JoSSEd
Journal of Science and Science Education
ISSN: 2774-1869 eISSN: 2774-2105

Development of Stem-Based Modules on The Growth and Development of Living Things for Students Fases (SMA/MA)

Regiani Zahira[1*], Renny Risdawati[2], Aulia Afza[1]

[1] Biology Education, PGRI University of West Sumatra, Padang, Indonesia
[2] Biology, PGRI University of West Sumatra, Padang, Indonesia

Received: Agusts 12, 2025
Revised: April 07, 2026
Accepted: April 16, 2026
Published: April 30, 2026

Corresponding Author:
Renny Risdawati
rennyrisdawati@gamil.com

DOI: 10.29303/jossed.v7i1.12508

Abstract: The availability of appropriate and structured teaching materials is a crucial aspect in supporting the effectiveness of the learning process. At SMA Negeri 2 Lubuk Sikaping, teachers use the Ministry of Education and Culture's guidebook as the primary reference during the teaching and learning process. However, to strengthen the learning process and adapt to students' needs, teachers also develop independent teaching materials in the form of modules, but these modules still contain the 2013 curriculum. One relevant approach to developing teaching materials is Science, Technology, Engineering, and Mathematics (STEM), particularly in the growth and development of living things. This requires students to implement projects, requiring them to utilize their skills in designing, observing, and reporting on their projects. This research is a research and development (R&D) study using the 4D model (Define, Design, Develop, and Disseminate), but is limited to the Development stage. The instruments used in this study include a validity questionnaire and a practicality questionnaire. The validity test was conducted by two lecturers and one teacher, while the practicality test involved one biology teacher and 30 students from Phase F (11) class. Validation results by lecturers and teachers indicate that the developed module has a very high validity rate, with a percentage of 94.68%. The module's practicality was also deemed highly practical by both teachers (94%) and students (91.74%). Thus, this STEM-based printed module is deemed highly valid and practical as a teaching material for the growth and development of living things at the high school level.

Keywords: High school; Growth and development of living things; Practicality; STEM-based module; Teaching material; Validity

Introduction

In the learning process, teachers as teachers as well as educators play a big role and responsibility in order to help improve the success of students influenced by the quality of teaching and internal factors of the students themselves (Hakimi., 2019) One of the supporting factors to support the smooth learning process is teaching material. Teaching materials are materials or learning materials provided to students to be mastered and used by students who function as learning resources(Agustina, 2018) According to (Raharjo and Lestariningsih, 2018) teaching materials have an influence on the learning process, and can even improve student competence if a teacher can be more creative in their use and not stick to just one teaching material. A teacher can use several teaching materials in one material so that more information can be obtained. Teaching materials themselves have many types, such as modules, LKS, enrichment books and so on.

that are arranged systematically, contain learning materials, methods, learning objectives based on basar competencies or indicators of competency achievement, instructions for self-study activities (Self Introductional) and provide opportunities for students to best themselves through practice questions presented in the module (Azka et al., 2019) Based on the results of interviews conducted with one of the teachers who taught in phase F at SMA N 2 Lubuk Sikaping in January 2025, in the teaching and learning process in the classroom the teacher used the guidebook from the Ministry of Education and Culture as the main reference. However, to strengthen the learning process and adapt to the needs of students in the classroom, the teacher also developed independent teaching materials in the form of modules, but the modules still contained 2013 curriculum material. Based on the analysis of the module of one of the biology teachers at SMAN 2 Lubuk Sikaping, it has been found that there are some fundamental deficiencies, namely the module cover does not exist, the pictures are not colored, there is no preface, learning outcomes (CP), and flow of learning objectives (ATP). In addition, this module does not include animal and human growth and development material, summaries, current practice questions, and self-assessment and evaluation as important

How to Cite:
Zahira, R., Risdawati, R., & Afza, A. (2026). Development of Stem-Based Modules on The Growth and Development of Living Things for Students Fases (SMA/MA). *Journal of Science and Science Education*, *7*(1), 1–8. https://doi.org/10.29303/jossed.v7i1.12508

components to measure student understanding. Meanwhile, according to (Ulfa et al., 2024) The characteristics of the independent curriculum teaching module are as follows; 1) Essential, namely each subject has a concept through learning experiences and various subjects, 2) Interesting, relevant, and challenging, namely teachers can instill student interest and actively involve students in learning related to cognitive and experiential learning, so that it is not too complicated and not too easy for children their age, 3) Relevant and contextual, namely related to cognitive elements and experiences previously gained and in accordance with the conditions of time and place where students are, and 4) Continuous, namely learning is intensified according to the level of student learning (phase 1, phase 2, phase 3).

