JISE 13 (2) (2024): 92-103

Journal of Innovative Science Education

https://journal.unnes.ac.id/journals/jise/

Innovation of Science Teaching Material Based on STEM-PjBL in the Implementation of the *Merdeka* Curriculum

Muhammad Aqmal Nurcahyo[1,2]✉, Yunika Afryaningsih[1]

[1,2]Elementary School Teacher Study Program, Universitas Nahdlatul Ulama Kalimantan Barat, Indonesia
[2]Doctoral Program on Elementary Education, Universitas Negeri Yogyakarta, Indonesia

Article Info

Article History :
February 2024
Accepted
May 2024
Published
August 2024

Keywords:
Merdeka curriculum; science teaching material; STEM-PjBL

Abstract

The learning process of Natural and Social Sciences (IPAS) requires adequate teaching materials and integrated with innovative approaches to make learning more interesting, practical, and fun. The integration of the STEM-PjBL approach can be an option in the development of teaching materials because it encourages students to develop process skills through real problem-solving-based learning, practicum implementation, and project activities. This study aims to produce IPAS teaching materials that are in accordance with the content of science based on STEM-PjBL for phase C of grade V thus supporting the implementation of the Merdeka curriculum and improving process skills as an integral part of science learning. The development method used is the Analysis, Design, Development, Implementation, Evaluation (ADDIE) model. Validation of teaching materials was carried out by media experts with a match rate of 88% (very feasible), material experts at 83% (very feasible), and language experts at 82% (very feasible). Additionally, small group trials with students resulted in an 80.14% (good), suggesting that the materials are engaging and effective. The integration of STEM-PjBL supports the implementation of the Merdeka curriculum, emphasizing the development of students' process skills through real-world problem-solving, practical activities, and projects. Given the high feasibility ratings from experts and positive feedback from students, the developed science teaching materials have the potential to be widely adopted in grade V, improving the overall science learning experience. Future research should explore long-term impacts, comparative effectiveness, teacher training, technological integration, and broader demographic studies. These materials enhance learning experiences, support the Merdeka curriculum, improve process skills, provide valuable teacher resources, and can inform educational policy.

✉ correspondence:
Jl. Parit Derabak, Sungai Raya, Kec. Sungai Raya, Kabupaten Kubu Raya, Kalimantan Barat 78122, Indonesia
E-mail: m.aqmalnurcahyo@unukalbar.ac.id

p-ISSN 2252-6412
e-ISSN 2502-4523

INTRODUCTION

The implementation of the Merdeka curriculum at the elementary school level that is currently implemented encourages a change in the learning paradigm. Through independent learning and strengthening the Pancasila students' profile (P3) and focusing on essential materials, the Merdeka curriculum is expected to be able to overcome current and future educational problems (Alimuddin, 2023). The profile of Pancasila students in the Merdeka curriculum has 6 elements, namely: (1) faith, fear of God Almighty and have noble morals, (2) global diversity, (3) mutual assistance, (4) independent, (5) critical reasoning, and (6) creative.

Natural and Social Sciences (IPAS) is a combination of natural and social sciences that study living and inanimate things in the universe and their interactions, and study human life as individuals as well as social beings who interact with their environment. The recent shift from the 2013 Curriculum to the *Merdeka Belajar* curriculum in Indonesia emphasizes the integration of natural science and social science learning into a unified unit under the term IPAS (Anisa et al., 2023). This change necessitates the development of suitable models for teacher training and professional development to effectively implement the National Curriculum, particularly in the context of social and natural sciences (Anif et al., 2020).

The implementation of science learning in science subjects in the Merdeka curriculum is considered still not optimal. Based on observations, the implementation of science learning in phase C of grade V elementary school is adjusted to the teacher's book and student book by dividing the content of science and social studies separately. Science content is taught in odd semesters while social studies content is in even semesters. In science learning, students are expected to have a critical thinking attitude, scientific attitude, and creative so that they can achieve science learning goals (Yasa et al., 2022). This is in line with the elements in IPAS, namely process skills, including: (1) observing, (2) questioning and predicting, (3) planning and conducting investigations, (4) processing, analyzing data, and information, (5) evaluating and reflecting, and (6) communicating results.

Efforts to create a science learning atmosphere that is fun and interesting for students require teachers to have the ability to design a good learning, apply learning models, and provide teaching materials that attract students' learning interests. Teaching materials are one of the teaching tools needed to support the learning process to be carried out optimally, effectively, and efficiently (Fanani et al., 2022). Teaching materials are designed to be a tool for teachers and students in learning related to certain topics or materials. Teaching materials aim to simplify complex concepts for students, making abstract material more understandable and engaging (Marsari & Rifma, 2023). The continuity of learning activities in elementary schools heavily relies on the use of teaching materials (Utari et al., 2023). Teaching materials can be printed or non-printed. According to Prastowo (2013) teaching materials in the form of text lessons consist of five components, namely: (1) title, (2) basic competencies or materials, (3) supporting information, (4) exercises, and (5) assessment.

