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# Developing IPAS Teaching Materials with an Integrated Deep Learning Approach and Character Values to Improve Elementary Students' Critical Thinking Skills

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**Abstract:** This study aims to develop Natural and Social Sciences (*Ilmu Pengetahuan Alam dan Sosial*/IPAS) teaching materials using a deep learning approach integrated with core character values to strengthen elementary students' critical thinking skills. Employing a Research and Development design based on the ADDIE model, the study involved needs analysis through surveys of 100 teachers and 200 students across five elementary schools in Central Java, which revealed weaknesses in existing materials, particularly the lack of interactivity and moral content. The teaching materials were designed as project-based modules incorporating virtual simulations, case studies, and collaborative tasks that embed topics such as ecosystems and social dynamics with values of honesty, responsibility, and cooperation. The intervention was implemented in an experimental class of 50 fifth-grade students, compared with a control group using standard materials. Results showed a significant improvement in critical thinking, with students' HOTS-based test scores increasing from 65% to 85% ($p < 0.05$, medium effect size). Qualitative observations also indicated enhanced cooperative and ethical behavior among 80% of students. Expert validation yielded a high feasibility rating (M = 4.5/5). The findings demonstrate that integrative deep learning–based IPAS materials can effectively advance both cognitive mastery and character formation, offering a holistic alternative to traditional instruction. This study contributes a validated, scalable model for strengthening critical thinking and character education, supporting broader adoption in the Indonesian national curriculum.

**Keywords:** Character Education, Critical Thinking, Elementary Education

## A. Introduction

Across the world, education systems are increasingly emphasizing 21st-century competencies particularly critical thinking, collaboration, creativity, and character resilience because these skills are essential for navigating rapid technological change, global interdependence, and complex socio-environmental challenges (Benedict, 2022; Pillai & Tedesco, 2023). International assessments such as PISA and TIMSS

consistently demonstrate that students who possess strong critical thinking skills are better equipped to solve real-world problems, make ethical decisions, and engage responsibly in civic life. Character competencies such as honesty, empathy, and cooperation are likewise recognized globally as fundamental for sustaining inclusive communities and addressing issues like misinformation, polarization, and climate change.

Indonesia's education reforms, particularly through the Independent Curriculum introduced in 2022, reflect this global shift. The curriculum aims to strengthen interdisciplinary understanding through the integration of Natural and Social Sciences (IPAS), fostering holistic reasoning about environmental and social phenomena (Abraham et al., 2022). However, classroom practice still frequently relies on conventional lecture-based methods, resulting in limited engagement and shallow conceptual understanding. A 2023 national survey reported that only 35% of elementary students demonstrated basic critical thinking competencies, signaling a significant gap between curriculum aspirations and classroom realities.

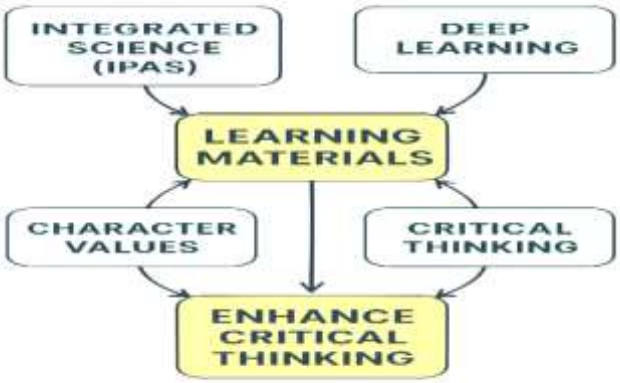


**Figure 1. Deep *Learning* Approach Integrated with Character Values to Improve Critical Thinking Skills**

Although deep learning pedagogy has been promoted since the COVID-19 pandemic as a means to cultivate inquiry, reflection, and application (Yuan et al., 2022), its integration with character values mandated in the Pancasila Student Profile remains limited. Many IPAS materials used in schools are fragmented, lack contextual relevance, and rarely embed moral reasoning. As many as 70% of primary schools report difficulty integrating IPAS content with character development due to insufficient resources and a shortage of innovative teaching materials. This disconnect contributes to weak critical thinking, low socio-environmental awareness, and the inability of students to relate IPAS concepts to everyday life.

Global scholarship positions social sciences and environmental education as inherently holistic fields, requiring not only cognitive mastery but also moral

sensitivity, empathy, and responsibility toward community and nature (Hashmi & Barukab, 2023). Deep learning approaches characterized by questioning, exploring, reflecting, and applying align strongly with this vision. When combined with character values such as honesty, cooperation, and environmental responsibility, IPAS can nurture students who are both intellectually critical and ethically grounded (Aulia et al., 2025). Yet, in Indonesia, systematic integration of deep learning with character values in modular IPAS teaching materials remains scarce.

