



# Ethnopedagogy of IPAS Armed with Pancasila and Artificial Intelligence as a 21<sup>st</sup> Century Learning Revolution

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**Abstract:** This study offers a comprehensive overview of the planning, implementation, and evaluation of innovative Science, Social, and Natural Sciences (IPAS) learning in elementary schools. The approach specifically integrates ethnopedagogy with Pancasila Education, while exploring the transformative potential of deep learning for personalized instruction. The research employed an exploratory sequential mixed-methods design, beginning with quantitative data collection and analysis, followed by qualitative data to deepen the understanding of the quantitative results. This method allowed for a holistic view of the effectiveness of IPAS learning based on ethnopedagogy and Pancasila Education, encompassing both quantitative aspects (increased interest and understanding) and qualitative aspects (implementation processes and perceptions). Key findings indicate that integrating ethnopedagogy and Pancasila Education in IPAS learning significantly increased student interest ( $p < 0.01$ ) and substantially improved IPAS conceptual understanding. Furthermore, this approach strengthened the Pancasila Student Profile dimensions. Student interest showed an average increase of 26.15%, while IPAS conceptual understanding rose by an average of 20%, both with  $p$ -values less than 0.01, signifying high statistical significance. The study's uniqueness lies in its holistic mixed-methods analysis of the synergy between ethnopedagogy, IPAS, and Pancasila Education. Additionally, it offers a visionary contribution by discussing the role of deep learning in driving a 21<sup>st</sup>-century learning revolution to create adaptive and personalized learning environments. The results provide a relevant implementation model for developing 21<sup>st</sup>-century competencies and excellent student character, aiming to guide educators and policymakers.

**Keywords:** 21<sup>st</sup> century competencies; Deep learning; Ethnopedagogy; IPAS; Pancasila education; Pancasila learner profile

## Introduction

### *The Critical Role of IPAS Learning and Existing Challenges*

Natural and Social Sciences (IPAS) learning plays a crucial role in shaping learners' scientific and social literacy, which is essential for understanding the complexity of the contemporary world (Cahyono & Widodo, 2018; Hidayat & Nurhayati, 2019). However, the IPAS curriculum in Indonesia often faces challenges of contextual relevance and the integration of local values. This can potentially create a gap between

teaching materials and the reality of students' lives. This phenomenon not only reduces students' interest in learning but also hinders the development of holistic character relevant to the nation's identity (Astuti & Dewi, 2018; Sari & Putra, 2019).

The gap between curriculum material and students' lived realities, as well as the lack of integration of local values, can directly undermine cognitive engagement and affective development. If curriculum design is not rooted in students' culture and context, it can directly reduce learning interest and impede comprehensive

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character formation. This indicates that for learning to be truly effective and holistic, it must align with students' life experiences and cultural backgrounds. A curriculum that neglects this aspect risks superficial engagement and fails to foster deeper identity and values.

#### *The Emergence of Ethnopedagogy and Pancasila Education as Solutions*

In addressing these challenges, the ethnopedagogy approach emerges as an innovative strategy that integrates local wisdom and culture into the learning process. This approach makes the learning experience more meaningful and contextual. Ethnopedagogy enables students to connect IPAS concepts with their socio-cultural reality, fostering an appreciation for local heritage and building a strong self-identity (Saputra & Rizky, 2019; Jannah & Rohman, 2021; Susanto & Prabowo, 2020; Sukmana & Arifin, 2021; Suryani & Pratama, 2021). Furthermore, the integration of Pancasila Education is crucial to ensure that IPAS learning not only develops knowledge and skills but also instills national values that form the foundation of the Pancasila Student Profile character. This integration has the potential to create citizens who are not only intellectually capable but also possess noble character, mutual cooperation, independence, critical reasoning, creativity, and global diversity (Lestari & Hadi, 2023; Nugraha & Setiawan, 2021).

