VOLUME 8 ISSUE 2
JANUARY 2024

E-ISSN: 2622-3384
P-ISSN: 2527-9939

JURNAL MEdu Mangifera Edu

Development of interactive e-modules to improve students' scientific literacy abilities: A literature review

Elin Herlina, Zaenal Abidin
Magister Pendidikan Biologi, Universitas Kuningan, Jl. Cut Nyak Dhien No.36A, Kuningan, West Java, Indonesia
*Corresponding author: elinherlina_84_mangiferaedu@gmail.com

ABSTRACT

This research aims to investigate the development of the interactive e-Module in the context of improving students' scientific literacy skills. The approach employed in this research involved a systematic literature review, detailing the latest developments from 2019 to 2023 in the use of interactive e-Modules to enhance scientific literacy among students in Indonesia and abroad. The Meta-synthesis techniques were applied in this research. The samples utilized were sourced from 2019-2023 and were retrieved from international journals Google Scholar, Scopus, and Eric with the keyword "Interactive e-module and Scientific literacy". A total of 233 journal articles were obtained and after being reviewed 209 articles were eliminated because they did not include international articles relevant to this research. Consequently, only 24 articles were used in this research. This type of research generally uses Research and Development (R&D). The research findings indicate that the E-Module is based on Discovery Learning, STEM (Science, Technology, Engineering, and Mathematics), PBL (Problem-Based Learning), PjBL (Project-Based Learning), IBL (Inquiry-Based Learning), SETS (Science, Environment, Technology, Society), SSI (Socio Scientific Issues), and Flipped classroom can improve students' Scientific Literacy. The type of technology used in making E-Modules included Macromedia Flash, Virtual Laboratory, Flip PDF Professional, PhET Applications, and Articulate Storyline. The implications of this literature review are anticipated to provide direction for the development of educational policies, curriculum design, and further research to increase scientific literacy in the digital era.

ARTICLE INFO

Keywords
Interactive e-module, Scientific literacy, Research and development.

Received
December 24, 2023

Revised
January 23, 2024

Accepted
January 25, 2024

Published
January 31, 2024

How to cite
Herlina, E. & Abidin, Z. (2024). E-modules to improve students' scientific literacy abilities: A literature review. *Jurnal Mangifera Edu*, *8*(2), 74-87. https://doi.org/10.31943/mangiferaedu.v8i2.181.

INTRODUCTION

In PISA 2022, the average international reading literacy score declined by 18 points, while Indonesia's score dropped by 12 points, placing it in the lower category compared to other countries (OECD, 2023). The decrease in literacy scores has prompted educators around the world to seek innovative solutions in the world of education. One such approach involves the creation of teaching materials in the form of e-modules using various technologies through different methods, strategies, and models of learning activities. This article discusses the development of the use of e-modules to improve students' scientific literacy skills from 2019-2023.

The Ministry of Education, Culture, Research, and Technology (Kemendikbudristek, 2023) has released the outcome of PISA 2022 which showed Indonesia's literacy learning outcomes ranking. The position has surged by 5 to 6 positions compared to PISA 2018. This increase is the

highest achievement in ranking (percentile) in Indonesia's history following PISA. The Minister of Education, Culture, Research and Technology, said that this increase in ranking shows the resilience of the Indonesian education system in overcoming learning loss due to the pandemic. Reading literacy, Indonesia's ranking in PISA 2022 rose 5 positions compared to before. For mathematical literacy, Indonesia's ranking in PISA 2022 also rose 5 positions, while for scientific literacy it rose 6 positions.

Director for Education and Skills, Organization for Economic Cooperation and Development (OECD, 2023), Andreas Schleicher commended the resilience of the Indonesian education system, especially during the Covid-19 pandemic. Schleicher acknowledged the last few years have been a very difficult time. However, Indonesian students generally succeeded in maintaining the quality of learning outcomes in their PISA scores.

Indonesia has been actively participated in PISA since it was first held in 2000. Participation in PISA allows Indonesia to monitor the quality of its education over time and compare it with other countries. PISA is administered every three years by the OECD to measure reading, mathematics, and science literacy in 15-year-old students. In 2022, PISA will be participated by 81 countries, consisting of 37 OECD countries and 44 partner countries. Apart from using PISA, since 2021 Indonesia has implemented a National Assessment (AN) to map the quality of education in each school and region more comprehensively.

Another significant factor that improved Indonesia's ranking in PISA 2022 was the impact of teacher training provided by the Ministry of Education, Culture, Research and Technology through the *Merdeka Mengajar* Platform accompanied by online and hybrid learning materials. A crucial breakthrough that is no less important is the implementation of the Independent Curriculum which simplifies the curriculum material so that teachers can focus on deeper learning, especially to strengthen students' literacy and numeracy skills. The Simplification of curriculum materials has proven effective in mitigating learning loss (Kemendikbudristek, 2023). Schools implementing the Independent Curriculum experienced 1 month of learning loss, compared to 5 months in schools that fully implemented the 2013 Curriculum. The simplification of this material is one of the main principles in designing the Independent Curriculum.

The Merdeka Curriculum is designed to reduce mandatory material in various subjects so that teachers have more time to use in-depth, interactive, and project-based learning. The Merdeka Curriculum supports teachers in carrying out diagnostic and learning assessments that are appropriate to each student's abilities. The Independent Curriculum textbooks also contain more activities designed to sharpen reasoning skills. As a result, learning with the Independent Curriculum is no longer oriented towards delivering material, but honing students' competence and character (Kemendikbudristek, 2023).

