



DEEP LEARNING APPROACH INTEGRATED WITH CHARACTER VALUES TO IMPROVE CRITICAL THINKING ABILITIES OF ELEMENTARY SCHOOL STUDENTS IN MAKASSAR CITY

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ABSTRACT

This research focuses on the development of natural and social science (IPAS) teaching materials that utilize an in-depth learning approach and integrate character values to improve the critical thinking skills of elementary school students in Makassar City (Mulyasa, 2020). The background of this research is the low level of critical thinking skills of students identified through initial observations and diagnostic tests, as well as the availability of teaching materials that are not optimal in facilitating the development of 21st-century skills (OECD, 2018). The in-depth learning approach was chosen because it encourages holistic understanding of concepts, connections between ideas, and continuous application of knowledge, not just memorization (Fullan & Quinn, 2016). The integration of character values such as independence, responsibility, and cooperation is expected to shape students who are not only cognitively competent but also have moral integrity (Lickona, 2019). This development research adopts the systematic ADDIE (Analysis, Design, Development, Implementation, Evaluation) model (Branch, 2009). The research subjects were fourth and fifth grade elementary school students in Makassar City. Data collection was conducted through needs questionnaires, expert validation sheets, observations, critical thinking ability tests (pre-test and post-test), and student and teacher response questionnaires (Sugiyono, 2019). The trial results are expected to show that the developed teaching materials have a high level of validity, are practical for use in the learning process, and are significantly effective in improving students' critical thinking skills. The implication of this research is the availability of innovative teaching materials that can be a valuable reference for curriculum development and science learning practices at the elementary education level.

Keywords: Science teaching materials, in-depth learning, character values, critical thinking, elementary school students.

1. INTRODUCTION

Education in the digital and global era demands the development of individuals who possess not only extensive knowledge but also essential skills for adaptation and innovation (Partnership for 21st Century Learning, 2019). One crucial skill students must possess is critical thinking, which enables them to analyze information, evaluate arguments, and make informed

decisions in a variety of situations (Facione, 2015). This ability is a crucial foundation for academic and future success (Lai, 2011).

In Indonesia, the Independent Curriculum (Curriculum Merdeka) introduces Natural and Social Sciences (IPAS) as an effort to integrate scientific, social, and environmental understanding from an early age, with the hope of developing students' holistic and critical thinking (Ministry of Education and Culture, 2022). However, the main challenge faced is how to design learning processes and teaching materials that effectively stimulate these critical thinking skills (Surya & Rahman, 2021). Initial observations in several elementary schools in Makassar City indicate that students' critical thinking skills are still relatively low, as evidenced by their tendency to accept information without question, difficulty in solving complex problems, and lack of ability to provide rational arguments (Fadillah, 2018).

One contributing factor to low critical thinking skills is teaching materials that do not encourage students to engage in higher-order thinking skills (HOTS) (Brookhart, 2010). Currently, dominant teaching materials tend to be textual, teacher-centered, and do not facilitate independent exploration and in-depth discussion (Ramadhan, 2019). Therefore, the development of innovative teaching materials that address this gap and are specifically designed to improve elementary school students' critical thinking skills is necessary.

The deep learning approach offers a promising solution (Biggs & Tang, 2011). This approach emphasizes in-depth conceptual understanding, the ability to connect ideas, and the application of knowledge in real-world contexts, rather than simply memorizing facts (Marton & Säljö, 1976). With deep learning, students are encouraged to actively engage in complex cognitive processes, such as analysis, synthesis, and evaluation, which are at the heart of critical thinking (Bostrom et al., 2020). The integration of deep learning into science teaching materials is expected to create a challenging and meaningful learning environment for students.

In addition to cognitive aspects, character building for students is also an important pillar in education (Ministry of Education and Culture, 2017). The integration of character values such as honesty, responsibility, independence, and cooperation in teaching materials can guide students to use their critical thinking skills ethically and responsibly (Ratnasari, 2020). These values not only shape good personalities but also strengthen students' abilities in social interactions, solving problems together, and becoming citizens who contribute positively (Lickona, 2019). Therefore, the development of science and science teaching materials that combine in-depth learning with the integration of character values is expected to produce holistic students, namely intellectually intelligent and noble, as well as faithful and devoted to God Almighty.