The synergy between ethnopedagogy and Pancasila Education is presented as a comprehensive solution that addresses both cognitive (meaningful IPAS concepts) and affective/character (local heritage, national values, Pancasila Student Profile) domains. The combination of these two approaches collectively addresses various layers of student development: cognitive understanding of IPAS, cultural appreciation, personal identity, national values, and specific character profiles. This indicates that the goal of education extends beyond mere content delivery to include the formation of identity and civic responsibility, signaling a paradigm shift from a purely knowledge-based learning to a more integrated and value-oriented educational model.

#### *Unique Contribution of the Study and Its Relevance in the 21<sup>st</sup> Century*

Despite the significant potential of ethnopedagogy and Pancasila Education, research that comprehensively examines their synergy in IPAS integration, with an in-depth mixed-methods approach, the use of deep learning approaches, and an explicit exploration of the transformative potential of artificial intelligence (AI) for personalization and adaptation of learning at the elementary school level, is still very limited.

Therefore, the uniqueness of this study lies in three main aspects, first the use of an explanatory sequential

mixed methods design for a holistic analysis of the entire learning cycle of ethnopedagogy-based IPAS and Pancasila Education; second the presentation of a detailed and practical implementation model; and third a visionary discussion of the role of deep learning as a driver of the 21<sup>st</sup>-century learning revolution, creating an adaptive and personalized learning environment, a topic not widely discussed in the context of ethnopedagogy in basic education.

The identified research gap and the uniqueness of this study highlight the future trajectory in educational research. It is not merely about proving effectiveness but about exploring how traditional pedagogical approaches (ethnopedagogy) can be synergized with cutting-edge technology (AI/deep learning) to meet the demands of future education, particularly personalization. This indicates a shift towards integrated and interdisciplinary solutions. This study is expected to serve as a guide for teachers and policymakers in developing innovative, character-based learning models relevant to the demands of the 21<sup>st</sup> century, including the utilization of the latest technology (Dewi & Puspitasari, 2020; Putra & Wijaya, 2022; Utami & Santoso, 2023).

## **Method**

### *Explanatory Sequential Mixed Methods Approach*

This study employs a mixed methods approach with an explanatory sequential design. This design begins with quantitative data collection and analysis in the first phase, followed by qualitative data collection and analysis in the second phase to help explain the quantitative results in more depth (Creswell & Poth, 2018; Sugiyono, 2017). This approach allows researchers to obtain a comprehensive picture of the effectiveness of ethnopedagogy-based IPAS learning and Pancasila Education, both from quantitative (increased interest and understanding) and qualitative (implementation process and perception) aspects.

The choice of an explanatory sequential mixed methods design is a deliberate and robust one for this type of research. This approach allows the study to move beyond merely knowing what happened (quantitative results) to understanding how and why it happened (qualitative insights). This provides a much richer and more actionable understanding of the intervention's success. By combining the "what" (quantitative results) with the "how" and "why" (qualitative processes and perceptions), the study gains a deeper, more nuanced understanding of the intervention's effectiveness. This approach is particularly powerful for educational interventions, as it can uncover the underlying mechanisms of change and identify contextual factors that contribute to success, making the findings more transferable and robust.

### *Research Subjects and Sampling Strategy*

The subjects of this study were students and teachers at SDN 2 Tambongwetan. This school was chosen due to its commitment to implementing an innovative curriculum that integrates local wisdom. The qualitative subjects (teachers and students) were selected using purposive sampling to identify key informants directly involved in the learning process.

### *Instruments and Data Collection Techniques*

Data collection was carried out using validated instruments and various techniques, including learning interest questionnaire: Used to measure the level of students' learning interest before (pre-test) and after (post-test) the implementation of learning. This questionnaire uses a Likert scale and has undergone validity and reliability tests. IPAS concept understanding test: Measures students' understanding of the IPAS concepts taught, with questions that integrate aspects of local wisdom and Pancasila values. This test was also administered as a pre-test and post-test and has been validated by experts. In-depth interviews: Conducted with IPAS teachers and selected student representatives. Structured interviews explored information regarding the planning, implementation strategies, challenges, and evaluation of learning, as well as their perceptions of the integration of local wisdom and Pancasila Education (Moleong, 2017). Participatory observation: Researchers conducted direct observations during the learning process, focusing on teacher and student interactions, implementation of teaching modules, student participation, and manifestations of Pancasila values. The observation sheet was equipped with a clear indicator grid (Bogdan & Biklen, 2007). Documentation study conducted to analyze documents such as the IPAS Teaching Module (Learning Design) based on ethnopedagogy and Pancasila Education, presentation materials, and teacher learning notes.