The Ministry of Education, Culture, Research, and Technology (Kemendikbudristek, 2023) has provided an explanation for these results, reflecting a gap or inequality in the literacy abilities of Indonesian students compared to the international average. Several factors have been identified as causes of low student literacy achievement: 1. Teacher Quality: The low quality of teachers in several regions of Indonesia can affect the quality of learning and student understanding; 2. Disparity in

Education Quality: The existence of disparities in education quality between regions can cause differences in access and quality of education in all regions of Indonesia; 3. Minimal Utilization of Learning Media: In the learning process, minimal use of learning media can cause a lack of student involvement and disinterest in the subject matter; 4. Use of Educational Facilities and Infrastructure: Although educational facilities such as computer laboratories and science laboratories already exist, their use is not optimal; 5. Decrease from Previous PISA Results: There was a decrease in scores from the previous PISA results in 2015, indicating improvements need to be made in the education system.

Improvement efforts can be directed at improving the quality of teacher education, improving the quality of education in all regions, developing interesting learning methods and media, and optimizing the use of educational facilities. Through this effort, it is hoped that Indonesia can overcome challenges in the field of student literacy and improve the overall quality of education.

According to the (OECD, 2023) Scientific literacy is defined as the ability to be actively involved in issues related to science and scientific ideas and as a reflective citizen. A scientifically literate will be willing to engage in discourse related to science and technology, which requires competence in explaining scientific phenomena, evaluating, and designing scientific investigations, and interpreting data and evidence scientifically. PISA assessments evaluate students' performance in science based on three key dimensions: 1. Context, namely personal, local or national, and global problems related to understanding science and technology; 2. Knowledge is an understanding of the main facts, concepts, and explanatory theories as the basis of scientific knowledge. This knowledge includes knowledge about natural and technological artifacts or content knowledge, knowledge about how ideas can be generated or procedural knowledge, and an understanding of the reasons underlying these procedures and justifications regarding use or epistemic knowledge; 3. Competence is the ability to explain a phenomenon scientifically, evaluate, design scientific investigations, and interpret scientific data and evidence.

The PISA 2022 data indicates that approximately 34% of students in Indonesia achieved Level 2 or above in science, significantly lower than the OECD average is 76%. At a minimum, students can recognize appropriate explanations for known scientific phenomena and can use that knowledge to identify in a simple case whether a conclusion is valid based on the data provided. In Indonesia, almost no students excel in science, meaning they are proficient at Level 5 or 6 of the OECD average of 7%. Students creatively and independently apply their knowledge of science to a variety of situations, including those with which they are unfamiliar (OECD, 2023).

In Indonesia, various scientific literacy competitions other than PISA, are conducted at different levels. At the National level, these competitions included: 1. National Science Olympiad (OSN); 2. Madrasah Science Competition (KSM); 3. Festival of Science and Technology (FST); 4. Youth Scientific Work Competition (LKIR); 5. Indonesian Science Project Olympiad (ISPO). At the regional level, scientific literacy competitions comprise 1. Regional Science Olympiad (OSR); 2. Science Competition between Middle/Senior High Schools throughout the Regency/City; 3. Youth Scientific Works Exhibition (PKIR). At the school level, various assessments contribute to scientific literacy such as: 1. National Standard School Examination (USBN); 2. End of Semester Exam (UAS); 3. Midterm Exam (UTS) and 4. Daily Assessment (PH).

Numerous studies on the use of teaching materials to improve students' scientific literacy skills in Indonesia and abroad, including The development of a STEM-based, E-Module on environmental pollution material effective in improving student learning outcomes and scientific literacy abilities (Prasetyo et al., 2021) and Online learning at the University of Toronto Canada using E-Modules can improve scientific literacy, develop reflection, critical thinking and communication (Fitzpatrick et al., 2021). Based on this background, further research is needed regarding the development of teaching materials such as the development of interactive e-modules to increase scientific literacy in Indonesia and abroad based on a systematic literature review.

METHOD

This research follows the Systematic Literature Review (SLR) methodology. The SLR is a process that allows the collection of relevant evidence on a particular topic that meets predetermined eligibility criteria (Wondimagegn, 2020). The six basic steps of SLR proposed by (Wondimagegn, 2020) namely: 1. *Protocol – SLR methodology step 1*. The first step is to determine the scope of the research, to develop a clear research focus. The questions in this research are How development of E - Modules improve students' scientific literacy skills based on scientific literature in the period 2019 to 2023; *2. Search – SLR methodology step 2*. The second step is to identify, select, and assess literature related to the research question. The target of this research is the development of E-modules to improve students' scientific literacy skills in Indonesia and abroad. These keywords are used to search for related literature in the period 2019 to 2023. The search process uses *Google Scholar, Scopus, and Eric databases* via the software *Publish and Perish*, with the keyword "*Interactive e-module and Scientific literacy*". The data obtained is stored in RIS form which is then reviewed using Mendeley. Data were visualized using VOS-viewer software; 3. *Appraisal – SLR methodology step 3*. The third step determines criteria for selecting relevant literature, by screening based on title, abstract, and full-text reading to ensure relevance to the research question. This step was taken to ensure whether the data obtained was suitable for use in this research or not. Literature standards that meet the requirements are as follows: a. The data was published in the 2019-2023 timeframe; b. Identification as a research journal; c. Relevance to the theme development of E-modules to improve students' scientific literacy skills; d. Accessibility of the complete journal manuscript; 4. *Synthesis – SLR methodology step 4*. In the fourth step, relevant data is extracted and classified from the selected sources to obtain information and conclusions. A total of 233 articles were found using the *database Google Scholar* and *Scopus* with the keyword "*Interactive e-module and Scientific literacy*". 209 articles were not international articles related to the research being discussed, so 24 international articles related to "*Interactive e-module and Scientific literacy*" in the research were selected; 5. *Analysis – SLR methodology step 5*. The analysis phase includes evaluating the synthesized data, extracting meaningful information, and concluding the selected sources. In this phase, 24 international articles were analyzed and answers to the research questions were found; 6. *Report – SLR methodology step 6*. The final step is the reporting phase, where the results obtained from literature the chosen then a meta-synthesis journal article is created.

