JURNAL UPI

Indonesian Journal of Multidiciplinary Research

IJOMR Indonesian Journal of Multidiciplinary Research

Journal homepage: http://ejournal.upi.edu/index.php/ IJOMR/

Trends in Information and Communication Technology (ICT)-Based Science, Technology, Engineering, and Mathematics (STEM) Teaching Materials Development in Science Learning in Indonesia: A Systematic Literature Review

Nor Aulida Rahmi, S. Syahmani, Andi Ichsan Mahardika, S. Suyidno, Fahmi Ibnu Suwandy*

Lambung Mangkurat University, Indonesia
*Correspondence: E-mail: noraulidarahmi@gmail.com

ABSTRACT

This study identified the most commonly used types of Science, Technology, Engineering, and Mathematics (STEM)-integrated, Information and Communication Technology (ICT)-based teaching materials in science education and to explore their development in Indonesia. A Systematic Literature Review (SLR) method was employed following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The selection of articles was based on eligibility criteria, including publication in SINTA-indexed journals, a publication period of 2020–2024, and a focus on science learning at the school level. From the 31 articles analyzed, e-modules emerged as the most dominant teaching material (22.58%) because of their interactivity and accessibility. Other teaching materials identified include e-LKPD, e-books, interactive multimedia, augmented reality, and virtual laboratories. The findings indicate that the development of STEM-based teaching materials enhances 21st-century skills, such as critical thinking, creativity, collaboration, and scientific literacy. However, their implementation remains limited, primarily focusing on the senior high school level. This study contributes a comprehensive mapping of ICT-based STEM teaching material development in Indonesia, providing a valuable reference for future innovations and integration of emerging technologies, including augmented reality, across various levels of education.

ARTICLE INFO

Article History:
Submitted/Received 29 Nov 2024
First Revised 30 Dec 2024
Accepted 18 Feb 2025
First Available online 19 Feb 2025
Publication Date 01 Mar 2025

Keyword:
ICT,
STEM,
Science learning,
Teaching materials.

1. INTRODUCTION

Science subjects are subjects that are still difficult for students to understand because they include direct experience to improve understanding rather than relying solely on memorization, so it is necessary to develop a scientific attitude to acquire knowledge (Dini *et al*., 2024; Ichsan *et al*., 2023). The characteristics of science materials show that science materials have a fairly abstract nature and the acquisition of concepts, materials, or laws learned in them comes from empirical research such as experimental activities, and exploration to understand the basic concepts of matter (Shana & Abulibdeh, 2020; Yanti *et al*., 2024). Science learning can be facilitated by developing teaching materials that meet the demands of 21st-century competencies.

In the 21st century, education plays a crucial role in preparing human resources that will support the development of a country in the future while ensuring the sustainability of the nation by producing the next generation equipped with specific skills to face various global challenges (Malikah *et al*., 2022). 21st-century education that develops along with the rapid advancement of information technology requires innovation to help learners develop appropriate skills and competencies. These skills include the use of communication tools, social media, critical thinking, and problem-solving so that they can access and utilize information in solving daily challenges (Munandar *et al*., 2022; Phandini *et al*., 2023). Teachers as learning facilitators are expected to facilitate the mastery of 21st-century skills, adapt to changes in learner characters, technological developments, and curriculum, and integrate these skills in learning to prepare competitive graduates in the era of globalization (Makaramani, 2015; Rahayu *et al*., 2022).

Information and Communication Technology (ICT)-based teaching helps learners realize new trends and technologies while offering flexibility and convenience that bring new dimensions to their learning (Chowdhury *et al*., 2022). Teaching materials are a set of materials that are systematically arranged to make it easier for students to understand learning materials and adapt learning to student characteristics so that it helps teachers and students learn in a more directed and organized manner (Cahyadi, 2019; Marsari & Rifma, 2023). Teaching materials based on ICT can make it easier for students to understand the material, student interest, or curiosity, encourage creativity motivate students to learn, and make learning more effective and flexible (Akcil *et al*., 2021; Musdahlipah *et al*., 2023).

The application of ICT-based Science, Technology, Engineering, and Mathematics (STEM) teaching materials has an important role in developing 21st-century skills. Technology is used to expand access to information, improve interaction and collaboration, and enrich learning experiences through mobile devices, online learning platforms, educational applications, interactive multimedia, and other supporting tools (Lestari & Kurnia, 2023). Several studies (Aâ *et al*., 2020; Dwiningsih *et al*., 2024; Oktaviyanti *et al*., 2023; Phandini *et al*., 2023; Sari & Kholiq, 2022; Sukma *et al*., 2023) Related to the development of ICT-based STEM teaching materials are considered valid, practical, and effective for improving students' critical thinking skills. Research by other liturater (Tarihoran & Anas, 2023; Wulanningtyas & Ratnasari, 2022; Wulansari *et al*., 2023) related to the development of ICT-based STEM teaching materials are considered valid, practical, and effective for improving students' creative thinking skills. Other research shows that the development of ICT-based STEM teaching materials is considered valid and practical to improve students' collaboration skills and is considered valid and effective to improve students' communication skills (Ahzari & Asrizal, 2023, Rahayu *et al*., 2023).

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

Although ICT-based STEM teaching materials have been widely recognized for their validity, practicality, and effectiveness, there are still few studies that systematically review their application in science education in Indonesia. Referring to STEM research trends in Indonesia, several topics have not been explored in depth, one of which is the need to develop teaching materials and learning media based on ICT and robotics to align STEM research trends in Indonesia with international trends (Ardwiyanti *et al*., 2021).

Based on the above review, this study aims to systematically review the latest research results on the development of STEM-integrated ICT-based teaching materials to improve various competencies such as 21st-century skills, literacy abilities, science process skills, and student learning motivation. The review was obtained from empirical articles on the development of teaching materials in science learning, namely the fields of biology, physics, and chemistry. Some research questions made to answer the research are as follows: 1) What types of STEM-integrated ICT teaching materials are most widely used in science learning? 2) How is the development of STEM-integrated ICT teaching materials in science learning in Indonesia?.