In the Merdeka curriculum, teaching materials act as supporting materials for teaching modules based on specific learning achievements and objectives. Teaching materials that should be used in the Merdeka curriculum are teaching materials that allow integrating between materials, competencies in student activities while cultivating students to think critically, creatively, and technologically literate (Fanani et al., 2022). The teaching materials used should be in line with the elements of process skills in science learning. Therefore, to support the minds on activity and hands on activity of students in learning science is to integrate a learning approach based on Science, Technology, Engineering, Mathematics (STEM) through Project Based Learning (PjBL) activities or known as STEM-PjBL in the teaching materials used.

Based on observations and interviews, the teaching materials used in the Merdeka curriculum are not appropriate. The factors that influence this include: (1) lack of teacher understanding in imaking innovative teaching materials in the implementation of the Merdeka curriculum, (2) lack of teacher competence in developing innovative teaching materials based on STEM-PjBL, and (3) teaching

materials used in science learning, especially science are not in line with the elements of science process skills. It is according to (Borg, 2003) if teachers' cognition, which includes their knowledge, beliefs, and pedagogical reasoning, significantly impacts the quality of teaching materials they develop.

Based on the description above, the research problem is "How is the development of innovative science teaching materials for science content based on STEM-PjBL in supporting the implementation of the Merdeka curriculum in elementary schools?". This research purpose is to produce innovative science teaching materials based on STEM-PjBL in supporting the implementation of the *Merdeka* curriculum in elementary schools. This teaching material is expected to be able to meet the needs of science process skill elements and can support the minds on activity and hands on activity of students in science learning through a series of science project activities.

To address these problems, innovative teaching materials can be developed for phase C of grade V by implementing STEM-PjBL. STEM education, encompassing science, technology, engineering, and mathematics, is recognized as an important educational model in primary and secondary schools, including elementary schools (Le Thi Tuyet et al., 2024). STEM education is in line with the needs of the 21st century, students are expected to have science and technology skills through reading, writing, observing, conducting experiments, and understanding science to develop existing competencies (Rochim et al., 2022). The primary purpose of STEM education in elementary schools is to enhance students' problem-solving abilities, creativity, independence, active learning participation, literacy in STEM subjects, and systematic and critical thinking skills (Susanti et al., 2020). Additionally, STEM education aims to cultivate both convergent and divergent thinking in students at all levels of schooling (Lu et al., 2021).

Implementing STEM positively influences classroom learning. Several studies that have been conducted show that STEM can be taught through cooperative learning (Nugroho & Nurcahyo, 2018). STEM can be applied in mobile learning so that it can train students' digital literacy, and STEM can improve creative thinking skills (Nurcahyo & Fatmawati, 2022; Nurcahyo & Setyowati, 2020). Moreover, the implementation of STEM education in elementary schools is supported by the 2030 Agenda for Sustainable Development, which highlights teachers as crucial for the improvement of education (Khuyên et al., 2020).

STEM education is not just about teaching individual subjects in isolation but rather about demonstrating how these subjects are interrelated and can be used together to address complex challenges (Çalışıcı & Sümen, 2018). Moreover, STEM education emphasizes the importance of active participation and experiential learning (Tank, 2017). Through STEM education, students learn to think critically, work collaboratively, and adapt to new challenges, preparing them for future success (Çetin & Demircan, 2020). The skills of students in understanding phenomena or problems can be taught in the classroom through the implementation of learning models, such as PjBL.

Incorporating project-based learning into STEM education has been identified as an effective strategy for enhancing students' skills and competitiveness in a knowledge-based society (Rizqiyana, 2021). This hands-on approach not only deepens students' understanding of STEM concepts but also hones their ability to collaborate, communicate, and think critically (Kormakova et al., 2023). PjBL is a learning model that utilizes project media to activate student learning activities both physically and psychologically, both independently and in groups (Kahar & Ili, 2022). Project-based learning is an instructional approach centered on constructivist principles, emphasizing context-specific learning, active student involvement, and social interaction for goal achievement (Kokotsaki et al., 2016).

STEM education with the PjBL learning model makes students active in learning, they are able to communicate, and share findings with their friends (Agung et al., 2022). STEM-PjBL can increase effectiveness, meaningful learning, and support students' careers in the future based on the experience of solving real problems with practicum activities in the classroom (Tseng et al., 2013). The STEM-PjBL approach has been found to be effective in increasing students' contextual understanding and problem-solving skills (Purwati et al., 2024). This early exposure to STEM subjects helps children develop essential skills such as problem-solving,

creativity, and logical thinking from a young age (Smith et al., 2022). Furthermore, the integration of STEM-based teaching materials in elementary classrooms can provide new avenues for teaching and learning, promoting iSTEM education (Arnone & Hanuscin, 2018).

By integrating STEM subjects with project-based learning, it allows students to make connections between different subjects and their prior knowledge, leading to a deeper understanding of STEM concepts (He, 2023). Science learning activities using a STEM approach with the PjBL model, making students active so as to provide a more meaningful learning experience, it has the potential to develop creativity and understanding of science concepts (Yulaikah et al., 2022). Science learning with STEM-PjBL not only has an impact on students, but also on improving teacher Pedagogical Content Knowledge (PCK) in designing innovative learning implementations as support for the implementation of the Merdeka curriculum and the realization of the Pancasila students' profile.