RESULTS AND DISCUSSION

As many 233 articles were found using *database Google Scholar*, *Scopus, and Eric* with the keywords "*Interactive e-module and Scientific literacy*", 209 articles were not international articles relevant to the research that is being discussed. Therefore, 24 international articles related to *Interactive E-Module* research and *Scientific Literacy* were selected for analysis from various journals.

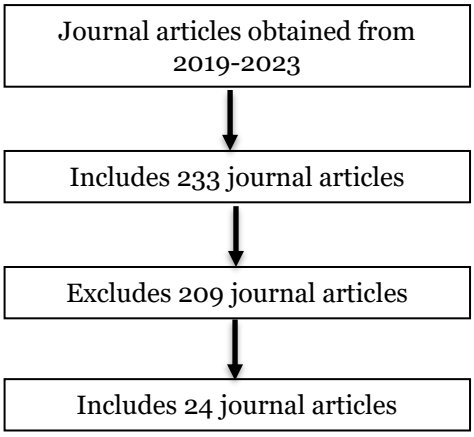


Figure 1. Journal Selection Process

Following the selection process, 24 international journal articles were acquired for analysis of the effectiveness of e-modules in improving students' literacy skills. Apart from that, the technology used in making e-modules and the methods, strategies, and learning models used when using e-modules to increase student literacy were identified. to facilitate the analysis was employed by VOS-viewer (Network Visualization).

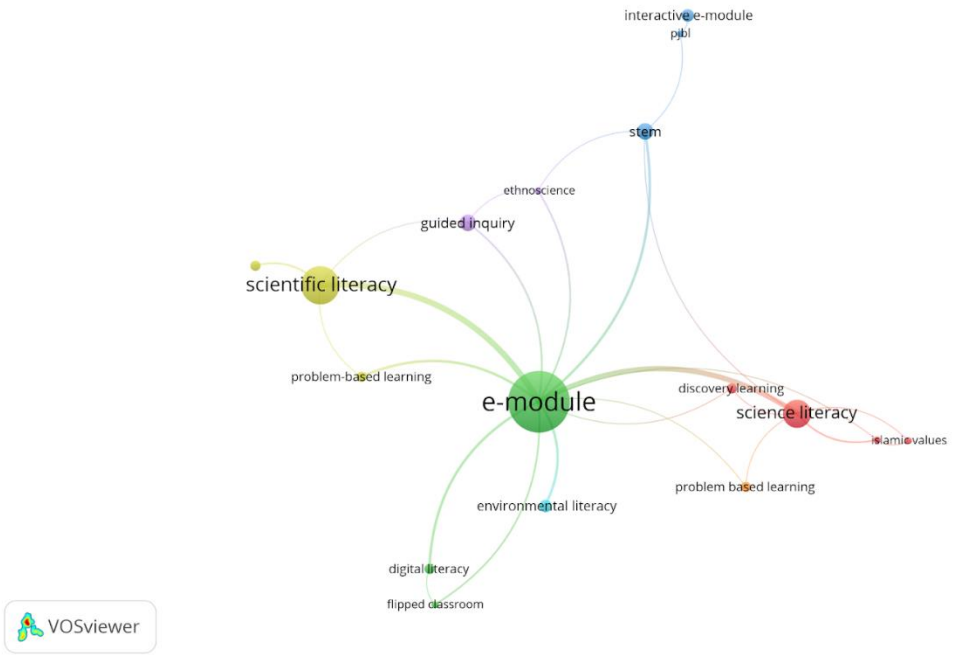


Figure 2.VOS-viewer (Network Visualization) display for Interactive E-Module and Scientific Literacy based on databases Google Scholar, Scopus, and Eric