### *Data Analysis Techniques and Validity Measures*

The data analysis techniques used include quantitative data analysis, data from the learning interest questionnaire and concept understanding test were analyzed using descriptive statistics (mean, standard deviation) to describe the initial and final conditions. To test the significance of the improvement, a paired-samples t-test was used with the aid of SPSS software. Qualitative data analysis, the collected data were analyzed using Miles et al. (2014) interactive model, which includes data reduction through the process of selecting, focusing, simplifying, and transforming raw data. Data presentation of the reduced data in the form of descriptive narratives, matrices, or charts; Conclusion drawing/verification, which is done tentatively and then verified by seeking supporting

evidence. This process is iterative and comparative (Miles et al., 2014).

The validity of qualitative data was ensured through source triangulation (teachers, students, documents) and method triangulation (interviews, observations, documentation) (Denzin & Lincoln, 2018). For quantitative data, instrument validity was tested through content validity (expert judgment) and construct validity (correlation test), while reliability was measured using Cronbach's Alpha coefficient.

The extensive steps for validity and reliability across both quantitative and qualitative data types (triangulation, expert validation, statistical tests) significantly enhance the credibility and generalizability of the study's findings. This methodological rigor provides a strong foundation for the conclusions drawn, especially important for innovative pedagogical approaches. The application of these diverse validation techniques means that the study's findings are not merely anecdotal or coincidental. Triangulation across different data sources and methods, in particular, strengthens confidence in the qualitative insights, while statistical validation supports the quantitative results. This methodological thoroughness makes the conclusions highly trustworthy and provides a solid basis for recommending the approach for wider implementation.

## **Result and Discussion**

### *Curriculum Planning and Material Integration*

The IPAS learning planning at SDN 2 Tambongwetan demonstrates an innovative and integrated approach. Teachers developed Teaching Modules that explicitly contain learning objectives aligning IPAS achievements with Pancasila values and local wisdom.

For example, the topic of the water cycle and its utilization is integrated with local wisdom such as the tradition of protecting springs and traditional irrigation systems, while instilling the value of Belief in One Supreme God as a form of gratitude and exemplifying the value of social justice seen in the fair distribution of water supply material. The developed teaching materials are equipped with visual illustrations and stories relevant to the local context, making them more interesting and easier for students to understand (Susanto & Wulandari, 2021; Wibowo & Suryani, 2022; Yuliani & Fitriani, 2023). Teachers also designed learning scenarios that encourage discussions, group work, and authentic problem-based projects, demonstrating a shift from passive reception to active knowledge construction.

The detailed planning and examples in Table 1 demonstrate the successful operationalization of abstract educational concepts (ethnopedagogy, Pancasila values, 21<sup>st</sup>-century skills) into concrete, teachable units. This is a significant achievement, as often such concepts remain theoretical without a clear implementation pathway. This table provides granular, actionable examples, showing how specific IPAS topics (e.g., Local Ecosystems) are linked to specific local wisdom (rice field irrigation systems), then to particular

Pancasila values (Belief in God, Unity, Social Justice), and finally to concrete learning activities (group discussions, simulations, mini-projects). This level of detail is highly valuable for practitioners (teachers, curriculum developers) looking to replicate or adapt this model. It transforms theoretical claims into a practical blueprint, demonstrating the feasibility and creativity of the integrated approach. It also serves as strong evidence for the study's claims of innovative planning.