Given this urgency, this study aims to (1) develop science and natural science teaching materials using an integrated in-depth learning approach with character values for elementary school students in Makassar City, and (2) analyze the validity, practicality, and effectiveness of the developed teaching materials in improving students' critical thinking skills. The results of this study are expected to provide a significant contribution to improving the quality of science and natural science learning and developing critical thinking skills for elementary school students in Makassar City.

2. METHODS

This research is a research and development (R&D) that aims to produce a science teaching material product based on an in-depth learning approach integrated with character values (Borg & Gall, 2007). The development model used is the ADDIE model (Analysis, Design, Development,

Implementation, Evaluation) because of its systematic, structured, and iterative characteristics, allowing product improvements at each stage (Branch, 2009).

1. Analysis Stage

At this stage, a series of analyses were conducted to identify needs and problems (Dick & Carey, 2005). First, a student needs analysis was conducted to understand the demographic characteristics, learning styles, initial abilities, and interests of fourth and fifth grade elementary school students in Makassar City through questionnaires and short interviews (Minister of Education, Culture, Research, and Technology Regulation No. 5 of 2022). Second, a curriculum analysis was conducted to review the Learning Outcomes (CP) and Learning Objectives (TP) for Science and Education in the Independent Curriculum, as well as to identify essential material relevant to the development of critical thinking and the integration of character values (Ministry of Education and Culture, 2022). Third, the analysis of Science and Education material aimed to determine the depth and breadth of material to be presented in the teaching materials, with a focus on concepts that require in-depth understanding and enable value integration (Tuanakotta, 2019). Fourth, a learning problem analysis was conducted to identify the causes of students' low critical thinking skills, including an evaluation of existing teaching materials (OECD, 2018). Fifth, analysis of the learning environment and availability of resources in target schools in Makassar City was carried out to ensure the relevance and implementation of realistic teaching materials (Sugiyono, 2019).

2. Design Stage

The design stage is the blueprint of the product to be developed (Reiser & Dempsey, 2012). First, the design of the teaching material framework includes the preparation of a syllabus, concept maps, specific learning objectives, and indicators of critical thinking skills to be achieved. Second, the selection of in-depth learning models and strategies that are relevant to the science material and the characteristics of elementary school students (e.g., problem-based learning, projects, or inquiry) (Biggs & Tang, 2011). Third, the determination of character values to be integrated (e.g., independence, responsibility, honesty, creativity, cooperation, environmental care) based on the Pancasila Student Profile and relevance to the science material (Kemendikbud, 2017). Fourth, the design of the teaching material structure includes the physical format (if printed) or digital, layout, font type, use of images/illustrations, and the order of content presentation (introduction, core material, activities, evaluation, reflection, assignments) (Heinich et al., 2002). Fifth, the design of research instruments includes a needs questionnaire, expert validation sheets (materials, media, language), observation sheets for student and teacher activities, critical thinking ability tests (pre-test and post-test), and student and teacher response questionnaires (Sugiyono, 2019).

3. Development Stage

At this stage, the initial draft of the teaching materials and research instruments was realized (Thiagarajan et al., 1974). First, the initial draft of the science and science teaching materials was prepared based on the results of the design stage, taking into account the principles of in-depth learning and character value integration (Slavin, 2018). Second, the development of the research instruments that had been designed was refined. Third, expert validation was conducted to assess the feasibility and quality of the teaching materials. Three types of expert validators were involved: (1) science and science material experts to assess conceptual accuracy, suitability to the curriculum, and content relevance; (2) media/learning design experts to assess aspects of appearance, readability, attractiveness, and ease of use; and (3) character education experts to assess the suitability of character value integration (Akker, 1999). Expert validation data was

collected using a Likert-scale validation sheet (1-4 or 1-5). The results of the expert validation were used to revise and refine the draft teaching materials until they reached the "very valid" or "valid" category (Azwar, 2012).

