Development of Ethno-STEM Integrated Teaching Materials on the Topic of Light Waves to Improve the Science Literacy of Grade XI Students

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Abstract - *This study aims to describe the characteristics, analyze validity, analyze practicality, and analyze the effectiveness of ethno-STEM integrated teaching materials of light wave materials to improve students' science literacy. This study uses the Research and Development (R&D) method with the ADDIE model, namely five stages: analysis, design, development, implementation, and evaluation. The population of this study is class XI students at SMAN 1 Cepiring with the research subjects of 68 students selected using purposive sampling techniques. The data collection technique used in this study used a test method in the form of a science literacy description test and a non-test method in the form of questionnaires and interviews. The data analysis techniques used in this study are in the form of the validity test of teaching materials, the practicality test of teaching materials, and the N-Gain test to analyze the effectiveness of teaching materials. The results of the study show that the teaching materials developed have characteristics that are presented in the features of "Let's Get to Know Culture", "Let's Observe", "Let's Think", "Let's Try", "Let's Solve", and "Let's Be Technological". Furthermore, the teaching material obtained validity with a score of 87.5% which was in the very valid category. Furthermore, based on the practicality test, a score of 96% was obtained where the teaching material was considered very practical to use, and was able to improve the science literacy of students in the medium category with an N-Gain score of 0.4571. Therefore, it can be concluded that the teaching materials are valid, practical, and can be used as a learning resource to improve students' science literacy.*

Keywords*: Teaching Materials; Ethno-STEM; Science Literacy.*

INTRODUCTION

Physics is a science that consists of various facts, natural phenomena, thought results, and experiments. However, some concepts in physics are often abstract, so students find it difficult to understand them (Rizaldi et al., 2020). In line with research conducted by Ady (2022), it shows that 74.19% of students have difficulty understanding physics concepts because they consider physics difficult and struggle with formulas and numbers. In fact, physics does not only focus on formulas, but the concept of physics can be applied in phenomena in everyday life. Other research also shows that students have difficulty understanding physics concepts because they tend to memorize formulas without understanding the concepts of the material (Mardiana et al., 2022). Obstacles in learning physics will make it difficult to achieve the learning objectives that have been designed.

Efforts to help achieve physics learning goals can be supported by high science learning ability. One of the abilities that can support science learning is science literacy. The importance of science literacy in physics learning makes science literacy the main goal in science learning in several countries (Valladares, 2021). This is also supported by research that states that intellectual ability and scientific perspective play a major role in the success of science learning, one of which is physics learning (Khurma et al., 2025). Based on the OECD

(Organization for Economic Co-operation and Development) in 2024, it is explained that science literacy is a person's ability to use scientific knowledge to identify questions in obtaining new knowledge, so that they can explain scientific phenomena based on the scientific evidence they obtain (OECD, 2024).

The importance of science literacy is not in line with the PISA results of students in Indonesia. Based on the PISA 2022 report released in December 2023, it states that Indonesia is still lagging behind in terms of science literacy with a score of 383, this score is still far below the global average of 485 (OECD, 2023). The low level of science literacy of students is also proven based on the results of needs analysis through initial diagnostic tests conducted at SMAN 1 Cepiring. Based on the results of the test, it was shown that the science literacy level of students was in the very low category with an average score of 47.74 (Murti & Sunarti, 2021). The factor of low science ability values can be derived from internal factors from students who consider science difficult and also external factors such as methods, models, strategies, and approaches in learning (Novita *et al*., 2017), learning that does not support students in developing science literacy, for example by rarely providing questions in the form of discourse (Suroso *et al*., 2021), and the use of learning resources that do not support science literacy (Fuadi *et al*., 2020).

Learning resources are one of the important aspects that can improve students' science literacy. Teaching materials are learning resources that can be used by students both in print and non-print form (Kosasih, 2020). Based on the results of the needs analysis, it is known that teachers have not developed many teaching materials in the physics learning process. This is also supported by the results of observations that show that the teaching materials used in physics subjects have not integrated the aspects of science literacy as a whole. Therefore, researchers are interested in developing teaching materials that integrate ethno-STEM. The ethno-STEM approach is learning that integrates five disciplines, namely local wisdom, science, technology, engineering, and mathematical calculations (Qori et al., 2020).