**Table 1. Integration of IPAS materials, local wisdom, and Pancasila values**

IPAS topic (science focus)	Social studies support materials (local wisdom)	Integration of Pancasila values	Learning activities
Local ecosystem (biotic-abiotic component interactions)	Rice field irrigation system with gilir technique (water management), tradition of mutual cooperation to clean the environment (local village)	Belief in one supreme god (protecting god's creation), unity (mutual cooperation), social justice (resource management)	Group discussion on local wisdom, simulation of rice field irrigation system, mini project to make ideal ecosystem model with local materials.
Force and motion (types of force, effect of force on motion)	Traditional games (engklek, gasing), traditional musical instruments (gamelan, angklung)	Deliberation (consensus during play), global diversity (understanding other cultures through games)	Simple experiments with spinning tops, analysis of force in engklek games, presentation of force principles in traditional musical instruments.
Properties and changes of objects (matter, physical/chemical changes)	Batik making (wax form change, coloring), traditional food processing (tempeh fermentation, cake making)	Independence (practice making something), creativity (batik motif design), mutual cooperation (working together to process food)	Practicum on making simple batik with wax, observation of fermentation, interviews with batik artisans/traditional food makers.
Ipas topic (science focus)	Social studies support materials (local wisdom)	Integration of Pancasila values	Learning activities

#### *Implementation of IPAS Learning Based on Ethnopedagogy and Pancasila Education*

The implementation of IPAS learning in the classroom demonstrates the teacher's success in acting as a dynamic facilitator. Teachers use an active learning approach that directly involves students in concept exploration. When studying alternative energy material, students are invited to identify local energy potential such as biomass from agricultural waste, then the teacher relates it to the values of independence and mutual cooperation in developing regional potential. Group discussions are facilitated to discuss social issues related to science materials, such as the impact of waste on the surrounding environment and the importance of keeping the village clean. Observations show a significant increase in students' active participation, curiosity, and critical reasoning skills. They are more courageous in asking questions, expressing opinions, and connecting the material with personal experiences. Interviews with students indicate that learning feels more alive and relevant because it involves their culture and daily lives, and instills a stronger understanding of Pancasila values (Gunawan & Sari, 2022; Rahman & Indriani, 2020). Teachers also consistently provide constructive feedback that helps students internalize

concepts and values. The increase in active student participation and learning relevance indicates that this approach successfully fosters deeper engagement by making learning personally meaningful and culturally aligned. This engagement is crucial for sustained motivation and understanding. When students see how learning material directly connects to their lives and cultural heritage, they become more motivated to learn, which in turn enhances cognitive comprehension and character development.

#### *Evaluation of IPAS Learning Based on Ethnopedagogy and Pancasila Education*

Evaluation is carried out holistically, covering cognitive, affective, and psychomotor aspects. Teachers use a project-based assessment rubric to assess the products produced by students through the creation of dioramas of local ecosystems and simple models of alternative energy, which reflect the understanding of IPAS concepts and the application of local wisdom. Performance observation is used to assess students' collaboration skills, initiative, and positive attitude in mutual cooperation and deliberation. The concept understanding test results show a significant increase from pre-test to post-test. The paired t-test results show

a value of  $t = 5.87$  with  $p < 0.01$ , which means there is a very significant difference in students' interest in learning after the implementation of this lesson. Similarly, the concept understanding test results show an average increase of 20% with  $p < 0.01$ , indicating a significant increase in understanding. Qualitatively, students show a better ability to apply IPAS knowledge to the context of daily life and Pancasila values (Pratiwi & Sukma, 2021; Wahyuni & Abdullah, 2019). These

quantitative results strongly validate the effectiveness of the integrated approach, demonstrating its capacity to enhance both student engagement and cognitive mastery. The statistically significant increases in learning interest and concept understanding provide strong empirical evidence that relevant and contextual learning can trigger students' internal motivation and facilitate deeper knowledge absorption.

