

Development Science E-Module Based PBL-Integrated STEM on Energy Material

Novia Puji Rahayu^{1*}, Arif Widiyatmoko², Mintarsih Arbarini³

¹ Department of Basic Education, Postgraduate Program at Semarang State University, Indonesia.

² Department of Chemistry, Faculty of Mathematics and Science, Semarang State University, Indonesia

³ Department of Non-Formal Education, Faculty of Education and Psychology, Semarang State University, Indonesia.

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Corresponding Author:

Novia Puji Rahayu

noviapuji77@gmail.com

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Abstract: This research is to develop E-module of STEM-PBL mater energy based science. The method used in development research was adapted from the RnD method with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The data collection technique was in the form of a validated questionnaire for language experts, materials, media, and teachers responses. E-module based Problem Based Learning contains five stages, namely; 1) orientation of students towards problems; 2) organizing students to learn; 3) guiding independent and group investigations; 4) develop and present the work; 5) analyze and evaluate the problem-solving process. In addition, the STEM in this e-module contains aspects of science, technology, engineering, and mathematics. The results of validation were, a percentage of 96.67% for language validation, a percentage of 95.00% for material validation, and a percentage of 96.00% for media validation, both of which were classified as very valid. Based on these results, it can be concluded that E-module based on STEM-PBL is feasible to be used in learning energy Materials.

Keywords: Energy material; E-module; Problem based learning; STEM

Introduction

Technology has had a significant impact on many areas, including education (Amin, 2023; Parveen & Ramzan, 2024). Along with the development of the digital era, providing an impact on learning (Pare & Sihotang, 2023). The phenomenon of rapid technological progress in the world can be seen from the challenges, environment, and technological innovation (OECD, 2017).

The use of digital technology in learning provides many benefits (Bernacki et al., 2020; Chu et al., 2024; Haleem et al., 2022). One of them uses an electronic module. Salfia (2021) mentioning that by adjusting the development of the era of teaching materials not only in the form of books but also can be taken from electronic module books (e-modules), making it easier for students to access various materials to be learned. E-modules presented in electronic format are not tied to place and

time, making it easier for students to learn the material (Febriani et al., 2024; Muljo et al., 2024; Nurhikmah et al., 2021; Wulandari et al., 2023). E-module is a digital and non-print teaching media that is systematically arranged and used for independent learning purposes, to develop students' ability to learn to solve problems in their own way (Arnita, 2021; Gufran & Mataya, 2020; Manalastas & De Leon, 2021; Pratama et al., 2022).

So far, many have developed with e-modules with several models of learning systems (Erdi & Padwa, 2021). The use of e-modules based on Problem-Based Learning in Science Learning, will be more interesting and build students enthusiastic in learning. According to Dewi et al. (2022) stating that students are more interested and interested in learning using the Problem Based Learning (PBL) model, with this model students become motivated to learn.

STEM (Science, Technology, Engineering, and Mathematics) on science learning in Indonesia has been

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an interesting field for a decade (Astuti et al., 2023; Febriansari et al., 2022; Widiyatmoko & Darmawan, 2023). STEM connects science, technology, engineering and mathematics with learning materials so as to develop critical thinking skills, creativity, literacy including scientific literacy (Hasanah et al., 2021). According to Tseng et al. (2013) PBL combined with STEM education can result in meaningful learning through the systematic integration of knowledge, concepts, and skills (Arlinwibowo et al., 2021; Hasanah et al., 2021; Kandil, 2021; Smith et al., 2022; Widowati et al., 2021).

Based on the results of observations in Islamic Elementary School Imama Semarang student response to the learning resources look less interested, because of the lack of pictures and too much writing on the material. Lack of interest and motivation to learn students who tend to listen, memorize, and copy the content of learning materials provided by teachers without finding meaning and understanding its application.

Based on these problems, it shows that there is a need for improvement so that student's scientific literacy can develop further. Energy matter and its transformation into one of the materials that require more attention. Energy change involves a variety of complex concepts and processes, which require students' ability to critically analyze, evaluate, and interpret information (Anindya & Suryanti, 2023).

Method

This study was conducted by the method of RnD (Research and Development), ADDIE development model. The ADDIE Model consists of five stages: analysis, design, development, implementation and evaluation (Khairani et al., 2023; Nur & Sundari, 2023; Rusni et al., 2023; Sulaeman et al., 2022; Zhang et al., 2023). This research is only up to the stage of development that is at the stage of validity test (Karseno & Astawan, 2021).