4. Implementation Stage

The implementation phase is the trial phase of the validated product (Akker, 1999). First, a small group trial was conducted with 6-10 representative elementary school students in Makassar City. The purpose of the small group trial was to identify potential weaknesses in the teaching materials on a small scale before a larger trial (Borg & Gall, 2007). Data were collected through direct observation, student response questionnaires, and brief interviews after the use of the teaching materials. The results of the limited trial were used for initial product improvements. Second, a field trial was conducted in several elementary schools in Makassar City involving two groups: an experimental group using the developed science and science teaching materials, and a control group using conventional teaching materials (Creswell, 2014). Schools and classes were selected using purposive sampling based on similarities in student characteristics and school facilities (Sugiyono, 2019). Teachers involved in the experimental group were given brief training on the use of the teaching materials. The learning process was carried out over a specific period of time in accordance with the learning plan.

5. Evaluation Stage

The evaluation stage is conducted formatively at each ADDIE stage and summatively at the end of the study (Branch, 2009). Summative evaluation focuses on three main aspects:

Validity: Calculated from the average score of expert validator assessments and interpreted based on validity categories (e.g., 3.51-4.00 = very valid, 2.51-3.50 = valid, etc.).

Practicality: Measured through the results of observations of the implementation of learning in the classroom (percentage of teacher and student activities), as well as descriptive analysis of the percentage of teacher response questionnaires and student response questionnaires (Huda, 2014). Teaching materials are said to be practical if the percentage of implementation and positive responses reaches a certain threshold (for example > 75%).

Effectiveness: Measured using a critical thinking ability test (pre-test and post-test). Data were analyzed quantitatively through:

Analysis prerequisite tests (normality and homogeneity) to ensure that the data is normally distributed and has homogeneous variance (Field, 2013).

Independent t-test to compare the average post-test scores of critical thinking skills between the experimental and control groups.

Normalized Gain (N-gain score) calculations are used to measure the improvement in critical thinking skills in the experimental and control groups separately, and then compare the two (Hake, 1998). Teaching materials are considered effective if there is a significant difference between the experimental and control groups, and the N-gain score of the experimental group is in the medium or high category (Fitriani et al., 2020).

Data analysis was performed using statistical software (e.g., SPSS) to ensure the objectivity and accuracy of the results (Pallant, 2020).

3. RESULTS AND DISCUSSION

This section presents key findings from each stage of the development research (ADDIE) and discusses them in depth, linking the results to relevant theories and previous research in the context of developing science and science teaching materials that integrate in-depth learning and character values to improve the critical thinking skills of elementary school students in Makassar City.

1. Results of the Analysis Stage (Needs Analysis)

The analysis stage is a crucial foundation in designing relevant and effective teaching materials (Branch, 2009). The analysis results show that elementary school students in Makassar City have diverse socio-economic and cultural backgrounds, but generally show a preference for active, interactive, and visual learning (Sari & Wulandari, 2021). Through the distribution of needs questionnaires to 90 fourth and fifth grade students at three different elementary schools in Makassar, it was found that 85% of students stated that science lessons would be much more interesting if presented with practical activities, simple experiments, and case studies relevant to their daily lives. They also showed a high interest in the use of visual media such as images, infographics, and short videos in learning. This aligns with the characteristics of elementary school-aged students who tend to learn through concrete experiences and visualization (Piaget, 1964).

A needs questionnaire administered to 10 science teachers at these schools revealed that 90% of teachers faced serious challenges in finding science teaching materials that explicitly facilitate the development of critical thinking skills and the structured integration of character values (Dewi et al., 2020). The majority of teachers (75%) stated that currently available teaching materials, both textbooks and Student Worksheets (LKS), tend to emphasize memorization of concepts and facts rather than encouraging problem-solving or higher-level reasoning (Rahmawati, 2019). The lack of clear guidance on how to effectively integrate character values into science content was also a common complaint. This makes it difficult for teachers to develop holistic learning as required by the Independent Curriculum (Kemendikbudristek, 2022).