The purpose of this research is to develop teaching materials for the Natural and Social Sciences (IPAS) for grade V, specifically phase C, by integrating the STEM-PjBL (Science, Technology, Engineering, Mathematics - Project-Based Learning) approach. This integration aims to make learning more engaging, practical, and enjoyable while enhancing students' process skills through real problem-solving, practical activities, and projects. The study seeks to support the implementation of the Merdeka curriculum by creating effective, validated materials that foster an improved science learning experience.

The urgency of this research lies in the need to improve the learning process for Natural and Social Sciences (IPAS) by addressing the current lack of engaging, practical, and fun teaching materials. The traditional approaches often fail to stimulate students' interest and do not adequately develop essential process skills. By integrating the STEM-PjBL approach, this research aims to create teaching materials that enhance real-world problem-solving abilities, practical implementation, and project-based learning, which are crucial for students' overall development. Furthermore, supporting the Merdeka curriculum requires innovative and validated resources to ensure its successful implementation. Given the high feasibility ratings from experts and positive feedback from students, the developed materials have the potential to significantly improve the quality of science education, making this research urgently needed to address these educational gaps and better prepare students for future challenges.

METHODS

The method used in this research is Research and Development (R &D). Development research is a process or steps to develop a new product or perfect an existing product, which can be accounted for (Sukmadinata, 2005). This research uses the Analyis, Design, Development, Implementation, Evaluation (ADDIE) development model. The advantages of the ADDIE model is its simplicity and applicability across various educational contexts, provides a structured framework that encompasses essential phases from analysis to evaluation, and a fundamental and straightforward methodology for producing educational materials that are tailored to students' needs (Cheung, 2016; Dolo, 2023; Martatiyana, 2023).

The research instruments used consisted of students' worksheets, validation sheets, and response questionnaires. The student worksheets used are the result of products that have been developed. The use of validation sheets ensures that the research instruments are reliable and accurately measure the intended outcomes, contributing to the overall quality and credibility of the research findings. These questionnaires allow researchers to efficiently collect data from a large number of participants. Additionally, questionnaires are popular in research due to their cost-effectiveness and ability to capture perspectives succinctly (Mes et al., 2019).

The flowchart of the research procedures is described as follows.

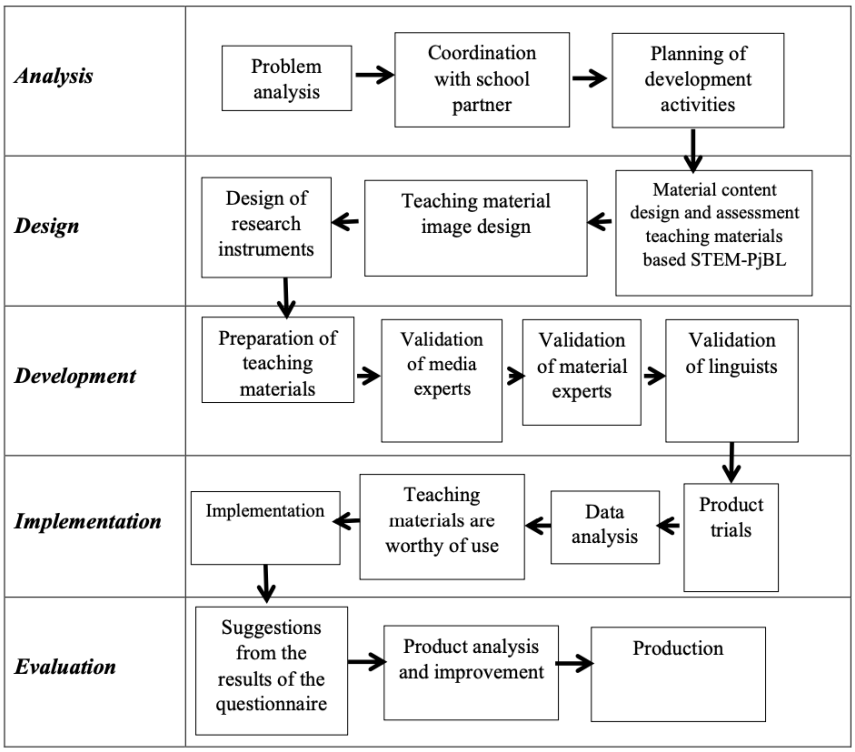

Figure 1. Flowchart of the research procedures

Based on the flowchart above, first procedure is analysis. Researchers analyzed the need for the development of STEM-PjBL based science content science teaching materials and the development requirements. Researchers carried out several procedures such as: (1) analyzing the learning outcomes of science in the Merdeka curriculum phase C, namely grade V elementary school; (2) analyze the material and experiments that can be carried out; (3) conduct literature studies on the application of STEM-PjBL; (4) analyze the needs and characteristics of grade V elementary school students; and (5) conduct direct observations and interviews with class teachers at partner elementary schools.