Analyze

This analysis phase is the earliest activity carried out to identify information related to data sources and library sources, analyze learning resources and student characteristics during learning. The results of the analysis at SD Islam Imama showed that the need to strengthen scientific literacy. This can be seen from the lack of understanding of teachers about science literacy, lack of supporting materials in science literacy activities, so that the problem continues to be the lack of implementation of science literacy during learning. Students have not been given the strengthening of scientific literacy skills, as well as the use of smartphones

that have not been optimally used in the student learning process.

Design

This design stage is necessary to design some of the elements needed in the manufacture of Learning media (Anafi et al., 2021). The stages carried out are developing content ideas, developing tasks and concepts and creating E-module storyboards.

Development

The activities carried out are creating visual content, graphics, recording videos, creating exercises (Gumulya, 2022). In this stage contains the following activities, 1) Create a sample for e-module design; 2) Develop an E-module that is tailored to the syntax of STEM-PBL.

The entire content and design of the IPAS e-module is developed using the help of the Canva app. Then the module is converted into an electronic form of the module using the Heyzine application.

Implementation

At this stage, validation is carried out to three experts, namely media, language, and material experts. Validators use an instrument in the form of a questionnaire with five likert scales (1=very less, 2=less, 3=Enough, 4=Good, and 5=Very Good) (Jayanti & Pertiwi, 2023). Instruments Giving scores using a Likert scale can be seen in Table 1.

Tabel 1. Interpretation Criteria of Module Validation

Score	Criteria
1	Very Not Good
2	Not Good
3	Quite Good
4	Well
5	Very Good

Scores from the questionnaire were analyzed using the Formula 1.

$$\%validity = \frac{score\ total}{score\ maximum} \times 100\% \tag{1}$$

Tabel 2. Learning Media Assessment Criteria

Score (%)	Criteria
0-20	Very Not Valid
21-40	Not Valid
41-60	Quite Valid
61-80	Valid
81-100	Very Valid

After the preset value is obtained, then the value is interpreted with the interpretation table of validity

assessment to determine the level of validity of the product developed as shown in Table 2.

Result and Discussion

The developed E-module is used to study energy matter and its changes. E-module development by

utilizing Canva website. The application is easy to operate and run on a PC or laptop. One of the features of canva is Heyzine. This feature is used to convert pdf files into e-modules. The energy materials STEM-PBL based IPAS E-module developed with Canva can be seen in Figure 1.