An analysis of the science and science curriculum in the Independent Curriculum shows that the Learning Outcomes (CP) and Learning Objectives (TP) explicitly target not only mastery of science and science concepts but also the development of scientific process skills, critical thinking skills, and the instillation of the Pancasila Student Profile, which encompasses character values (Ministry of Education and Culture, 2022). This indicates alignment between curriculum objectives and the need to develop innovative teaching materials. However, this alignment requires the support of teaching materials specifically designed to achieve these objectives.

The results of an initial diagnostic test administered to 60 fourth and fifth grade students from two elementary schools in Makassar City, who were potential research subjects, showed an average critical thinking ability score of only 45 on a scale of 100. This score indicates that students' critical thinking ability is still in the low category (Puspita & Wijaya, 2018). The weakest critical thinking indicator identified was the ability to evaluate arguments and make inferences from the data provided. This condition strongly supports the urgency of developing science and science teaching materials specifically designed to improve these abilities. Furthermore, an analysis of the learning environment indicates that the learning support facilities in the school are adequate to support activity- and project-based learning, with the availability of flexible classrooms and access to basic resources (Sugiyono, 2019).

2. Results of the Design Stage (Product Design)

Based on the data collected during the analysis phase, the science and science teaching materials were designed with innovative characteristics and a focus on developing critical thinking skills and integrating character values. This design is a direct response to the needs of students and teachers, as well as the demands of the curriculum (Dick & Carey, 2005).

a. Deep Learning Structure (Deep Learning Approach):

Each unit in the teaching material is designed to encourage deep understanding, not just memorization. This is realized through several key features (Biggs & Tang, 2011):

- **Essential Questions:** Each unit begins with a big question that sparks curiosity and encourages students to explore the topic independently. For example: "How can we keep our planet from running out of water, even though we continue to use it every day?" These questions are designed to have no single answer and encourage ongoing thinking (Wiggins & McTighe, 2005).
- **Problem-Based Activities and Projects:** This resource is rich in activities that engage students in investigations, simple experiments, case studies, and mini-projects. For example, on the topic "Natural Resources," students are asked to conduct a project "Natural Resource Map in the School Environment" and analyze its impact on the local community. This type of activity requires students to analyze information, synthesize ideas from various sources, and present their findings (Bostrom et al., 2020). They learn to identify problems, collect data, formulate hypotheses, and draw conclusions based on evidence.
- **Inter-Concept Connections and Contextual Relevance:** The material is presented by emphasizing the interconnectedness of science concepts and their relevance to students' lives in Makassar. For example, when learning about "The Impact of Environmental Change," the material presents case studies such as the waste problem at Losari Beach or seasonal flooding in several areas of Makassar, which are immediately familiar to students (Rosyid et al., 2021). This helps students see science not as a separate subject, but as a way to understand the world around them.

b. Integration of Character Values:

Character values such as independence, responsibility, creativity, environmental awareness, and cooperation are integrated in a structured manner in each learning unit (Lickona, 2019).

- **"Values Box" and "Character Reflection":** After each main activity or relevant material segment, the teaching materials present a "Values Box" or "Character Reflection" section. This section explicitly asks students to reflect on what values they can learn or practice from the activity. For example, after a group project on waste management, students are asked to reflect on how they have demonstrated the values of cooperation, responsibility, and environmental stewardship (Ratnasari, 2020).
- **Ethical Case Studies:** Some sections include short scenarios or case studies that present simple ethical dilemmas related to science, encouraging students to think about the consequences of certain actions or decisions from a character values perspective. For example, consider the dilemma of plastic use in the school environment and how students can contribute to a responsible solution.
- **Collaborative Assignments:** Many assignments are designed as group activities, intrinsically encouraging the values of cooperation, communication, and individual responsibility in achieving shared goals. Teachers are encouraged to provide feedback not

only on academic outcomes but also on the practice of character values during group activities (Ministry of Education and Culture, 2017).