**Table 2.** Comparison of student learning interest and concept understanding (pre-test vs. post-test)

Variable	Average Pre-test	Average Post-test	Increase (%)	p-value (t-test)	Description
Learning Interest (Scale 1-5)	3.25	4.10	26.15	< 0.01	Very Significant
Concept Understanding (Scale 0-100)	65.20	78.24	20.00	< 0.01	Very Significant

#### *Integration of Deep Learning in the Implementation of the Merdeka Curriculum*

The relationship between deep learning (in the context of artificial intelligence) and the Merdeka Curriculum is very close, especially in efforts to realize curriculum goals that focus on personalizing learning, developing 21<sup>st</sup>-century competencies, and adapting to the times (Kementerian Pendidikan dan Kebudayaan, 2022). The application of deep learning technology can be a catalyst in achieving these goals. It is important to note that the term "deep learning" in the context of education is often interpreted in two different contexts, first as AI technology, which refers to artificial intelligence algorithms and models that analyze data for personalization, recommendation, and automation; and second as a pedagogical approach (deep learning) that refers to teaching strategies that encourage students to understand concepts deeply, think critically, and apply knowledge rather than just memorizing. Both interpretations have great potential to support and enhance the implementation of the Merdeka Curriculum (BPMP Bengkulu, 2025).

#### *Personalization of Learning*

The Merdeka Curriculum fundamentally emphasizes differentiated learning, an approach that adapts the learning process to the needs, interests, and learning styles of individual students (Astuti & Sumarsono, 2023). In this regard, deep learning offers a highly effective solution. With its ability to analyze large volumes of student data, such as test results, material preferences, learning patterns, and comprehension speed, deep learning algorithms can, first is analyze student data in depth to create personalized learning models; second is identify knowledge gaps and individual strengths; third is recommend tailored materials and activities; fourth is facilitate self-paced learning; and fifth is create personalized learning paths to optimize students' learning experiences (SMPN2 Bangunrejo, 2025; Tapalova & Zhiyenbayeva, 2022).

#### *Development of 21<sup>st</sup> Century Competencies*

The Merdeka Curriculum is oriented towards developing students with essential 21<sup>st</sup>-century competencies, including critical thinking, creativity, collaboration, and communication skills (MAN 1 Ternate, 2024). Studies show that deep learning highly emphasizes these skills to ensure students are ready to face the challenges of the era (Wathon, 2024). As a pedagogical approach, deep learning encourages first, deep thinking, where students are encouraged to understand concepts thoroughly, not just memorize, and connect them to real contexts (Fahum UMSU, 2024); second, analysis and evaluation through more complex data processing and pattern recognition by deep learning-based systems, students can be trained to analyze information in depth and make critical evaluations (Yang & Li, 2022; Mayasari et al., 2024); and third, problem-solving with adaptive systems, students can be presented with challenges appropriate to their level, effectively training problem-solving abilities (LPPPI Publishing, 2024).

#### *Teacher Efficiency and Support*

Deep learning as part of artificial intelligence can greatly assist teachers in managing repetitive administrative tasks, such as automated assessment, analysis of student learning outcome data, and identification of students who need further attention or intervention (RRI, 2024). The utilization of AI can also help teachers make decisions regarding learning strategies and resource allocation (Gamelab Indonesia, 2024). This automation allows teachers to focus more on personal interactions with students, provide more in-depth guidance, and design more meaningful learning experiences, in line with the philosophy of the Merdeka Curriculum.

#### *Development of Interactive and Adaptive Learning Content*

The use of deep learning technology enables the development of more interactive and dynamic learning

content, such as simulations, adaptive educational games, or intelligent tutor systems that can interact with students in real-time and be customized (Hwang et al., 2016; Gamelab Indonesia, 2024; Johnson & Smith, 2024). This is highly relevant to the Merdeka Curriculum's efforts to create an engaging and relevant learning environment for students (LPPPI Publishing, 2024).

#### *Accessibility of Education*

The support of deep learning and artificial intelligence can enable the design of more inclusive digital learning platforms. AI can help bridge the education access gap by providing more personalized and adaptive solutions (Publikasi Abidan, 2024). This means that access to education can be expanded for students in various locations, including remote areas, thus reducing the accessibility gap and ensuring every child has equal access to quality education (RRI, 2024).

