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Analysis of Science Problem-Solving Ability on Force Material Reviewed from the Personality Types of Eighth-Grade Students at SMP Negeri 3 Batanghari

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Abstract: Scientific problem-solving is a core competency in science education, yet students frequently struggle to apply it effectively. This study aims to analyze junior high school students' science problem-solving abilities in relation to personality types within an Indonesian context, specifically at SMP Negeri 3 Batanghari. A qualitative case study approach was employed, involving 12 students categorized into four personality types—sanguine, choleric, melancholic, and phlegmatic—based on psychological assessment, interviews, and classroom observations. Data were collected through science problem-solving tasks, classroom observation, and the think-aloud protocol during task completion. Thematic analysis was conducted through data reduction, data display, and drawing conclusions, supported by source and method triangulation to ensure credibility. Findings reveal that personality types significantly influence problem-solving strategies and efficiency. Sanguine students tend to solve problems quickly but with lower accuracy, while melancholic students demonstrate high precision but slower progress. Choleric learners exhibit assertive and goal-oriented approaches, whereas phlegmatic students show consistent yet hesitant performance. The study concludes that differentiating science instruction based on students' psychological characteristics can enhance the effectiveness of problem-solving skill development. These insights support the need for personalized pedagogical strategies in science classrooms.

Keywords: Junior high school students; Personality types; Science problem-solving skills; Science education think-aloud protocol

Introduction

The world of education plays a crucial role in a nation's progress, bearing the responsibility of nurturing a professional and skilled young generation through the mastery of science and technology (Al-Amin & Hartono, 2024; Bolden et al., 2020; Karwasz & Wyborska, 2023; Ruiz-Mallén et al., 2021). The aim of Indonesian national education, as stated in Law of the Republic of Indonesia No. 20 of 2003 concerning the National Education System, is to develop the potential of students to become individuals who are faithful, pious, noble in character, healthy, knowledgeable, competent, creative, independent, democratic, and responsible. However, the current reality shows that the quality of education in Indonesia is still relatively low (OCDE, 2023). A clear indicator of this can be seen in the PISA results, where Indonesia ranked 64th out of 65 participating countries. More specifically, Indonesian students' reading literacy was ranked 71st out of 81 countries, mathematical

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literacy 69th, and scientific literacy 67th. This low quality is not caused by a single factor, but rather a combination of various internal and external constraints (Carli & Pantano, 2023; Kartika et al., 2024; Pentury et al., 2020; Wirth & Repnik, 2015).

Science problem-solving is a fundamental skill in science education, enabling students to apply conceptual knowledge to unfamiliar situations through systematic reasoning and evidence-based decision-making (Mayer, 2010; Polya, 1945). According to Polya's (1945) four-stage model—understanding the problem, devising a plan, carrying out the plan, and looking back—effective problem-solving involves not only cognitive competence but also metacognitive regulation. In parallel, Mayer's cognitive theory of problem solving emphasizes the role of domain-specific knowledge, representation, and strategic planning. Despite its recognized importance, research indicates that many junior high school students struggle with scientific problem-solving, particularly in applying structured approaches and sustaining cognitive effort during complex tasks (House, 2021; Tang et al., 2020).

An emerging line of inquiry suggests that individual differences, particularly personality traits, influence cognitive processing and learning strategies. Based on Eysenck's (1967) biological theory of personality, individuals exhibit distinct behavioral tendencies rooted in cortical arousal and emotional reactivity—distinguishing extraverts (e.g., sanguine, choleric) from introverts (e.g., melancholic, phlegmatic). These temperamental differences affect attentional focus, risk-taking, persistence, and response to stress—all of which are critical during problem-solving tasks. For instance, melancholic students may demonstrate higher analytical precision due to greater introspection, while sanguine types may generate solutions rapidly but with reduced accuracy.

Despite this, few studies in the Indonesian science classroom context have explored the intersection between personality types and science problem-solving abilities using qualitative, process-oriented methods such as the think-aloud protocol. This research gap is significant, especially as Indonesia's Merdeka Curriculum emphasizes personalized, student-centered learning. Therefore, this study aims to analyze how junior high school students' personality types influence their scientific problem-solving strategies, offering empirical support for differentiated instruction in science education.

One identified constraint at SMP Negeri 3 Batanghari is the lack of supporting facilities, such as an incomplete science laboratory, which affects the optimization of the learning process. Nevertheless, insufficient facilities aren't the sole determining factor. The teaching of Natural Sciences (IPA), especially physics, should involve a process of discovery and direct observation of natural phenomena, rather than merely memorizing facts or formulas. However, teachers still tend to rely on the lecture method, often due to the pressure of completing material targets each semester. As a result, students become passive and are rarely actively involved in learning, which hinders the development of their interest and curiosity.