The Merdeka Curriculum teaching module also refers to media, methods, instructions, and guidelines that are systematically designed, attractive, and certainly, according to the needs of students (Ulfa et al., 2024). As a follow-up, the improvement plan includes adding elements that do not yet exist, such as preface, learning outcomes (CP), flow of learning objectives (ATP), material, summary, exercises, self-assessment, and evaluation to improve the quality of the module. Therefore, it is necessary to adjust or add material in the form of a more suitable module so that the teaching and learning process becomes more effective. The module is designed by applying certain methods or approaches, one of which is the STEM approach.

STEM stands for an interdisciplinary learning approach between Science, Technology, Engineering and Mathematics. STEM-based modules are the development of traditional teaching modules that integrate elements of science, technology, engineering, and mathematics (Khairiyah, 2019) STEM-based modules are educational frameworks designed to integrate the disciplines of science, technology, engineering, and mathematics into a cohesive learning experience. These modules aim to enhance students' understanding and application of STEM concepts through structured and engaging activities (Aris and Mansor, 2023).

STEM learning integrates various disciplines to create a more holistic and relevant learning experience. STEM, which stands for Science, Technology, Engineering and Mathematics, is an educational approach that integrates these four disciplines into a cohesive learning paradigm.

STEM understanding is essential in modern education,as it prepares students for a rapidly evolving world where these fields are increasingly interconnected. This approach not only focuses on mastering theory, but also integrates cross-disciplinary knowledge with practical applications in the real world, so as to train students' critical thinking, problem-solving, innovation, and collaboration skills (Aris and Mansor, 2023)

At the high school level, Biology contains various materials that can be developed through project-based activities, one of which is the topic of growth and development. In the learning outcomes of this topic, students generally carry out projects to grow plants. The learning objectives emphasize the ability of students to compare the process of growth and development in plants. This activity encourages students to hone their design skills, make observations, and compile project reports systematically. Based on these objectives, the STEM approach is deemed suitable for this material, namely S (Science) observing what are the factors that affect plant growth, T (Technology) utilizing the right tools for planting, Engineering (Engineering) designing tools and Mathematics (Mathematics) calculating the results of the plant growing project (Rosa, 2022) .This is also supported by the results of interviews that have been conducted.

Another study on STEM modules for junior high school students on the topic of analyzing the concept of energy, various sources of energy, and changes in the form of energy in everyday life including photosynthesis, revealed that the module was not only able to improve students' concept understanding but also practicality with a score of 80%, making it a relevant teaching - material in facilitating independent learning (Zulaiha and Kusuma, 2020).

Methods

This research is a research and development (R&D) conducted on July 28, 2024/2025 academic year at SMA Negeri 2 Lubuk Sikaping and PGRI University of West Sumatra. The product developed is a STEM-based print module on the material of growth and development of living things for phase F (class XI).

Development Model

The development model used is the 4-D model (Define, Design, Develop, Disseminate) developed by Thiagarajan and Semmel, but in this study it was only carried out until the Develop stage due to limited time and costs. The steps of the 4-D model applied in this study are:

1. *Define:*

   Front end analysis Identifying biology learning problems found in schools. Student analysis Assessing the characteristics of learners, including learning media preferences. Task and concept analysis: Based on learning outcomes and the flow of learning objectives in the Merdeka Curriculum. Analysis of learning objectives Developed based on the results of task and concept analysis.

2. *Design:*

   Designing a module framework and content format consisting of cover, introduction, material, evaluation,

glossary, and author's bio. The module is organized using STEM principles and adapts to students' characteristics.

3. *Develop:*

The validity test was conducted by two lecturers and one biology teacher based on aspects of content feasibility, language, presentation, graphics, and STEM integration. Practicality test was conducted by one teacher and 30 students of phase F (class XI) including ease of use, efficiency, and benefits of the module.

Trial Subjects

The subjects of this study consisted of: (1) One biology teacher at SMA Negeri 2 Lubuk Sikaping; (2) 30 students of class XI (Phase F) from the same school.