#### *Important Notes on Deep Learning in Education*

It is important to note that the term "deep learning" in the context of education is often interpreted in two different contexts, first as an AI technology, which refers to artificial intelligence algorithms and models that analyze data for personalization, recommendation, and automation. Second as a pedagogical approach (deep learning) that refers to teaching strategies that encourage students to understand concepts deeply, think critically, and apply knowledge rather than just memorizing. This approach aims to provide a more meaningful and enjoyable learning experience, as well as to develop mind, heart, taste, and practice in an integrated manner (BPMP Bengkulu, 2025). The deep learning curriculum (as a pedagogy) integrates three main elements: Mindful Learning, Meaningful Learning, and Joyful Learning (Ramadhan & Nurcahyo, 2022; MAN 1 Ternate, 2024).

Both in terms of AI technology and pedagogical approaches, deep learning has great potential to support and improve the implementation of the Merdeka Curriculum, especially in the aspects of personalizing learning and developing student competencies. The challenge is how to integrate it effectively, address infrastructure gaps, and prepare teachers to utilize it.

The integration of deep learning into the Merdeka Curriculum signifies a shift towards technologically enhanced education that can adapt to individual needs, moving beyond a one-size-fits-all model. This paves the way for a more responsive and inclusive learning environment, where technology serves as a key facilitator for personalized learning experiences and relevant competency development.

#### *Prospects of Deep Learning in Personalizing Ethnopedagogy-Based IPAS Learning as a 21<sup>st</sup> Century Learning Revolution*

Integrating deep learning as the core of artificial intelligence in ethnopedagogy-based IPAS learning offers revolutionary transformative potential for learning personalization and adaptation. Deep learning models, particularly recurrent neural networks (RNNs) or transformer models, can be trained using student interaction data, quiz responses, module reading patterns, and local wisdom preferences. These systems can analyze data for:

- Adaptive content recommendations:** Automatically recommend IPAS materials, local wisdom materials, or case studies related to Pancasila values that best suit each student's unique learning style, comprehension speed, and interests. For example, if students show interest in traditional farming topics, the system can present more content that integrates science (photosynthesis, soil types) and social studies (ancient irrigation systems, the role of farmers in society) with Pancasila values (mutual cooperation in farming).
- Identification of learning difficulties:** Through real-time identification of IPAS concepts that students find difficult to understand based on error patterns or time spent on a topic. The system can then recommend personalized interventions, such as additional explanation videos, interactive simulations, or different local wisdom-based remedial exercises.
- More specific and in-depth intelligent feedback:** On students' essay or project assignments related to the interpretation of Pancasila values in the context of IPAS. For instance, the system can highlight parts of an essay that lack clear arguments or suggest relevant local wisdom references to enrich students' analysis (Al-Shami & Abdul-Jabbar, 2021; Chen & Hwang, 2020).

The implementation of deep learning requires ethical data collection, adequate technological infrastructure, and the development of models specific to the Indonesian educational context. Nevertheless, the potential to create a highly personalized, adaptive, and locally culturally rooted learning ecosystem is enormous, promising significant improvements in learning effectiveness and realizing a true learning revolution. This visionary application of AI points to a future where education is highly individualized and culturally rooted, ensuring optimal support for every student and potentially leading to a true learning revolution. With AI's ability to tailor content, identify difficulties, and provide intelligent feedback, education can move from a uniform model to a learning experience uniquely customized to each student's needs and preferences, while retaining cultural relevance and national values.

The findings of this study strongly confirm that the ethnopedagogical approach, when integrated with Pancasila Education, is a highly effective strategy to increase learning interest and understanding of IPAS

concepts in elementary schools. The significant increase in students' learning interest, quantitatively evidenced, corroborates the argument that relevant and contextualized learning can trigger students' internal motivation (Putra & Wijaya, 2022; Utami & Santoso, 2023). This aligns with various studies showing that teaching materials connected to students' life experiences and culture are more easily absorbed and internalized (Astuti & Dewi, 2018; Sari & Putra, 2019).