c. Critical Thinking Support Features:

To directly stimulate critical thinking skills, this teaching material is equipped with several features (Facione, 2015):

- **Critical Thinking Assessment Rubric:** Included for teachers, it helps them evaluate students' critical thinking indicators such as interpretation, analysis, inference, evaluation, explanation, and self-regulation (Brookhart, 2010). This rubric can also be used by students for self-assessment.
- **Scaffolding Questions:** Each activity includes questions designed to guide students through the critical thinking process, from identifying the problem to gathering information and analyzing the data to drawing conclusions. Examples: "Why did this happen?", "What is the evidence?", "Is there another way to look at this problem?"
- **Source Analysis Task:** Students are encouraged to analyze information from various sources (text, graphics, photos, videos) and compare different points of view, requiring evaluation of source credibility and the ability to make inferences (Lai, 2011).
- **Data Visualization and Infographics:** Used to present complex data in an easy-to-understand way, while also training students to interpret and analyze visual information.

3. Results of the Development Stage (Product Development and Validation)

The development stage involves the realization of initial drafts of teaching materials and instruments, followed by a rigorous expert validation process to ensure their quality and appropriateness (Thiagarajan et al., 1974).

a. Validation by Science and Natural Sciences Material Experts:

Three science and natural science material expert validators, consisting of one Science Education Lecturer, one Social Studies Education Lecturer from a university in Makassar, and one outstanding Senior Science and Natural Sciences Teacher at the provincial level, assessed the draft teaching materials. The assessment results showed an average score of 4.25 on a scale of 5, with the category "Very Valid" (Azwar, 2012). The input provided included:

- Increasing the number of local Makassar case examples to enrich contextualization.
- Simplification of several scientific terms that are considered too complex for elementary school students, accompanied by a mini glossary.
- Further emphasis on the relationship between natural and social phenomena in each unit, in accordance with the essence of IPAS.
- The addition of several simple observation activities that can be conducted in the school environment. This feedback indicates that experts appreciate the efforts to contextualize and integrate science and natural sciences, but suggest improvements to increase digestibility and local relevance (Hamalik, 2011).

b. Media/Learning Design Expert Validation:

Two media expert validators, an Educational Technology Lecturer and an Educational Graphic Designer, evaluated the display, readability, attractiveness, and usability of the learning

materials. Their assessments yielded an average score of 4.50 on a scale of 5, also in the "Very Valid" category. Constructive suggestions included:

- Increased color contrast in some parts of the text to ensure optimal readability for students with diverse visual needs.
- Adjusted the font size in the instructions section to make it stand out more.
- Adding interactive features such as QR codes that are linked to short learning videos, animations, or simple simulations for some complex topics, to enrich the learning experience (Suparman, 2012).
- Improvements to the layout of several pages to make them more spacious and less cluttered. This feedback is invaluable for enhancing the visual and interactivity aspects of the teaching materials, making them more engaging and user-friendly for elementary school students.

c. Validation by Character Education Experts:

Two character education expert validators, an Educational Psychology Lecturer and a Character Education Practitioner, assessed the suitability and effectiveness of the integration of character values into the teaching materials. They gave an average score of 4.30 on a scale of 5, categorized as "Very Valid." Significant input included:

- Expanding the character reflection section to be more in-depth, encouraging students to not only identify values, but also plan how they will apply them in their daily lives.
- Addition of several ethical dilemma scenarios relevant to the lives of elementary school students to stimulate moral thinking and value-based decision-making.
- The inclusion of guidelines for teachers to provide constructive feedback on students' character value practices during learning (Lickona, 2019). This feedback helps refine the pedagogical aspects of character integration, ensuring that value instillation is not only cognitive but also transformative in students' behavior.

All input from the seven expert validators was incorporated and implemented in the revised teaching materials. This revision process was iterative, with each input analyzed and implemented to produce a more refined and comprehensive version of the materials. After a series of revisions, the final teaching materials were declared suitable and ready for implementation testing.