The second procedure is design. Researchers determine the elements needed in designing the *Merdeka* curriculum teaching materials, including general information, teaching material content (reference material, assessment/exercise, reflection instrument completeness documents), and completeness documents (linkage to the Merdeka curriculum and completeness per category of teaching materials).

The third procedure is development. Researchers create science teaching materials based on STEM-PjBL science content that are useful for students and schools in supporting the implementation of the *Merdeka* curriculum. This stage contains the conceptual framework that has been designed to be developed. Teaching materials will contain a series of STEM-PjBL activities in accordance with the material discussed in the phase C of grade V elementary school.

The fourth procedure is implementation. Researchers implement science teaching materials based on STEM-PjBL that have been developed in grade V elementary school students. Researchers also distributed questionnaires of student responses related to the practical value of using teaching materials. The last procedure is evaluation. Researchers analyze and improve STEM-PjBL based teaching materials developed based on the input received.

The study was conducted at SD Negeri 39 Pontianak Kota with respondents of grade V students for the 2023/2024 academic year. The research lasted for six months starting from the preparation stage, developing teaching materials, collecting and processing data, until the completion of the report. The research instrument used consists of a validation sheet and a response questionnaire. Analysis of research data in the form of product feasibility analysis obtained from the validation

results of experts, namely media experts, material experts, and language experts. The interpretation of the validation results is seen in the following table.

Table 1. Criteria for interpretation of validation questionnaire

Average score (%)	Response criteria
0-20	Very unfeasible
21-40	Unfeasible
41-60	Feasible enough
61-80	Feasible
81-100	Very feasible

(Source: Sudaryono, et al. 2013)

The feasibility of validation results is seen from the results of student response questionnaires through the Likert scale by providing several statements. The calculated questionnaire score will be converted into a percentage using the following formula.

$$\text{Score (\%)} = \frac{Total\ score\ of\ each\ student}{Maximum\ number\ of\ scores} \text{ x } 100\% \quad (1)$$

The interpretation of student response questionnaires is seen in the Table 2.

Table 2. Criteria for interpretation of student response questionnaire

Average score (%)	Response criteria
0-20	Very bad
21-40	Not good
41-60	Good enough
61-80	Good
81-100	Very good

(Source: Riduwan, 2015)

RESULTS AND DISCUSSION

The results of the study are described according to the procedrues of ADDIE development model. Based on the results of the needs analysis at SD Negeri 39 Pontianak Kota, a design was carried out to develop science teaching materials based on STEM-PjBL in supporting the implementation of the *Merdeka* curriculum in elementary schools. Furthermore, researchers analyze learning outcomes, learning objectives, learning objectives flow and choose science material in science learning in the Merdeka curriculum. Researchers chose 3 materials "Magnetism, Electricity, and Technology for Life" which contained 3 main learning topics. Furthermore, researchers formulate this material which will be presented in teaching materials in the form of students' worksheets along with project activities that are integrated with the STEM-PjBL learning approach. This STEM-PjBL integrated students' worksheets is expected to be able to assist students in solidifying and understanding concepts well (Ningsih et al., 2023).

The research activity plan begins with preparing the design of teaching materials that have been selected. The researcher also mapped the topic in material 3 "Magnetism, Electricity, and Technology for Life" in the formulation of learning activities based on STEM-PjBL. Researchers also identify problems and experienced by students in everyday life. Researchers chose problems regarding efforts to save electricity use and a comfortable environment to live in. The project activity that will be carried out by students is "Eco-friendly House".

Furthermore, researchers compile the content that must be contained in the teaching materials of the Merdeka curriculum, namely general information, the content of teaching materials (reference materials, assessments/exercises, documents for completeness of reflection instruments), and completeness documents (linkages with the Merdeka curriculum and completeness per category of teaching materials).

The description of the content in the science teaching materials based STEM-PjBL must certainly be related to 6 dimensions in the Pancasila students' profile, namely: (1) faith, fear of God Almighty and have noble morals, (2) global diversity, (3) mutual assistance, (4) independent, (5) critical reasoning, and (6) creative. Therefore, the STEM-PjBL syntax used must also support the dimensions of the Pancasila students' profile in question.

After formulating the relationship, the researcher also compiled a complete range of teaching materials developed. Overall, the general information contained in this teaching material includes: (1) title page, (2) introduction, (3) table of contents, (4) instructions for use, (5) introduction, (6) STEM-PjBL syntax, (7) STEM-PjBL learning

steps, (8) STEM integrated learning, (9) about learning, (10) activities 1-10, and (11) author profile.

Researchers also look for and determine the design of illustrations/supporting images on teaching materials in order to attract students' learning interest. In addition, researchers also prepare instruments in the form of validation sheets (media experts, material experts, and language experts) and student questionnaire response sheets.

Furthermore, regarding the content of the teaching materials, namely in the form of integrated project activities of the STEM-PjBL learning approach that will be carried out by students in groups. The design of the contents of teaching materials that have been developed can be shown below.

