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The Development of LED-Based Smart Solar System Model to Improve Fifth-Grade Students' Understanding of Science Concepts

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Abstract

This study was motivated by elementary school students' low conceptual understanding of the solar system because the topic involves abstract concepts that are difficult to visualize. This study aimed to develop an LED-based Smart Solar System Model, a three-dimensional learning medium designed to visualize the structure and movement of the solar system for fifth-grade elementary school students, and to determine its feasibility and effectiveness in improving students' conceptual understanding of science. The study employed the Research and Development (R&D) method using the ADDIE model, which consists of the Analysis, Design, Development, Implementation, and Evaluation stages. Data were collected through observations, interviews, documentation, and tests, while the product feasibility was evaluated through expert validation. The results showed that the LED-based Smart Solar System Model was classified as highly feasible, with validation scores of 95% from content experts, 90% from media experts, 96% from pedagogical experts, and 82% from instrument experts. The implementation of the media also improved students' conceptual understanding, as indicated by the increase in the mean score from 52.19 on the pretest to 72.29 on the posttest. The results of the paired-samples t-test yielded a t-value of 8.421 with a significance value of 0.000 ($p < 0.05$), indicating a significant difference between the pretest and posttest scores. These results demonstrate that the LED-based model provides an effective, concrete alternative for teaching abstract astronomical concepts in elementary schools. However, the study was conducted in a single school, warranting further research across broader educational contexts and grade levels.

Keywords: LED Lights Media, Science Conceptual Understanding, Smart Solar System Model

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Abstrak

Penelitian ini dilatarbelakangi oleh rendahnya pemahaman konsep siswa sekolah dasar mengenai tata surya karena materi tersebut bersifat abstrak sehingga sulit divisualisasikan. Penelitian ini bertujuan untuk mengembangkan Smart Solar System Model berbasis teknologi LED, yaitu media pembelajaran tiga dimensi yang dirancang untuk memvisualisasikan susunan dan pergerakan tata surya sehingga membantu siswa kelas V sekolah dasar memahami konsep IPA, serta mengetahui kelayakan dan efektivitas media tersebut dalam meningkatkan pemahaman konsep siswa. Penelitian ini menggunakan metode Research and Development (R&D) dengan model ADDIE yang meliputi tahapan Analysis, Design, Development, Implementation, dan Evaluation. Teknik pengumpulan data dilakukan melalui observasi, wawancara, dokumentasi, serta tes. Kelayakan produk dinilai melalui validasi oleh ahli materi, ahli media, ahli pedagogik, dan ahli instrumen. Hasil penelitian menunjukkan bahwa Smart Solar System Model berbasis teknologi LED memperoleh kategori sangat layak, dengan persentase penilaian sebesar 95% dari ahli materi, 90% dari ahli media, 96% dari ahli pedagogik, dan 82% dari ahli instrumen. Penggunaan media juga meningkatkan pemahaman konsep siswa, yang ditunjukkan oleh peningkatan nilai rata-rata dari 52,19 pada pretest menjadi 72,29 pada posttest. Hasil uji Paired Sample t-Test menunjukkan nilai t sebesar 8,421 dengan nilai signifikansi 0,000 ($p < 0,05$), yang menunjukkan adanya perbedaan yang signifikan antara hasil pretest dan posttest. Hasil-hasil ini menunjukkan bahwa model berbasis LED merupakan alternatif yang efektif dan konkret untuk mengajarkan konsep-konsep astronomi yang abstrak di sekolah dasar. Namun, penelitian ini dilakukan di satu sekolah saja, sehingga diperlukan penelitian lebih lanjut di berbagai konteks pendidikan dan jenjang kelas yang lebih luas.

Kata Kunci: Smart Solar System Model, Media Lampu LED, Pemahaman Konsep Sains

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INTRODUCTION

Education plays a fundamental role in improving the quality of human resources and preparing individuals to adapt to the rapid development of science, technology, and society. As a lifelong process, education is expected to develop students' knowledge, skills, attitudes, and competencies that enable them to solve real-life problems and contribute positively to society. To achieve these educational goals, the curriculum serves as the primary guideline for planning, implementing, and evaluating learning activities. In Indonesia, the implementation of the Merdeka Curriculum emphasizes student-centered learning that encourages students to develop critical thinking, creativity, communication, collaboration, and problem-solving skills through meaningful learning experiences (Amalia et al., 2025; Gumilar, 2023).