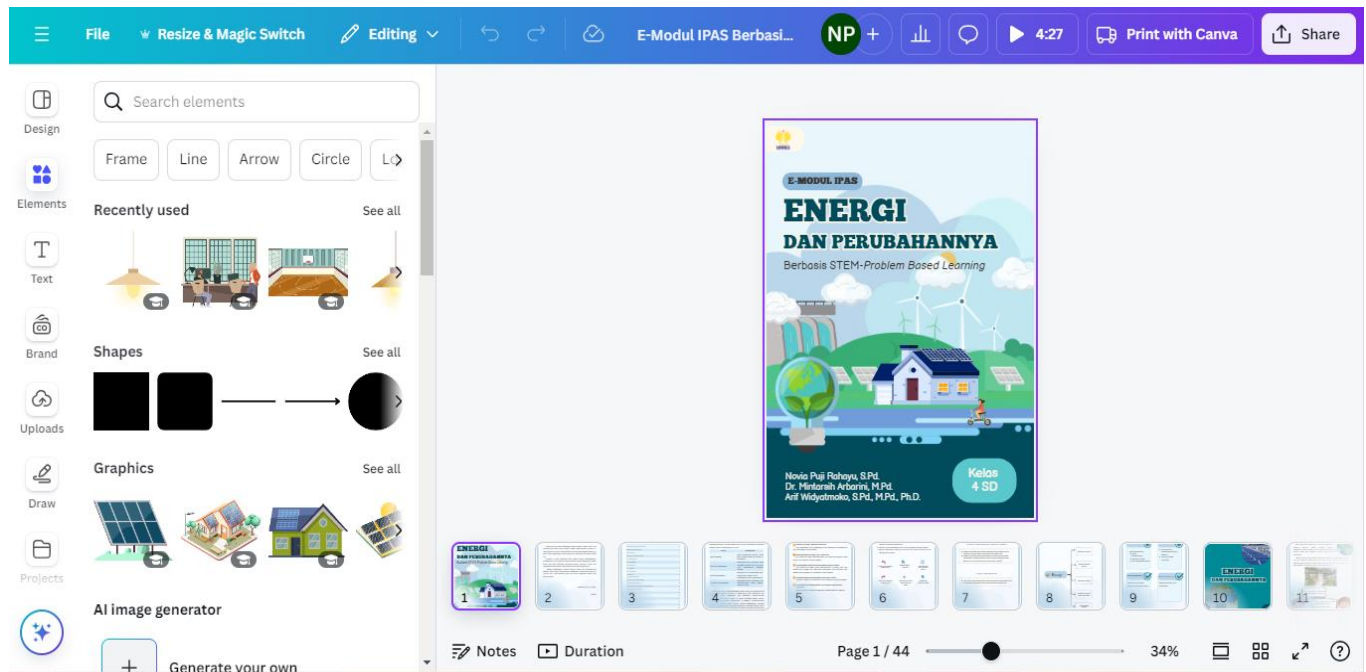


Figure 1. Creating an e-module in canva

Problem Based Learning on E-Module

Stages of learning model Problem Based Learning, which consists of 5 stages of learning. The first stage of student orientation to the problem, shown in Figure 2.

The E-module validation assessment is carried out by material experts, linguists and media experts. Validity test of e-module obtained from the questionnaire (Abdurrahman et al., 2022; Heliawati & Rubini, 2020; Listiana et al., 2023; Oktarina et al., 2023). Validity test conducted by lecturers and teachers. The results of the validation are in Table 3.

Table 3. The Results of the Media Validation Assessment

Validity Test	Score (%)	Criteria
Language Expert	96.67	Very Valid
Materials Expert	95.00	Very Valid
Media Expert	96.00	Very Valid

Table 3 states that the e-module being developed has a percentage of 96.67% for language aspect and included in the very valid criteria. From the aspect of language, e-modules and interactive multimedia are considered quite communicative, and relevant to the level of language development of students. The material aspect got a percentage of 95.00% included in the very

valid criteria, means E-module-based STEM-PBL feasible and ready to be used for learning on the material energy Class IV SD. The media aspect got a percentage of 96.00% included in the very valid criteria, this means that the E-module has enough to meet the elements, such as the arrangement of images and writing, writing color, and completeness of presentation. Overall the results of the e-module is declared very valid.

This is in accordance with research conducted by Yatin et al. (2023) where the use of STEM-based e-modules using Canva media is considered very valid, has a percentage of 89.68% for language expert, 95.21% for materials expert and 96.57% for media expert. Media presented online can increase the attractiveness or positive response as a student's learning experience.

Research by Phandini et al. (2023) the overall media expert assessment of both aspects received a score of 58, a total percentage of feasibility, namely 77.50%, and the results of the material expert assessment received a score of 61 with a percentage of 98% calculated according to the formula. Electronic modules with a STEM approach based on the PBL model as a science learning medium for environmental pollution material are in the very feasible category.

1. Orientasi Siswa Terhadap Masalah

AYO MENGAMATI

Pada kehidupan sehari-hari, kita biasa melakukan berbagai kegiatan. Semua kegiatan tersebut memerlukan energi. Semakin banyak kegiatan yang kita lakukan maka akan semakin banyak energi yang dikeluarkan.

Seperi ketika kita beraktivitas sehanari, maka kita merasa lelah. Setelah itu, kita tentunya beristirahat, mulai dari duduk, minum atau bahkan mengonsumsi makanan. Maka energi kita akan kembali putih. Energi juga ada disekitar kita, salah satunya adalah energi listrik!



Andi, mengapa air bisa dipakai membuat listrik ya?

Iya ya, padahal kan air tidak memiliki energi listrik? Coba kita cari tahu yuk!

2

2. Mengorganisasi Siswa Untuk Belajar

AYO MENCoba

Kalian sudah melakukan kegiatan "Ayo Identifikasi". Kalian sudah menemukan masalah terkait dengan Energi di sekitar lingkungan kita. Selanjutnya tuliskan beberapa pernyataan hasil pengamatan yang kalian temukan dan tuliskan pertanyaan kalian tentang permasalahan energi!

Tuliskan hasil pengamatan!

Tuliskan pertanyaan kalian!