Research Instruments

The instruments used in this study were validity questionnaire and practicality questionnaire. The questionnaire uses a 5-point Likert scale: SS (5), S (4), KS (3), TS (2), STS (1) The instrument was modified from (Yunas, 2025) and (Riduwan, 2013).

Data Analysis Technique

The validity and practicality of the module were calculated using the percentage Formula 1

$$\frac{Total\ Scores\ Obtained \times 100\%}{Total\ Highhest\ score} \quad (1)$$

The assessment criteria according to the modification of Riduwan (2013) can be seen in Table 1.

Tabel 1. Assessment criteria

Percentage Range	Validity/Practicality Category
81–100%	Very Valid/ Very Pratical
61–80%	Valid / Pratical
41–60%	Moderately Valid / Moderately Pratical
21–40%	Less Valid / Less Pratical
0–20%	Not Valid / Not Pratical

Results and Discussion

The development of STEM-based learning modules on the material of Growth and Development of Living Things was carried out using the 4D development model (Define, Design, Develop, Disseminate), but in this study it was limited to three stages, namely: define, design, and develop.

Design Stage

At this stage, researchers designed modules that included various important components in accordance with the learning needs of SMA / MA students. The module was designed using Times New Roman fonts with sizes 12-22 pt for the subtitle and 12 pt for the content, with spaces of 1.0-1.5. The components in the module consist of The module begins with a cover page that presents the title of the material, curriculum logo, Tut Wuri Handayani symbol, university logo, class name, author's name, and a green background adapted to the characteristics of high school students, along with supporting illustrations. It is followed by a preface containing the author's expressions of gratitude, the purpose of writing the module, and instructions for use for both teachers and students. The module also includes a table of contents, a list of images, and usage guidelines to assist users in navigating the material. A brief description of the material is provided to introduce the learning content. Furthermore, STEM-based activities are included in the form of assignments that integrate science, technology, engineering, and mathematics. The learning materials are organized into two meetings, each consisting of subtopics, learning objectives, STEM activities, summaries, exercises, and formative assessments. The formative assessment includes 10 multiple-choice questions designed to measure students' understanding gradually, while the final evaluation consists of 20 multiple-choice questions to assess mastery of concepts and their application. In addition, the module provides a glossary explaining key terms, as well as a bibliography and author profile to ensure the scientific validity and credibility of the module.

Development Stage (Develop)

This stage aims to produce modules that are valid and practical for use in the learning process. Evaluation is done through expert validation and practicality test by teachers and students.

a. Module Validity Results

The module was validated by three experts (two lecturers and one teacher). The validation covers five aspects, namely content eligibility, language, presentation, graphics, and STEM stages. The validation results can be seen in Table 2.

Tabel 2. Module Validity Results

No	Aspect	Validator			Nm	Value Validity (%)	Criteria
		1	2	3			
A	Content feasibility	35	40	39	114	95	Very Valid
B	Language Component	23	25	25	73	97	Very Valid
C	Presentation	29	34	33	96	91,4	Very Valid
D	Graphics	22	25	23	75	93	Very Valid
E	STEM stage	18	20	20	58	97	Very Valid
Total						411	
Average						94,68	Very Valid

Based on the results obtained an average value of 82 with very valid criteria which indicates that this stem-based module is suitable for development. This assessment refers to the five aspects contained in the validation questionnaire, namely very valid criteria including aspects of content feasibility with a value of 95%, aspects of language components with a value of 97%, aspects of presentation with a value of 91.4%, aspects of graphics with a value of 93%, and aspects of the stem stage with a value of 97%. All of these aspects are appropriate, so that all aspects are declared very valid.

b. Module practicality results

The practicality test was conducted by one biology teacher and 30 students of class XI (Phase F) at SMA Negeri 2 Lubuk Sikaping. Practicality assessment was divided into three aspects: ease of use, efficiency of learning time, and benefits.

The practicality results of the STEM-based module by teachers

Table 3. Results of Module Practicality Test by Teachers

No	Aspect	Number	SM	Practicality Score (%)	Criteria
A	Ease of Use	38	40	95	Very Pratical
B	Efficient Learning Time	9	10	90	Very Pratical
C	Benefits	34	35	97	Very Pratical
Total				84	
Average				94	Very Pratical

In Table 3 above is the result of the practicality test by the teacher. The teacher's analysis of the questionnaire for the practicality test resulted in an average score of 94% with very practical criteria. The results are considered practical because they meet the practical criteria, which include aspects of ease of use with a value of 95% with very practical criteria, aspects of efficient learning time with a value of 90% very practical criteria, and aspects of benefits with a value of 97% very practical criteria, consequently, these three criteria are considered very practical. It can be concluded that the stem-based module on the material of growth and development of living things developed is practically used by teachers in the biology learning process.