One of the compulsory subjects implemented under the Merdeka Curriculum is Natural and Social Sciences (IPAS). IPAS integrates concepts from natural and social sciences to help students understand natural phenomena and social issues through scientific inquiry and real-world contexts (Gumilar, 2023). The learning process is expected not only to improve students' knowledge but also to develop scientific literacy, higher-order thinking skills, and conceptual understanding that can be applied in everyday life. However, previous studies have reported that the implementation of IPAS learning in elementary schools still encounters several challenges, including limited instructional media, low student participation, and teachers' difficulties in presenting abstract scientific concepts effectively (Ramadhani & Amelia, 2025; Susilowati et al., 2025). These problems were also identified during the preliminary study conducted at the research site. Classroom observations and interviews with the fifth-grade teacher indicated that students experienced difficulties in understanding the solar system because the topic contains abstract concepts that are difficult to visualize, while the available instructional media were still limited. Consequently, students' conceptual understanding of the solar system remained low.

One of the most challenging topics in elementary IPAS is the solar system. The topic contains abstract concepts because celestial objects cannot be directly observed during classroom learning. Consequently, many students experience difficulties in understanding the characteristics of planets, explaining the relationships among celestial bodies, and visualizing the structure of the solar system. Learning activities that depend primarily on textbooks and teacher explanations often fail to provide meaningful learning experiences, resulting in misconceptions and low conceptual understanding. Therefore, there is a need for instructional media that can transform abstract concepts into concrete visual representations and actively engage students in the learning process. Previous studies have recommended the use of interactive and concrete instructional media to help students visualize abstract concepts more effectively and improve their understanding of the solar system (Elvadola et al., 2023).

Conceptual understanding is one of the most important learning outcomes in science education because it reflects students' ability to explain concepts in their own words, classify objects according to their characteristics, distinguish examples from non-examples, and apply concepts to solve problems in different situations (Amin et al., 2018). Students with strong conceptual understanding are more capable of connecting new knowledge with their previous learning, resulting in meaningful and long-lasting learning experiences. Research has shown that meaningful learning supported by appropriate instructional media contributes significantly to improving students' conceptual understanding (Damayanti & Abimanyu, 2025).

Several studies have developed instructional media for teaching the solar system, including interactive multimedia, three-dimensional models, and digital learning applications (Kusumaningtyas et al., 2025; Yuniarti et al., 2024). These studies have demonstrated positive

impacts on students' motivation and learning outcomes. However, most existing studies focus on either conventional physical models or digital media separately (Anisa et al., 2025; Nadzif et al., 2022). Although several solar system models utilize lighting as a visual aid, most of them function only as demonstration media and provide limited opportunities for students to interact directly with the learning process. Moreover, previous studies have not specifically integrated LED-based visualization into a three-dimensional instructional medium designed to facilitate elementary school students' conceptual understanding of the solar system. Studies integrating LED lighting technology into a three-dimensional Smart Solar System Model to improve elementary school students' conceptual understanding of IPAS remain limited. In this study, the Smart Solar System Model is defined as a three-dimensional instructional medium equipped with LED lighting to visualize planetary positions and characteristics, allowing students to observe abstract concepts more concretely during science learning. Therefore, there is a need to develop an innovative instructional medium that combines concrete visualization with interactive technology to provide more meaningful learning experiences (Abbas et al., 2020).

Based on this research gap, this study develops an LED-Based Smart Solar System Model for fifth-grade elementary school students. The developed media combines a three-dimensional solar system model with LED lighting technology to visualize planetary positions and characteristics more realistically. This study aims to develop the instructional media, evaluate its feasibility through expert validation, and examine its effectiveness in improving students' conceptual understanding of IPAS. Accordingly, this study seeks to answer the following questions: (1) How feasible is the LED-Based Smart Solar System Model for use in elementary science learning? and (2) To what extent is the developed instructional media effective in improving fifth-grade students' conceptual understanding of the solar system? The findings are expected to contribute to the development of innovative instructional media, enrich the literature on elementary science education, and provide practical guidance for teachers in implementing more engaging and meaningful IPAS learning.