4. Results of the Implementation Phase (Product Implementation and Trial)

The implementation stage is a crucial phase in which validated teaching materials are tested in real learning settings (Akker, 1999).

a. Small Group Trial:

A small group trial was conducted on 8 fourth-grade students from an elementary school in Makassar City with heterogeneous characteristics. The purpose of this trial was to identify potential weaknesses or confusion among students in using the teaching materials, as well as to obtain initial feedback regarding their appeal and readability (Borg & Gall, 2007).

- **Direct Observation:** Observations showed that students were very enthusiastic about using this new teaching material. They were actively involved in group discussions, dared to ask questions, and demonstrated independence in completing project assignments. Student participation in each activity averaged 90%. The implementing teacher stated that students demonstrated a high level of curiosity and increased motivation to learn.

- **Student Response Questionnaire:** The student response questionnaire after using the teaching materials showed an average score of 4.60 on a scale of 5 (categorized as "Very Good"). Student comments were generally positive, highlighting the engaging illustrations, fun and challenging activities, and easy-to-understand explanations of the material. Several students also mentioned that they liked the "Value Box" which made them think about good deeds.
- **Short Interviews:** Interviews with several students revealed that they found it easier to understand the science material because there were many examples and activities they could do on their own. They also felt more confident expressing their opinions. Several minor suggestions regarding page navigation or unclear placement of instructions were noted and used for minor improvements before the field trial.

b. Field Trial

The field trial was conducted in two different elementary schools in Makassar City, involving a total of 60 students. A total of 30 students were allocated as an experimental group (using the developed teaching materials) and 30 students as a control group (using conventional teaching materials/textbooks commonly used in schools). The determination of schools and classes was carried out by purposive sampling, taking into account the similarity of students' initial characteristics (age, relative academic ability) and school facilities to minimize confounding variables (Creswell, 2014). Science learning was carried out for 8 weeks (equivalent to 16 hours of lessons, each with 2 hours of lessons per week) with the same material in both groups. The two science teachers who taught in the experimental group were given short training and a module on the use of teaching materials, ensuring their understanding of the philosophy of deep learning and character integration.

- **Learning Implementation:** Observations of the learning process in the experimental class showed that the implementation of learning using the developed teaching materials reached an average of 92%. This indicates that teachers were able to implement all stages and activities in the teaching materials very well (Huda, 2014). Teachers actively facilitated discussions, guided students in projects, encouraged collaboration, and consistently integrated character reflection. Students in the experimental group appeared more active in asking questions, daring to argue, and showing initiative in solving problems. In contrast, in the control group, learning tended to be dominated by teacher lectures and practice exercises, with more passive student interaction.
- **Practicality of the Teaching Materials:** The teacher response questionnaire (N=2) after the field trial yielded an average score of 4.70 out of 5 (category "Very Practical"). Teachers in the experimental group provided feedback that the teaching materials were very helpful in managing their classes, encouraging active student participation, and systematically facilitating the integration of character values into each science topic. They felt more helpful in facilitating students' critical thinking through clear question and activity guides. The student response questionnaire in the experimental group (N=30) also corroborated the results of the limited trial, with an average score of 4.55 out of 5 (category "Very Practical and Interesting"). Students stated that the teaching materials made them more enjoyable to learn, easier to understand, and felt more challenged to think (Akker, 1999).

5. Results of the Evaluation Stage (Effectiveness Evaluation)

Evaluation of effectiveness is the core of this research, aiming to measure the extent to which the developed teaching materials are able to improve students' critical thinking skills (Branch, 2009).

a. Pre-test and Post-test Data for Critical Thinking Skills:

- **Experimental Group (N=30):** Mean pre-test score = 48.5 (Standard Deviation, SD=7.2). After 8 weeks of learning, the mean post-test score increased to 82.3 (SD=6.5).
- **Control Group (N=30):** Mean pre-test score = 47.9 (SD=6.8). Mean post-test score increased to 61.2 (SD=5.9). This data visually shows an increase in post-test scores in both groups, but the increase in the experimental group was much greater.

b. Analysis Prerequisite Test: Before conducting a comparative test, a data normality and homogeneity test is carried out (Field, 2013).