5

3. Membimbing Penyelidikan Mandiri dan Kelompok

AYO SELIDIKI

Kalian sudah menuliskan pernyataan sementara (hipotesis). Selanjutnya kalian akan menjawab rumusan masalah yang telah dibuat dan membuktikaninya!

Perlengkapan Penyelidikan

Siapkan alat dan bahan pendukung seperti buku pelajaran, bacaan berita, maupun internet.

Langkah-langkah Penyelidikan

- Membentuk kelompok yang terdiri dari 4-5 orang
- Mencari informasi mengenai dampak yang ditimbulkan akibat penggunaan energi yang berlebihan beserta solusi yang dapat dilakukan.
- Melakukan diskusi dengan anggota kelompok masing-masing dengan bimbingan guru.
- Menuliskan hasil penyelidikan pada lembar kerja yang telah disediakan.
- Melakukan analisis dan evaluasi dengan menjawab beberapa pertanyaan pada lembar kerja yang telah disediakan.

7

4. Mengembangkan dan Menyajikan Karya

AYO BERKARYA

Kalian sudah mendapatkan berbagai informasi dari teks sebelumnya. Selanjutnya kalian akan mengerjakan LKPD berikut!

LEMBAR KERJA PESERTA DIDIK (LKPD)

Tuliskan Anggota Kelompok :

- _____
- _____
- _____
- _____
- _____

Peracobaan 1 : Kertas Spiral yang Bergerak

Alat dan Bahan :

1. Karton berukuran 15 x 15 cm	5. sumpit
2. gunting	6. lilin
3. benang 15 - 20 cm	7. pensil
4. jarum	8. korek api

Langkah Percobaan :

- Buat pola spiral pada kertas karton
- Gunting mengikuti pola
- Lubangi ujungnya dengan jarum dan masukkan benang
- Ikat benang dan kaitan ujung satunya pada sumpit
- Nyalakan lilin dan posisikan kertas sekitar 5 cm di atas api.
- Amati yang terjadi pada kertas spiral yang kalian pegang.

Diskusikan pertanyaan berikut:

- Energi apa saja yang ada pada percobaan ini?
- Perubahan energi apa yang kalian lihat?

19

5. Menganalisis dan Mengevaluasi Proses Pemecahan Masalah

AYO MENJAWAB

Jawablah pertanyaan-pertanyaan berikut dengan tepat!

- Berdasarkan informasi yang diperoleh, jelaskan apa yang dimaksud dengan energi!
- Berdasarkan informasi yang diperoleh, sebutkan dan jelaskan macam-macam energi!
- Bagaimana perubahan energi yang terjadi pada panel surya hingga menjadi energi listrik yang digunakan dirumah!
- Apakah manusia dapat menghasilkan energi? Faktor apa saja yang mempengaruhi manusia mendapatkan energi?
- Bagaimana cara manusia dalam menghemat energi?

21

AYO MEMBACA

Energi

Energi sangat penting bagi kehidupan manusia karena segala aktivitas manusia membutuhkan energi. Energi tidak dapat dilihat tetapi dapat dirasakan manfaatnya. Energi adalah kemampuan untuk melakukan pekerjaan. Energi membuat mesin bekerja. Energi juga membuat makhluk hidup berkembang. Jika energi habis, maka suatu benda itu tidak akan bisa melakukan kerja (usaha). Contoh anak menggunakan energi yang dimilik untuk berlari, jika energi habis maka ia tidak bisa melanjutkan lari.

Dengan energi yang cukup, maka aktivitas sehari-hari bisa dilakukan dengan maksimal. Namun, jika energi yang dimiliki kurang atau tidak mencukupi, maka aktivitas yang dilakukan manusia menjadi kurang maksimal.



Selain energi yang dimiliki manusia. Energi juga ada disekitar kita. Keberadaan dan peran energi dalam kehidupan manusia sangatlah penting, sehingga ketersediaannya juga mesti kita perhatikan.

Hingga dapat dikatakan, manusia tidak dapat hidup tanpa energi.

8

Dimasa kini teknologi LED telah menjadi salah satu yang paling banyak digunakan dalam berbagai peralatan elektronik. Lampu LED biasanya digunakan untuk pencahayaan didalam ruangan.

Lampu LED menawarkan berbagai keuntungan bagi penggunaannya mulai dari efisiensi energi hingga jangka waktu penggunaan yang panjang.