METHODS

This study employed the Research and Development (R&D) method using the ADDIE development model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected because it provides a systematic framework for developing educational products, beginning with needs analysis and continuing through product design, development, implementation, and evaluation (Fauziah & Rohmah, 2024). The Research and Development approach aims not only to produce an educational product but also to evaluate its feasibility and effectiveness before it is implemented in the learning process.

To evaluate the effectiveness of the developed instructional media, this study employed a pre-experimental research design, specifically the one-group pretest–posttest design. This design involved a single experimental group without a control group. Although the one-group pretest–posttest design is susceptible to internal validity threats, such as maturation and testing effects, these potential threats were minimized by administering the pretest and posttest within the same instructional period, using the same teacher, learning materials, instructional duration, and classroom setting throughout the study. Students completed a pretest before the implementation of the LED-Based Smart Solar System Model and a posttest after participating in the learning activities. The comparison between the pretest and posttest scores was used to determine the

effectiveness of the developed instructional media in improving students' conceptual understanding of Natural and Social Sciences (IPAS).

The study was conducted at SDN Tengah 03 Jakarta, a public elementary school. The participants consisted of 32 fifth-grade students. During the Analysis stage, classroom observations, teacher interviews, and curriculum analysis were conducted to identify students' learning characteristics, difficulties in understanding the solar system topic, the availability of instructional media, and learning needs that served as the basis for developing the LED-Based Smart Solar System Model. During the Design stage, the prototype of the LED-Based Smart Solar System Model was designed by determining the media specifications, preparing the storyboard, developing instructional materials, formulating learning objectives and indicators, and designing the research instruments. During the Development stage, the instructional media were produced based on the approved design and subsequently validated by content experts, media experts, pedagogical experts, and instrument experts. Suggestions from the experts were used to revise and improve the product before classroom implementation. During the Implementation stage, the revised instructional media were implemented in classroom learning involving the research participants. Students completed the pretest before using the media and the posttest after the learning activities to evaluate the effectiveness of the developed instructional media. Finally, during the Evaluation stage, the developed instructional media were evaluated based on expert validation results, students' conceptual understanding test scores, and feedback obtained during classroom implementation. The evaluation results were used to make final revisions to the developed instructional media (Fauziah & Rohmah, 2024).

The data collection techniques employed in this study included observation, interviews, expert validation, and tests. Classroom observations and teacher interviews were conducted to obtain information regarding learning conditions, students' characteristics, and the challenges encountered in teaching the solar system topic. Expert validation was carried out by content experts, media experts, pedagogical experts, and instrument experts to evaluate the quality, content accuracy, instructional design, and feasibility of the developed instructional media. Students' conceptual understanding was measured using pretest and posttest instruments administered before and after the implementation of the LED-Based Smart Solar System Model. The research instruments consisted of observation sheets, interview guidelines, expert validation sheets, and conceptual understanding test items that were validated prior to their use to ensure the validity and reliability of the collected data (Wartoni & Benyamin, 2020). At the Analysis stage, observation sheets and interview guidelines were used to collect data on learning conditions and students' needs. During the Development stage, expert validation sheets were employed to evaluate the feasibility of the developed instructional media. During the Implementation stage, validated pretest and posttest instruments were administered to measure students' conceptual understanding after learning with the developed instructional media.

The collected data were analyzed using both qualitative and quantitative approaches. Qualitative data obtained from observations, interviews, and experts' suggestions were analyzed descriptively and used to revise and improve the instructional media. Quantitative data obtained from expert validation were analyzed using feasibility percentages to determine the appropriateness of the developed instructional media. Students' conceptual understanding scores were analyzed descriptively by calculating the mean, minimum score, maximum score, and standard deviation. Before hypothesis testing, a Shapiro–Wilk normality test was conducted as a prerequisite for parametric statistical analysis. Since the data were normally distributed, the effectiveness of the LED-Based Smart Solar System Model in improving students' conceptual

understanding was analyzed using a Paired Sample t-Test in SPSS with a significance level of 0.05. The developed instructional media were considered effective if a statistically significant difference was found between the pretest and posttest scores.