Results of module practicality by students

The results of the practicality test conducted by 30 phase F students showed that the practicality value of the stem-based module on the material of the growth and development of living things obtained an average of 91.74% with very practical criteria. It is declared practical because the details of this practicality, namely in the aspect of user convenience, obtained a value of 92.75% with very practical criteria, the efficient aspect of learning time with a value of 91.33% with very practical criteria, and the benefit aspect with a value of 91.14% with very practical criteria. All aspects are appropriate, so all aspects are declared very practical.

Tabel 4. Module Practicality Test Results by Students

No	Aspect	Number	SM	Practicality Score (%)	Criteria
A	Ease of Use	1113	1.200	92,75%	Very Pratical
B	Efficient Learning Time	274	300	91,33%	Very Pratical
C	Benefits	957	1.050	91,14%	Very Pratical
Total				2346	
Average				91,74%	Very Pratical

In Table 4 above, it is known that the overall average percentage of the practicality of the stem-based module from 30 students is 91.74% with very practical criteria. This shows that the stem-based module on the material of growth and development of living things developed is very practical to be used by students.

Validity of stem-based module

The developed module is valid and can be utilized for learning thanks to expert validation. The validator is tasked with assessing the Module produced, if there are suggestions and revisions so that the module developed is valid.

The results obtained for the validity of stem-based modules on the material of growth and development of living things obtained an average value of 94.68% with very valid criteria after follow-up according to the validator's suggestions. The feasibility of content, language, presentation, graphics, and stem stages were evaluated during the module validity test.

After making adjustments according to the validator's suggestions, the module validity results in terms of content feasibility were declared very valid with a validation score of 95%. In accordance with the input from the validator, improvements have been made to several parts of the module, including ambiguous sentences, covers, unclear image descriptions, top

layouts with too much distance, preface, and instructions for using the module. In addition, scientific verbs and data observation tables have been added, and revisions have been made to the self-assessment, formative assessment, and evaluation questions. The answer key for the self-assessment has also been prepared. All these iniprovements and additions have been adjusted to the suggestions of the validators.

It can be concluded that the content of the module is in accordance with the Learning Outcomes (CP), Learning Objectives (IP), and Flow of Learning Objectives (ATP) which are adjusted to the applicable curriculum, namely the independent curriculum, the developed modnie is adapted to the development of SMA/MA students and adapted to the teaching materials needed by SMA/MA students. This is in accordance with the opinion of (Nuryasana and Desiningrum, 2020) states that teaching materials are very important to add insight to students, as well as material that is arranged systematically so that it can make it easier for students to learn and understand the material. In addition, the Science, Technology. Engineering, and Mathematics (STEM) approach is also applied in the development of this module to improve students' critical thinking skills, problem solving, and scientific skills. The application of the STEM approach in the learning module proved to be effective in improving concept understanding and active learner involvement, as stated by (Syahri et al., 2021) that STEM-based learning makes a positive contribution to improving learning outcomes and 21st century skills of students.

Validity from the linguistic aspect was declared very valid with a validation value of 97%. It can be concluded that the module developed readability and fonts and writing used can be read and understood without causing confusion and easy to understand by students. In the module, the sentences used have been adjusted to the Indonesian Spelling Rules (EBI). This is in line with the assertion of (Kartikasari et al., 2015) that there are seven markers that must be seen in the fulfillment of practicality, including (1) communicative, (2) dialogical and interactive, (3) straightforward. (4) order of thought (5) coherence, (6) conformity with correct Indonesian language rules, and (7) use of symbols or symbols that are in accordance with the development of students. In line with that (Afifah and Andriani, 2025) in his research emphasized that the use of communicative, coherent and EBI-compliant language in STEM-based modules is very important to improve readability and effectiveness of student understanding.