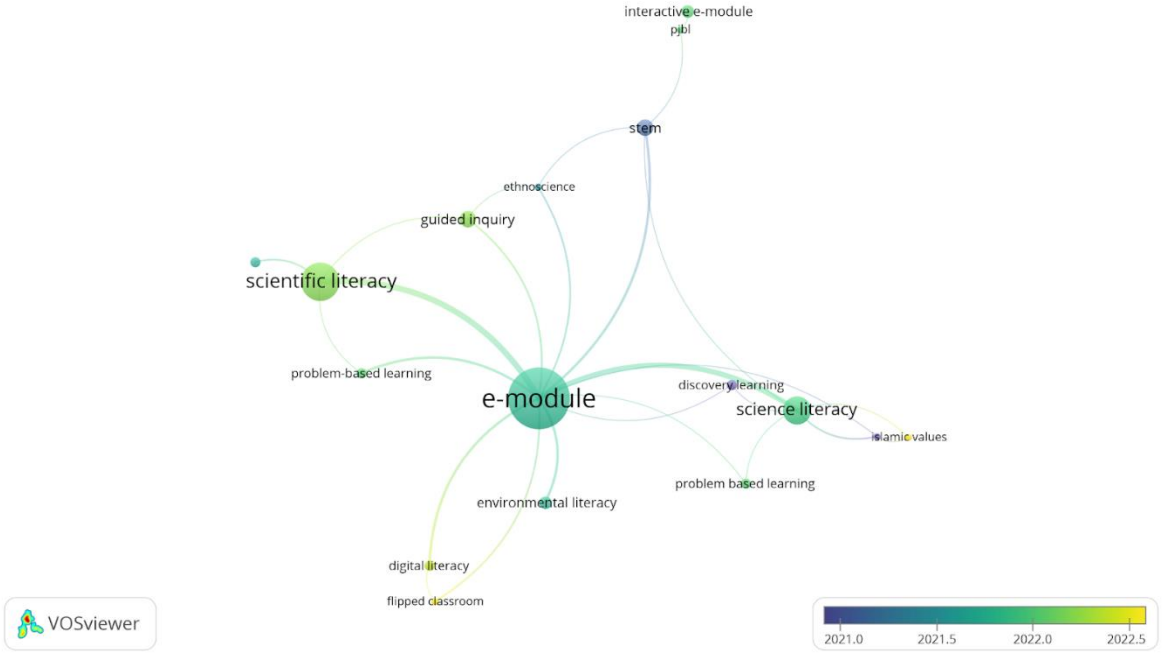


Figure 3. VOS-viewer (Overlay Visualization) display for Interactive E-Module and Scientific Literacy based on databases Google Scholar, Scopus, and Eric

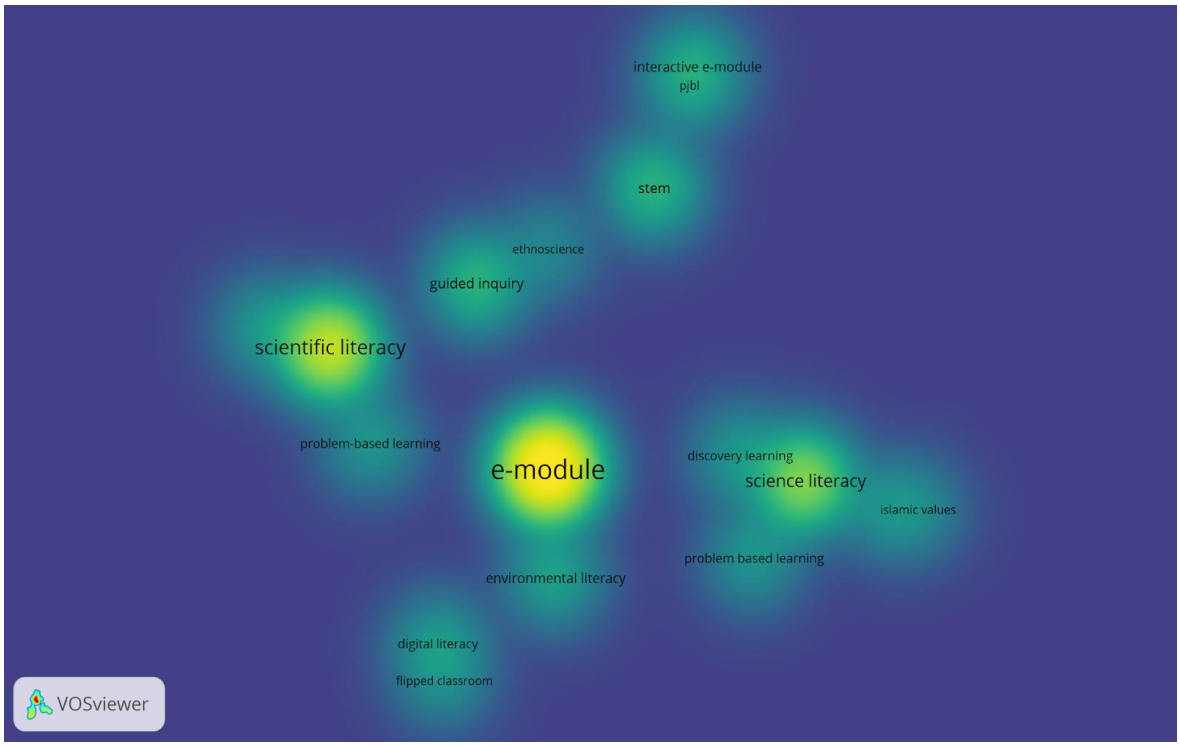


Figure 4. VOS-viewer (Density Visualization) display for Interactive E-Module and Scientific Literacy based on the Google Scholar, Scopus, and Eric database

Important information from the journals we have reviewed is presented in Table 1.

Table 1. Important Information about *Interactive E-Module* and *Scientific Literacy*