RESULTS AND DISCUSSION

Product Development

This study produced a Smart Solar System Model, an instructional medium based on LED lighting technology, developed using the ADDIE model. The tool was designed to help students understand the concept of the solar system through concrete and interactive visualizations. The developed product consists of a three-dimensional model representing the Sun and eight planets, constructed from Styrofoam balls of different sizes to illustrate the relative characteristics of each planet. The planets are mounted on supporting rods and arranged according to the order of the solar system on a circular base equipped with an information board containing the names and basic characteristics of each planet. LED lights are installed at the center of the model to represent the Sun as the primary light source. The LED circuit is connected to a switch and powered by a low-voltage electrical source, allowing the light to illuminate the model during classroom instruction. The use of a physical three-dimensional model was chosen because elementary school students are in the concrete operational stage of cognitive development and therefore learn abstract scientific concepts more effectively through direct observation and manipulation of tangible learning media. The developed product displays the arrangement of planets in the solar system with additional LED lights as a light source, allowing students to observe the position and characteristics of each planet more clearly.

Figure 1. LED-Based Smart Solar System Model

The educational media developed was then validated by subject matter experts, media experts, pedagogical experts, and instrument experts before being implemented with students. The validation results indicate that the educational media developed at falls into the category of "highly suitable" for use in IPAS instruction on the solar system.

Product Validation Results

The experts' assessment results showed that the media received a "highly suitable" rating. The subject matter expert validation scored 95%, the media expert validation scored 90%, the pedagogical expert validation scored 96%, and the instrument expert validation scored 82% (see Table 1). Based on the validation results, the Smart Solar System Model, which utilizes LED lighting technology, meets the criteria for suitability for use in the learning process.

Table 1. Media Validation Results

Validator	Percentage (%)	Category
Content Expert	95%	Highly Feasible
Media Expert	90%	Highly Feasible
Pedagogical Expert	96%	Highly Feasible
Instrument Expert	82%	Highly Feasible

Effectiveness of the Media on Conceptual Understanding

The effectiveness of the media was determined by comparing students' pretest and posttest results. The research results showed an increase in concept comprehension scores following the use of the LED-based Smart Solar System Model. The students' average score increased from 52.19 on the pretest to 72.29 on the posttest (see Table 2). These findings indicate that the developed media is capable of helping students better understand the concept of the solar system. The results of the hypothesis testing indicate a significant difference between the scores before and after the use of the teaching aid. Thus, the Smart Solar System Model teaching aid, which utilizes LED lighting technology, is deemed effective in enhancing students' conceptual understanding.

Table 2. Comparison of Pretest and Posttest Results

Data	Pretest	Posttest
Mean Score	52.19	72.29

Before hypothesis testing was conducted, the normality of the pretest and posttest data was first tested using the Shapiro-Wilk test. This test aims to determine whether the data distribution is normal, as this is one of the requirements for using parametric statistics. The results of the normality test are presented in Table 3.

Table 3. Results of the Shapiro-Wilk Normality Test

Variable	Statistic	df	Sig.	Interpretation
Pretest	0.966	32	0.403	Normal
Posttest	0.973	32	0.592	Normal

Based on Table 3, the Shapiro–Wilk significance (Sig.) values were 0.403 for the pretest data and 0.592 for the posttest data. Both values were greater than 0.05 (Sig. > 0.05), indicating that the pretest and posttest data were normally distributed.

Hypothesis testing was conducted using a Paired Sample t-Test to determine the difference in students' conceptual understanding before and after the implementation of the LED-Based Smart Solar System Model. The results of the hypothesis test are presented in Table 4.

Table 4. Results of the Paired Sample t-Test

Variable	Mean Difference	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Posttest–Pretest	20.10	13.51	2.39	8.421	31	0.000

Based on Table 4, the mean difference between the pretest and posttest scores was 20.10. The results of the Paired Sample t-Test revealed a calculated t-value of 8.421 with a significance value of 0.000. Since the significance value was lower than 0.05 (0.000 < 0.05), a statistically significant difference was found between the pretest and posttest scores. These findings indicate that the LED-Based Smart Solar System Model was effective in improving the conceptual understanding of IPAS among fifth-grade elementary school students. Since the normality assumption was satisfied, a parametric statistical analysis using the Paired Sample t- Test could be applied to examine the effectiveness of the LED-Based Smart Solar System Model in enhancing students' conceptual understanding of IPAS.