The results of the validity of the module in terms of presentation aspects which were declared very valid obtained a score of 91.4% The material in the module is presented completely and in accordance with the designed ATP sequence, has a clear flow of leaming objectives. The module has evaluation questions as an exercise to assess self-understanding. The clarity of the flow of learning objectives (ATF) and learning objectives (TP) can help students become directed in using the module. This is in line with the opinion of (Sardiman, 2021) which states that the preparation of learning materials that follow the flow of objectives will make it easier for students to understand the content and achieve the expected competencies. In addition, the existence of evaluation questions in the module is also important as a measuring tool for students' understanding of the material, as well as to encourage independent learning. In addition, the preparation of STEM-based modules that follow the order of ATP and TP not only increases the effectiveness of material delivery, but also aligns with the constructivistic principle that learning is built gradually from concrete to abstract (scaffolding) as explained in the Merdeka Curriculum Guide (Aditomo, 2024).

The validity of the module in terms of the components of the graphic aspect, obtained a validation score of 93% with very valid criteria. In accordance with the vabdator's suggestion that the image displayed size is clarified again and the researcher has made improvements to the size of the module image. This includes a layout that attracts students' attention in utilizing the module and photos that are relevant to the material presented, as well as the type and size of the font used in the module. This also shows that the module design that has been designed is good, with clear letters and writing. According to (Prastowo, 2015) graphic elements in teaching materials are very important because they can increase the attractiveness and facilitate understanding of the material by students. Visual aspects such as illustrations, colors, layouts, and proper typography can facilitate visual learning styles and clarify the information conveyed. In line with that according to (Afifah dan Andriani, 2025) graphic aspects in STEM modules not only function as visual decorations, but also support the process of understanding concepts effectively. Elements such as relevant illustrations, neat layout, consistent typography, and contrasting colors are able to increase students visual engagement and facilitate visual learning styles in STEM education. This is in line with the finding that visual representation of numerical graphics in teaching materials is proven to improve students graph interpretation and construction skills in the STEM domain, which further strengthens the readability and attractiveness of teaching materials

Based on the stem stage aspect, this module obtained a validation score of 97% with very valid criteria. This shows that the module has successfully helped students understand the four stem aspects of science, technology, engineering and mathematics. In addition, it can help students complete project assignments, and can make it easier for teachers to convey information quickly, According to (Afriana et al.,

2016) the STEM approach can improve students problem-solving skills, critical bunking, and creativity in completing learning projects. The module developed based on STEM is considered capable of integrating these four aspects in a real contest that supports 21st century learning outcomes.

Practicality of stem-based module

The purpose of this test is to evaluate how useful the resulting module is The three criteria for amazing the practicality test are ease of use, efficient learning time, and benefits. The practical test at SMA Negeri 2 Lubuk Sikaping was attended by 30 students of class XIV and 1 biologist.

Based on the analysis of the results of the practicality test questionnaire by teachers and students, it is known that the stem-based module on the material of growth and development of living things with an average value of 94% is declared very practical by teachers and an average value of 91.74% is declared very practical by students. It can be concluded that the module can facilitate the teacher in the learning process in delivering material about the growth and development of living things and can help students in understanding concepts that are not yet understood in the material of the growth and development of living things.

The module has an average score of 95% from teachers with very practical criteria and an average score of 92.75% from students with very practical criteria, when viewed in terms of ease of use. It can be concluded that this module is easy to use by teachers and students, flexible in its use, and can be used repeatedly as needed. This is in accordance with (Ramadhani dan Izzati, 2023) states that the level of practicality of the module is arranged systematically with the aim of making it easier for students to understand the material as well as a guide for teachers in delivering the material. In addition, (Afifah dan Andriani, 2025) the development of STEM-based learning modules is important to provide learning experiences that are more meaningful applicable, and encourage 21st century skills. This kind of module can also be an alternative teaching material that encourages independent learning and supports optimal competency achievement.

The module has an average score of 90% with very practical criteria from teachers and an average score of 91.33% with very practical criteria from students, in terms of learning time efficiency. It can be said that, using modules increases learning efficiency and allows students to learn independently based on their own learning style. By using modules the teacher does not need to write down so much material on the blackboard. Stating (Rafi'y and Qalbi, 2023) Leaming modules allow learners to learn according to their own level of understanding, because they can process material at a pace that suits their abilities. In line with that (Villegas-Ch et al., 2025) STEM modules allow adaptive and self-paced learning, meaning that students can manage learning time according to their individual styles and abilities. Thus. STEM modules not only save teachers time (because there is no need to record long materials on the blackboard) but also increase the effectiveness of students time in achieving competencies