No	Title	Reference	Information
1	Validity and Effectiveness of e-Modules	(Suwandi et al., 2023)	Discovery Learning-based e-modules combined with scaffolding on virus material are effective in empowering students' scientific literacy.
2	Development of e-module STEM integrated ethnoscience to increase 21st century skills	(Zakiyah & Sudarmin, 2022)	The integrated e-module of the STEM approach with ethnoscience and 21st century skills development is very effective as an additional learning resource for students.
3	Development of interactive digital module based on virtual laboratories in the covid-19 pandemic era in dynamic fluid materials	(Kusyanti, 2021)	The interactive digital module based on a virtual laboratory on dynamic fluid material is very feasible, easy, and attracts students' interest in studying physics at home during the C-19 pandemic.
4	Improving Critical Thinking Skills of Junior High School Students in Science Learning Using the Development of Interactive E-Module-Based Based Macromedia Flash	(Meryastiti et al., 2023)	Macromedia flash-based interactive e-modules are effective in improving students' critical thinking skills
5	The Ecosystem Problem-Based Learning E-module To Train Critical Thinking Skills During COVID-19 Pandemic	(Hanida & Rachmadiarti, 2022)	The ecosystem problem-based learning e-module for training high school students' critical thinking skills was declared very feasible in terms of validity, readability, and practicality.
6	Development of E-module Based on Science, Technology, Engineering, and Mathematics (STEM) To Improve Science Literacy of Junior High School Students	(Hutomo et al., 2022)	The use of e-modules based on Science, Technology, Engineering, and Mathematics (STEM) that have been developed is suitable for use as an alternative learning resource for substance-pressure material in science learning.
7	Module of Human Circulatory System through Levels of Inquiry-Based to Improve Students' Science Literacy	(Raupu et al., 2022)	The human circulatory system e-module based on the level of inquiry is valid, practical, and effectively used in increasing students' scientific literacy
8	Environmental Pollution Module Based on SETS with Islamic Value to Improve Student's Science Literacy	(Nisa et al., 2022)	The SETS-based environmental pollution module with Islamic values is very worthy of study. This is effective in improving three aspects of scientific literacy.
9	The Effectiveness of Interactive e-Module for Natural Science Subject at Equality Education Program	(Febriani & Kustiyono, 2022)	The interactive e-module for science subjects on the classification of living things is suitable for use to support the learning activities of class VII students

No	Title	Reference	Information
10	Developing e-module based on socio-scientific issues to improve students scientific literacy	(Dalaila et al., 2022)	The SSI-based immune system e-module developed is valid, practical, and used in learning immune system material and is effective in improving the scientific literacy skills of high school students
11	Improvement of Students' Science Literacy Skills Using STEM-Based E-Modules	(Prasetyo et al., 2021)	The development of a STEM-based E-Module on environmental pollution material is effective in improving student learning outcomes and the scientific literacy abilities of class VII students
12	Development of Environmental Pollution E-Module Containing Socio Scientific Issue to Train Students' Scientific Literacy	(Fitriani & Amalia, 2023)	The environmental pollution e-module which contains Socio Scientific Issues is valid for use in science learning and can train students' scientific literacy skills
13	The need for implementation of guided inquiry in the development of electronic modules (e-modules) to improve students' scientific literacy	(Andriani et al., 2023)	Guided inquiry-based electronic module (e-module) to improve students' scientific literacy skills
14	Validity of e-module integrated scientific literacy using the smartphone-assisted IBL model to improve student competence	(Yulkifli et al., 2023)	An integrated physical science literacy e-module using the smartphone-assisted IBL model can be applied in physics learning to improve student competence
15	The Concept of Literacy Vocational-Based E-Module of Technical Mechanical Subject	(Maulana et al., 2022)	Vocational literacy-based e-modules are built based on abilities, problems, and needs that suit the characteristics of vocational school students so that they can be used to identify and improve their vocational literacy abilities
16	Islamic Literacy-Based Physics E-Module with STEM (Science, Technology, Engineering, and Mathematics) Approach	(Diani et al., 2021)	Physics e-modules based on Islamic literacy with a STEM approach can increase student literacy
17	The effectiveness of using e-modules in atomic structure material to improve scientific literacy ability of students	(Fatma et al., 2021)	The use of e-modules on atomic structure material has proven to be effective in improving students' scientific literacy skills.
18	Module electronic sound and light wave developed by scientific approach for improving science literacy	(Nenchi et al., 2021)	There is an increase in science literacy in students by using the e-module of sound waves and light based on a scientific approach
19	Implementation of e-module endocrine system based on Problem-Based Learning (PBL) to improve scientific literacy and cognitive learning outcome	(Rahmawati et al., 2021)	PBL-based electronic modules can improve student literacy.

No	Title	Reference	Information
20	The validity of science e-module based on the authentic problem	(Yunita et al., 2021)	Authentic learning based on valid e-modules is used to increase scientific literacy and self-efficacy in science learning in junior high schools
21	Innovative digital tools in EBP and information literacy education for undergraduate nursing students	(Chan, B., Wei, R., & Fetherston, 2020)	Interactive Online Module developed in Australia to measure information literacy (IL) skills in Evidence-Based Practice (EBP). In the interactive module integrated screen capture videos, split screen tutorials, e-portfolios, and digital badges.
22	Preprint Peer Review Enhances Undergraduate Biology Students Disciplinary Literacy and Sense of Belonging in STEM	(Otto et al., 2023)	In America, a way of teaching students was developed through peer-review courses (full curriculum) and short peer-review modules embedded in disciplinary courses. Instructors who cannot offer a complete course on peer review may still consider incorporating the module into existing science courses as a way to develop students' disciplinary literacy, scientific identity, and sense of belonging in STEM. In essence, the development of scientific literacy is carried out through peer review of scientific manuscripts.
23	Enhancing science literacy and communication among the next generation of scientists in an online learning environment	(Fitzpatrick A, Andreopoulos S, 2021)	Online learning at the University of Toronto Canada using E-Modules can improve scientific literacy, and develop reflection, critical thinking, and communication.
24	Leveraging Online Tutorials and Performance Assessment to Improve Information Literacy Instruction	(Kowalik, 2022)	Literacy Instruction at Marquette University is carried out by utilizing Online Tutorials and Performance Assessment by developing eight independent tutorials with the Articulate Storyline e-learning creation tool. To enable others to utilize and extend the tutorial, the source files and working demo are placed on GitHub (http://marquetterml.github.io/information-literacy-modules/)

Interactive E-Module Development Trends During the 2019-2023 period, there has been a significant increase in the development of E - Modules to improve students' scientific literacy skills. A variety of innovations and new technologies are being integrated into science learning contexts, including interactive simulations, creative learning software, and online platforms that support student interaction. In the VOS-viewer results, the results from 24 journal articles used a digital *literacy* e-module that employed *Macromedia Flash* and a *virtual laboratory*. This was demonstrated in interactive E-module-based research, where *Macromedia Flash* was shown to effectively enhance students' critical thinking skills (Meryastiti et al, 2023). The software used is *Macromedia Flash* and is integrated with the *PheT* simulation allowing students to actively engage and learn independently and minimize teacher guidance.

