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Development of STEM-PjBL Based E-Modules Assisted by Google Sites on Solar System Material in Grade VI Elementary School

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Abstract: This study aims to develop and test the feasibility of a STEM-Project Based Learning (STEM-PjBL) e-module on the Solar System material for sixth-grade elementary school students. The study used the Research and Development (R&D) method with the ADDIE development model which includes the stages of analysis, design, development, implementation, and evaluation. Product feasibility was reviewed from the aspects of validity, practicality, and effectiveness. The validity test was conducted by media experts, linguists, and material experts. The validation results showed that the e-module was in the very valid category, with a validity percentage of 88% for media experts, 97% for language experts, and 95% for material experts. The practicality of the e-module was assessed through a questionnaire of teacher and student responses in two elementary schools. The results of the practicality test showed a very positive response with a very practical category, both from teachers and students. The effectiveness of the e-module was analyzed based on the improvement in learning outcomes using the N-Gain score. The results showed an increase in understanding of the solar system concept, with an N-Gain value of 0.69 (medium category) and 0.77 (high category). These findings indicate that the STEM-PjBL-based e-module is effective in improving student learning outcomes and conceptual understanding. Therefore, the developed e-module is suitable for use as an innovative and contextual science learning medium in elementary schools.

Keywords: E-module; IPA; Solar system; STEM-PjBL

Introduction

Education is a conscious and planned effort to actively develop students' potential for the sake of building national civilization. Entering the 21st century, fundamental changes are needed in the learning process through the integration of information technology (Msambwa et al., 2024; Herlinawati et al., 2024). Students are required to master science and operate technology effectively to compete globally through various learning innovations (Usmeldi et al., 2017). One relevant innovation is the use of electronic teaching materials in the form of e-modules. E-modules are multi-format digital teaching materials that include text, images, videos, and simulations to facilitate independent learning and increase student engagement (Staneviciene & Žekienė, 2025). The use of e-modules has been proven effective in improving conceptual understanding, especially in abstract material (Ayani et al., 2025; Anjarwati et al., 2025).

Developing e-modules integrated with the STEM-PjBL (Science, Technology, Engineering, and Mathematics-Project Based Learning) approach is a strategic solution for enhancing critical thinking, creativity, and problem-solving skills (Almulla, 2023; Purwanti et al., 2023). In this context, technology serves as a bridge between scientific theory and real-world applications (Çelik & Baturay, 2024). Google Sites is a potential web-based platform for developing e-modules due to its ease of access without the need for special programming (Fariz et al., 2025; Valfa et al., 2023). This platform enables structured, flexible, and collaborative

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presentation of materials through the integration of various digital services (Diani & Sukartono, 2022; Afonso et al., 2025). Google Sites is particularly well-suited for visualizing solar system material that is difficult to observe directly or is abstract (Hidayat et al., 2023; Giorio et al., 2025). Interactive visualizations through videos and animations in e-modules help students construct a clearer understanding of complex concepts (Sikumbang et al., 2025; El Hammoumi et al., 2022).

However, conditions in the field present significant challenges. Observations and interviews at several elementary schools in Tanjung Mutiara District (SDN 32 Muaro Putuih, SDN 31 Ujung Labung, SDN 20 Pasar Tiku, SDN 25 Pasir Tiku, and SDN 14 Banda Gadang) revealed that science learning is still dominated by printed materials and lecture methods. Teachers are not yet accustomed to utilizing digital platforms like Google Sites due to time and training constraints. Consequently, summative exam results show an average student score of only 66.81, still below the Learning Objective Achievement Criteria (KKTP) of 70, with a completion rate of only around 32-33%.

The low participation and understanding of these concepts emphasizes the need for more contextual, interactive, and engaging learning resources (Sembung et al., 2022; Daud, 2024; Betu, 2023). Based on this background, this study aims to develop a STEM-PjBL-based e-module using Google Sites for the solar system. This development is expected to facilitate the visualization of abstract concepts and encourage active student engagement, enabling them to more easily understand the material and apply the acquired skills to their daily lives.

Method

This study employed a Research and Development (R&D) methodology aimed to develop and test the feasibility of a STEM-Proj ect Based Learning (STEM-PjBL) e-module using Google Sites for the solar system topic for sixth-grade elementary school students (Hikmah et al., 2025; Budiarti et al., 2023). The ADDIE development model was used because it is systematic and allows for continuous evaluation of product quality in terms of validity, practicality, and effectiveness. The analysis phase was conducted through observations and interviews at several elementary schools in Tanjung Mutiara District to identify learning needs, curriculum suitability, student characteristics, and teaching materials. The analysis revealed limitations in the use of STEM-based digital teaching materials, so the solar system topic was chosen because it presents an abstract concept that requires visualization and a contextual approach through project-based learning. In the design and development phase, the e-module was designed based on the five-phase STEM-PjBL syntax and developed into an initial prototype using Google Sites. The product was validated by subject matter experts, media experts, and linguists, then revised based on input from the validators until a final prototype was obtained that was suitable for testing. The e-module structure includes learning materials, project activities, interactive media, and evaluation instruments.