In terms of benefits, the module has an average score of 97% with very practical criteria by teachers and an average score of 91.14% with very practical criteria by students. The use of modules can help teachers in redcing the teacher's workload in explaining the material repeatedly, modules can also improve students' concept understanding of the material of the growth and development of living things because it contains images that help students understand the subject matter. This is in accordance with (Ilhami, 2021) which claims that modules are more representative and flexible. Modules have advantages in the process of use. Besides being able to be used in the classroom in groups, modules are also designed in individual learning, In line with that according to (Simbolon et al., 2023) The implementation of STEM-based learning modules provides significant benefits in supporting teaching effectiveness and stadent understanding. Through the integration of Science, Technology, Engineering, and Mathematics elements, these modules are designed to stimulate students' critical thinking problem solving and creativity (better problem solving, logical thinking, and technological literacy).

Conclusion

Based on the research that has been done, it can be concluded that a stem-based module has been produced on the material of growth and development of living things for phase F SMA/MA. The results showed that the validity value obtained very valid criteria with an average value of 94.66 and the results of the practicality test conducted by students and teachers obtained very practical criteria with an average of 94 by teachers and 91.74 by students.

Acknowledgments

The authors would like to express their deepest gratitude to Dr. Reruny Risdawati, Mi and Aulia Afza, M.Pd as supervisors who have provided guidance, direction, and motivation during the process of preparing this work. The guidance given is very meaningful in completing thus research well.

The author would also like to thank Mrs. Resti Hidayati Saputri, S.Pd who has provided support, opportunities, and facilities in conducting research at school. The enthusiasm and assistance provided were an important part in the sanooth running of this activity.

Finally, the author sealizes that this work is far from perfect. Therefore, all input and constructive criticism are expected for future improvements.

Author Contribution
Regiani Zahira. Dr. Renny Risdawati, M.Si, Aulia Afza, MPd

Funding
This research does not receive funding from any external party

Conflict of Interest Statement
The authors declare that there is no conflict of interest that could affect the results or interpretation of this research

References

Aditomo, A. (2024). Panduan Pembelajaran dan Asesmen Pendidikan Anak Usia Dini, Pendidikan Dasar, dan Pendidikan Menengah Edisi Revisi Tahun 2024. *Jakarta: Badan Standar, Kurikulum, Dan Asesmen Pendidikan Kemendikbudristek.*, 1–72.

Afifah, S., & Andriani, P. (2025). Integrasi Pendekatan STEM dalam Pengembangan Modul Materi Fungsi. *Pendekar: Jurnal Pendidikan Berkarakter*. *8*(2), 168–179. https://doi.org/10.31764/pendekar.v8i2.31356

Afriana, J., Permanasari, A., & Fitriani, A. (2016). Penerapan project based learning terintegrasi STEM untuk meningkatkan literasi sains siswa ditinjau dari gender. *Jurnal Inovasi Pendidikan IPA*, *2*(2), 202. https://doi.org/10.21831/jipi.v2i2.8561

Agustina, A. (2018). Upaya Meningkatkan kemampuan Guru Menerapkan Bahan Ajar Di SMA Negeri 3 Organ Komering Ulu. *Jurnal of Education Studies*, *3*(1).

Al Azka, H. H., Setyawati, R. D., & Albab, I. U. (2019). Pengembangan Modul Pembelajaran. *Imajiner: Jurnal Matematika Dan Pendidikan Matematika*, *1*(5), 224–236. https://doi.org/10.26877/imajiner.v1i5.4473

ILHAMI, S. (2021). Pengembangan Modul Pembelajaran Biologi Berorientasi Model Siklus Belajar Untuk Siswa Sma/Ma Kelas X. *PAEDAGOGY : Jurnal Ilmu Pendidikan Dan Psikologi*, *1*(2), 149–161. https://doi.org/10.51878/paedagogy.v1i2.805

Kartikasari, Y., Widodo, Mulyanto, . dan, & Karomani. (2015). Kelayakan Isi dan Bahasa Pada Buku Teks BUPENA Bahasa Indonesia Kelas VII. *Jurnal Kata (Bahasa, Sastra, Dan Pembelajarannya)*, *3*(3), 1–6. Retrieved from https://jurnal.fkip.unila.ac.id/index.php/BINDO1/article/view/9237

Mohd Aris, M. A. Bin, & Binti Mansor, R. (2023). STEM Based Teaching and Learning Module Development for Year 5 Plant Topics. *International Journal of Academic Research in Progressive Education and Development*, *12*(2), 1397–1412. https://doi.org/10.6007/ijarped/v12-i2/17349

Nida'ul Khairiyah, S. P. (2019). *Pendekatan Science, Technology, Engineering dan Mathematics (STEM)*. Guepedia.com.