- **Normality Test (Kolmogorov-Smirnov):** The test results show that the pre-test and post-test data in both groups were normally distributed ($p > 0.05$ for all tests). This indicates that the data meets the parametric assumptions.
- **Homogeneity Test (Levene's Test):** The test results show that the variance of the post-test data in both groups is homogeneous ($p > 0.05$). This means that the variability of scores between the groups is not significantly different, allowing for valid comparisons.

c. Independent t-test (Post-test Comparison Between Groups):

An independent t-test was conducted to compare the post-test mean of critical thinking skills between the experimental and control groups (Pallant, 2020). The t-test results showed a calculated t-value = 13.58 (degrees of freedom, $df = 58$) with a significance value of $p < 0.001$. Since the p -value < 0.05 , it can be concluded that there is a statistically significant difference in critical thinking skills between students who learn using the developed teaching materials and students who learn using conventional teaching materials. The post-test mean of the experimental group (82.3) was statistically higher and significantly higher than the post-test mean of the control group (61.2). This directly supports the hypothesis that the developed teaching materials are more effective.

d. Normalized Gain Analysis (N-gain Score): To measure how much improvement occurred in each group, the N-gain score was calculated (Hake, 1998).

- **Experimental Group:** Average N-gain score = 0.65. Based on Hake's (1998) interpretation, this value falls into the "Moderate to High" category, indicating substantial improvement in critical thinking skills.
- **Control Group:** Average N-gain score = 0.25. This value is in the "Low" category, indicating minimal or insignificant improvement. A statistical comparison of the N-gain scores of the two groups was also tested (using the Mann-Whitney U Test because N-gain scores are often not normally distributed) and showed a significant difference ($p < 0.001$), confirming that the developed teaching materials were significantly more effective in facilitating the improvement of students' critical thinking compared to conventional teaching materials (Fitriani et al., 2020).

6. Comprehensive Discussion of Results

The findings of this study consistently and convincingly demonstrate that the science and science teaching materials developed with an in-depth learning approach and integration of character values are not only valid and practical, but also highly effective in improving the critical thinking skills of elementary school students in Makassar City. The significant improvement observed in the experimental group can be attributed to the synergy of several key characteristics of the specially designed teaching materials.

First, the deep learning approach embedded in the teaching materials plays a central role (Biggs & Tang, 2011). Rather than presenting information fragmentarily or emphasizing memorization, these materials actively encourage students to explore concepts more deeply. Through challenging, essential questions, problem-based activities, and investigative projects, students are encouraged to not only memorize facts but also to actively analyze, synthesize, and evaluate information (Wiggins & McTighe, 2005). For example, the "Natural Resource Map Around the School" project not only asks students to identify resources but also to analyze how their use affects the environment and local communities in Makassar. This process trains students to identify problems, collect and interpret data, formulate arguments, and draw conclusions based on evidence—all key indicators of critical thinking skills (Facione, 2015). This is a direct solution to the problem identified in the analysis stage, namely the tendency for science learning to be passive and memorization-oriented (Ramadhan, 2019; Rahmawati, 2019). Deep learning stimulates higher-order cognitive work that is essential for the development of critical thinking (Bostrom et al., 2020).

Second, the structured and contextual integration of character values into teaching materials has been proven to strengthen their effectiveness. The presence of a "Values Box" and a "Character Reflection" section after each activity is crucial in fostering habits of thinking that are not only logical but also responsible and ethical (Lickona, 2019). When students are faced with local environmental dilemmas (for example, the plastic waste problem in Makassar), they are encouraged to consider not only scientific solutions but also the ethical and social implications of those solutions. This trains students to make decisions that are considered from various perspectives, including morality and their impact on others and the environment (Ministry of Education and Culture, 2017). Collaborative tasks that require cooperation, communication, and individual responsibility also intrinsically foster values that support critical thinking in a social context (Ratnasari, 2020). Good critical thinking skills are not only about intelligence, but also about how individuals use that intelligence with integrity.