The integration of the five disciplines is closely related to the context aspect, the knowledge aspect, and the scientific attitude aspect of science literacy. This is expected to improve science literacy competence. Previous research has focused on developing physics learning materials to improve scientific literacy, but the integration of local cultural wisdom such as wayang, batik, fireworks celebrations, and kuda lumping into light wave topics remains limited. (Lisdawati et al., 2025; Mufidah et al., 2025; Saddia et al., 2025). Accordingly, this study contributes novelty by developing Ethno-STEM based teaching materials to improving scientific literacy through the integration of Indonesian cultural practices, including wayang, batik, fireworks celebrations, and kuda lumping, into light wave topics. Therefore, this study aims to describe the characteristics, validity, practicality, and effectiveness of ethno-STEM integrated teaching materials in improving the science literacy of students in grade XI on light wave topic.

RESEARCH METHODS

This study uses the Research and Development (R&D) method with the ADDIE model, namely five stages: analysis, design, development, implementation, and evaluation (Robert Maribe Branch, 2009). This research was carried out at SMAN 1 Cepiring with 68 samples selected by *purposive sampling*. The data collection techniques used in this

study are the test method in the form of science literacy description questions and the non-test method in the form of validity questionnaires and questionnaires on the practicality of teaching materials.

The data analysis technique used in this study consisted of a validity test using a likert scale consisting of five answer choices. The results of the assessment given by the validator will then be analyzed using the following formula.

$$P = \frac{f}{N} x\ 100\%$$

Description:
P : Percentage of Assessment
f : the score obtained
N : maximum score

Furthermore, the results are interpreted based on the following categories.

Table 1. Category of Teaching Material Validity

Percentage (%)	Category
0-20	Very Invalid
21-40	Less Valid
41-60	QuiteValid
61-80	Valid
81-100	Very Valid

In addition to the validity test, the teaching materials were also analyzed for readability using the rumpang test. The results of the test are then analyzed with the following formula.

$$(P) = \frac{obtained\ score}{maximum\ score}\ x\ 100$$

The results are then presented using the criteria in Table 2 as follows.

Table 2. Category Readability Teaching Materials

Interval (%)	Category
$P \leq 37$	Low
$37 \leq x \leq 57$	Midle
$P > 57$	High

(Zidatunnur & Rusilowati, 2021)

Furthermore, the practicality of the teaching materials is analyzed using the same formula as the validity of the teaching materials, which is then interpreted using Table 3 as follows.

Table 3. Interpretation of Practical Results

Persentase (%)	Category
0-20	Very Impractical
21-40	Less Practical
41-60	Quite Practical
61-80	Practical
81-100	Very Practical

(Nuryasana & Desiningrum, 2020)

The effectiveness of the teaching materials was analyzed by comparing control classes and experiments through pretest and posttest scores. The score was then analyzed using *IMB SPSS Statistic 27*. The tests used are the data normality test, homogeneity test, and N-Gain Test. The N-Gain results are then interpreted based on Table 4 as follows.

Table 4. N-Gain Test Results

Value	Category
$\langle g \rangle < 0{,}3$	Low
$0{,}3 \leq \langle g \rangle \leq 0{,}7$	Midle
$\langle g \rangle > 0{,}7$	High

(Sudarmin et al., 2019)

RESULTS AND DISCUSSION

Based on the research that has been conducted, results and discussions were obtained in answering the research objectives, namely describing the characteristics, analyzing the validity, practicality, and effectiveness of ethno-STEM integrated teaching materials in improving students' science literacy.

Results

The teaching materials developed are teaching materials that integrate ethno-STEM in an effort to improve students' science literacy. The teaching materials developed have characteristics that distinguish them from other teaching materials. The characteristics of the teaching

materials developed are presented in the instructions for the use of teaching materials, around teaching materials, and several features of student activities that are integrated with ethno-STEM in supporting their science literacy competencies.