Kelabihan utama Lampu LED adalah efisiensi energinya yang tinggi. Dengan menggunakan Lampu LED, Anda dapat menghemat banyak biaya listrik. Selain itu, Lampu LED tidak menghasilkan panas sehingga tidak perlu ditambahkan sistem pendingin untuk mencegah kerusakan.



Lampu LED juga sangat tahan lama. Jenis lampu ini umumnya bisa bertahan selama 50,000 jam atau lebih. Jadi, dengan menggunakan Lampu LED, Anda tidak perlu sering-sering mengganti lampu yang rusak atau kendur. Untuk mendapatkan gambaran, 50,000 jam setara dengan 5,7 tahun penuh!

Tidak hanya itu saja, warna cahayanya yang dihasilkan oleh Lampu LED juga lebih terang dan jernih dibandingkan lampu jenis lain. Hal ini membuat penggunaan Lampu LED sangat menarik untuk lokasi tertentu seperti gedung kantor, rumah, toko, dan lainnya.

Karena semua keuntungan yang ditawarkan oleh Lampu LED, banyak orang di Indonesia yang mulai beralih dari penggunaan lampu biasa ke lampu LED. Ditambah dengan harganya yang terjangkau, maka tidak heran jika pemakaian Lampu LED di Indonesia semakin meningkat.

18

4. Mengembangkan dan Menyajikan Karya

AYO BERKARYA

Kalian sudah mendapatkan berbagai informasi dari teks sebelumnya. Selanjutnya kalian akan mengerjakan LKPD berikut!

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Alat dan Bahan :

1. Karton berukuran 15 x 15 cm	5. sumpit
2. gunting	6. lilin
3. benang 15 - 20 cm	7. pensil
4. jarum	8. korek api

Langkah Percobaan :

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- Gunting mengikuti pola
- Lubangi ujungnya dengan jarum dan masukkan benang
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- Nyalakan lilin dan posisikan kertas sekitar 5 cm di atas api.
- Amati yang terjadi pada kertas spiral yang kalian pegang.

Diskusikan pertanyaan berikut:

- Energi apa saja yang ada pada percobaan ini?
- Perubahan energi apa yang kalian lihat?

19

Setiap bulan semua pelanggan listrik PLN harus membayar biaya pemakaian energi listrik sesuai dengan banyaknya energi listrik yang digunakan. Biasanya energi listrik yang dipertugaskan dinyatakan dalam satuan kilo watt-jam atau kWh. Banyaknya energi listrik yang digunakan pada satu rumah dapat dilihat pada gardu rumah (meteran listrik).

Dengan tarif listrik tertentu, misal sekitar Rp 500,- / kWh, pihak PLN ataupun pemakai listrik dapat mengetahui besar biaya pemakaian listrik selama sebulan.

Berikut contoh menghitung penggunaan listrik pada sebuah lampu

Satu Lampu 60 Watt



Pemakaian 30 hari

Tiap hari rata-rata digunakan 5 jam

Total penggunaan daya listrik selama satu bulan = 60 W x 5 J x 30 hari = 9000 Wh = 1 kWh

18

Figure 2. Display of e-module based PBL integrated STEM: (a) PBL phase orientation; (b) PBL phase organizing to learn; (c) PBL phase guiding independent and group investigations; (d) PBL phase develop and present the work; (e) analyzing and evaluating the problem-solving process; (f) Energy material; (g) technological aspect; (h) technical aspects; and (i) Mathematical aspects of the e-module

Conclusion

STEM-PBL based E-modules are compiled using Canva's website, and run through heyzine's website. E-module based Problem Based Learning contains five stages, namely; 1) orientation of students to problems; 2) organizing students to learn; 3) guiding independent and group investigations; 4) developing and presenting works; 5) analyzing and evaluating the problem solving process. In addition, the STEM in this e-module contains aspects of science, technology, engineering, and mathematics. The result of language validation was 96.67%, material validation was 95.00%, and media validation was 96.00%, both of which were classified as very valid. Based on these results, it can be concluded that E-module based on STEM-PBL is feasible to be used in learning energy Materials.

Author Contributions

All authors completed this paper cooperatively. Each stages carried out together.

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Conflicts of Interest

We declare that the authors in this article do not have a conflict of interest with anyone either individual or any institution.