The implementation and evaluation phase was conducted through a limited trial in elementary schools using a pretest–posttest design. The practicality of the e-module was analyzed through teacher and student response questionnaires, while effectiveness was analyzed based on learning activities and improved learning outcomes using N-Gain and statistical tests. The evaluation results were used to determine the e-module's suitability as an innovative and effective science learning medium.

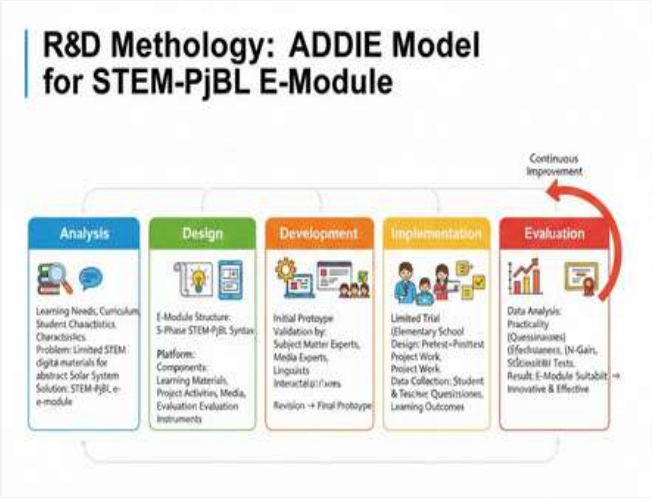

Figure 1. Research scheme

Result and Discussion

The trial was conducted using an e-module in the Solar System learning activity. During the learning process, students were asked to study the material, complete project activities, and follow the instructions and exercises provided in the e-module using Google Sites. After completing the learning activity, students were asked to complete a practicality response questionnaire.

Table 1. Student Questionnaire Results

School	Students (N)	Total Score	Mean Score	Percentage (%)	Category
SDN 20 Pasar Tiku	16	1100	3.44	85.94	Very Practical

Table 2. Teacher Questionnaire Results

Respondent	Items	Total Score	Mean Score	Percentage (%)	Category
SDN 20 Pasar Tiku	20	72	3.60	90.00	Very Practical

Based on the results of the questionnaire data processing in the table above, it is clear that the developed e-module received a percentage of 85.94%, while teachers received 90.00%, indicating it was very easy or practical to use. Students stated that the e-module's instructions were easy to understand, the attractive design, and the project activities helped them grasp the concept of the solar system more concretely. Furthermore, the use of the e-module also increased student interest and engagement during the learning process. Overall, the results of the product trial at SDN 20 Pasar Tiku indicate that the developed STEM-PjBL-based e-module is practical, making it suitable for use as a supporting teaching material in science lessons on the Solar System. These trial results served as the basis for final product revisions before proceeding to the implementation phase.

Trial Results at SDN 25 Pasar Tiku

The STEM-PjBL-based e-module trial was conducted at SDN 25 Pasir Tiku with 23 students as respondents. This trial aimed to determine the practicality, understandability, and appeal of the developed e-module before its wider implementation. The trial was conducted using the e-module, supported by Google Sites, for the Solar System lesson. Students used the e-module as the primary learning resource, following the learning instructions, studying the material, and carrying out the project activities presented in the e-module. After completing the entire learning series, students were asked to complete a practicality questionnaire.

The results of the questionnaire data analysis showed that the developed e-module was easy to use and understand, with 86.36% of students finding it easy to use and understand, while teachers found it 92.50%. The e-module's design was considered attractive, the language used simple and appropriate for elementary school students, and the presentation of the material, accompanied by project activities, helped students better understand the concept of the solar system. Students also stated that using the e-module made the learning process more enjoyable and encouraged their active participation (Song et al., 2021; El-Sabagh, 2021). Overall, the results of the product trial at SDN 25 Pasir Tiku indicated that the developed STEM-PjBL-based e-module was practical, making it suitable for use in science and science teaching on the Solar System. The findings from this trial phase were used as considerations for final product revisions before entering the implementation phase.