Figure 2. Design display of teaching material content

Making science teaching materials based on STEM-PjBL began to be carried out by researchers. Interesting teaching materials are certainly supported by interesting embodiments as well. The cover design of the teaching materials can be shown below.

Figure 3. Cover design of teaching materials

The teaching materials that have been made are then validated to determine their feasibility. Exposure to validation results is outlined as follows.

Table 3. Results of media validation

No.	Indicators	Score
1	Design of students' worksheet	21
2	Presentation	23
Total		44
Persentage		88%
Category		Very feasible

Table 4. Results of material validation

No.	Indicators	Score
1	Accuracy of indicators	15
2	Content feasibility	51
3	Learning	17
Total		83
Persentage		83%
Category		Very feasible

Table 5. Results of language validation

No.	Indicators	Score
1	Grammar	20
2	Systematics of writing	21
Total		41
Persentage		82%
Category		Very feasible

Based on the results of the validation of teaching materials that have been carried out, media validation results of 88% (very feasible), material validation results of 83% (very feasible), and language validation results of 82% (very feasible).

The implementation phase of the science teaching materials based on STEM-PjBL, validated by media experts, material experts, and language experts, was conducted with phase C grade V students at SD Negeri 39 Pontianak Kota. The study utilized small group trials to refine the teaching materials, ensuring alignment with the Merdeka curriculum and obtaining detailed feedback on their effectiveness. The small group setting allowed researchers to measure students' understanding, evaluate their readiness, assess the learning methods'

effectiveness, maintain student interest, and evaluate the design and presentation of the materials.

The developed teaching materials, in the form of student worksheets, were accessible both in print and online at https://online.fliphtml5.com/uwpfp/pfwm/. Nine students participated, divided into three groups, over three sessions of 70 minutes each. The focus was on the energy topic under the eco-friendly house learning theme, using a STEM approach and a project-based learning (PjBL) model. The sessions included discussion, assignment, and project methods, following the STEM-PjBL syntax of reflection, research, discovery, application, and communication. The activities included: (1) understanding the problem, (2) defining the problem, (3) searching and collecting information, (4) finding solutions, (5) designing energy-efficient house prototypes, (6) making energy-efficient house prototypes, (7) testing criteria, (8) reflection and redesign, (9) presentation, and (10) solution reflection.

Figure 4. Learning activities

Each group carries out all activities in the students' worksheets that have been given starting from understanding and defining problems regarding the energy crisis, finding alternative solutions that are right to solve energy crisis problems, designing prototypes of eco-friendly house, to making prototypes of eco-friendly house. Each group was given freedom in designing the prototype of the energy house to make it according to the materials that had been planned beforehand.

After completing the lesson, students are asked to fill out a response questionnaire sheet to find out the effectiveness of the students' worksheets that has been developed. This questionnaire aims to see the interest of students when using science teaching materials containing science, especially in carrying out activities based on STEM-PjBL. The results of the questionnaire that has been given show the following results.

Table 6. Results of student response

No.	Indicators	Score
1	Design	151
2	Dimension of knowledge	140
3	Language	101
4	Attractiveness and convenience	149
Total		541
Total amount		675
Percentage		80,14 %
Category		Good

The results of the student response questionnaire amounted to 541 with a percentage of 80.14% with a good category. So it can be concluded that science teaching materials based on STEM-PjBL suitable for use in elementary school learning so that widespread trials can be carried out further.

The small group trials revealed that the teaching materials were both effective and practical. Students were highly engaged, showing strong interest and participation. They grasped the material well and applied problem-solving and critical thinking skills in creating energy-efficient house prototypes. Positive feedback highlighted the materials' clarity, relevance, and interactive nature, leading to further refinement. The materials aligned well with the Merdeka curriculum and were accessible in both print and online formats, ensuring a flexible learning environment. Overall, the learning experience was positive, with students enjoying and benefiting from the practical, hands-on activities.

Following the implementation phase, the next step is evaluation. This process starts with analyzing the validation data of science teaching materials based on STEM-PjBL, gathered from media experts, material experts, and language experts. Additionally, the data from student response questionnaires after a small group trial are analyzed. The feedback from these respondents will be used to refine the teaching materials into a final

product, which can then be more broadly tested and distributed on a larger scale.

The development of science teaching materials based on STEM-PjBL, specifically student worksheets, has led to several key findings. Researchers discovered that these integrated teaching materials can significantly support the implementation of the Merdeka curriculum, particularly in elementary schools. This teaching material provides several benefits for students, namely it can improve the ability of students to analyze problems in everyday life and increase their learning motivation. This is in line with research that has been conducted by (Pane et al., 2022) if there is a problem in teaching materials, it can increase students' ability to analyze so that students are able to solve problems related to daily life related to problems in the material.