References

- Abdurrahman, A., Dewi Lengkana, D. L., & others. (2022). Design and Validation of STEM Integrated e-Modules on Environmental Pollution to Improve Problem-Solving Skills. *Jurnal Pendidikan MIPA*, 23(1), 754-765. Retrieved from <http://repository.lppm.unila.ac.id/44573/>
- Amin, A. S. (2023). Teknologi Dalam Pendidikan: Dampaknya Terhadap Perkembangan Kognitif dan Emosional Siswa. *JKKP: Jurnal Kajian Pendidikan Dan Psikologi*, 1(1), 20-25. <https://doi.org/10.61397/jkpp.v1i1.11>
- Anafi, K., Wiryokusumo, I., & Leksono, I. P. (2021). Pengembangan Media Pembelajaran Model Addie Menggunakan Software Unity 3D. *Jurnal Education and Development*, 9(4), 433-438. Retrieved from <https://journal.ipts.ac.id/index.php/ED/article/view/3206>
- Anindya, V. H. K., & Suryanti. (2023). Implementasi Pendekatan STEAM pada Materi Perubahan Energi dalam Meningkatkan Kemampuan Berpikir Kritis Siswa Kelas III. *Jurnal Penelitian Pendidikan Guru Sekolah Dasar*, 11(6), 1237-1249. Retrieved from <https://ejournal.unesa.ac.id/index.php/jurnal-penelitian-pgsd/article/view/53516>
- Arlinwibowo, J., Retnawati, H., & Kartowagiran, B. (2021). How to integrate STEM education in the Indonesian curriculum? A systematic review. *Challenges of Science*, 18-25. <https://doi.org/10.31643/2021>.
- Arnita, R. (2021). *Pengembangan E-Modul Berbasis Stem (Science, Techonology, Engineering And Mathematic) Pada Materi Fluida Statis Dan Fluida Dinamis Di Sma N 6 Kota Jambi* [Universitas Jambi]. Retrieved from [https://repository.unja.ac.id/21534/1/BAB 1.pdf](https://repository.unja.ac.id/21534/1/BAB%201.pdf)
- Astuti, W., Sulastri, S., Syukri, M., & Halim, A. (2023). Implementasi pendekatan science, technology, engineering, and mathematics untuk meningkatkan kemampuan literasi sains dan kreativitas siswa. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, 11(1), 25-39. <https://doi.org/10.24815/jpsi.v11i1.26646>
- Bernacki, M. L., Greene, J. A., & Crompton, H. (2020). Mobile technology, learning, and achievement: Advances in understanding and measuring the role of mobile technology in education. *Contemporary Educational Psychology*, 60, 101827. <https://doi.org/10.1016/j.cedpsych.2019.101827>
- Chu, T., Wang, L., & Zhang, X. (2024). Digital Futures : How Technologies Shape Today. *Journal of Education, Humanities and Social Sciences*, 33, 7-11. <https://doi.org/10.54097/atrv0492>
- Dewi, Y. N. D., Achmad, K. S., & Rahim, A. (2022). Penerapan Model Problem Based Learning Untuk Meningkatkan Hasil Belajar Siswa Kelas IV. *Pinisi Journal PGSD*, 1(1), 30-36. <https://doi.org/10.56916/ejip.v1i1.7>
- Erdi, P. N., & Padwa, T. R. (2021). Penggunaan E-Modul Dengan Sistem Project Based Learning. *JAVIT: Jurnal Vokasi Informatika*, 1(1), 21-25. <https://doi.org/10.24036/javit.v1i1.13>
- Febriani, A., Handini, N., Annisa, F., Afriani, N., & Armilah, A. (2024). Pengaruh Penggunaan E-Modul IPA Materi Organ Gerak Hewan dan Manusia Terhadap Hasil Belajar Siswa di SD/MI. *Madani: Jurnal Ilmiah Multidisiplin*, 1(12). Retrieved from <https://jurnal.penerbitdaarulhuda.my.id/index.php/MAJIM/article/view/1557>
- Febriansari, D., Sarwanto, S., & Yamtinah, S. (2022). Konstruksi model pembelajaran STEAM (Science, Technology, Engineering, Arts, and Mathematics) dengan pendekatan design thinking pada materi energi terbarukan. *JINoP (Jurnal Inovasi Pembelajaran)*, 8(2), 186-200. Retrieved from <https://ejournal.umm.ac.id/index.php/jinop/article/view/22456>
- Gufuran, G., & Mataya, I. (2020). Pemanfaatan E-Modul Berbasis Smartphone Sebagai Media Literasi Masyarakat. *JISIP (Jurnal Ilmu Sosial Dan*