2. METHODS

2.1. Types of Research

This type of research is a systematic literature review that uses SINTA indexed journal articles as the main research object, and uses a qualitative approach because the data produced is in the form of descriptions. This research is adjusted to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines. Several criteria from PRISMA are used including eligibility criteria, information sources, search strategies, selection processes, data collection processes, and data items (Ridho & Dasari, 2023). Thematic analysis was used to identify trends in ICT-based STEM teaching materials.

The article search process is carried out using Publish or Perish with data sources from Google Scholar and is limited to publication types in the form of research articles published by journals and SINTA-indexed articles. The keywords used in the search are “STEM-Based Teaching Material Development” and “ICT-Based STEM Teaching Material Development” in the “Search” column. The year of publication in the selection of this article is articles published in the last 5 years, namely from 2020 to 2024 to ensure the relevance and novelty of the findings obtained. The articles obtained were then selected according to the research article criteria as shown in **Table 1**. Articles were identified based on the type of STEM-integrated ICT-based teaching materials in science learning (biology, chemistry, physics, and science). This research also explores the development and implementation of these teaching materials in Indonesia in improving various student skills in various educational levels ranging from elementary, and junior high, to high school students.

Table 1. Article criteria.

Specifications	Criteria
Publication Type	Research articles published in SINTA-indexed journals and articles.
Year of Publication	2020-2024
Place of Research	Indonesia
Independent Variable	ICT-based teaching materials integrated with STEM in science learning
Field of Research	Biology, chemistry, physics, and science
Research Subject	Elementary, Junior High, and High School Students

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

2.2. Flow of Research Activities

Based on **Figure 1**, the research process was conducted through four main stages: identification, screening, eligibility, and inclusion, which aimed to obtain articles that were most relevant to the focus of the research study. The stages of the research activity flow began with the identification stage which was carried out by searching for articles using Publish or Perish with Google Scholar as the main data source. The keywords used in the search process were "STEM-based teaching materials development" and "ICT-based STEM teaching materials development". To ensure compatibility with the latest trends, this study limits articles published from 2020 to 2024. From the initial search results, 100 articles were found which were then further selected. Furthermore, the screening stage was carried out by reviewing the title and abstract of each article obtained with the aim that the selected articles were relevant and the focus of the research. At this stage, 60 articles were obtained for further analysis. Next, in the eligibility evaluation stage, an examination of the articles was carried out to assess their suitability for the criteria in **Table 1**. After further review and analysis, 44 articles were declared to meet the predetermined research criteria. Finally, the included stage is further selection to ensure that the selected articles have relevance to the development of ICT-based STEM teaching materials in science learning in Indonesia. From the final results of this process, 31 articles were selected as the basis for this study. The selected articles were then evaluated using thematic analysis to identify patterns of development and implementation of ICT-based teaching materials integrated with STEM in science learning in Indonesia at various levels of education.

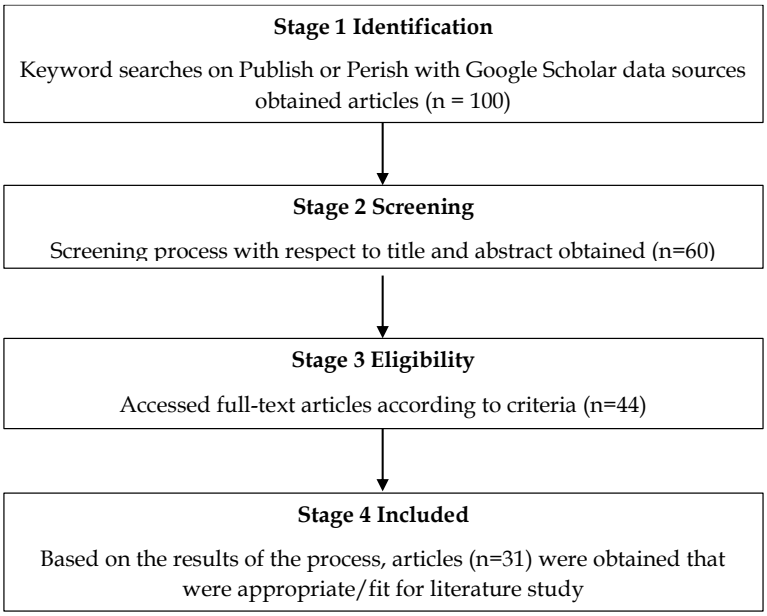

Figure 1. Flow of activities.

3. RESULTS AND DISCUSSION

3.1. Types of STEM-Integrated ICT-based Teaching Materials

Researchers obtained 31 articles from searching SINTA-indexed national journal articles. The articles obtained were adjusted to the STEM-integrated ICT-based teaching materials in science learning presented in **Table 2**.

The utilization of information and communication technology is expected to make the teaching and learning process run efficiently according to the needs and development of the times, considering that most Indonesians have used the internet (Warsa & Kholiq, 2022). The

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

utilization of information and communication technology can be applied to develop teaching materials to improve student competence. Along with the development of the times in the form of rapid technological advances in the world, teaching materials are not only limited to books but also in the form of e-modules to make it easier for students to access various materials (Salfia, 2021). This is in line with the results of the analysis of STEM-integrated ICT-based teaching materials in science learning showing the highest percentage, namely 22.58%, namely the development of teaching materials in the form of e-modules. The dominance of e-modules of 22.58% reflects their accessibility and interactivity, in line with the trend of digital transformation in education.

Table 2. The results of the analysis of STEM-integrated ICT-based teaching materials.

ICT Teaching Materials	F	P
E-Module	7	22,58%
Interactive Multimedia	2	6,45%
E-LKPD	6	19,35%
E-Learning	2	6,45%
E-Book	6	19,35%
Augmented Reality	2	6,45%
Website	2	6,45%
Laboratorium Virtual	2	6,45%
Video	1	3,22%
Mobile Learning	1	3,22%

The use of STEM-integrated e-modules allows students to gain a holistic understanding of the relationship between natural sciences through 21st-century learning experiences (Adha *et al*., 2023; Nazifah & Asrizal, 2022). E-modules are beneficial for students because they contain clear objectives, learning materials, and activity sheets, and allow students to check their understanding independently, increase interest in learning, and present dynamic, effective, and fun learning materials through multimedia such as videos, animations, simulations, and questions with immediate feedback (Noris *et al*., 2024; Rizal *et al*., 2024; Zakaria *et al*., 2024). E-modules developed with the STEM-PBL learning approach (Phandini *et al*., 2023), STEM-PjBL learning (Fauzi & Hayya, 2022), and STEM-Inquiry learning (Irmawati *et al*., 2021).