The E-Module interface is equipped with *Virtual Laboratory* with the *Flip PDF Professional* application which contains self-study videos with applications like *vokoscreen*, *YouTube* link, *PhET*

applications, and *Quizizz* for interactive learning. This research was conducted during the Covid-19 pandemic. The results show that Interactive digital modules based on virtual laboratories on dynamic fluid material are very feasible, and easy, and attract students' interest in studying physics at home (Kusyanti, 2021).

The results of the VOS-viewer analysis of 20 journal articles show that there are variations in methods, strategies, and learning models in developing E-Modules, ranging from collaborative approaches to Problem-Based Learning designs (*Problem-Based Learning*), *Discovery Learning*, STEM *(Science, Technology, Engineering, and Mathematics)*, PBL (*Problem-Based Learning*), PjBL (*Project Based Learning*), IBL (*Inquiry-Based Learning)*, SETS (*Science, Environment, Technology, Society*), SSI (*Socio Scientific Issues),* and *Flipped classroom*.

The implications of using E-Modules consistently have a positive impact on students' scientific literacy abilities. Students who are involved in technology-based learning tend has been associated with enhanced comprehension of science concepts (scientific literacy), analytical skills, and critical thinking *abilities*. Despite positive progress, several challenges and barriers remain, including issues of technology accessibility, digital divide, and sustainability of implementation. Therefore, it is necessary to find a solution to ensure that all students can access and benefit from the development of the E-Module.

In Indonesia, research that has been carried out (Rahmawati et al., 2021) including the application of e-modules on endocrine system material in problem-based learning can improve scientific literacy and student learning outcomes. (Dalaila et al., 2022) Researched that the development of socio-scientific-based e-modules can increase students' scientific literacy. (Raupu et al., 2022) examined the use of the Human Respiration System Module using an Inquiry approach to increase students' scientific literacy. The findings from this literature review show that there is continuity and development in the E - Module development approach. This shows that this field continues to develop over time.

Interactive Online Module developed in Australia to measure information literacy (IL) skills in Evidence-Based Practice (EBP). In the interactive module integrated screen capture videos, split screen tutorials, e-portfolios, and digital badges (Chan, B., Wei, R., & Fetherston, 2020).

In the United States of America (USA), a way of teaching students was developed through peer-review courses (full curriculum) and short peer-review modules embedded in disciplinary courses. Instructors who cannot offer a complete course on peer review may still consider incorporating the module into existing science courses as a way to develop students' disciplinary literacy, scientific identity, and sense of belonging in STEM. In essence, the development of scientific literacy is carried out through peer review of scientific manuscripts (Otto et al., 2023).

In Canada, at the University of Toronto, online learning using E-Modules can improve scientific literacy, and develop reflection, critical thinking, and communication. E-modules are used to overcome challenges faced by students in engagement, independent learning, and soft skills development. E-modules provide resources for selecting and researching a topic, provide guidelines for developing engaging conversations, and connect students to peer discussion forums regarding video programming options. This e-module also contains interactive activities where students can

assess speaking examples and receive feedback, allowing them to reflect on their speaking from the audience's perspective (Fitzpatrick A, Andreopoulos S, 2021).

Table 2. Explanation of the learning model used in developing *Interactive E-Module* in improving *Scientific Literacy*

Learning Model	Short Description	Learning Stages	Student Engagement	Teacher's Role
Problem-Based Learning (PBL)	Students are faced with real-world problems and must find solutions through investigation and collaboration.	1. Problem orientation, 2. Organizing learning, 3. Investigation, 4. Development and presentation, 5. Reflection and evaluation	High, actively looking for solutions, implementing scientific literacy	Facilitator, guide
Discovery Learning	Students discover new concepts and knowledge through independent exploration and experimentation.	1. Question formulation, 2. Data collection, 3. Data analysis, 4. Drawing conclusions, 5. Implementation	Tall, explorative, and independent, implementing scientific literacy	Facilitator, resource provider
STEM (Science, Technology, Engineering and Mathematics)	A learning approach that integrates all four STEM fields to solve real-world problems.	Variables depend on the project/problem	High, collaborative, and creative, implementing scientific literacy	Facilitator, guide
PjBL (Project Based Learning)	Students work on long-term projects that involve planning, research, and presentations.	1. Topic selection, 2. Project planning, 3. Project implementation, 4. Results presentation, 5. Evaluation	Tall, independent, and responsible, implementing scientific literacy	Facilitator, guide, mentor
IBL (Inquiry-Based Learning)	Students are asked questions and problems that encourage them to seek information and build their understanding.	1. Identify questions/ problems, 2. Develop a hypothesis, 3. Collect data, 4. Data analysis, 5. Drawing conclusions and communicating	High, active in finding out, implementing scientific literacy	Facilitator, discussion guide
SETS (Science, Environment, Technology, Society)	A learning approach that links science concepts with environmental, technological, and social issues.	Variables depending on the topic	High, critical, and reflective, implementing scientific literacy	Facilitator, discussion guide
SSI (Socio Scientific Issues)	Students discuss and analyze social issues related to science and technology.	1. Introduction of the issue, 2. Exploration of perspectives, 3. Information collection, 4. Debate and discussion, 5. Drawing conclusions and recommendations	Tall, argumentative, and collaborative, implementing scientific literacy	Facilitator, discussion moderator
Flipped Classroom	Students learn concepts outside of class through videos, readings, or online materials, and deepen understanding through in-class activities and discussions.	1. Independent learning outside the classroom, 2. Activities and discussions in class, 3. Strengthening concepts and assessments	Variables depend on material and activity, implementing scientific literacy	Facilitator, discussion guide, material provider