- Pendidikan*, 4(2), 10-15.
<https://doi.org/10.58258/jisip.v4i2.1060>
- Gumulya, D. (2022). Penerapan Model Pembelajaran Addie: Applied, Develop, Design, Implement, Evaluation Pada Perancangan Media Edukatif Tematik. *Jurnal Lentera Widya*, 4(1), 7-17. Retrieved from
<https://jurnal.idbbali.ac.id/index.php/lenterawidya/article/view/431%0Ahttps://jurnal.idbbali.ac.id/index.php/lenterawidya/article/download/431/386>
- Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers*, 3, 275-285.
<https://doi.org/10.1016/j.susoc.2022.05.004>
- Hasanah, Z., Tenri Pada, A. U., Safrida, S., Artika, W., & Mudatsir, M. (2021). Implementasi Model Problem Based Learning Dipadu LKPD Berbasis STEM untuk Meningkatkan Keterampilan Berpikir Kritis pada Materi Pencemaran Lingkungan. *Jurnal Pendidikan Sains Indonesia*, 9(1), 65-75.
<https://doi.org/10.24815/jpsi.v9i1.18134>
- Heliawati, L., & Rubini, B. (2020). The effectiveness of stem-modeling-based e-modules of voltaic cell-material on creativity and concept mastery through online learning. *International Journal of Innovation, Creativity and Change*, 13(7), 783-798. Retrieved from
<https://repository.unpak.ac.id/tukangna/repo/file/files-20220925191048.pdf>
- Jayanti, M. A., & Pertiwi, K. R. (2023). Pengembangan e-modul berbasis pbl untuk meningkatkan kemampuan analisis dan rasa ingin tahu siswa. *JINoP (Jurnal Inovasi Pembelajaran)*, 9(1), 112-127.
<https://doi.org/10.22219/jinop.v9i1.23178>
- Kandil, B. (2021). The stem of meaningful learning. *Middle Eastern Journal of Research in Education and Social Sciences*, 2(3), 15-24.
<https://doi.org/10.47631/mejress.v2i3.268>
- Karseno, S., & Astawan, I. G. (2021). Pengembangan Media Game Edukasi Berbasis Android Pada Topik Bilangan Bulat Kelas Vi Sekolah Dasar. *Jurnal Teknologi Pembelajaran Indonesia*, 11(1), 16-25.
https://doi.org/10.23887/jurnal_tp.v11i1.621
- Khairani, L. A., Djulia, E., & Bunawan, W. (2023). Interactive multimedia development based on stem in improving science learning outcomes. *Randwick International of Education and Linguistics Science Journal*, 4(2), 428-435.
<https://doi.org/10.47175/rielsj.v4i2.719>
- Listiana, L., Millah, F., & Suharti, P. (2023). Development and Validation of Learning Strategy for Creative Thinking Skills Empowerment: STEM-Based E-Modules. *Jurnal Penelitian Pendidikan IPA*, 9, <https://doi.org/10.29303/jppipa.v9iSpecialIssue.6003>
- Manalastas, R. S., & De Leon, S. P. (2021). Development and evaluation of electronic instructional module in matter. *European Journal of Humanities and Educational Advancements*, 2(8), 107-127. Retrieved from <https://shorturl.asia/UMr6O>
- Muljo, A., Anggreni, F., & Maulida, S. (2024). Pengembangan E-Modul Persamaan Lingkaran Kelas XI MA dengan Menggunakan Aplikasi Heyzine. *Jurnal Ilmiah Pendidikan Matematika Al Qalasadi*, 8(1), 113-121. Retrieved from <https://journal.iainlangsa.ac.id/index.php/qalasadi/article/view/8368>
- Nur, H. M., & Sundari, T. D. N. (2023). Using ADDIE approach for development of student worksheet based STEM (Science, Technology, Engineering and Mathematic) to improve problem solving skills at state junior high school 3 in Ternate city Indonesia. *International Journal of Scholarly Research and Reviews*, 02(02), 084-088.
<https://doi.org/10.56781/ijssr.2023.2.2.0041>
- Nurhikmah, H., Hakim, A., & Wahid, M. S. (2021). Interactive e-module development in multimedia learning. *Al-Ishlah: Jurnal Pendidikan*, 13(3), 2293-2300. <https://doi.org/10.35445/alishlah.v13i3.863>
- Oktarina, R., Fitria, Y., Ahmad, S., & Zen, Z. (2023). Development of STEM-Oriented E-Modules to Improve Science Literacy Ability of Elementary School Students. *Jurnal Penelitian Pendidikan IPA*, 9(7), 5460-5465.
<https://doi.org/10.29303/jppipa.v9i7.4503>
- Pare, A., & Sihotang, H. (2023). Pendidikan Holistik untuk Mengembangkan Keterampilan Abad 21 dalam Menghadapi Tantangan Era Digital. *Jurnal Pendidikan Tambusai*, 7(3), 27778-27787. Retrieved from
<https://jptam.org/index.php/jptam/article/download/11268/8858>
- Parveen, D. S., & Ramzan, S. I. (2024). The Role of Digital Technologies in Education. *International Research Journal on Advanced Engineering and Management*, 2(6), 2029-2037. [https://doi.org/10.52058/2786-4952-2022-7\(12\)-41-45](https://doi.org/10.52058/2786-4952-2022-7(12)-41-45)
- Phandini, I., Miharja, F. J., Husamah, H., Fauzi, A., & 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.
<https://doi.org/10.21831/jipi.v9i2.60871>
- Pratama, S., Haenilah, E. Y., & Adha, M. M. (2022). Is there a need for an e-module focused on contextual teaching and learning to improve student critical thinking? A preliminary examination into needs assessment. *International Journal of Educational*