3.2. STEM Integrated Research Themes in Supporting Science Learning

The various kinds of competencies needed by students in the 21st century are called 21st-century skills and the concept of education is known as 21st-century learning, with this, educators have a role to develop 21st-century skills in preparing for learning in schools (Khalifah *et al*., 2021). Along with this development, teaching materials are materials used to assist teachers in teaching activities in the classroom, and the development of teaching materials must adapt to technological developments, learner characteristics, and 21st-century skills (Saris *et al*., 2025).

The skills to be achieved in 2nd-century education are communication, collaboration, critical thinking/problem-solving, and creativity/innovation skills which are often referred to as 4C skills (Makhrus *et al*., 2019; Trisnawati & Sari, 2019). To support the skills to be achieved in 21st-century education, the STEM approach has a very important role. Through the application of STEM in experimental or project activities, cognitive learning outcomes can be improved to form scientific attitudes and skills, because students are trained in carrying out activities that develop 4C skills, namely creativity, critical thinking, collaboration, and communication (Milala *et al*., 2024).

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

Another ability that students must have been the ability of scientific reasoning with the aim that the knowledge gained by students can be applied in solving various problems they encounter and apply argumentation skills to express opinions to show the extent of students' understanding of their reasoning abilities (Ayuni *et al*., 2022).

The basic literacies that students should apply in their daily activities are literacy, numeracy, scientific literacy, ICT literacy, financial literacy, and cultural and civic literacy. In this study, disaster literacy is also added, namely literacy that involves knowledge about which areas are prone to natural disasters and whether the area where one lives is prone to natural disasters (Sari *et al*., 2022) The research themes are presented in **Table 3**.

Table 3. STEM integrated research themes.

Themes	F	P
Learning Resources	6	19.35%
Critical Thinking	5	16.13%
Critical Thinking & Creative	1	3.22%
Creative Thinking	5	16.13%
Creative Thinking & Collaboration	1	3.22%
Creative Thinking & Science Process Skills	1	3.22%
Communication	1	3.22%
Science Literacy	3	9.67%
Science Literacy & Numeracy Literacy	1	3.22%
Data & Technology Literacy	1	3.22%
Disaster Literacy	1	3.22%
Student Scientific Reasoning	1	3.22%
Conceptual Understanding and Caring Attitude	1	3.22%
Student Motivation	1	3.22%
HOTS	1	3.22%
Self Regulated	1	3.22%

3.3. Development of ICT-based STEM Teaching Materials

Based on the search for articles based on the article criteria in **Table 1**, 31 articles were analyzed. From the data made by analyzing the data according to the title, scientific level, author's name, and journal, as well as the characteristics of development research which can be seen in **Table 4**.

The era of Industrial Revolution 4.0 led to the Internet of Things (IoT) and Artificial Intelligence (AI) technology, while in the era of Society 5.0 people are integrated with technological systems and process big data (Ananingtyas *et al*., 2022). Along with the development of the digital era, technology has a significant impact on the field of education, namely the impact of learning (Pare & Sihotang, 2023; Amin, 2023). Achieving learning objectives in the classroom can be assisted by using teaching materials. Digital teaching materials developed with technology not only assist teachers in delivering subject matter but also support students' independent learning, especially during online learning (Apriani *et al*., 2021; Munzil *et al*., 2022).

The results of the analysis of ICT-based teaching materials integrated with STEM in science learning show the highest percentage of 22.58%, namely the development of teaching materials in the form of e-modules. E-modules are digital learning guides that provide structured material with audio, animation, and navigation features. With interactive properties and access through devices such as cell phones or computers, e-modules help

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

teachers explain material and improve students' understanding and learning outcomes. (Pramana *et al*., 2020; Seruni *et al*., 2019). E-modules contain images, audio, video, animation, and online quizzes that train independence, provide feedback, and measure learning outcomes (Fauzi & Hayya, 2022; Nanda & Rahmah, 2023; Asrizal, 2023). Electronic module development needs to be adjusted and integrated with the learning model (Phandini *et al*., 2023) and the right learning approach (Aripin & Suryaningsih., 2024). Based on research by (Phandini *et al*., 2023; Rahayu *et al*., 2024) who developed PBL-based science e-modules integrated with STEM. The integration of PBL with the STEM approach can produce meaningful learning, by contextualizing problems and combining knowledge, concepts, and skills systematically.

Table 4. Article development of STEM-integrated ICT-based teaching materials.

No	Title	Scientific Level	Author & Journal	Characteristics
1	"*The Development of Electrolysis Cell Teaching Material Based on STEM-PjBL Approach Assisted by Learning Video: A Need Analysis"*	1	Jurnal Pendidikan IPA Indonesia (Widarti *et al*., 2020)	• Videos can visualize concepts to students more efficiently and interactively. • The research aims to explore the needs of teachers and students for the development of teaching materials for electrolysis cells assisted by learning videos.
2	"*STEM-AR Based Ecology and Biodiversity E-book Development for Increasing Students'Scientific Reasoning*"	2	Jurnal Penelitian Pendidikan IPA (Khoeriah *et al*., 2023)	• Augmented Reality (AR) is a type of technology-based innovation that integrates two- and three-dimensional virtual objects into a real-world environment and then projects the virtual objects in real-time.
3	"*Development of an E-book Based on STEM-Integrated Creative Problem Solving on Environmental Change Material to Improve Students' Critical Thinking and Creative Thinking"*	2	Jurnal Penelitian Pendidikan IPA (Sukma *et al*., 2023)	• The advantages of STEM-based e-books integrated creative problem solving are learning that supports student activities to think critically and creatively. • The application of STEM that encourages students to think from all areas helps students develop their creativity
4	"*Developing STEM-Based Interactive E-Books to Improve Students's Science Literacy"*	2	Tadris: Journal of Education and Teacher Training (Yuberti *et al*., 2022)	• The e-book will be packaged in an interactive, practical, and engaging way based on science literacy features combined with STEM learning. • E-books can be accessed through electronic devices such as mobile phones, tablets, and laptops/computers
5	"*Development of E-Learning Based PBL-STEM Learning Tools on Students' Science Process Skills and Critical Thinking Ability*	2	Jurnal Penelitian Pendidikan IPA (Dwiningsih *et al*., 2024)	• Through STEM learning, students have higher-order thinking skills and science and technology process skills that are seen from reading, writing, observing, and doing science.