Discussion

The research results indicate that the Smart Solar System Model educational media, based on LED lighting technology, was rated as "highly feasible" based on validation scores of 95% from content experts, 90% from media experts, 96% from pedagogical experts, and 82% from instrument experts. These high validation percentages indicate that the developed media meets the criteria for content, presentation, ease of use, and suitability for the characteristics of elementary school students. The high feasibility of the media indicates that the development process conducted using the ADDIE model is capable of producing learning products that align with students' needs and learning objectives. This aligns with the view of Adeoye et al. (2024), who state that the ADDIE model is a systematic development model that allows for evaluation at every stage, resulting in more focused and high-quality products.

The Smart Solar System Model, based on LED lighting technology, was developed with the characteristics of elementary school students in the concrete operational stage in mind. At this stage, students tend to grasp concepts more easily when they are presented through objects that can be directly observed and manipulated. Therefore, the use of a three-dimensional solar system model equipped with LED lights helps students visualize the relationships between the planets and the position of the Sun more vividly. This finding supports the opinion of Sadewi et al. (2020), who explain that concrete media can provide direct learning experiences, making learning more meaningful and leaving a deeper impression on students.

In addition to demonstrating a high level of feasibility, the developed media was also proven effective in improving students' conceptual understanding. This improvement can be attributed to the characteristics of the Smart Solar System Model, which combines a three-dimensional representation of the solar system with LED lighting technology to transform abstract concepts into concrete learning experiences. Through direct observation of the relative positions of the planets and the representation of the Sun using LED lighting, students were able to visualize concepts that are difficult to understand through textbooks or verbal explanations alone. As a result, students became more actively involved in the learning process, enabling them to construct

conceptual understanding through observation and interaction with the instructional media. The research results showed an increase in the average score from 52.19 on the pretest to 72.29 on the posttest. These findings indicate that the developed media supported students in understanding the solar system more meaningfully by providing concrete visualization of abstract scientific concepts. According to Melati et al. (2025), conceptual understanding is demonstrated not only through the ability to recall information but also through the ability to explain, interpret, and connect concepts to relevant situations.

This improved conceptual understanding is also supported by the concrete and interactive nature of the media. The use of concrete media allows students to directly observe the shapes, positions, and arrangements of the planets, making previously abstract concepts easier to understand. This finding aligns with the results of a study by Melyandina and Awiria (2023), which states that the use of concrete media can increase students' engagement in learning because they are directly involved in the learning process. Additionally, Sadewi et al. (2020) explain that concrete media can reduce verbalism in learning and help students connect lesson material with their real-life experiences.

The significant improvement in students' conceptual understanding indicates that the Smart Solar System Model contributed positively to the learning process by facilitating concrete visualization and active learning experiences. Rather than relying solely on verbal explanations, students were able to observe the arrangement of the planets directly and relate the learning material to visual representations provided by the model. This learning experience helped reduce the abstract nature of the solar system topic and enabled students to construct a better understanding of scientific concepts. According to Damayanti and Abimanyu (2025), meaningful learning occurs when students are able to connect new information with their existing knowledge structures. The use of the Smart Solar System Model facilitates this process through concrete visualization, making the concept of the solar system easier to understand and remember.

When viewed from the perspective of conceptual understanding indicators, the use of this media helps students rephrase concepts in their own words, provide examples and counterexamples, classify celestial objects, and apply concepts in daily life. This aligns with the indicators of conceptual understanding proposed by Marchilia et al. (2024), namely the ability to explain concepts, provide examples, identify non-examples, classify objects based on specific characteristics, and apply concepts in various situations. Therefore, the improvement in students' learning outcomes indicates that the developed media successfully supports the achievement of these indicators of conceptual understanding.

The primary advantage of the developed Smart Solar System Model lies in the combination of a three-dimensional model with LED lighting technology to represent the Sun. The use of LED lights provides greater visual appeal compared to conventional teaching aids, thereby enhancing students' attention and motivation to learn. Mulyosari and Khosiyono (2023) stated that learning media serve to clarify the delivery of messages, increase students' attention, and help create a more effective learning experience. Thus, the use of LED lights in this media serves not only as an aesthetic element but also as a means to clarify the concepts being studied.