The first part of the teaching material is the introduction. In this section, the teaching materials developed have characteristics as a differentiator from other teaching materials presented in the instructions for use and around teaching materials. Instructions for use are guidelines that must be done in using teaching materials, while teaching materials explain the overview of ethno-STEM integration contained in teaching materials to improve students' science literacy.

The second part of the teaching material is part of the content, this part is the description of light wave material. This section is the distinguishing part from other teaching materials. The teaching materials developed contain features that integrate ethno-STEM in supporting learning to improve students' science literacy. These features include "Let's Get to Know Culture", "Let's Observe", "Let's Think", "Let's Try", "Let's Solve", and "Let's Be Technological". In addition, there are also practice questions that integrate science literacy competencies in it.

The results of the validity show that the teaching materials are in the category of being very valid. The validity results are shown in Table 4 as follows.

Table 4. Validity Test Results

No	Validator	Score (%)	Category
1	D-01	90.0	Very Valid
2	G-01	85.0	Very Valid
Average		**87.5**	**Very Valid**

Furthermore, in the practicality test of teaching materials, a practicality score of 95% was obtained, which showed that the teaching materials developed were practically used by students. The results of the practicality test are shown in Table 5. as follows.

Table 5. Practicality Test Results

No	Aspects	Score (%)	Category
1	Convenience	98	Very practical
2	Efficiency	95	Very practical
3	Discrimination	95	Very practical
	Average	**96**	**Very practical**

In the effectiveness test of teaching materials, the N-Gain test was obtained in the experimental class and the control class as shown in Table 6 as follows.

Table 6. N-Gain Test Results

Group	N-Gain	Category
Experiment	0.4571	Medium
Control	0.2359	Low

These results show that in experimental classes that use ethno-STEM teaching materials in learning, they are able to increase the science literacy of students in the medium category. Different results were obtained by the control class that did not use ethno-STEM teaching materials in learning only able to increase the science literacy of students in the low category.

Discussion

The teaching materials developed are teaching materials that integrate five disciplines, namely culture, science, technology, engineering, and mathematical calculations (Wahyuni et al., 2023). The integration of the five disciplines is presented in the features or activities of students. The content section in the teaching materials focuses on integrating ethno-STEM to support the mastery of science

literacy, both in terms of personal, local, and global contexts. Students are expected to be able to develop the three science literacy competencies, namely explaining phenomena scientifically, designing and evaluating investigations, and utilizing scientific evidence for decision-making (Thomas, 2023). The preparation of content in this teaching material prioritizes aspects of local context and science knowledge so that learning is more meaningful and in accordance with Indonesian culture.

In the first feature, namely "Let's Get to Know Culture", students were presented with local cultural information that was directly related to the concept of light waves. This feature contains practical examples such as puppet performances, batik dips, and folklore, so that it is able to bridge the knowledge of concepts and scientific facts. In addition, this feature serves to train the competence to explain phenomena scientifically while strengthening content knowledge according to science literacy. Furthermore, the "Let's Observe" feature provides an ethnoscience-based learning experience to train students' procedural skills. Through the addition of images and videos, students are directed to make empirical observations and understand the principles of scientific investigation, including the repetition of measurement and control of variables. This feature aims to hone students' ability to design and evaluate inquiry designs critically.

The "Let's Think" and "Let's Try" features were developed to stimulate critical thinking and creativity. The "Let's Think" feature directs ethnoscience-based discussions so that students are able to formulate arguments and make scientific conclusions. Meanwhile, the "Let's Try" feature facilitates simple experimentation and the application of technology, so that learners learn to prove concepts practically and strengthen their science identity as innovators in learning. Finally, the "Let's Solve" and "Let's Technology" features complement learning with practice questions and introduction to science-based technology. The practice question feature serves to deepen conceptual understanding and improve competence in explaining phenomena scientifically, while the "Let's Be Technological" feature introduces the use of light properties in the latest technology. Based on this, this teaching material fully equips students to think scientifically, solve problems, and innovate based on science in the context of culture and daily life.