Research Literacy Instruction at Marquette University USA is carried out by utilizing Online Tutorials and Performance Assessment by developing eight independent tutorials with the Articulate Storyline e-learning creation tool. To enable others to utilize and extend the tutorial, the source files and working demo are placed on GitHub (http://marquetterml.github.io/information-literacy-modules/). (Kowalik, 2022) provides valuable insight into the implementation of this instructional strategy, emphasizing the use of technology to enhance research literacy skills.

This research contributes to bridging the gap between theory and practice by presenting a comprehensive literature review of recent research on interactive e-modules and scientific literacy, developing a theoretical model of how interactive e-modules can improve scientific literacy and providing practical recommendations for teachers, policymakers, and the public on how to use interactive e-modules to increase scientific literacy. The research holds significant implications for research, practice, and society: 1. Implications for Research: a. Encourage further research on the Effectiveness of interactive e-modules in increasing scientific literacy in various contexts (educational levels, subjects, and more.), Optimal interactive e-module design to increase scientific literacy and Factors influencing the use of interactive e-modules by students and teachers, b. Developing more valid and reliable instruments to measure scientific literacy, c. Conduct longitudinal research to track the long-term impact of using interactive e-modules on students' scientific literacy. ; 2. Implications for Practice: a. Assisting teachers in the development and utilization of interactive e-modules to enhance students' scientific literacy, b. Providing guidance for policymakers in developing programs and policies that support the use of interactive e-modules in education, c. Improving the quality of science learning by providing more interesting and effective learning resources; 3. Implications for Society: a. Increasing public awareness about the importance of scientific literacy, b. Providing the public with access to quality science learning resources, c. Encourage society to be more involved in decision-making related to science and technology.

CONCLUSION

The systematic literature review spanning the periode of 2019-2023 highlights a positive trend in the use of digital technology to enhance students' scientific literacy skill through the development of E-Modules. The integration of various technologies, including *Macromedia Flash*, *Virtual Laboratory*, and *Flip PDF Professional* application which contains self-study videos with applications *vokoscreen*, *YouTube* link, *PhET* applications, *Quizizz*, and *Articulate Storyline* has been a significat focus. This technology integration includes the use of simulations, interactive multimedia, educational games, and online learning platforms that support scientific literacy. There are variations in methods, strategies, and learning models in developing E-Modules, ranging from collaborative approaches to Problem-Based Learning designs (*Problem-Based Learning*), Discovery Learning, STEM (*Science, Technology, Engineering, and Mathematics*), PBL (*Problem-Based Learning*), PjBL (*Project-Based Learning*), IBL (*Inquiry-Based Learning*), SETS (*Science, Environment, Technology, Society*), SSI (*Socio Scientific Issues*), and Flipped classroom. The implications of these findings served as a foundation for developing more inclusive and technology-

oriented educational policies, as well as providing guidance for practitioners and researchers in improving digital-based science learning practices.

ACKNOWLEDGMENT

I would like to express my sincere gratitude to all those who have contribute to the completion of this project and also Department of Magister Biology Universitas Kuningan for cooperation and willingness this program.

REFERENCES

Andriani, S., Sukarmin, S., & Masykuri, M. (2023). The need for implementation of guided inquiry in the development of electronic modules (e-modules) to improve students' scientific literacy. AIP Conference Proceedings. Https://pubs.aip.org/aip/acp/article/2727/1/020062/2895050

Chan, B., Wei, R., & Fetherston, C. (2020). Innovative digital tools in ebp and information literacy education for undergraduate nursing students. Journal of Information Literacy, 14(2), 128–140. https://doi.org/https://doi.org/10.11645/14.2.2794

Dalaila, I., Widiyaningrum, P., & Saptono, S. (2022). Developing e-module based on socio-scientific issues to improve students scientific literacy. Journal of Innovative Science Education, 11(3), 285-294. https://journal.unnes.ac.id/sju/index.php/jise/article/view/54500

Diani, R., Yanti, Y., Hartati, N. S., Fujiani, D., & Hasanah, I. F. (2021). Islamic literacy-based physics e-module with STEM (science, technology, engineering, and mathematics) approach. In Journal of Physics: Conference Series (Vol. 1796, No. 1, p. 012098). IOP Publishing. https://doi.org/10.1088/1742-6596/1796/1/012098

Fatma, E., Susilawati, S., & Linda, R. (2021). The effectiveness of using e-modules in atomic structure material to improve scientific literacy ability of students. AIP Conference Proceedings. https://pubs.aip.org/aip/acp/article-abstract/2360/1/050040/598353

Febriani, H. A., & Kustiyono, K. (2022). The effectiveness of interactive e-module for natural science subject at equality education program. Indonesian Journal of Curriculum and Educational Technology Studies, 10(2). https://journal.unnes.ac.id/sju/index.php/jktp/article/view/59892

Fitriani, R. (2023). Development of environmental pollution e-module containing socio scientific issue to train students' scientific literacy. Journal of Environmental and Science Education, 3(1), 14-20. https://journal.unnes.ac.id/sju/index.php/jese/article/view/59915