Table 3. Student Questionnaire Results

School	Students (N)	Total Score	Mean Score	Percentage (%)	Category
SDN 25 Pasir Tiku	22	1520	3.45	86.36	Very Practical

Table 4. Teacher Questionnaire Results

Respondent	Items	Total Score	Mean Score	Percentage (%)	Category
SDN 25 Pasar Tiku	20	74	3.70	92.50	Very Practical

Implementation took place after the STEM-PjBL-based e-module was revised based on the results of the limited trial and found practical (Yolanda & Yohandri, 2025). The next stage in this development research and development was the product implementation phase. The implementation phase aimed to determine the effectiveness of using the e-module in science and science teaching on the Solar System under actual learning conditions. The product was implemented at SDN 31 Ujung Labung and SDN 32 Muaro Putuih. The selection of these two schools was based on the suitability of student characteristics, the curriculum used, and the availability of digital learning support facilities. At this stage, the e-module was fully utilized in the learning process without any specific guidance from the researcher, thus illustrating the actual use of the product by teachers and students. The implementation was carried out by using the e-module as the primary teaching material in science and science lessons (Rusni et al., 2023).

Students participated in the entire series of learning activities contained in the e-module, from introduction to the material, STEM-based activities, project implementation, and learning evaluation (Oktaviah et al., 2023; Nurfazlina et al., 2025; Hadiyanti et al., 2021). To determine the effectiveness of the product, measurements were conducted through learning outcome tests, observations of student activities, and analysis of improvements in conceptual understanding. After the STEM-PjBL-based e-module was revised based on the results of the limited trial and found to be practical, the next stage in this development research

was the product implementation phase (Alim et al., 2025). The implementation phase aimed to determine the effectiveness of using the e-module in science and science teaching on the Solar System under actual learning conditions (Yenita et al., 2022; Ervana et al., 2022).

The product was implemented at SDN 31 Ujung Labung and SDN 32 Muaro Putuih. The selection of these two schools was based on the suitability of student characteristics, the curriculum used, and the availability of digital learning support facilities. The implementation involved implementing e-modules as the primary learning material in science lessons. Students participated in the entire series of learning activities contained in the e-modules, from introduction to the material and STEM-based activities to project implementation and learning evaluation (Liunima et al., 2025; Septiani & Sukmawati, 2025). To determine the effectiveness of the product, measurements were conducted through learning outcome tests, observations of student activities, and analysis of improvements in conceptual understanding. Based on the N-gain results, the average N-gain score at SDN 31 Ujung Labung was 0.69, which is considered moderate ($0.30 < \text{N-gain} < 0.70$). Converted to a percentage, 0.69 equates to a 69% increase in student understanding from pretest to posttest. This means that the use of the developed modules or learning methods significantly improved student understanding, although not yet at a high level (Tong et al., 2022; Yaseen et al., 2025; Monib et al., 2025).

Meanwhile, at SDN 32 Muaro Putuih, the average N-Gain was 0.77, which is considered high ($\text{N-Gain} \geq 0.70$). Converted to a percentage, this value represents a 77% increase in student understanding from pretest to posttest. This indicates that the learning implemented at SDN 32 Muaro Putuih is highly effective in improving student understanding of the material taught. Based on these results, it can be concluded that the developed learning module has proven effective in improving student understanding, both at SDN 31 Ujung Labung and at SDN 32 Muaro Putuih. The differences in N-Gain levels between schools indicate that the module's effectiveness is also influenced by other factors, such as classroom conditions, student motivation, and teacher teaching style. Therefore, this module is worthy of wider use and can be considered in efforts to improve the quality of learning in elementary schools (Islamiati et al., 2024; Abdulrahaman et al., 2020; Brown et al., 2025).

Conclusion

Based on the results of the research and discussion, it can be concluded that the STEM-PjBL based e-module on the Solar System material for sixth grade elementary school students is proven to be valid, practical, and effective. The validity tested by experts shows that the e-module is suitable for use in terms of material, language, and media. The validity value of media experts is 88% with a very valid category, the validity value of language experts is 97% with a very valid category, the validity value of material experts is 95% with a very valid category. The practicality of the e-module is high, as evidenced by the positive responses of teachers and students during the trial. The practicality value of student responses at SDN 20 Pasar Tiku is 85.94% with a very practical category, the practicality value of teacher responses is 90.00% with a very practical category. While the practicality value of student responses at SDN 25 Pasir Tiku is 86.36% which means very practical and the teacher response value is 92.50% with a very practical category. In addition, student learning outcomes increased significantly after using e-modules, with an average N-Gain value at SDN 31 Ujung Labuang of 0.69 in the medium category with a percentage of 69% which means it is quite effective. and the n-Gain results at SDN 32 Muaro Putuih of 0.77 are in the high category with a percentage of 77% which means Effective. which shows an increase in understanding of the concept of the solar system through the STEM-PjBL approach.

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Author Contributions

Conceptualization; methodology; validation; formal analysis; investigation; S. Y.; resources; data curation; writing—original draft preparation; writing—review and editing; visualization: R. A. All authors have read and approved the published version of the manuscript.

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Conflicts of Interest

The researchers funded this research independently.

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