Based on the results of validation by two subject matter experts, the teaching materials developed obtained a validity score of 87.5%, which is included in the very valid category. Validation is carried out using assessment instruments that include four main aspects, namely content, presentation, language, and graphics in accordance with the National Education Standards Agency (BSNP). In terms of content and teaching materials, the validity value is at 86%, which is included in the very valid category (Rismawati & Purwaningsih, 2024). This proves that the teaching materials are in accordance with the basic competencies and learning outcomes of the Independent Curriculum, contain the concepts of light waves completely and accurately, and are associated with local cultural phenomena and values. Various examples of application, such as fireworks performances, shadow puppets, dyed batik, rainbow folklore, and lumping horse performances are used to explain the concepts of reflection, refraction, diffraction, dispersion, interference, and polarization of light. Teaching materials are also arranged with a systematic and logical flow, in accordance with the steps of the STEM approach which consists of problem

identification, technology exploration, design, and strengthening scientific concepts to hone students' critical thinking and problem-solving skills (Nalasari et al., 2021).

In addition to testing the validity of teaching materials on four aspects, teaching materials were also tested for readability using the rumpang test. Readability is a natural and natural reading process that is reflected through the ability to fill in the parts that are deliberately blanked in the rumpang test (Choeriyah et al., 2021). The group test has a uniform format, using the original text without modification, except for the omission of certain words used as filler items. This type of test does not require question item analysis and is known to have a high level of reliability. In this study, researchers omitted every 8th word from each sentence in the text as part of the test construct (Fatkhurrohman & Astuti, 2020). This test was tested on 35 students in an experimental class. This test is carried out to find out how easy or difficult the teaching material is understood by students. The results of the readability test in this study showed a very high readability level with an average score of 95%. This shows that the teaching materials developed are easy to understand by students.

The practicality of teaching materials is an important aspect in determining the quality and success of the implementation of teaching materials in the field. The results of the practicality test of the development of ethno-STEM integrated teaching materials on light wave materials show that the developed products can be used very easily to use, efficiently, and attractive to students (Wati et al., 2022). Involving 35 learners, the test resulted in an average score of 96%, with a breakdown of 98% ease of use thanks to communicative language, clear instructions, and relevant illustrations. The attraction aspect also obtained a high score of 95%, supported with images, graphics, photos of local culture, and STEM exploration activities that make abstract concepts easier to understand and learning more meaningful.

In addition, the efficiency of the teaching materials also received a very practical score of 95%, which allows students to learn independently, anytime and anywhere according to their needs and learning speed (Akmal & Saputra, 2020). The existence of these teaching materials also makes it easier for teachers to manage the learning process and help students understand abstract concepts more concretely and applicatively. Based on this high level of practicality, ethno-STEM integrated teaching materials not only meet the quality standards of good teaching materials,but also have significant potential in optimizing the learning experience and improving students' overall science literacy.

The ethno-STEM integrated teaching materials developed have met the criteria for validity and practicality, so that they can be used in the learning process (Lastri, 2023). Furthermore, an effectiveness test was carried out to measure the increase in students' science literacy, especially in light wave materials. This test compares the increase in the level of science literacy of students in the experimental and control classes, with questions consisting of 10 questions described from level 1a to level 6 of science literacy. The results of the normality and homogeneity test with the help of SPSS showed that the data were distributed normally and homogeneously, and *the Paired Sample T-Test* showed that there was a significant difference in the increase in the science literacy score of students in both classes. However, based on the N-Gain test, it showed that the increase in science literacy ability in the experimental class obtained a score of 0.4571 which

indicates that it was in the medium category, while the control class only obtained a score of 0.2359 in the low category. These results indicate that ethno-STEM teaching materials are effective in increasing the science literacy of students in the medium category (Guntara, 2021).