Fitzpatrick A, Andreopoulos S, F. L. E. (2021). Enhancing science literacy and communication among the next generation of scientists in an online learning environment. Biochem Mol Biol Educ. 2021;49:856–8. https://doi.org/https://doi.org/10.1002/bmb.21584

Hanida, J. R., & Rachmadiarti, F. (2022). The ecosystem problem-based learning e-module to train critical thinking skills during COVID-19 pandemic. Journal of Biology Education. https://journal.unnes.ac.id/sju/index.php/ujbe/article/view/55257

Hutomo, B. A., Saptono, S., & Subali, B. (2022). Development of e-module based on science, technology, engineering, and mathematics (STEM) to improve science literacy of junior high school students. *Journal of Innovative Science Education*, *11*(2), 241-249. https://journal.unnes.ac.id/sju/index.php/jise/article/view/54066

Kemendikbudristek. (2023). PISA 2022 dan Pemulihan Pembelajaran di Indonesia.

Kowalik, E. e-mail: josotl@iu. edu. W. site: (2022). Leveraging online tutorials and performance assessment to improve information literacy instruction. Journal of Teaching and Learning with Technology, Vol. 11, 62–65. https://doi.org/doi: 10.14434/jotlt.v11i1.34348

Kusyanti, R. (2021). Development of interactive digital module based on virtual laboratories in the covid-19 pandemic era in dynamic fluid materials. International Journal of Active Learning.

https://www.learntechlib.org/p/219439/

Maulana, A., Puspita, A. J., Pangastuti, K. K., Daryati, D., & Arthur, R. (2022). The concept of literacy vocational-based e-module of technical mechanical subject. In Journal of Physics: Conference Series (Vol. 2377, No. 1, p. 012068). IOP Publishing. https://doi.org/10.1088/1742-6596/2377/1/012068

Meryastiti, V., Ridlo, Z. R., Supeno, S., & Rahayuningsih, R. (2023). Improving critical thinking skills of junior high school students in science learning using the development of interactive e-module based Macromedia Flash. Journal of Innovative Science Education, 12(2), 163-172. https://journal.unnes.ac.id/sju/index.php/jise/article/view/55080

Nenchi, M., Budi, A. S., & Rustana, C. E. (2021). Module electronic sound and light wave developed by scientific approach for improving science literacy. In *Journal of Physics: Conference Series* (Vol. 2019, No. 1, p. 012007). IOP Publishing. https://doi.org/10.1088/1742-6596/2019/1/012007

Nisa, K., Indriyanti, D. R., & Parmin, P. (2022). Environmental pollution module based on SETS with islamic value to improve student'science literacy. Journal of Innovative Science Education, 11(1), 62-71. https://journal.unnes.ac.id/sju/index.php/jise/article/view/47111

OECD. (2023). PISA 2022 assessment and analytical framework,. PISA, OECD Publishing, Paris,. https://doi.org/https://doi.org/10.1787/dfe0bf9c-en

Otto, J. L., McDowell, G. S., Balgopal, M. M., & Lijek, R. S. (2023). Preprint peer review enhances undergraduate biology students' disciplinary literacy and sense of belonging in STEM. Journal of Microbiology & Biology Education, 24(2). https://doi.org/10.1128/jmbe.00053-23

Prasetyo, D., Marianti, A., & Alimah, S. (2021). Improvement of students' science literacy skills using STEM-based e-modules. Journal of Innovative Science Education, 10(2), 216-221. https://journal.unnes.ac.id/sju/index.php/jise/article/view/43539

Rahmawati, J. M., Lestari, S. R., & Susilo, H. (2021). Implementation of e-module endocrine system based on problem based learning (PBL) to improve scientific literacy and cognitive learning outcome. AIP Conference Proceedings. https://doi.org/10.1063/5.0043175

Raupu, M. S., Latjompoh, M., & Solang, M. (2022). E-module of human circulatory system through levels of inquiry-based to improve students' science literacy. Journal of Biology Education, 11(2), 263-271. https://journal.unnes.ac.id/sju/index.php/ujbe/article/view/58239

Suwandi, R. A., Suciati, S., & Suranto, S. (2023). Validity and effectiveness of e-modules. The International Journal of Interdisciplinary Educational Studies, 19(1), 1. https://search.proquest.com/openview/5ab772b44155c7a7af7303c7166cd884/1?pq-origsite=gscholar&cbl=5529411

Wondimagegn, et al. (2020). Method for conducting systematic literature review and meta-analysis for environmental science research. Journal Www.Elsevier.Com/Locate/Mex. https://doi.org/http://dx.doi.org/10.1016/j.scitotenv.2019.134581

Yulkifli, Y., Risma, M., Festiyed, F., & Azis, H. (2023). Validity of e-module integrated scientific literacy using the smartphone-assisted IBL model to improve student competence. In Journal of Physics: Conference Series (Vol. 2582, No. 1, p. 012051). IOP Publishing. https://doi.org/10.1088/1742-6596/2582/1/012051

Yunita, A., Suyidno, S., & Syahmani, S. (2021). The validity of science e-module based on the authentic problem. In Journal of Physics: Conference Series (Vol. 1760, No. 1, p. 012037). IOP Publishing. https://doi.org/10.1088/1742-6596/1760/1/012037

Zakiyah, N. A., & Sudarmin, S. (2022). Development of e-module STEM integrated ethnoscience to increase 21st century skills. International Journal of Active Learning, 7(1), 49-58. https://journal.unnes.ac.id/nju/index.php/ijal/article/view/34410