- Studies in Social Sciences*, 2(3).
<https://doi.org/10.53402/ijess.v2i3.127>
- Rusni, I., Fitria, Y., Ahmad, S., & Zen, Z. (2023). Development of E-Modules Oriented by A Science, Technology, Engineering, Art, and Mathematics (STEAM) Approach to Improve High Level Thinking Ability. *Jurnal Penelitian Pendidikan IPA*, 9(9), 7179-7188.
<https://doi.org/10.29303/jppipa.v9i9.5345>
- 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.
<https://doi.org/10.56495/jrip.v1i1.62>
- Smith, K., Maynard, N., Berry, A., Stephenson, T., Spiteri, T., Corrigan, D., Mansfield, J., Ellerton, P., & Smith, T. (2022). Principles of problem-based learning (PBL) in STEM education: Using expert wisdom and research to frame educational practice. *Education Sciences*, 12(10), 728.
<https://doi.org/10.3390/educsci12100728>
- Sulaeman, N. F., Triwulandari, S., & Syam, M. (2022). Development of STEM-based teaching materials with engineering design process model on global warming: Validity aspect. *Jurnal Pembelajaran Fisika*, 11(2), 69-76.
<https://doi.org/10.19184/jpf.v11i2.31534>
- Widiyatmoko, A., & Darmawan, M. S. (2023). Implementasi STEM Pada Pembelajaran IPA di Indonesia: Review Artikel Tahun 2018-2023. *Seminar Nasional IPA*, 8, 391-400. Retrieved from <https://proceeding.unnes.ac.id/snipa/article/view/2321>
- Widowati, C., Purwanto, A., & Akbar, Z. (2021). Problem-based learning integration in STEM education to improve environmental literacy. *International Journal of Multicultural and Multireligious Understanding*, 8(7), 374-381.
<https://doi.org/10.18415/ijmmu.v8i7.2836>
- Wulandari, S. I., Pamelasari, S. D., & Hardianti, R. D. (2023). Penggunaan E-Modul Berbasis Etnosains Materi Zat dan Perubahannya dalam Usaha Meningkatkan Kemampuan Berpikir Kritis Siswa SMP. *Proceeding Seminar Nasional IPA*, 103-113. Retrieved from <https://proceeding.unnes.ac.id/index.php/snipa/article/view/2294>
- Yatin, A., Z., & Ginanjar Arip, A. (2023). Pengembangan E-Modul Berbasis STEM Dengan Media Canva Untuk Meningkatkan Literasi Sains dan Numerasi Siswa SMP. *Jurnal Ilmiah Wahana Pendidikan*, 9(22), 888-903.
<https://doi.org/10.5281/zenodo.10152999>
- Zhang, Z., Yue, S., Wang, J., & Yang, P. (2023). An innovative teaching model of automotive manufacturing process based on ADDIE model. *Applied Mathematics and Nonlinear Sciences*, 9(1), 1-16. <https://doi.org/10.2478/amns.2023.1.00098>