azizah, L., & Syafiuddin, A. (2022). Review Tentang: Efektivitas Pengolahan Air Limbah yang Ada di Indonesia. *Jurnal Sosial Sains*, 2(8), 907-920. <https://doi.org/10.59188/jurnalsosains.v2i8.453>
- Nurrijal, N. (2022). Integrated Digital Module Learning Management System (LMS) Development in Microbiological Practices. *Edutechnium Journal of Educational Technology*, 1(1), 13-26. Retrieved from <https://edutechnium.com/journal/index.php/edutechnium/article/view/3%0Ahttps://edutechnium.com/journal/index.php/edutechnium/article/download/3/2>
- OECD. (2019). *PISA 2018 Assessment and Analytical Framework*. <https://doi.org/10.1787/b25efab8-en>
- OECD. (2020). *PISA 2018 Results (Volume IV)*. <https://doi.org/10.1787/48ebd1ba-en>
- Permanasari, A. (2016). STEM Education: Inovasi dalam Pembelajaran Sains. *Prosiding Seminar Nasional Pendidikan Sains VI*, 23-34. Retrieved from <https://media.neliti.com/media/publications/173124-ID-stem-education-inovasi-dalam-pembelajara.pdf>
- Pramana, M. W. A., Jampel, I. N., & Pudjawan, K. (2020). Meningkatkan Hasil Belajar Biologi Melalui E-Modul Berbasis Problem Based Learning. *Jurnal Edutech Undiksha*, 8(2 SE-Articles), 17-32. <https://doi.org/10.23887/jeu.v8i2.28921>
- Sanova, A., Bakar, A., Afrida, A., Kurniawan, D. A., & Aldila, F. T. (2022). Digital Literacy on the Use of E-Module Towards Students' Self-Directed Learning on Learning Process and Outcomes Evaluation Courses. *JPI (Jurnal Pendidikan Indonesia)*, 11(1), 154-164. <https://doi.org/10.23887/jpi-undiksha.v11i1.36509>
- Scherer, R., Siddiq, F., & Tondeur, J. (2019). The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers & Education*, 128, 13-35. <https://doi.org/10.1016/j.compedu.2018.09.009>
- Shofiyah, N., Afrilia, I., & Wulandari, F. E. (2020). Scientific Approach and the Effect on Students Scientific Literacy. *Journal of Physics: Conference Series*, 1594(1). <https://doi.org/10.1088/1742-6596/1594/1/012015>
- Siddaway, A. P., Wood, A. M., & Hedges, L. V. (2019). How to Do a Systematic Review: A Best Practice Guide for Conducting and Reporting Narrative Reviews, Meta-Analyses, and Meta-Syntheses. *Annual Review of Psychology*, 70, 747-770. <https://doi.org/10.1146/annurev-psych-010418-102803>
- Sidiq, R., & Najuah. (2020). Pengembangan E-Modul Interaktif Berbasis Android pada Mata Kuliah Strategi Belajar Mengajar. *Jurnal Pendidikan Sejarah*, 9(1), 1-14. <https://doi.org/10.21009/JPS.091.01>
- Sophonhiranrak, S. (2021). Features, barriers, and influencing factors of mobile learning in higher education: A systematic review. *Heliyon*, 7(4), e06696. <https://doi.org/10.1016/j.heliyon.2021.e06696>
- Surahman, E., & Surjono, H. D. (2017). Pengembangan adaptive mobile learning pada mata pelajaran biologi SMA sebagai upaya mendukung proses blended learning. *Jurnal Inovasi Teknologi Pendidikan*, 4(1). Retrieved from <https://journal.uny.ac.id/index.php/jitp/article/view/9723>
- Sureni, S., Leksono, S. M. & Biru, L. T. (2023). Pengembangan Modul Elektronik (E-Modul) Berbasis Flip PDF Profesional pada Tema Pencemaran Lingkungan untuk Meningkatkan Literasi Sains Siswa SMP Kelas VII. *Jurnal Pendidikan Mipa*, 13(2), 350-357. <https://doi.org/10.37630/jpm.v13i2.944>
- Ubaidillah, N. Z., Baharuddin, N. N., Kasil, N., & Ismail, F. (2020). Students' Perception of the Use of Technology in Education. *Environment-Behaviour Proceedings Journal*, 5, 117-122. <https://doi.org/10.21834/ebpj.v5i15.2374>
- Wohlin, C., Runeson, P., Höst, M., Ohlsson, M. C., Regnell, B., & Wesslén, A. (2012). *Experimentation in software engineering* (Vol. 236). Berlin: Springer. [https://doi.org/10.1007/978-3-642-29044-2\\_4](https://doi.org/10.1007/978-3-642-29044-2_4)
- Yusmar, F., & Fadilah, R. E. (2023). Analisis Rendahnya Literasi Sains Peserta Didik Indonesia: Hasil Pisa Dan Faktor Penyebab. *LENSA (Lentera Sains): Jurnal Pendidikan IPA*, 13(1), 11-19. <https://doi.org/10.24929/lensa.v13i1.283>