This teaching material utilizes the local cultural context that is close to students to facilitate the formation of meaningful and relevant scientific understanding (Wibowo & Ariyatun, 2020). Various features such as "Let's Get to Know Culture", "Let's Think", "Let's Try", "Let's Solve", "Let's Observe", and "Let's Technology" provide opportunities for students to actively build knowledge, make predictions, design experiments, evaluate evidence, and conclude answers based on scientific data. This is in line with the theory of constructivism which emphasizes that students form their own knowledge based on real experiences and familiar cultural contexts, making science literacy more meaningful and applicable in daily life (Masfufah & Ellianawati, 2020).

The results of the analysis also show that this teaching material has a positive impact on three aspects of science literacy, namely aspects of knowledge, competence, and scientific attitudes. The increase in scores was significant, such as the value of level 1a questions increased by 17%, level 2 questions increased by 30%, level 3 questions increased by 40%, and level 4 questions increased by 33%. However, in questions with higher levels of difficulty (levels 5 and 6), students' achievements are not optimal, especially in the aspects of epistemic knowledge and the ability to research, evaluate, and draw conclusions from scientific data. This can be caused by the limited time for learning implementation, students' initial abilities, and the lack of optimal design of teaching materials for the needs of high-level thinking.

Therefore, this study concludes that the implementation of ethno-STEM integrated teaching materials can improve students' science literacy, especially in the aspects of content and procedural knowledge, as well as some aspects of scientific competence and attitudes. Despite being in the medium category, this increase remains significant and makes this teaching material a potential alternative to be used in science learning that is relevant to the local context of students (Rahmawati et al., 2020). It is hoped that the developer of teaching materials can expand the scope of activities and extend the duration of implementation to optimize the mastery of aspects of epistemic knowledge and high-level thinking skills of students.

CONCLUSION

Based on the results of the research and discussions that have been carried out, in this study it can be concluded that the teaching materials developed have characteristics that are presented in the instructions for use, around teaching materials, features of student activities such as "Let's Get to Know Culture", "Let's Observe", "Let's Think", "Let's Try", "Let's Technology", and "Let's Solve". Furthermore, the teaching materials developed obtained a validity level of 87.5% which shows that it is in the category of very valid.

The teaching materials developed have a very practical level of practicality with a score of 96%. The effectiveness of teaching materials in improving science literacy is in the medium category with an N-Gain of 0.4571.

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REFERENCES

Ady, W. N. (2022). Analisis Kesulitan Belajar Siswa SMA terhadap Mata Pelajaran Fisika pada Materi Gerak Lurus Beraturan. *Jurnal Pendidikan Dan Ilmu Fisika*, *2*(1), 104. https://doi.org/10.52434/jpif.v2i1.1599

Akmal, N., & Saputra, E. (2020). Persepsi Literasi Matematika Mahasiswa Terhadap Nilai-Nilai Keislaman. *Jurnal Dedikasi Pendidikan*, *8848*(2), 381–391.

Branch, R. M. (2009). Approach, Instructional Design: The ADDIE. In *Department of Educational Psychology and Instructional Technology University of Georgia* (Vol. 53, Issue 9).

Choeriyah, H., Yulianti, D., & Yulianti, I. (2021). Pengembangan Lembar Kerja Siswa (LKS) Fisika Berbasis Problem Based Learning UntukMeningkatkan Kemampuan Pemecahan Masalah. *UPEJ (Unnes Physics Education Journal)*, *10*(1), 81–87. http://journal.unnes.ac.id/sju/index.php/upej

Fatkhurrohman, M. A., & Astuti, R. K. (2020). Pengembangan modul fisika dasar I berbasis literasi sains. *Pancasakti Science Education Journal*, *5*(9), 4–11.

Fuadi, H., Robbia, A. Z., Jamaluddin, J., & Jufri, A. W. (2020). Analisis faktor penyebab rendahnya kemampuan literasi sains peserta didik. *Jurnal Ilmiah Profesi Pendidikan*, *5*(2), 108–116.