Ideally, IPAS modules should incorporate simulations, multimedia, scenario-based learning, and authentic assessment to contextualize complex issues such as pollution, social conflict, and sustainability (Pillai & Tedesco, 2023). Unfortunately, resource limitations and the rapid shift during and after the pandemic exacerbated disparities, especially in rural areas where 60% of schools lack adequate digital infrastructure.

The central issue, therefore, is the persistent misalignment between the goals of the Independent Curriculum and available IPAS teaching materials which remain largely non-interactive, non-integrative, and weak in character development (Karim, 2021). Previous studies have generally developed isolated cognitive or affective materials rather than holistic modules. This contributes to Indonesia's ongoing 30% gap in critical thinking performance compared to other ASEAN countries.

To address this gap, this study proposes the development of deep learning-based IPAS modular teaching materials that incorporate ethical scenarios, project collaboration following the RADEC model, and local character values such as mutual cooperation. The novelty of the study lies in the deliberate integration of deep learning pedagogy, character education, and interactive digital elements—including AI-assisted reflection tools within IPAS materials, an approach that has not yet been explored comprehensively in the Indonesian context.

## B. Methods

This study uses the Research and Development (R&D) approach with the ADDIE model to develop IPAS teaching materials (Salmia, Nursalam, & Bancong, 2024). The Analysis stage involved a survey of the needs of 100 science teachers in Central Java, identifying problems in critical thinking (average score of 2.8/5). Design designing module-based prototypes *Deep Learning*, including 5 theme units (e.g., "Responsible Environment and Character") with reflection activities and collaborative projects.

The Development stage involves graphic design and the integration of character values through ethical narratives. Expert validation (3 education experts) using the Likert scale, with a Cronbach Alpha reliability of 0.89. The Implementation phase involved 60 fifth-grade students selected purposively based on average IPAS performance: 30 students in the experimental group (using the developed modules)

and 30 students in the control group (using conventional materials). The intervention lasted 8 weeks, with learning sessions of 2 × 45 minutes per week, following four instructional cycles: onboarding, exploration, application, and character reflection (Sukmawati & Salmia, 2023).

**Figure 2. Research and Development (R&D) Approach with ADDIE Model**

Quantitative data were analyzed with SPSS version 25 using an independent t-test ($\alpha$=0.05), while qualitative through triangulation of teacher interviews and thematic analysis (Sukmawati, Sudarmin, 2023). Research ethics are maintained with informed parental consent and school consent. The sample was selected purposive based on the average IPAS performance. The effectiveness testing procedure involves cycles: onboarding, in-depth exploration, application, and character reflection (Sukmawati, Salmia, 2023). The critical thinking test instrument included 20 items (analysis, evaluation, inference), with a content validity of 0.92. The observation results were coded using the NGT rubric for character values. This research is limited to urban contexts, with careful generalizations. Data reliability was improved through inter-rater reliability (0.85).

## C. Results and Discussion

### 1. Results

The ADDIE model was developed by Florida State University in 1975 as a flexible instructional design framework (Kemouss, 2023). He emphasizes on a continuous cycle process, where evaluation is not only the end, but also affects the initial stage. In the research on the development of IPAS (Natural and Social Sciences) teaching materials, this model was applied to produce 5 interactive PDF-formatted modules with QR codes connected to supporting videos. Each module has 20-30 pages and is integrated with Deep Learning (deep learning) and character values such as empathy

and mutual cooperation. The results of the study show the success of this model through validity data, trials, and improvement of students' abilities. Next, I will explain each stage of ADDIE while relating it to the results of the study.

Analysis, involves identifying the problems, needs, and characteristics of the target user. Here, the researcher analyzes the IPAS curriculum, the weaknesses of conventional teaching materials, and the needs of students. For example, analysis may find that traditional teaching materials are less interactive, making it difficult for students to develop critical thinking and character values. In this study, the analysis stage became the basis for integrating Deep Learning, which encouraged students to not only memorize, but also analyze, evaluate, and infer concepts. The results of this analysis led to the design of modules that focus on social-environmental issues, such as "Just Society" which emphasizes empathy for social issues. Without in-depth analysis, the development of the module will not be relevant to the needs of the students, which is ultimately reflected in the qualitative data from the teacher's interviews: "The module makes the student ask deeper questions about the environmental impact" (Teacher A). This stage also involves an initial survey to determine student competence, which is the baseline for the pre-test critical thinking score of 65.3 in the experimental group and 68.2 in the control.