Although this study focused primarily on cognitive gains measured through objective pretest and posttest instruments, the tactile and manipulative nature of the LED-based model naturally stimulates students' collaborative engagement and hands-on exploratory skills. In this context, Cahayu et al. (2023) emphasize the necessity of integrating non-test evaluation instruments to assess affective and psychomotor domains, which are crucial for cultivating 21st-century science competencies. Therefore, future implementations should incorporate

comprehensive observation rubrics alongside cognitive tests to thoroughly evaluate how direct physical interactions with the model develop students' practical inquiry skills and scientific attitudes.

CONCLUSION

This study successfully developed an LED-Based Smart Solar System Model as an instructional medium for Natural and Social Sciences (IPAS) learning using the ADDIE development model, which consists of the Analysis, Design, Development, Implementation, and Evaluation stages. The results of expert validation indicated that the developed instructional media met the feasibility criteria in terms of content, media design, pedagogy, and research instruments, demonstrating that it is appropriate for classroom implementation.

The effectiveness test further revealed that the use of the LED-Based Smart Solar System Model significantly improved fifth-grade students' conceptual understanding of the solar system. The comparison between the pretest and posttest scores showed a significant increase in students' learning achievement after using the developed instructional media. These findings indicate that integrating three-dimensional visualization with LED technology can transform abstract concepts into more concrete and meaningful learning experiences, thereby enhancing students' conceptual understanding and engagement in IPAS learning.

Overall, this study demonstrates that the LED-Based Smart Solar System Model is both feasible and effective as an innovative instructional medium for elementary school science education. The findings contribute to the development of technology-supported learning media and provide an alternative instructional resource for improving conceptual understanding in IPAS learning.

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REFERENCES

Abbas, B., Halimah, A., Nursalam, N., & Mattoliang, L. A. (2020). Pengembangan media pembelajaran interaktif berbasis multimedia. *Al Asma : Journal of Islamic Education, 2*(1), 97–110. https://doi.org/10.24252/asma.v2i1.13380

Adeoye, M. A., Wirawan, K. A. S. I., Pradnyani, M. S. S., & Septiarini, N. I. (2024). Revolutionizing education: Unleashing the power of the ADDIE model for effective teaching and learning. *Jurnal Pendidikan Indonesia, 13*(1), 202–209. https://doi.org/10.23887/jpiundiksha.v13i1.68624

Amalia, E. N., Ramadhani, P., Rossianti, Y. A., Parsha, S., Khoirunnisa, K., & Budiono, H. (2025). Problematika guru dalam pembelajaran IPA pada Kurikulum Merdeka. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 10*(2), 289–300. https://doi.org/10.23969/jp.v10i02.24241

Anisa, N. F., Panjaitan, A. D. U., Tanjung, Y. I., & Fairuz, T. (2025). Systematic literature review: The influence of learning media on student learning outcomes on solar system material. *Indonesian Science Education Research, 7*(1), 48–57. https://doi.org/10.24114/iser.v7i1.68224

Amin, D. I., Sutrisno, S., & Sigit, D. (2018). Instrumen asesmen pemahaman konseptual berorientasi higher order thinking skills keterampilan proses dan sikap terhadap sains pada bahan kajian hidrokarbon dan minyak bumi. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan, 3*(9), Article 5. https://doi.org/10.17977/jptpp.v3i9.13342

Gumilar, E. B. (2023). Problematika pembelajaran IPA pada kurikulum merdeka di sekolah dasar/ madrasah ibtidaiyah. *Jurnal Pedagogy, 16*(1), 129–145. https://doi.org/10.63889/pedagogy.v16i1.159

Cahayu, S. A., Sampurna, R., Nadira, N., & Risnita, R. (2023). Instrumen evaluasi non-tes ranah afektif dan psikomotorik pembelajaran IPA berbasis keterampilan abad ke-21. *EDU-BIO: Jurnal Pendidikan Biologi*, *6*(2), 1–13. https://doi.org/10.30631/edubio.v6i2.53

Damayanti, A. I., & Abimanyu, A. (2025). The application of David Ausubel's theory of meaningful learning in enhancing students' conceptual understanding. *Indonesian Journal of Educational Technology, 4*(1), 51–59. https://doi.org/10.26858/ijet.v4i1.8044

Elvadola, C., Juwantara, R. A., Kurniasih, T. I., & Rasitiani, A. . (2023). Pengembangan media interaktif tata surya pada pembelajaran untuk meningkatkan hasil belajar IPA kelas VI SDN 1 Gunung Terang. P*edagogia: Jurnal Ilmiah Pendidikan Dasar Indonesia*, *5*(1), 149–156. https://doi.org/10.52217/pedagogia.v5i1.1219