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

Table 4 (continue). Article development of STEM-integrated ICT-based teaching materials.

No	Title	Scientific Level	Author & Journal	Characteristics
6	"*Development of E-Module with STEM Nuances to Improve Students' Creative Thinking Skills*	2	Jurnal Penelitian Pendidikan IPA (Wulansari *et al.*, 2023)	• The advantage of e-modules compared to other print media is that they are interactive and can be accessed via mobile phones, laptops, or computers.
7	"*STEM-PBL integrative electronic module: Is that effective in improving students' critical thinking skills?*	2	Jurnal Inovasi Pendidikan IPA (Phandini *et al.*, 2023)	• Electronic modules were developed to facilitate the implementation of lesson plans using technology
8	"*The Effectiveness of Respiratory System E-Module Based STEM to Improve Conceptual Understanding and Caring Attitudes towards the Dangers of Cigarettes in High School Students*	2	Unnes Science Education Journal (Anggraeni *et al.*, 2024)	• E-modules as good teaching materials must have several characteristics, namely self-instruction (self-study), self-contained (contains the main material), stand-alone (learning media alone without the need for other media), adaptive (according to student characteristics) and user-friendly (easy to use).
9	*"Development of STEM-Based E-LKPD on Senses System Material to Improve Creative Thinking Ability"*	2	Jurnal Penelitian Pendidikan IPA (Torihoran & Anas, 2023)	• LKPD are used to improve creative thinking skills that involve investigation and thinking to analyze research data.
10	"*Developing STEM Electronic Student Worksheet with Problem-Based Learning to Enhance Communication Skills"*	2	Tadris: Journal of Education and Teacher Training (Rahayu *et al.*, 2023)	• The developed e-worksheet incorporates a virtual laboratory, which allows students to conduct online experiments.
11	"*Inquiry-Integrated STEM on Electronic Student Worksheet: An Effort to Stimulate Creative Thinking and Collaborative Skills"*	2	Jurnal Ilmiah Pendidikan Fisika Al-BiRuNi (Anugrah *et al.*, 2023)	• Integrating STEM can prepare students with an understanding of succeeding in an increasingly technology-based and science-oriented world • Integrating Inquiry models into electronic student worksheets helps students better understand concepts and ideas and helps them develop creative and collaborative thinking
12	"*Using e-Worksheet Integrated with PBL-STEM Activities to Improve Disaster Literacy of Junior High School Students"*	2	Jurnal Pendidikan MIPA (Sari *et al.*, 2022)	• Creating e-LKPDs with Microsoft Sway with the advantage of being able to easily add text, images, documents, videos, diagrams, or other types of content.

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

Table 4 (continue). Article development of STEM-integrated ICT-based teaching materials.

No	Title	Scientific Level	Author & Journal	Characteristics
13	*"Development of STEM-Based Digital Student Worksheet to Improve Students' Numeracy and Science Literacy"*	2	Jurnal Penelitian Pendidikan IPA (Kamal *et al.*, 2024)	• The advantage of using digital LKPD is its ability to simplify and narrow the boundaries of space and time in the learning process. • The integration of STEM-based learning models in digital LKPDs can create an effective learning atmosphere, helping to explore students' literacy skills.
14	*"Development of STEM-Based E-Learning on Renewable Energy Topic to Improve the Student's Creative Thinking Skills"*	2	Jurnal Penelitian Pendidikan IPA (Nazhifah *et al.*, 2023)	• The application of the internet in learning is using e-learning to present teaching materials that are varied, interactive, and tailored to student needs.
15	*"Development of a Virtual Lab in Science-Physics Learning Based on the STEM Approach"*	2	Jurnal Penelitian Pendidikan IPA (Rahmi *et al.*, 2022)	• Virtual laboratory is an interactive multimedia-based software. A virtual laboratory is a tool that can be used to visualize abstract concepts so that students can more easily understand the concepts taught.
16	"*Development of STEM-Based Interactive Multimedia as an Effort to Increase Student Learning Motivation in Biology Learning"*	2	Jurnal Pendidikan MIPA (Basri, 2023)	• Media development uses the Ispring Suite 9 application because ISpring allows users to create media such as slides, quizzes with various forms of questions, simulations, screen recordings, and videos, and to publish learning content in the form of HTML 5 which is easily accessible.
17	(Indah & Cahya, 2024) *"Development of Physics Websites Based on STEM Assisted of Google Sites on Momentum and Impulse Materials to Improve Creative Thinking Skills"*	2	Jurnal Penelitian Pendidikan IPA (Ningrum, 2024)	• Google Sites is a website-building platform that can incorporate various features to support the learning process.
18	*"Advancement of STEM-Based E-Student Worksheet To Enhance The HOTS of Elementary School Students"*	2	Journal of Education Technology (Zainil *et al.*, 2022)	• The developed learner worksheets are made by adapting the learning process to technological advances and utilizing them for the online learning process.
19	*"Improving Students' Critical Thinking Skills through the STEM Digital Book"*	3	Journal of Innovative Science Education (Aâ *et al.*, 2020)	• Information technology-based teaching materials in digital format in the form of digital books developed as a form of innovation to keep up with the times.

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

Table 4 (continue). Article development of STEM-integrated ICT-based teaching materials.