Nuryasana, E., & Desiningrum, N. (2020). Pengembangan Bahan Ajar Strategi Belajar Mengajar Untuk Meningkatkan Motivasi Belajar Mahasiswa. *Jurnal Inovasi Penelitian*, *1*(5), 967–974. https://doi.org/10.47492/jip.v1i5.177

Prastowo, A. (2015). *Panduan Kreatif Membuat Bahan Ajar Inovatif*. DIVA Press.

Rafi'y, M., & Qalbi, Z. (2023). Pengembangan Modul Pembelajaran dalam Meningkatkan Hasil Belajar Mahasiswa: Tinjauan Kepraktisan dan Keefektifan. *Journal Education Innovation*, *1*(1), 77–86. https://jurnal.ypkpasid.org/index.php/jei

Raharjo, B. W., & Lestariningsih, E. D. (2018). Pengaruh Bahan Ajar Berbasis Komputer Terhadap Hasil Belajar Siswa Pada Mata Pelajaran Bahasa Indonesia Di Sma 1 Jekulo Kudus. *KREDO : Jurnal Ilmiah Bahasa Dan Sastra*, *1*(2), 119–134. https://doi.org/10.24176/kredo.v1i2.1949

Ramadhani, R., & Izzati, N. (2023). Keefektifan dan Kepraktisan Modul Dasar Pemrograman. *Journal of Mathematics Education and Science*, *6*(1), 47–53. https://doi.org/10.32665/james.v6i1.1142

Sabila Rosa, S. (2022). *Analisis Keterampilan Berpikir Kritis Siswa Sma Melalui Stem Pjbl Pada Materi Pertumbuhan Dan Perkembangan* [skripsi S1]. Universitas Pendidikan Indonesia Bandung.

Sardiman, A. D. (2021). *Media Pendidikan: Pengertian, Pengembangan, dan Pemanfaatannya*. Rajawali.

Simbolon, J., Sakti, I., Wardana, R. W., Sutarno, S., & Nursaadah, E. (2023). Pengembangan E-Modul Berbasis Stem Pada Materi Suhu Dan Perubahannya Untuk Siswa Kelas Vii Smp. *DIKSAINS : Jurnal Ilmiah Pendidikan Sains*, *3*(2), 108–117. https://doi.org/10.33369/diksains.3.2.108-117

Syahri, W., Muhaimin, M., Syamsurizal, S., & Rusdi, M. (2021). Development of an Instructional Design Model for Physical Chemistry based on Multiple Representatives. *International Journal of Instruction*, *14*(2), 517–534. https://doi.org/10.29333/iji.2021.14229a

Ulfa, S., Irvani, A. I., & Warliani, R. (2024). Pengembangan Modul Ajar Fisika Kurikulum Merdeka. *Jurnal Pendidikan Fisika Dan Sains (JPFS)*, *7*(1), 51–59. https://doi.org/10.52188/jpfs.v7i1.562

Villegas-Ch, W., Buenano-Fernandez, D., Navarro, A. M., & Mera-Navarrete, A. (2025). Adaptive intelligent tutoring systems for STEM education: analysis of the learning impact and effectiveness of personalized feedback. *Smart Learning Environments*, *12*(1). https://doi.org/10.1186/s40561-025-00389-y

Hakimi, H. (2019). Pengaruh Modul Pembelajaran Berbasis Problem Based Learning Terhadap Peningkatan Motivasi Belajar Dan Hasil Belajar Peserta Didik Pada Mata Pelajaran Pai KelaS XI SMK Negeri 2 Kerinci. *EDU RESEARCH*, *1*(1), 68-74. https://doi.org/10.47827/jer.v1i1.41.

Zulaiha, F., & Kusuma, D. (2020). Pengembangan Modul

Berbasis STEM untuk Siswa SMP. *Jurnal Pendidikan Fisika Dan Teknologi*, *6*(2), 246–255. https://doi.org/10.29303/jpft.v6i2.2182.