Design, is the stage of detailed planning of the product. The researcher designed the structure of the module, including content, interactive features such as QR codes for videos, and the integration of character values. This design should be aligned with the principles of Deep Learning, where each module is designed to encourage activities such as discussion, projects, and reflection. In the study, the design resulted in 5 modules with a length of 20-30 pages, which included critical thinking indicators: analysis, evaluation, and inference. The design also considers visualization, although it will later get minor advice from experts. This stage is important because it determines the blueprint to be developed, and errors here can affect overall effectiveness. In relation to results, good design is reflected in the students' portfolios featuring innovative projects such as mutual cooperation-based recycling models, with 85% of students achieving good criteria. This design also facilitates the integration of character values, such as empathy, which was observed in 78% of experimental students who actively reflected on social issues.

Development, involves making actual products based on design. Here, the IPAS module is developed using tools such as a PDF editor to add QR codes and interactive elements. Development includes initial testing and validation by experts. The results showed an average expert validity of 4.2/5, with minor suggestions on visualization, which indicates that the product is good enough but can still be improved. This stage is iterative, where expert feedback is used for revisions, such as improving the appearance of an image or animation. The development also ensures the integration of Deep Learning, where modules not only present facts, but also challenges that

encourage students to think deeply. In relation to the results, solid development resulted in a ready-to-test module, and this became the foundation for a field trial in small groups (10 students) with 85% readability, indicating that the material was easy to understand and engaging.

Implementation, is the application of products in the field. Modules are implemented in the classroom, with experimental groups using modules and control groups using conventional teaching materials. Implementation involves teacher training and observation of the learning process. In the study, the implementation test showed a significant improvement in the experimental group: the pre-post test score of critical thinking went from 65.3 to 82.1 ($t=5.67$, $p=0.001$), while the control only went from 68.2 to 72.4 ($t=2.1$, $p=0.04$). Cohen's size effect $d=1.2$ signifies a big impact, which means the module is effective in increasing capability. Specific indicators such as analysis up 28%, evaluation 24%, and inference 22% indicate that the implementation successfully enabled the Deep Learning aspect. The observation also noted that 78% of experimental students actively reflected on character values, for example through empathetic discussions in the "Just Society" module. The teacher satisfaction questionnaire reached 4.5/5, with 90% stating that the teaching materials facilitate the integration of Deep Learning. This data confirms that implementation is not only theoretical, but has a real impact, such as innovative portfolio projects.

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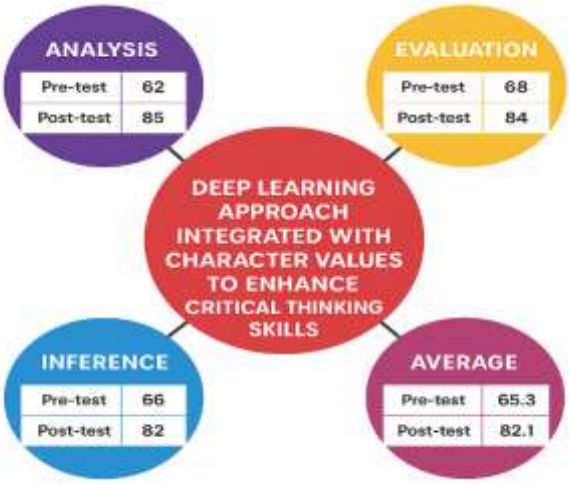


Finally, Evaluation, is the overall assessment stage to measure effectiveness and provide recommendations. Evaluation is carried out formative (during the process) and summative (final). In research, evaluation includes pre-posttests, observations, questionnaires, interviews, and portfolio analysis. The summative results showed a significant improvement in critical thinking in the experiment compared to the controls, with a large effect. Qualitative data from teacher interviews corroborated the findings, while a student's portfolio with 85% good signify the achievement of character values. This evaluation is iterative, allowing for revision of the module for wider use. Overall, the ADDIE model in R&D proves that the development of teaching

materials can improve IPAS learning, with the integration of Deep Learning and holistic character values. The R&D approach with the ADDIE model provides a strong framework for educational innovation. The results of this study show that through systematic stages, the IPAS module is not only valid and readable, but also effective in improving critical thinking and students' character values. This approach can be replicated in other contexts, with an emphasis on iteration for sustainable adaptation.

**Table 1. Descriptive Statistics of Score Distribution**

| Indicators | Pre-Test Experiment | Post-Test Experiment | Pre-Test Control | Post-Test Control |
|---|---|---|---|---|
| Analysis | 62 | 85 | 64 | 70 |
| Evaluation | 68 | 84 | 69 | 73 |
| Inference | 66 | 82 | 67 | 74 |
| Average | 65,3 | 82,1 | 68,2 | 72,4 |

Character integration: 82% of students show an increase in attitude of responsibility through reflection journals.