No	Title	Scientific Level	Author & Journal	Characteristics
20	"Pengembangan Bahan Ajar Berbasis STEM dengan Memanfaatkan *Augmented Reality* dalam Meningkatkan Kemampuan Berpikir Kritis"	3	Jurnal Tadris IPA Indonesia (Oktaviyanti *et al*., 2023)	• The teaching materials developed utilize smartphones in the form of Augmented Reality which provides interesting material with 3D visuals that look real to foster critical thinking skills.
21	*"Development of Electronic Modules Based on STEM to Train Students' Creativity: Validity and Practicality Analysis"*	3	Berkala Ilmiah Pendidikan Fisika (Melisa *et al*., 2021)	• Electronic modules are a form of presentation of self-learning materials presented in electronic format, making students more interactive with video tutorials, animation, and audio to enrich the learning experience.
22	*"Developing STEM-Integrated Interactive Multimedia to Improve Students' Data Literacy and Technology Literacy"*	3	JEP (Jurnal Eksakta Pendidikan) (Ahzari & Asrizal, 2023)	• Interactive multimedia presents the material with audio, images, animation, and video, making it easier for students to understand the material.
23	"*Development of WEB-FIST (STEM-Based Physics Web) to Train Students' Critical Thinking on the Topic of Parabolic Motion"*	3	Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram (Sari & Kholiq, 2022)	• Web utilization is expected to help students understand abstract physics concepts, repeat difficult material, and gain reinforcement through learning resources such as e-books, articles, and teacher-made practice questions.
24	*"Development of STEM-Integrated Static Fluid E-Modules to Improve Students' Creative Thinking and Science Process Skills"*	3	Jurnal Eksakta Pendidikan (JEP) (Shiddiq & Asrizal, 2023)	• E-modules are made interactive with the addition of videos, images, Google Forms, and PhET simulations that can motivate students to learn, train independence, provide feedback, and measure learning outcomes.
25	*"Development of MolBEST (STEM-Based Mobile Learning) on Elasticity Materials"*	3	Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram (Warsa & Kholiq, 2022)	• Smartphones used by students can be a medium to support the learning process called mobile learning as the utilization of information and communication technology in the learning process.

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

Table 4 (continue). Article development of STEM-integrated ICT-based teaching materials.

No	Title	Scientific Level	Author & Journal	Characteristics
26	"Pengembangan LKPD Materi Arthropoda Berbasis STEM Berteknologi *Augmented Reality*"	4	Bioeduca: Journal of Biology Education (Destiara *et al*., 2021)	• Augmented reality is a technology that can visualize 2-dimensional objects into 3 dimensions so that they can look real which helps the learning process.
27	"Pengembangan E-Book Berbasis STEM Pada Materi Ekosistem untuk Melatihkan Kemampuan Literasi Sains Siswa"	4	Berkala Ilmiah Pendidikan Biologi (BioEdu) (Andaresta & Rachmadiarti, 2021)	• Learning media in the form of technology-based e-books with flipbook types that have a small size, are not easily weathered, are easy to carry, and display multimedia/animation illustrations.
28	"*Feasibility Analysis of the Development of STEM-Based Physics E-Book with Self-Regulated Learning on Global Warming Topics Indonesian Journal of Teaching in Science*"	4	Indonesian Journal of Teaching in Science (Lestari *et al*., 2024)	• E-books are made with the "Book Creator" website which includes tools in the form of text and images, can be inserted audio and video recordings, and is connected to the Canva application and Google Drive to access the questions to be entered.
29	"*Development of STEM-Based E-Modules on Colloid Material to Train Scientific Literacy Skills"*	4	Jurnal Penelitian dan Pengembangan Pembelajaran (Nanda & Rahmah, 2023)	• Electronic teaching materials in the form of e-modules contain animations, images, videos, and so on that are practical and able to improve students' critical thinking skills.
30	*"Development of STEM-based interactive e-module on ecology topic for senior high schools' student"*	4	Assimilation: Indonesian Journal of Biology Education (Fauzi & Hayya, 2022)	• E-modules are an innovation from the development of accessible printed modules connected to software that contains images, audio, video, animation, and tests or quizzes. E-modules are developed with Flip PDF Professional
31	"Pengembangan Aplikasi PraMetaVirLab (Praktikum Metabolisme Virtual Laboratorium) Berbasis STEM Sebagai Media Pembelajaran Biologi "	4	Biodik: Jurnal Ilmiah Pendidikan Biologi (Rahma *et al*., 2024)	• The PraMetaVirLab application with a STEM approach has the advantage of being able to do practicum safely, and easily accessible without being constrained by space, tools, materials, and time, besides that, it can be accessed anywhere and accessed offline and used for practice questions.

In addition to e-modules, one of the teaching materials in the current digitalization era that can be developed is e-books. The results of the analysis of ICT-based teaching materials integrated with STEM in science learning show a percentage of e-books and e-worksheets of 19.35%. E-books are electronic versions of printed books that can be read on digital devices and incorporate features such as images, video, audio, and hyperlinks. Interactive e-book

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

content helps educators develop attitudes, determination, and depth of material and provides a more personalized learning experience because students can learn individually (Maulida *et al*., 2022; Yuberti *et al*., 2022). Based on research by Sukma *et al* (2023) the advantages of STEM-based e-books integrated with creative problem solving are learning that supports student activities to think critically and creatively. E-books integrated with the STEM approach play a role in improving science literacy (Andaresta & Rachmadiarti, 2021; Yuberti *et al*., 2022), as well as self-regulated (Lestari *et al*., 2024).

While ICT-based teaching materials integrated with STEM in this finding have the lowest percentage are mobile learning and learning videos. The development of mobile learning teaching materials is needed as a novelty, especially to improve the quality of learning. Mobile learning applications that have components for STEM learning which contain lesson plans, modules, learning media, student worksheets, videos of learning implementation, and tools for assessment are innovations in the world of education (Firdaus & Hamdu, 2020). The development of teaching materials and learning media based on ICT and robotics needs to be initiated immediately to align Indonesia's STEM research trends with international trends. (Ardwiyanti *et al*., 2021). This is very important to improve the 21st-century skills and literacy abilities of students from various levels of education. With more ICT-based teaching materials, learners can be more flexible in accessing materials. In addition, STEM integration makes it possible to provide more meaningful learning.