Guntara, Y. (2021). Normalized Gain Ukuran Keefektifan Treatment. *Universitas Sultan Ageng Tirtayasa*, *March*, 1–3. https://doi.org/10.13140/RG.2.2.27603.40482

Khurma, O. A., Jarrah, A., & Ali, N. (2025). PISA 2022 insights on intellectual curiosity, perspective-taking, and science achievement: Examining the mediating pathways. *International Journal of Educational Research Open*, *8*. https://doi.org/10.1016/j.ijedro.2024.100414

Kosasih, E. (2020). *Pengembangan Bahan Ajar* (F. B. Sari (ed.); 2nd ed.). Bumi Aksara, Yogyakarta. https://doi.org/6024449569

Lastri, Y. (2023). Pengembangan dan Pemanfaatan Bahan Ajar E-Modul Dalam Proses Pembelajaran. *Jurnal Citra Pendidikan*, *3*(3), 1139–1146. https://doi.org/10.38048/jcp.v3i3.1914

Lisdawati, Syamsuriwal, Pasaribu, M., & Sani, N. K. (2025). Pengembangan Bahan Ajar Berbasis Etnosains Kaili Pada Materi Getaran Dan Gelombang. *Jurnal Pendidikan Fisika Tadulako*, *13*, 231–243. https://doi.org/10.22487/jpft.v13i2.4702

Mardiana, N., Prayogi, S. Y., S, S., Haslina, S., & Harizan, M. (2022). Android-Based Digital Teaching Materials as Online Learning in New Normal Era to Improve Physics HOTS for High School Students. *Journal of Natural Science and Integration*, *5*(1), 90. https://doi.org/10.24014/jnsi.v5i1.15468

Masfufah, F. H., & Ellianawati. (2020). Peningkatan Literasi Sains Siswa Melalui Pendekatan Contextual Teaching And Learning (CTL) Bermuatan Etnosains. *Unnes Physics Education Journal* , *9*(2), 129–138. http://journal.unnes.ac.id/sju/index.php/upej

Mufidah, R., Qomaria, N., Rakhmawan, A.,

Wahyuni, E. A., Bagus, D., Ipa, P., Keguruan, F., & Trunojoyo, U. (2025). E-Module IPA Bermuatan Etnovlog Pantai Lon Malang Madura : Bahan Ajar untuk Meningkatkan Literasi Sains Siswa. *Journal of Progressive Science Education*, *1*(1), 19–33.

Murti, W. W., & Sunarti, T. (2021). Pengembangan Instrumen Tes Literasi Sains Berbasis Kearifan Lokal di Trenggalek. *Jurnal Hasil Kajian, Inovasi, Dan Aplikasi Pendidikan Fisika*, *7*(1).

Nalasari, K. A., Suarni, N. K., & Wibawa, I. M. C. (2021). Pengembangan Bahan Ajar Berbasis Web Google Sites pada Tema 9 Subtema Pemanfaatan Kekayaan Alam di Indonesia untuk Siswa Kelas IV Sekolah Dasar. *Jurnal Teknologi Pembelajaran Indonesia*, *11*(2), 135–146. https://doi.org/10.23887/JURNAL_TP.V11I2.658

Novita, D., Sari, A., Rusilowati, A., & Nuswowati, M. (2017). Pengaruh Pembelajaran Berbasis Proyek terhadap Kemampuan Literasi Sains Siswa. In *Pancasakti Science Education Journal PSEJ* (Vol. 2, Issue 2). http://e-journal.ups.ac.id/index.php/psej

Nuryasana, E., & Desiningrum, N. (2020). Pengembangan bahan ajar strategi belajar mengajar untuk meningkatkan motivasi belajar mahasiswa. *Jurnal Inovasi Penelitian*, *1*(5), 967–974.

OECD. (2023). *PISA 2022 Results (Volume I) The State of Learning and Equity in Education*. OECD Publishing, Paris. https://doi.org/https://doi.org/10.1787/53f23881-en.

OECD. (2024). *PISA 2022 Results (Volume III): Creative Minds, Creative Schools*. OECD Publishing, Paris. https://doi.org/https://doi.org/10.1787/765ee8c2-en

Qori, P. H., Sudarmin, S., Sumarni, W., Subali, B., & Saptono, S. (2020). Implementation of STEM Integrated Ethnoscience-based Vocational Science Learning in Fostering Students' Higher Order Thinking Skills (HOTs). *International Journal of Active Learning*, *5*(2), 53–61.