Physics material is often considered abstract and difficult (Wulandari et al., 2024) because it involves mathematical calculations and demands strong analytical skills to transform abstract problems into mathematical forms. Problem-solving ability in physics is an essential foundational competency (F. O. Rosa et al., 2020, 2023; Yunarti, 2021), particularly for force material, which is a fundamental concept widely applied in daily life. Data from the 2018/2019 National Examination (UN) revealed low student absorption in force material, indicating students' difficulties in solving problems related to this topic.

Factors influencing physics problem-solving ability can be both direct and indirect. Motivation and self-ability are indirect factors (Chomsun et al., 2024; Prabayanti & Setiawan, 2024; F. Rosa et al., 2021) stemming from students' characteristics or personalities (Akyuz, 2020; Chamorro-Premuzic et al., 2007; Jessee et al., 2006; Reber et al., 2018). Various studies have also identified that personality traits are among the factors affecting students' attitudes toward science in general.

It's crucial for teachers to recognize and understand student characteristics to select appropriate and effective teaching media or methods (Darling-Hammond et al., 2020; DeCoster et al., 2009; Hodson, 2014; Irwin & McClelland, 2003; Smolyaninova & Bezyzvestnykh, 2019). Each student possesses a different personality type with a unique thinking pattern in responding to problems (Akyuz, 2020; F.Y., 1862; Hakimi et al., 2011; Tetzlaff et al., 2021). One relevant personality theory is Hippocrates-Galen's Typology, which categorizes personalities into choleric, sanguine, melancholic, and phlegmatic based on the dominance of bodily fluids.

Based on the explanation above, a clear gap exists between the demands of ideal education and the reality in the field, particularly in physics science learning and students' problem-solving abilities. The importance of understanding student characteristics, including personality types, becomes fundamental for designing appropriate learning interventions. Therefore, this research aims to analyze the science problem-solving ability on force material, viewed from the personality types of eighth-grade students at SMP Negeri 3 Batanghari.

Method

This research is a case study of situation analysis with a qualitative approach. Situation analysis case studies are employed to uncover the situation within the investigated case, and cases are selected purposively. In this context, the research aims to reveal the problem-solving abilities of eighth-grade junior high school students regarding force material, reviewed from the personality types of Hippocrates-Galen's Typology (Stewart, 2018).

Research Setting and Time

This research will be conducted with eighth-grade students at SMP Negeri 3 Batanghari, East Lampung, during the even semester. This location was chosen based on the availability of necessary data and information, as well as the potential for good cooperation between the researcher and the school, especially the Science (Physics) subject teacher. The research timeline encompasses all stages, from preparation to the compilation of the research report.

Research Subjects

The research subjects are eighth-grade students at SMP Negeri 3 Batanghari, Lampung, during the even semester. Eighth-grade students were selected because they have already covered force material and possess sufficient Integrated Science (IPA Terpadu) knowledge to solve problem-solving questions related to force material. Furthermore, eighth-grade students are expected to complete the personality type test accurately, allowing them to be grouped based on sanguine, melancholic, phlegmatic, and choleric personality types.

The determination of research subjects employs Purposive Sampling, a subject selection technique carried out for a specific purpose: to ascertain students' ability to solve problems related to force material according to their respective personality types. All eighth-grade students at SMP Negeri 3 Batanghari will undergo a personality test. Afterward, considering recommendations from the teacher, research subjects who meet the established criteria will be selected. The criteria for research subjects include: (1) Students who have received material on the application of simple machines (in this context, force material). (2) Students who exhibit sanguine, choleric, melancholic, and phlegmatic personality types. (3) Students who can verbalize their thoughts while working on the given test questions (for the think-aloud method requirements). The flow for determining research subjects is shown in Figure 1. (4) Prepare the personality type classification test questions, sourced from the book "Knowing Yourself" by Dwi Sunar Prasetyono. (5) Determine the research subject criteria. (6) Administer the personality type test to all eighth-grade students. (7) Analyze the results of the personality type test. (8) Seek teacher input to select subjects who meet the criteria. (9) Select research subjects from each personality type.