The integration of local wisdom in every aspect of IPAS (science with social studies support) makes abstract scientific and social concepts more concrete and applicable, in accordance with the learning needs of students in their developmental phase. The systematic preparation of Teaching Modules and attractive presentation materials forms the foundation of this successful implementation. The detailed learning design, with a grid linking each basic competency to Pancasila values and local wisdom, proves that curriculum innovation requires careful planning (Susanto & Wulandari, 2021; Yuliani & Fitriani, 2023). Teachers' success in facilitating local wisdom-based discussions and projects, as well as consistently linking material to Pancasila values, demonstrates high pedagogical competence in creating a student-centered and character-based learning environment (Gunawan & Sari, 2022; Rahman & Indriani, 2020). This process not only improves cognitive understanding but also strengthens the dimensions of the Pancasila Student Profile such as mutual cooperation, critical reasoning, and global diversity.

The main novelty of this study lies in its comprehensive mixed methods analysis, providing a holistic picture of how ethnopedagogy can be synergized with Pancasila Education in IPAS learning. The implementation model presented, from planning to evaluation, offers practical guidance for schools and teachers. Furthermore, the prospective exploration of the role of deep learning as a key component of artificial intelligence in personalizing ethnopedagogy-based IPAS learning is a significant contribution that distinguishes this study from previous research (Al-Shami & Abdul-Jabbar, 2021; Chen & Hwang, 2020).

This holistic analysis not only provides a practical model but also opens new avenues for highly individualized and culturally rooted learning, aligning with global trends in AI-driven education. The implementation of deep learning, although requiring further research and development, could revolutionarily pave the way for highly individualized learning innovations, ensuring each student receives optimal support according to their learning needs and preferences, while remaining rooted in cultural values and Pancasila. This aligns with the global trend of

utilizing AI to create smart and responsive learning ecosystems, which can ultimately strengthen the effectiveness of ethnopedagogical approaches in modern contexts and steer education towards a learning revolution (Huang & Wu, 2020; Li & Wang, 2023; Brown & Davis, 2025).

## Conclusion

This study concludes that the integration of ethnopedagogy and Pancasila Education in Natural and Social Sciences (IPAS) learning in elementary schools successfully increased students' learning interest and IPAS concept understanding significantly, while strengthening the dimensions of the Pancasila Student Profile. This is evidenced by an average increase in learning interest of 26.15% and concept understanding of 20%, both with a  $p$ -value  $< 0.01$ , indicating very high significance. The novelty of this study lies in the holistic mixed methods analysis of the synergy of ethnopedagogy, IPAS, and Pancasila Education, as well as the visionary discussion of the role of deep learning as a driver of the 21<sup>st</sup>-century learning revolution to create an adaptive and personalized learning environment. The ethnopedagogical approach, which integrates local wisdom and culture, makes the learning experience more meaningful and contextual for students, fosters appreciation for local heritage, and builds a strong self-identity. The integration of Pancasila Education ensures that IPAS learning not only shapes knowledge and skills but also instills national values that are the foundation of the Pancasila Student Profile character. In the context of the Merdeka Curriculum, deep learning (as an AI technology) has great potential for personalizing learning by analyzing student data to recommend materials, identify learning difficulties, and provide intelligent feedback. In addition, deep learning (as a pedagogical approach) encourages students to think deeply, analyze, evaluate, and solve problems, in line with 21<sup>st</sup>-century competencies. The implications of this research are significant for curriculum development and learning practices in Indonesia, underscoring that education rooted in local culture and national values, supported by the potential of AI technology, can produce graduates who are academically intelligent, solid in their cultural identity, and possess the character of Pancasila.

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#### Author Contributions

B.R. contributed to conceptualization, investigation and funding of the research; A.F.N., H.M.Z., and S.W. contributed to methodology and guided the research; B.R. and A.F.N. contributed to software; B.R., A.F.N., H.M.Z., and S.W. contributed to validation, formal analysis, data curation, writing and resources, writing-review and editing were performed; B.R. contributed to the preparation of the original draft. All authors have read and approved the published version of the manuscript.

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#### Conflicts of Interest

In writing this article, we emphasize that there are no conflicts of interest that could reduce the objectivity or integrity of the results presented.

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