Rahmawati, Y., Ridwan, A., Faustine, S., Syarah, S., Ibrahim, I., & Mawarni, P. C. (2020). Pengembangan Literasi Sains Dan Identitas Budaya Siswa Melalui Pendekatan Etno-Pedagogi Dalam Pembelajaran Sains. *Edusains*, *12*(1), 54–63. https://doi.org/10.15408/es.v12i1.12428

Rismawati, E., & Purwaningsih, E. (2024). Development Of Physics Teaching Materials On The Subject Of Light Interference Based On Discovery-inquiry For Senior High School Students. *Journal of Physics: Conference Series*, *2866*(1), 012120. https://doi.org/10.1088/1742-6596/2866/1/012120

Rizaldi, D. R., Jufri, A. W., & Jamaluddin, J. (2020). PhET: Simulasi Interaktif Dalam Proses Pembelajaran Fisika. *Jurnal Ilmiah Profesi Pendidikan*, *5*(1), 10–14. https://doi.org/10.29303/jipp.v5i1.103

Saddia, A., Amir, F., & Hutapea, B. (2025). Bahan Ajar Digital Model Oe3c-Etnofisika Berbantuan Augmented Reality Untuk Meningkatkan Kemampuan Berpikir Kritis Dan Literasi Fisika Siswa. *JPF (Jurnal Pendidikan Fisika) FKIP UM Metro*, *13*(2), 239–254.

Sudarmin, S., Sumarni, W., Rr Sri Endang, P., & Sri Susilogati, S. (2019). Implementing the model of project-based learning : integrated with ETHNO-STEM to develop students' entrepreneurial characters. *Journal of Physics: Conference Series*, *1317*(1). https://doi.org/10.1088/1742-6596/1317/1/012145

Suroso, J., Indrawati, Sutarto, & Mudakir, I. (2021). Profile of high school students science literacy in east java. *Journal of*

Physics: Conference Series ICOPAMBS 2020, *1832*(1). https://doi.org/10.1088/1742-6596/1832/1/012040

Thomas, M. (2023). *PISA 2025 Science Framework*. OECD, Paris. https://pisa-framework.oecd.org/science-2025/idn_ind/

Valladares, L. (2021). Scientific Literacy and Social Transformation: Critical Perspectives About Science Participation and Emancipation. *Journal Science and Education*, *30*(3), 557–587. https://doi.org/10.1007/s11191-021-00205-2

Wahyuni, S., Sari, J., Palittin, I. D., & Henukh, A. (2023). Development of Student Worksheets Based on Etno-STEM on Sound Waves. *Kasuari: Physics Education Journal (KPEJ)*, *6*(1), 37–45. https://doi.org/10.37891/KPEJ.V6I1.345

Wati, D. K., Saragih, S., & Murni, A. (2022). Validitas dan Praktikalitas Bahan Ajar Matematika Berbantuan FlipHtml5 untuk Memfasilitasi Kemampuan Pemahaman Matematis Siswa Kelas VIII SMP/MTs pada Materi Koordinat Kartesius. *Juring (Journal for Research in Mathematics Learning)*, *5*(4), 287. https://doi.org/10.24014/juring.v5i4.16717

Wibowo, T., & Ariyatun, A. (2020). Kemampuan Literasi Sains Pada Siswa Sma Menggunakan Pembelajaran Kimia Berbasis Etnosains. *Jurnal Edusains*, *12*(2), 214–222. https://doi.org/10.15408/es.v12i2.16382

Zidatunnur, S. F., & Rusilowati, A. (2021). Keterbacaan dan Kepraktisan Bahan Ajar Digital Gerak Melingkar Berbantuan Scratch Berbasis STEM untuk Mahasiswa. *Unnes Physics Education Journal*, *10*(2), 131–138. http://journal.unnes.ac.id/sju/index.php/upej