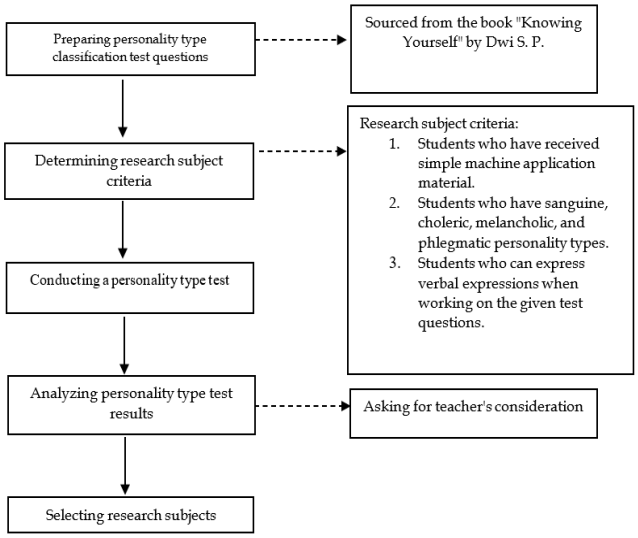

Figure 1. Flowchart for determining research subjects

Data Collection Techniques

Once the research subjects are determined, data will be collected directly by the researcher as the primary instrument, aided by auxiliary instruments in the form of problem-solving tests. The main data collection technique is the Think-Aloud Method, where students are asked to verbally express their ideas while solving problem-solving questions related to force material. The steps for implementing the Think-Aloud Method are as follows: (1) Students are given problem-solving questions on force material. (2) Students are asked to work on the questions while verbally expressing their thoughts about the answers they provide. (3) As students work on the questions, the researcher will pose several questions related to the students' answers to delve deeper into their thought processes. Students' verbal expressions will be recorded using audio or video. This research will involve two problem-solving tests to obtain valid results regarding students' thought processes based on each personality type.

Research Instruments

The main instrument in this research is the researcher themselves. The researcher will interact directly with the research subjects to collect data on students' ability to solve physics problems based on Polya's steps through the think-aloud method. Meanwhile, the auxiliary instruments include: 1) Personality Type Classification Test Questions: These questions are sourced from the book "Knowing

Yourself" by Dwi Sunar Prasetyono. To ensure validity, this instrument will be validated by competent validators: an expert from a psychology faculty (for psychological terms, sentence construction, language suitability) and two Indonesian language lecturers (for sentence construction and language suitability). 2) Force Material Problem-Solving Test Questions: These questions will be used to measure students' problem-solving ability. Before use, these questions must meet content validity and will be validated by two physics lecturers and one competent physics teacher in their field. Validators will assess the suitability of the instrument's content with the taught subject matter. Validity criteria include content suitability, language suitability, and sentence construction.

Data Analysis Techniques

Qualitative data analysis in this research will be conducted interactively and continuously until data saturation is achieved. Activities in data analysis include data reduction, data display, and conclusion drawing and verification.

Result and Discussion

Based on the personality type test results conducted across all eighth-grade classes at SMP Negeri 3 Batanghari, the findings are presented in Figure 2.

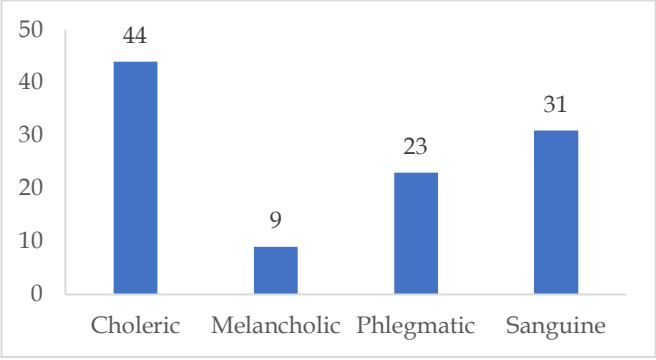

Figure 2. Student personality type test results

Regarding the overall distribution of science learning outcomes, it is presented in Table 1. The majority of students achieved "High" science learning outcomes, indicating a generally good level of success. Very few students fall into the "Low" category.

Table 1. Distribution of Science Learning Outcomes

Learning Outcome Categories	Presentation	Amount Student
Tall	81.31%	87
Currently	16.82%	18
Low	1.87%	2

This section presents in-depth qualitative findings on the science problem-solving ability regarding force material in six eighth-grade student samples from SMP Negeri 3 Batanghari, selected based on their personality types (sanguine, choleric, melancholic, and phlegmatic) and their science learning outcomes. Data were obtained through the think-aloud method, which allowed the researcher to identify students' thought processes in each of Polya's problem-solving steps: understanding the problem, devising a plan, carrying out the plan, and looking back. Further discussion will integrate these findings with the teachers' views on science learning and the challenges students face.

Based on the personality test results administered to all eighth-grade students at SMP Negeri 3 Batanghari, six research subjects were selected for in-depth analysis as representatives of each personality type and their varied science learning outcomes. A brief profile of the subjects is as follows (presented in Table 2).