4. CONCLUSION

This research makes a fundamental contribution to highlighting the development of ICT-based STEM teaching materials in science learning in Indonesia. The findings highlight the use of e-modules as the most dominant teaching material, as it can increase interactivity and accessibility for students for interactive learning in the classroom in achieving learning objectives. The ICT-based STEM teaching materials developed are in the form of e-modules, e-liked, e-books, e-learning, interactive multimedia, interactive videos, augmented reality, websites, and virtual laboratories. This research reveals the importance of adapting teaching materials to learning models and 21st-century needs, such as critical thinking, creativity, collaboration, and communication skills. In addition, the use of ICT in the development of teaching materials supports independent learning and encourages students' mastery of science literacy, technology, and science process skills. The limitation of this research is that the article search was conducted by focusing on learning in high school. The implication for future research is that it can explore the development of ICT-based STEM teaching materials widely in various levels of education and develop ICT-based STEM teaching materials by combining STEM with several learning models to be packaged with digital-based teaching materials.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

6. REFERENCES

Aâ, Q., Rusilowati, A., and Lisdiana, L. (2020). Improving students' critical thinking skills through the STEM digital book. *Journal of Innovative Science Education*, *9*(2), 237-243.

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

Adha, T. Z., Asrizal, A., and Rahim, F. R. (2023). Development of E-module integrated STEM approach to improve students' critical and creative thinking skills. *Physics Learning and Education*, *1*(2), 62-70.

Ahzari, S., and Asrizal, A. (2023). Developing STEM-integrated interactive multimedia to improve students' data literacy and technology literacy. *Jurnal Eksakta Pendidikan (JEP)*, *7*(1), 63-73.

Akcil, U., Uzunboylu, H., and Kinik, E. (2021). Integration of technology to learning-teaching processes and google workspace tools: A literature review. *Sustainability*, *13*(9), 5018.

Amin, A. S. (2023). Teknologi dalam pendidikan: Dampaknya terhadap perkembangan kognitif dan emosional siswa. *Jurnal Kajian Pendidikan Dan Psikologi*, *1*(1), 20-25.

Ananingtyas, R. S. A., Sakti, R. E., Hakim, M. H., and Putra, F. N. (2022). Pengembangan media pembelajaran berbasis arduino pada pembelajaran stem dalam meningkatkan literasi sains dan digital. *Briliant: Jurnal Riset Dan Konseptual*, *7*(1), 178-186.

Andaresta, N., and Rachmadiarti, F. (2021). Pengembangan e-book berbasis stem pada materi ekosistem untuk melatihkan kemampuan literasi sains siswa. *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, *10*(3), 635-646.

Anggraeni, D. A., Lisdiana, L., Parmin, P., and Subali, B. (2024). The effectiveness of respiratory system e-module based stem to improve conceptual understanding and caring attitudes towards the dangers of cigarettes in high school students. *Unnes Science Education Journal*, *13*(2), 101-108.

Anugrah, A., Herlina, K., and Suyatna, A. (2023). Inquiry-Integrated STEM on electronic student worksheet: An effort to stimulate creative thinking and collaborative skills. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *12*(2), 251-263.

Apriani, R., Harun, A. I., Erlina, E., Sahputra, R., and Ulfah, M. (2021). Pengembangan modul berbasis multipel representasi dengan bantuan teknologi augmented reality untuk membantu siswa memahami konsep ikatan kimia. *JIPI (Jurnal IPA dan Pembelajaran IPA)*, *5*(4), 305-330.

Ardwiyanti, D., Prasetyo, Z. K., and Wilujeng, I. (2021). STEM research trends in indonesia: A systematic literature review. *Journal of Science Education Research Journal*, *1*, 38-45.

Aripin, I., and Suryaningsih, Y. (2024). Penerapan model problem based learning (pbl) berbantuan e-modul untuk meningkatkan kemampuan pemecahan masalah siswa SMA pada materi pencemaran lingkungan. *Pedagogi Biologi*, *2*(01), 10-16.

Asrizal, A. (2023). Development of STEM-integrated static fluid e-modules to improve students' creative thinking and science process skills. *Jurnal Eksakta Pendidikan (JEP)*, *7*(2), 171-1784.

Ayuni, M. S., Distrik, I. W., and Viyanti, V. (2022). The effect of E-LKPD assisted PJBL-STEM learning model on scientific reasoning ability and argumentation performance of class XII science students in renewable energy materials. *Physics Education Research Journal*, *4*(2), 79-86.

Basri, R. (2023). Development of STEM-based interactive multimedia as an effort to increase student learning motivation in biology learning. *Jurnal Pendidikan MIPA*, 24(1), 384-392.

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

Cahyadi, R. A. H. (2019). Pengembangan bahan ajar berbasis ADDIE model. *Halaqa: Islamic Education Journal*, *3*(1), 35-42.

Chowdhury, M., Islam, S., and Pabel, A. S. M. S. (2022). Uses of information and communication technology (ICT) for learning by business students: A study in Sylhet Region. *Journal of Research & Method in Education*, *12*(6), 41-46.

Destiara, M., Himmah, N., AND Indriyani, S. (2021). Pengembangan LKPD materi arthropoda berbasis STEM berteknologi augmented reality. *Bioeduca: Journal of Biology Education*, *3*(1), 37-45.

Dini, N. A. I., Ikhsan, M., Pamungkas, O., and Kuswanto, H. (2024). ICT-based teaching materials on science learning to improve 21st-century skills: A systematic review. *IJORER: International Journal of Recent Educational Research*, *5*(5), 1239-1251.

Dwiningsih, K., Sukarmin, S., Lutfi, A., Hidayah, R., Suyono, S., Azizah, U., and Alya, A. (2024). Development of e-learning based PBL-STEM learning tools on students' science process skills and critical thinking ability. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 7171-7178.

Fauzi, R., and Hayya, A. W. (2022). Development of STEM-based interactive e-module on ecology topic for senior high schools' student. *Assimilation: Indonesian Journal of Biology Education*, *5*(2), 89-100.

Firdaus, S., and Hamdu, G. (2020). Pengembangan mobile learning video pembelajaran berbasis STEM (Science, Technology, Engineering and Mathematics) di sekolah dasar. *JINOTEP (Jurnal Inovasi dan Teknologi Pembelajaran): Kajian dan Riset Dalam Teknologi Pembelajaran*, *7*(2), 66-75.