Integrating STEM-PjBL into teaching materials is a novel approach that actively engages students, especially in science learning. The provided activities help students develop the dimensions of the Pancasila students' profile, which is a key aspect of the Merdeka curriculum. The integration of STEM education in which there is a PjBL paradigm can be considered a priority that can be integrated into classroom teaching (Agustin et al., 2022). STEM-PjBL models not only improve students' concept understanding but also foster engagement, innovation, and real-life application of scientific concepts (Sirait & Maulida, 2023). By closely linking scientific concepts to real-life experiences, students are encouraged to move beyond memorization and develop a deeper understanding of STEM subjects (Pramesti et al., 2022). Additionally, these models focus on honing students' creative thinking skills, problem-solving abilities, and mastery of concepts (Darmawan, 2020; Putri & Dwikoranto, 2022).

Developing teaching materials can significantly aid teachers in delivering effective science lessons using quality STEM-PjBL, thereby training students in various disciplinary skills. This is in line with what was conveyed by Wahono et al., (2023) if STEM education focuses on direct practice activities to prepare students to face the times, besides learning activities using STEM approaches can improve problem solving, higher-order thinking skills, and collaboration.

CONCLUSION

The development of science teaching materials based on STEM-PjBL has effectively supported the *Merdeka* curriculum in elementary schools by enhancing students' problem-solving skills and motivation. These materials, available in both print and digital formats, align with the Pancasila students' profile and encourage active engagement. They foster interdisciplinary skills, problem-solving, and collaboration. To further improve, broader implementation across schools and grade levels is recommended, along with teacher training for effective use. Continuous feedback from students and educators should refine the materials, ensuring they meet diverse learning needs and support high-quality science education.

ACKNOWLEDGEMENT

We gratefully thank to Ministry of Education, Culture, Research and Technology, Research Institutions and Community Service of Universitas Nahdlatul Ulama Kalimantan Barat, Faculty of Teacher Training and Education of Universitas Nahdlatul Ulama Kalimantan Barat, and SD Negeri 39 Pontianak Kota for their invaluable support and contribution to this project.

REFERENCES

Agung, I. D. G., Suardana, I. N., & Rapi, N. K. (2022). E-Modul IPA dengan Model STEM-PjBL Berorientasi Pendidikan Karakter untuk Meningkatkan Hasil Belajar Siswa. *Jurnal Imiah Pendidikan Dan Pembelajaran*, *6*(1), 120. https://doi.org/10.23887/jipp.v6i1.42657

Agustin, Y., Lufri, Ali Amran, & Ellizar. (2022). Meta-Analysis of the Influence of the STEM-Based Project Based Learning (PjBL) Model on Science Learning. *International Journal Of Humanities Education and Social Sciences (IJHESS)*, *2*(3), 1040–1053. https://doi.org/10.55227/ijhess.v2i3.331

Alimuddin, J. (2023). Implementasi Kurikulum Merdeka di Sekolah Dasar. *Jurnal Ilmiah KONTEKSTUAL*, *4*(02), 67–75. https://doi.org/10.46772/kontekstual.v4i02.995

Anif, S., Sutopo, A., & Prayitno, H. J. (2020). Lesson Study Validation: Model for Social and Natural Sciences Teacher Development in the Implementation of National Curriculum in Muhammadiyah Schools, Indonesia. *Universal Journal of Educational Research*, *8*(1), 253–259. https://doi.org/10.13189/ujer.2020.080132

Anisa, A., Tusapipah, A., Agustin, A. S., Sandy, U. P., & Setyaningrum, V. (2023). *Development of Science Process Skill Assessment for Fifth-Grade Students in Pontianak City*. *1*(0), 144. https://doi.org/10.24235/sicee.v1i0.14564

Arnone, K., & Hanuscin, D. L. (2018). An Exploratory Cross-Sectional Survey Study of Elementary Teachers' Conceptions and Methods of STEM Integration. *Journal of Research in Stem Education*, *4*(2), 159–178. https://doi.org/10.51355/jstem.2018.43

Borg, S. (2003). Teacher Cognition in Language Teaching: A Review of Research on What Language Teachers Think, Know, Believe, and Do. *Language Teaching*, *36*(2), 81–109. https://doi.org/10.1017/s0261444803001903

Çalışıcı, H., & Sümen, Ö. Ö. (2018). Metaphorical Perceptions of Prospective Teachers for STEM Education. *Universal Journal of Educational Research*, *6*(5), 871–880. https://doi.org/10.13189/ujer.2018.060509

Çetin, M., & Demircan, H. Ö. (2020). STEM Education in Early Childhood. *Inönü Üniversitesi Eğitim Fakültesi Dergisi*, *21*(1), 102–117. https://doi.org/10.17679/inuefd.437445

Cheung, L. (2016). Using the ADDIE Model of Instructional Design to Teach Chest Radiograph Interpretation. *Journal of Biomedical Education*, *2016*, 1–6. https://doi.org/10.1155/2016/9502572

Darmawan, A. (2020). The Influence of Project Based Learning-Stem Model on Student Learning Outcomes. *Jurnal Pena Sains*, *7*(2), 113–119. https://doi.org/10.21107/jps.v7i2.6443

Dolo, F. X. (2023). Development of Hybrid Audiovisual E-Book With Local Wisdom-Based Real-World Problems in Ngada's Wela Maka. *Ijils*, *1*(2), 61–70. https://doi.org/10.25078/ijils.v1i2.3181