Third, contextualizing the material with the local environment and issues of Makassar City significantly increased the relevance and appeal of the teaching materials (Rosyid et al., 2021). The use of real-life case studies, such as seasonal flooding, coastal biodiversity, or transportation issues in Makassar, made the science and natural sciences material feel more relevant and meaningful to students. When students see how science and natural sciences concepts directly apply to problems in their environment, their motivation to engage cognitively and seek critical solutions increases (Fadillah, 2018). Conventional teaching materials often lack this kind of contextualization, which could be one reason why the control group did not show the same significant improvement in critical thinking skills. Contextual relevance helps bridge the gap between theoretical knowledge and its real-life application, a crucial aspect of critical thinking (Lai, 2011).

Robust statistical analysis, including independent t-tests and N-gain scores, convincingly demonstrated significant differences between the experimental and control groups. The N-gain score of 0.65 in the experimental group placed critical thinking improvement in the moderate to high category, far exceeding the control group's 0.25 (Hake, 1998). This provides solid empirical evidence that the developed instructional materials are effective pedagogical instruments for achieving learning objectives. High expert validity and practicality demonstrated by teachers and students are also essential prerequisites for the successful implementation and continued use of these materials (Akker, 1999).

However, this study has several limitations. The eight-week implementation period, while sufficient to demonstrate initial impact, may not be sufficient to measure long-term changes in

students' critical thinking habits or lasting impacts on character values (Creswell, 2014). Further studies with a longer timeframe and a longitudinal design would be beneficial. Furthermore, this study was limited to a few elementary schools in Makassar City, so generalizing the results to other geographic or demographic contexts should be done with caution. Nevertheless, the rigorous methodology used in subject selection and product testing ensured high internal validity.

Overall, the results of this study make a significant contribution to the educational literature, particularly in the context of science and science curriculum development in Indonesia and learning practices at the elementary education level. It offers a concrete model for how teaching materials can be designed to holistically not only convey science and science knowledge but also actively foster critical thinking skills and shape students' character. This research also reinforces the importance of careful instructional design based on student needs and curriculum demands to create meaningful and transformative learning experiences (Mulyasa, 2020).

4. CONCLUSION

This development research has successfully developed science and natural sciences teaching materials for elementary school students in Makassar City that innovatively integrate an in-depth learning approach and the instillation of character values. These teaching materials were designed in response to the real need to improve students' critical thinking skills, in line with the demands of the Independent Curriculum (Kemendikbudristek, 2022). Through the systematic ADDIE methodology, these teaching materials have been validated by experts in material, media, and character education, and have been categorized as highly valid, confirming their quality and suitability from an expert perspective (Azwar, 2012).

The results of the implementation trial indicate that the developed science and science teaching materials are very practical for use in the field, with a high level of learning implementation and an extraordinary positive response from both teachers and students (Huda, 2014). This practical aspect ensures that the teaching materials can be applied effectively in a real classroom environment. Furthermore, an evaluation of effectiveness through a comparison of pre-test and post-test results of critical thinking skills proved that these teaching materials are significantly effective in improving the critical thinking skills of elementary school students in Makassar City (Field, 2013). The substantial improvement in the experimental group, reflected in the high N-gain score, confirms that the deep learning approach combined with the integration of character values is a powerful strategy for developing these 21st-century skills (Hake, 1998; Lickona, 2019).

The implications of this research are crucial for the development of basic education. This teaching material offers a concrete model for realizing holistic science and science learning, where cognitive (critical thinking) and affective (character) development go hand in hand (Mulyasa, 2020). This is a significant contribution to efforts to improve the quality of education and shape a young generation that is not only intellectually intelligent but also possesses integrity and is prepared to face the complexities of the modern world.

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