Ichsan, I., Suharyat, Y., Santosa, T. A., and Satria, E. (2023). The effectiveness of STEM-based learning in teaching 21 st century skills in generation Z student in science learning: A meta-analysis. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 150-166.

Irmawati, I., Syahmani, S., and Yulinda, R. (2021). Pengembangan modul IPA pada materi sistem organ dan organisme berbasis STEM-inkuiri untuk meningkatkan literasi sains. *Journal of Mathematics Science and Computer Education*, *1*(2), 64-73.

Kamal, F. A., Subali, B., Astuti, B., Rusilowati, A., and Widiyatmoko, A. (2024). Pengembangan LKPD digital berbasis STEM untuk meningkatkan literasi numerasi dan sains peserta didik. *Jurnal Penelitian Pendidikan IPA*, *10*(5), 2454-2464.

Khalifah, I., Sakti, I., and Sutarno, S. (2021). Pengembangan LKPD berbasis project based learning untuk melatihkan keterampilan berpikir kritis pada materi induksi elektromagnetik. *DIKSAINS: Jurnal Ilmiah Pendidikan Sains*, *1*(2), 69-80.

Khoeriah, I. A., Permana, I., and Pursitasari, I. D. (2023). STEM-AR based ecology and biodiversity e-book development for increasing students' scientific reasoning. *Jurnal Penelitian Pendidikan IPA*, *9*(10), 8837-8845.

Lestari, D. A., Suwarma, I. R., and Suhendi, E. (2024). Feasibility analysis of the development of STEM-based physics e-book with self-regulated learning on global warming topics. *Indonesian Journal of Teaching in Science*, *4*(1), 1-10.

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

Lestari, D. I., and Kurnia, H. (2023). Implementasi model pembelajaran inovatif untuk meningkatkan kompetensi profesional guru di era digital. *JPG: Jurnal Pendidikan Guru*, *4*(3), 205-222.

Makaramani, R. (2015). 21st century learning design for a telecollaboration project. *Procedia-Social and Behavioral Sciences*, *191*, 622-627.

Makhrus, M., Harjono, A., Syukur, A., Bahri, S., and Muntari, M. (2018). Identifikasi kesiapan LKPD guru terhadap keterampilan abad 21 pada pembelajaran IPA SMP. *Jurnal ilmiah profesi pendidikan*, *3*(2), 124-128.

Malikah, S., Fauziati, E., and Maryadi, M. (2022). Perspektif connectivisme terhadap pembelajaran daring berbasis google workspace for education. *Edukatif: Jurnal Ilmu Pendidikan*, *4*(2), 2050-2058.

Marsari, H., and Rifma, R. (2023). The development of STEM-based teaching materials to improve science literacy for grade iii elementary school students. *AL-ISHLAH: Jurnal Pendidikan*, *15*(2), 1297-1309.

Maulida, S. I., Adnyana, P. B., and Bestari, I. A. P. (2022). Pengembangan e-book berbasis problem based learning pada materi perubahan lingkungan dan daur ulang limbah untuk siswa di MAN Karangasem. *Jurnal Pendidikan Biologi Undiksha*, *9*(2), 116-129.

Melisa, M., Susilowati, E., and Dewantara, D. (2021). Development of electronic modules based on STEM to train students' creativity: Validity and practicality analysis. *Berkala Ilmiah Pendidikan Fisika [Physics Education Scientific Periodical]*, *9*(3), 335-348.

Milala, K. N. B., Harahap, F., and Hasruddin, H. (2024). Developing STEM-based LKPD to improve student's critical thinking abilities. *Inovasi Kurikulum*, *21*(4), 2243-2262.

Munandar, R. R., Suhardi, E., and Husna, M. N. (2022). Development of STEM-based flipbook learning media on the bloodstream system materials for junior high school. *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran*, *8*(2), 367-374.

Munzil, M., Affriyenni, Y., Mualifah, S., Fardhani, I., Fitriyah, I. J., and Muntholib, M. (2022). Development of problem based learning based e-modules in the form of flipbooks on environmentally friendly technology materials as an independent learning material for students especially online learning. *Jurnal Pendidikan Sains Indonesia*, *10*(1), 37-46.

Musdahlipah, M., Wicaksana, E. J., Yelianti, U., and Widyaningsih, P. R. (2023). Analysis of the need for ICT (Information and Communication Technology) based biology teaching materials at the high school level. *BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan*, *5*(2), 243-249.

Nanda, A., and Rahmah, S. (2023). Development of STEM-based e-modules on colloid material to train scientific literacy skills. *Jurnal Teknologi Pendidikan: Jurnal Penelitian dan Pengembangan Pembelajaran*, *8*(3), 610-623.

Nazhifah, N., Wiyono, K., and Ismet, I. (2023). Development of STEM-based e-learning on renewable energy topic to improve the students creative thinking skills. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9575-9585.

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

Nazifah, N., and Asrizal, A. (2022). Development of STEM integrated physics e-modules to improve 21st century skills of students. *Jurnal Penelitian Pendidikan IPA*, *8*(4), 1783-1789.

Ningrum, D. I. P. C. (2024). Development of physics websites based on STEM assisted of google sites on momentum and impulse materials to improve creative thinking skills. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 6766-6776.

Noris, M., Nurhajarurahmah, S., Darmin, D., Iksan, M., Alkhair, A., Khatimah, N. H., and Avila, D. Z. (2024). The development of scientific-based e-modules to improve conceptual understanding of nutrition students in biotechnology subjects. *Journal of Excellence Humanities and Religiosity*, *1*(1), 110-121.

Oktaviyanti, R., Fatmahanik, U., and Fadly, W. (2023). Pengembangan bahan ajar berbasis stem dengan memanfaatkan augmented reality dalam meningkatkan kemampuan berpikir kritis. *Jurnal Tadris IPA Indonesia*, *3*(3), 303-314.

Pare, A., and Sihotang, H. (2023). Pendidikan holistik untuk mengembangkan keterampilan abad 21 dalam menghadapi tantangan era digital. *Jurnal Pendidikan Tambusai*, *7*(3), 27778-27778.