Fauziah, E., & Rohmah, U. S. (2024). Pengembangan materi dan bahan ajar PAI dengan model Dick and Carey. *Social Science Academic, 2*(1), 67–78. https://doi.org/10.37680/ssa.v2i1.4740

Kusumaningtyas, A. W., Luky, Z. S., Putri, N. K., & Thohir, M. A. (2025). The use of method design thinking in making solar system learning media for elementary school students. *JP2SD (Jurnal Pemikiran dan Pengembangan Sekolah Dasar), 13*(1), 81–93. https://doi.org/10.22219/jp2sd.v13i1.34100

Marchilia, E., Wahyun, R., & Hendriana, E. C. (2024). Penerapan model pembelajaran discovery learning berbasis budaya terhadap kemampuan pemahaman konsep matematis siswa kelas V pada mata pelajaran matematika SDN 7 Serukam. *Pendas: Jurnal Ilmiah Pendidikan Dasar, 9*(3), 232–239. https://doi.org/10.23969/jp.v9i03.17612

Melati, B. C., Suwarna, P. I., & Hertanti, E. (2025). Comparative study of students' conceptual understanding in two different curricula on the light and electromagnetic waves materials. *Jurnal Pendidikan Matematika dan Sains, 13*(2), 347–359. https://doi.org/10.21831/jpms.v13i2.87915

Melyandina, S., & Awiria, A. (2023). Implementasi media maket terhadap pemahaman belajar siswa pada pelajaran IPA materi sistem tata surya SD. *Education Journal of Bhayangkara, 3*(2), 153–160. https://doi.org/10.31599/edukarya.v3i2.2645

Mulyosari, E. T., & Khosiyono, B. H. C. (2023). Pengaruh penggunaan media pembelajaran berbasis teknologi dalam pembelajaran terhadap motivasi belajar siswa sekolah dasar. *Edukatif: Jurnal Ilmu Pendidikan, 5*(6), 2395–2405. https://doi.org/10.31004/edukatif.v5i6.5037

Nadzif, M., Irhasyuarna, Y., & Sauqina, S. (2022). Pengembangan media pembelajaran interaktif IPA berbasis Articulate Storyline pada materi sistem tata surya SMP. *JUPEIS Jurnal Pendidikan dan Ilmu Sosial, 1*(3), 17–27. https://doi.org/10.55784/jupeis.Vol1.Iss3.69

Ramadhani, A., & Amelia, F. R. (2025). Kendala dan tantangan pembelajaran IPA di UPT SD Negeri 064995 Kota Medan dalam implementasi Kurikulum Merdeka. *Jurnal Penelitian Ilmu Pendidikan Indonesia, 4*(2), 1150–1155. https://doi.org/10.31004/jpion.v4i2.547

Sadewi, K. I. A., Ardana, I. K., & Wiyasa, I. K. N. (2020). Model pembelajaran generatif berbantuan media konkret terhadap kompetensi pengetahuan IPA. *Journal for Lesson and Learning Studies, 3*(2), 203–211. https://doi.org/10.23887/jlls.v3i2.26810

Susilowati, D., Saputro, B. A., & Sutono, A. (2025). The effect of strengthening the literacy movement in natural and social sciences (IPAS) learning on improving students' scientific literacy and critical thinking skills. *Primary: Jurnal Pendidikan Guru Sekolah Dasar, 14*(1), 11–28. https://doi.org/10.33578/jpfkip-v14i1.p11-28

Wartoni, W., & Benyamin, P. I. (2020). Strategi pengembangan tes objektif (pilihan ganda). *Diegesis: Jurnal Teologi, 5*(1), 1–8. https://doi.org/10.46933/DGS.vol5i1%25p

Yuniarti, H., Sholikah, R., Agustin, R. D., Matsuri, M., & Sulastri, S. (2024). Pemanfaatan media pembelajaran 3D sistem tata surya untuk meningkatkan minat belajar peserta didik pada mata pelajaran IPAS kelas VI SDN 01 Klodran. *Social, Humanities, and Educational Studies (SHES): Conference Series, 7*(4), 440. https://doi.org/10.20961/shes.v7i4.97104