Fanani, A., Rosidah, C. T., Juniarso, T., Roys, G. A., Putri, E. S., & Vannilia, V. (2022). Bahan Ajar Digital Berbasis Multiaplikasi Mata Pelajaran IPAS SD. *Jurnal Pembelajaran, Bimbingan, Dan Pengelolaan Pendidikan*, *2*(12), 1175–118. https://doi.org/10.17977/um065v2i122022p1175-118

He, J. (2023). The Teaching Strategies to Improve Students of Immigrants in STEM Learning Within the K-6 Setting. *Journal of Education Humanities and Social Sciences*, *8*, 619–626. https://doi.org/10.54097/ehss.v8i.4318

Kahar, L., & Ili, L. (2022). Implementasi project based learning untuk meningkatkan aktivitas belajar siswa. *Orien: Cakrawala Ilmiah Mahasiswa*, *2*(2), 127–134. https://doi.org/10.30998/ocim.v2i2.8129

Khuyên, N. T. T., Biên, N. V, Lin, P. L., Lin, J., & Chang, C. Y. (2020). Measuring Teachers' Perceptions to Sustain STEM Education Development. *Sustainability*, *12*(4), 1531. https://doi.org/10.3390/su12041531

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-Based Learning: A Review of the Literature. *Improving Schools*, *19*(3), 267–277. https://doi.org/10.1177/1365480216659733

Kormakova, V. N., Chernyavskikh, S. D., Satler, O. N., & Trikula, L. N. (2023). Digitalization in STEM Education: Experience of Empirical Research. *Research Result Pedagogy and Psychology of Education*, *9*(1). https://doi.org/10.18413/2313-8971-2023-9-1-0-01

Le Thi Tuyet, T., Nguyen Thi, K., Tran Duc, H., Tran Thi Giao, X., Vo Thi, N., Huynh Kim Tuong, V., Do Thi Nhu, U., & Le Thi Mai, A. (2024). STEM Education in Primary Schools of Southeast Asian Countries: An Analysis of Scientific Publications in the Scopus Database From 2000 to 2022. *Eurasia Journal of Mathematics Science and Technology Education*, *20*(4), em2433. https://doi.org/10.29333/ejmste/14432

Lu, S.-Y., Lo, C., & Syu, J.-Y. (2021). Project-Based Learning Oriented STEAM: The Case of Micro–bit Paper-Cutting Lamp. *International*

Journal of Technology and Design Education, *32*(5), 2553–2575. https://doi.org/10.1007/s10798-021-09714-1

Marsari, H., & Rifma, R. (2023). The Development of STEM-Based Teaching Materials to Improve Science Literacy for Grade III Elementary School Students. *Al-Ishlah Jurnal Pendidikan*, *15*(2), 1297–1309. https://doi.org/10.35445/alishlah.v15i2.2809

Martatiyana, H. U. D. R. (2023). Application of the Addie Model in Designing Digital Teaching Materials. *Jurnal Pendidikan Dan Pengajaran Guru Sekolah Dasar (Jppguseda)*, *6*(1), 105–109. https://doi.org/10.55215/jppguseda.v6i1.7525

Mes, M. A., Chan, A. H. Y., Wileman, V., Katzer, C. B., Goodbourn, M., Towndrow, S., Taylor, S. J. C., & Horne, R. (2019). Patient Involvement in Questionnaire Design: Tackling Response Error and Burden. *Journal of Pharmaceutical Policy and Practice*, *12*(1). https://doi.org/10.1186/s40545-019-0175-0

Ningsih, A. F., Wibowo, F. C., & Astra, I. M. (2023). *PENGEMBANGAN LKPD BERBASIS STEM-PROJECT BASED LEARNING PADA MATERI INDUKSI ELEKTROMAGNETIK*. https://doi.org/10.21009/03.1102.pf24

Nugroho, O. F., & Nurcahyo, M. A. (2018). Analisis literasi pendidikan STEM pada siswa dan pemehaman konsep. *Journal of Natural Science Teaching*, *01*(02), 121–124. https://journal.iainkudus.ac.id/index.php/Thabiea/article/view/4395

Nurcahyo, M. A., & Fatmawati, R. A. (2022). *Jurnal Pendidikan Informatika dan Sains*. *11*(2), 211–219. https://doi.org/10.31571/saintek.v11i2.4840

Nurcahyo, M. A., & Setyowati, D. (2020). Mobile Learning BERMUATAN Science, Technology, Engineering, Mathematics (STEM) Sebagai Upaya Peningkatan Literasi Digital. *Jurnal Pendidikan Informatika Dan Sains*, *10*(2), 185–194. https://doi.org/10.31571/saintek.v10i2.3187

Pane, E. P., Manurung, H. M., Simangunsong, A. D., Mobo, F. D., Siahaan, T. M., & Manurung, S. (2022). The Effect of Stem-Based Learning Module on Students Learning Outcomes and Motivation in General Chemistry Courses. *IJECA (International Journal of Education and Curriculum Application)*, *5*(2), 211. https://doi.org/10.31764/ijeca.v5i2.10212

Prastowo, A. (2013). *Panduan Kreatif Membuat Bahan Ajar Inovatif*. Yogyakarta: Diva Press.