Phandini, I., Miharja, F. J., Husamah, H., Fauzi, A., and Nuryady, M. M. (2023). STEM-PBL integrative electronic module: Is that effective in improving students' critical thinking skills?. *Jurnal Inovasi Pendidikan IPA*, *9*(2), 118-126.

Pramana, M. W. A., Jampel, I. N., and Pudjawan, K. (2020). Meningkatkan hasil belajar biologi melalui e-modul berbasis problem based learning. *Jurnal Edutech Undiksha*, *8*(2), 17-32.

Rahayu, M., Distrik, I. W., and Suyatna, A. (2023). Developing STEM electronic student worksheet with problem-based learning to enhance communication skills. *Tadris: Jurnal Keguruan dan Ilmu Tarbiyah*, *8*(2), 315-325.

Rahayu, N. P., Widiyatmoko, A., and Arbarini, M. (2024). Development science e-module based PBL-integrated STEM on energy material. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 4536-4542.

Rahma, R. A., and Wardhani, I. Y. (2024). Pengembangan aplikasi prametavirlab (praktikum metabolisme virtual laboratorium) berbasis STEM sebagai media pembelajaran biologi kelasxii sma/ma:(development of the stem-based prametavirlab (virtual laboratory metabolism practicum) application as a media for biology learning). *BIODIK*, *10*(2), 121-131.

Rahmi, M., Saminan, S., Syukri, M., Yusrizal, Y., Khaldun, I., Artika, W., and Huda, I. (2022). Development of a virtual lab in science-physics learning based on the STEM approach. *Jurnal Penelitian Pendidikan IPA*, *8*(4), 2057-2061.

Ridho, M. H., and Dasari, D. (2023). Systematic literature review: Identitas matematika dalam pembelajaran matematika. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *7*(1), 631-644.

Rizal, H. P., and Genisa, M. U. (2024). Validitas E-Modul PhET interactive simulation dalam meningkatkan pemahaman konsep fisika terintegrasi biologi bagi mahasiswa pendidikan biologi. *Didaktika Biologi: Jurnal Penelitian Pendidikan Biologi*, *8*(1), 39-44.

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

Salfia, E. (2021). Pengembangan bahan ajar berbasis e-modul interaktif menggunakan model pembelajaran berbasis masalah pada materi integral SMA Kelas XII. *Jurnal Riset Ilmu Pendidikan*, *1*(1), 12-18.

Sari, D. A. W., and Kholiq, A. (2022). Development of WEB-FIST (STEM-Based Physics Web) to train students' critical thinking on the topic of parabolic motion. *Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram*, *10*(3), 750-757.

Sari, W. P., Abdurrahman, A., and Lengkana, D. (2022). Using e-Worksheet Integrated with PBL-STEM Activities to Improve Disaster Literacy of Junior High School Students. *Jurnal Pendidikan MIPA*, *23*(3), 881-893.

Saris, R. J., Arafah, K., and Wahyuni, A. S. A. (2025). The development of STEM-based teaching materials to enhance students' critical thinking skills. *International Journal of Social Science and Human Research*, *8*(02), 1025–1031.

Seruni, R., Munawaoh, S., Kurniadewi, F., and Nurjayadi, M. (2019). Pengembangan modul elektronik (e-module) biokimia pada materi metabolisme lipid menggunakan Flip pdf professional. *Jurnal Tadris Kimiya*, *4*(1), 48-56.

Sukma, I. M., and Marianti, A. (2023). Development of an e-book based on STEM-integrated creative problem solving on environmental change material to improve studentsâ€™ critical thinking and creative thinking. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6111-6121.

Syahputra, E. (2024). Pembelajaran abad 21 dan penerapannya di Indonesia. *Journal of Information System and Education Development*, *2*(4), 10-13.

Tarihoran, S. Y., and Anas, N. (2023). Development of STEM-based E-LKPD on senses system material to improve creative thinking ability. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 2693-2700.

Trisnawati, W. W., and Sari, A. K. (2019). Integrasi keterampilan abad 21 dalam modul sociolinguistics: Keterampilan 4c (collaboration, communication, critical thinking, dan creativity). *Jurnal Muara Pendidikan*, *4*(2), 455-466.

Warsa, N. D. A., and Kholiq, A. (2022). Development of MolBEST (STEM-Based Mobile Learning) on elasticity materials. *Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram*, *10*(3), 618-627.

Widarti, H. R., Rokhim, D. A., and Syafruddin, A. B. (2020). The development of electrolysis cell teaching material based on stem-pjbl approach assisted by learning video: A need analysis. *Jurnal Pendidikan IPA Indonesia*, *9*(3), 309-318.

Wulanningtyas, M. E., and Ratnasari, A. S. (2022). Development of STEM-based e-worksheets to improve creative thinking ability on the topics of angles. *Jurnal Pendidikan MIPA*, *23*(4), 1680-1691.

Wulansari, K., Razak, A., Chatri, M., and Fajrina, S. (2023). Development of e-module with stem nuances to improve students' creative thinking skills. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 5540-5546.

Yanti, M., Rahayu, D. P., and Rabbani, A. (2024). Analysis of the implementation of science learning based on teachers' technological pedagogical and content knowledge (tpack) capabilities. *Journal of Science Education Research*, *8*(1), 42-55.

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970

Yuberti, Y., Komikesari, H., and Lubis, M. (2022). Developing STEM-based interactive e-books to improve students' science literacy. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, *7*(1), 177-188.

Zainil, M., and Kenedi, A. K. (2022). Advancement of STEM-based e-student worksheet to enhance the HOTS of elementary school students. *Journal of Education Technology*, *6*(3), 478-488.

Zakaria, A., Enawaty, E., Lestari, I., Muharini, R., and Erlina, E. (2024). Development of an interactive multimedia based e-modul on geometric isomer material. *Hydrogen: Jurnal Kependidikan Kimia*, *12*(2), 385-401.

DOI: https://doi.org/10.17509/ijomr.v5i1.81543
p- ISSN 2776-608X e- ISSN 2776-5970