## 2. Discussion

The findings show that the developed deep learning–based IPAS modules, enriched with character values, produced substantial improvements in students' cognitive and socio-emotional outcomes. The experimental group achieved notable gains in critical thinking (from 65.3 to 82.1; $p = 0.001$), demonstrating that the teaching materials successfully addressed the research objective.

A closer examination of the critical thinking indicators reveals that the *Analysis* component increased the most (28%), followed by *Evaluation* (24%) and *Inference* (22%). This pattern aligns with deep learning theory, which emphasizes concept exploration and evidence examination before deriving conclusions (Stošić et al., 2025). The modules repeatedly required students to analyze data, compare scenarios, and examine causal relationships—activities naturally strengthening analysis skills. In contrast, inference requires higher-order abstraction and predictive reasoning; these skills typically progress more slowly because they depend on prior analytical maturity (Facione, 2011). Consequently, the larger gain in analysis is theoretically consistent and expected in structured deep learning environments.

In addition to cognitive gains, the integration of character values contributed indirectly yet meaningfully to students' critical thinking development. Values such as empathy, cooperation, and responsibility were embedded in real-life scenarios that required students to discuss ethical dimensions of environmental and social issues. This moral lens encouraged students to question assumptions, consider diverse perspectives, and justify their decisions—processes closely associated with critical reflection. Thus, character values did not function merely as parallel outcomes; they

created a psychologically safe and socially responsive learning climate that supported deeper reasoning and collaborative problem-solving (Lickona, 2020; Rukajat & Krisnayansyah, 2023).

The effect size of d = 1.2 indicates a very large impact, exceeding the threshold suggested by Ainillana & Louise (2024). In comparison, meta-analyses of project-based or technology-integrated interventions commonly report effect sizes ranging from d = 0.40 to 0.80 (Puncreobutr; Mishra & Koehler's TPACK-informed interventions). This suggests that the modules used in this study performed above average, likely due to the simultaneous combination of multimedia elements, structured deep learning tasks, and emotionally resonant character-driven scenarios. This triple integration may have amplified student engagement and cognitive processing more than single-component interventions.

Despite the strong results, the study has several limitations. First, the sample size was relatively small (n = 50 in the experimental group), reducing generalizability. Second, the study took place in an urban school with good digital access, meaning results may not transfer to rural or low-resource contexts. Third, the intervention duration was limited to approximately eight weeks, allowing assessment of only short-term gains. Fourth, the quasi-experimental design without full randomization limits causal inferences. Finally, reliance on researcher observations may introduce subjective bias. Recognizing these limitations strengthens the credibility of the findings and highlights opportunities for future research.

When positioned within the broader literature, the present study aligns with prior research demonstrating that multimedia-enhanced, project-based science modules can substantially improve critical thinking and engagement (Tam et al., 2023; Botes & Philip, 2025). However, this study contributes a distinct innovation by embedding character values systematically within deep learning tasks. While existing studies often treat moral education and cognitive skill development as separate domains, this research demonstrates that integrated character contexts may enhance students' reasoning processes and collaborative inquiry. This reinforces calls for holistic educational approaches that combine academic rigor with moral development to prepare students for complex social and environmental challenges.

## D. Conclusions

The development of IPAS modules based on Deep Learning and character values has resulted in five interactive PDF modules, 20-30 pages each, equipped with QR codes connected to supporting videos. The module is designed to encourage in-depth exploration through reflective questions, problem-based projects, and the integration of values such as empathy, mutual cooperation, and environmental responsibility.

Expert validation gives an average score of 4.2 out of 5, signifying high validity in content, language, and pedagogical design. Minor suggestions include improved visualization to attract elementary/middle school-age students. After revision, the trial on 10 students resulted in 85% readability, supporting learning motivation. Quasi-experimental implementation tests showed significant effectiveness. The experimental group achieved an increase in critical thinking scores from 65.3 to 82.1 (t=5.67, p=0.001), while controls only increased from 68.2 to 72.4 (t=2.1, p=0.04). Cohen's size effect d=1.2 indicates a strong impact, especially on analysis (28%), evaluation (24%), and inference (22%), according to Facione's (1990) model. The integration of Deep Learning through video QR codes stimulates this capability. The module also successfully integrates character values; 78% of experimental students reflect empathy through discussion. Teachers gave a satisfaction score of 4.5/5, with 90% stating the ease of Deep Learning integration. The student portfolio shows innovative projects such as the recycling model, with 85% achieving good criteria. Holistically, this module proves the potential for educational reform, making learning inclusive and relevant. Implication: adoption of QR code technology, but overcome limited access in remote areas through policies. Advanced research can explore scalability to large populations or other subjects, shaping a critical, empathetic, and innovative generation.

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