Pramesti, D. A., Probosari, R. M., & Indriyanti, N. Y. (2022). Effectiveness of Project Based Learning Low Carbon STEM and Discovery Learning to Improve Creative Thinking Skills. *Journal of Innovation in Educational and Cultural Research*, *3*(3), 444–456. https://doi.org/10.46843/jiecr.v3i3.156

Purwati, H., . S., Indiati, I., & Melly Savira, A. (2024). The Influence of STEM: Integrated PjBL Learning Models on Students' Mathematical Creative Thinking Abilities Examined From a Metacognitive Perspective. *Kne Social Sciences*. https://doi.org/10.18502/kss.v9i6.15302

Putri, M. A. N., & Dwikoranto, D. (2022). Implementation of STEM Integrated Project Based Learning (PjBL) to Improve Problem Solving Skills. *Berkala Ilmiah Pendidikan Fisika*, *10*(1), 97. https://doi.org/10.20527/bipf.v10i1.12231

Riduwan. (2015). *Dasar-dasar Statistika*. Bandung: Alfabeta.

Rizqiyana, A. F. (2021). Stem (Science, Technology, Engineering, and Mathematics) Approaches Using Thematic Learning Media to Develop Critical Thinking. *Dinamika Jurnal Ilmiah Pendidikan Dasar*, *13*(1), 20. https://doi.org/10.30595/dinamika.v13i1.8827

Rochim, R. A., Prabowo, P., Budiyanto, M., Hariyono, E., & Prahani, B. K. (2022). The Use of STEM-Integrated Project-based Learning Models to Improve Learning Outcomes of Junior High School Students. *Proceedings of the Eighth Southeast Asia Design Research (SEA-DR) & the Second Science, Technology, Education, Arts, Culture, and Humanity (STEACH) International Conference*

(SEADR-STEACH 2021), *627*, 211–218. https://doi.org/10.2991/assehr.k.211229.034

Sirait, J. V., & Maulida, R. (2023). Needs Analysis of the Development STEM-PjBL Based LKPD to Train Students' Critical Thinking Skills. *Journal of Educational Sciences*, *7*(3), 488. https://doi.org/10.31258/jes.7.3.p.488-498

Smith, K., Maynard, N., Berry, A., Stephenson, T., Spiteri, T., Corrigan, D., Mansfield, J., Ellerton, P., & Smith, T. C. (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

Sudaryono, et al. (2013). *Pengembangan Instrumen Penelitian Pendidikan*. Yogyakarta: Graha Ilmu.

Sukmadinata, N. S. (2005). *Metode Penelitian Pendidikan.* Bandung: PT Remaja Rosdakarya.

Susanti, D., Prasetyo, Z. K., & Retnawati, H. (2020). Analysis of Elementary School Teachers' Perspectives on Stem Implementation. *Jurnal Prima Edukasia*, *8*(1), 40–50. https://doi.org/10.21831/jpe.v8i1.31262

Tank, K. M. (2017). Supporting Integrated STEM in the Elementary Classroom: A Professional Development Approach Centered on an Engineering Design Challenge. *International Journal of Stem Education*, *4*(1). https://doi.org/10.1186/s40594-017-0058-3

Tseng, K. H., Chang, C. C., Lou, S. J., & Chen, W. P. (2013). Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PjBL) environment. *International Journal of Technology and Design Education*, *23*(1), 87–102. https://doi.org/10.1007/s10798-011-9160-x

Utari, D. M., Suhartiningsih, S., Nurdianasari, N., & Finali, Z. (2023). Development of Indonesian Language Teaching Materials Based on Local Wisdom on Historical Narrative Text Material for Grade v Students at SDN 5 Kebondalem Banyuwangi. *International Journal of Social Science and Human Research*, *06*(04). https://doi.org/10.47191/ijsshr/v6-i4-05

Wahono, B., Husna, A., Hariyadi, S., Anwar, Y., & Meilinda, M. (2023). Development of integrated STEM education learning units to access students' systems thinking abilities. *Jurnal Inovasi Teknologi Pendidikan*, *10*(1), 1–9. https://doi.org/10.21831/jitp.v10i1.52886

Yasa, A. D., Kumala, F. N., Pandak, A. S. bin, & Raharja, A. S. (2022). Pengembangan Buku Digital Berbasis Inkuiri Pada Muatan IPA Materi Listrik Di SDN Kota Malang. *Jurnal Jendela Pendidikan*, *2*(04), 510–518. https://doi.org/10.57008/jjp.v2i04.310

Yulaikah, I., Rahayu, S., & Parlan, P. (2022). Efektivitas Pembelajaran STEM dengan Model PjBL Terhadap Kreativitas dan Pemahaman Konsep IPA Siswa Sekolah Dasar. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *7*(6), 223. https://doi.org/10.17977/jptpp.v7i6.15275