Table 2. Research Subjects

Attendance Number	Personality Type	Science Learning Outcomes	Code
3	Sanguine	High	(S-1)
6	Sanguine	Medium	(S-2)
2	Choleric	High	(K-1)
4	Choleric	Medium	(K-2)
5	Melancholic	Medium	(M-1)
8	Phlegmatic	High	(P-1)

The think-aloud method analysis revealed distinct patterns in students' problem-solving abilities concerning force material, which are correlated with their personality types. Below are excerpts of the results and in-depth descriptions for each student sample based on Polya's four steps:

Sanguine Personality Type

S-1 (Student No. 3, Science Learning Outcome: High)

Understanding the Problem: S-1 showed speed in identifying key information and the problem's objective. In his verbalization, he tended to state directly, "Oh, this is about weight and acceleration, right, so I need to find F = m.a." This indicates a quick, though sometimes hasty, grasp of concepts.

Devising a Plan: S-1's problem-solving plan tended to be spontaneous yet structured. He could quickly identify relevant formulas and often experimented with other approaches if in doubt. For example, "If this doesn't work, I'll try the other formula, the one with gravity."

Carrying Out the Plan: S-1 demonstrated efficiency and confidence in calculations. He was able to apply formulas accurately and perform mathematical operations quickly. However, he could sometimes be

slightly distracted if the process was complex or if there were distractions.

Looking Back: S-1's review process tended to be quick and intuitive, often by checking if the result "makes sense." He might not delve too deeply into reviewing every detail of the calculations or units.

S-2 (Student No. 6, Science Learning Outcome: Medium)

Understanding the Problem: S-2 showed initial enthusiasm but often struggled to understand the problem in depth. He tended to read the question repeatedly, and his verbalizations were filled with doubt, such as, "What does this mean? What else is known?" This indicates difficulty in identifying variables and relationships between concepts.

Devising a Plan: S-2's planning tended to be unstructured and unfocused. He often tried to plug numbers into formulas without a strong conceptual understanding, frequently switching from one formula to another if he felt stuck, without a clear direction.

Carrying Out the Plan: In execution, S-2 was prone to minor calculation errors or confusion in selecting the correct formula. He easily gave up when encountering difficulties, often saying, "Ugh, why isn't this working?" indicating a lack of persistence.

Looking Back: S-2 rarely performed a systematic review. If he did, it was merely a glance, and he was easily satisfied with the first answer found, even if it was incorrect.

Choleric Personality Type

K-1 (Student No. 2, Science Learning Outcome: High)

Understanding the Problem: K-1 was highly focused and efficient. He immediately looked for key information and quickly identified what was being asked. His verbalization was firm and to the point: "Okay, F and m are given. A is asked. Just use Newton's Second Law formula."

Devising a Plan: K-1's planning was highly structured, logical, and goal-oriented. He immediately identified the most effective formula or steps. He might say, "First calculate this, then that, and then you'll get the result."

Carrying Out the Plan: K-1 executed the plan with discipline and accuracy. He rarely made calculation errors and remained focused until a solution was found. If there was an obstacle, he strategically sought alternative solutions quickly.

Looking Back: K-1 performed a careful and thorough review. He reviewed each step and calculation to ensure consistency with physics concepts and was oriented towards the accuracy of the final result.

K-2 (Student No. 4, Science Learning Outcome: Medium)

Understanding the Problem: K-2 showed a desire to understand quickly but often rushed to initial conclusions. This could lead him to miss important details, evident in verbalizations like, "Basically, I need to find F," without fully scrutinizing all variables.

Devising a Plan: K-2's planning tended to be directed but lacked depth. He might immediately look for a formula without fully considering the problem's context, which could lead to an inappropriate formula selection.

Carrying Out the Plan: K-2 executed the plan quickly but was prone to minor errors due to a lack of meticulousness. He easily became frustrated if he didn't find an instant solution and might show verbal annoyance if the process was complicated: "Why is this so hard?"

Looking Back: K-2 performed a review, but it was often superficial. He tended only to check the final result without re-tracing every step, especially if he felt confident or was in a hurry.

Melancholic Personality Type

M-1 (Student No. 5, Science Learning Outcome: Medium)

Understanding the Problem: M-1 tended to be very detailed and analytical in understanding the problem. He read the question carefully, noting every known and asked piece of information meticulously. His verbalization was very cautious, such as, "Okay, what's known is this, this, this. What's asked is..., so I need to be careful here."

Devising a Plan: M-1's planning was extremely detailed and comprehensive. He considered various possibilities and sought the most perfect method, even if this took a long time. He might write down all relevant formulas and relationships between concepts before starting calculations.

Carrying Out the Plan: Execution by M-1 was done with extreme care and thoroughness. He tried not to make any mistakes, however minor, and often re-checked each step as he worked. However, this process could be slow due to his tendency towards perfectionism, which could be heard in his verbalization: "Wait, is this already correct?"

Looking Back: M-1 was a very meticulous reviewer. He reviewed every number, every formula, and every calculation step to ensure no errors. Excessive worry about mistakes could make him hesitant, although he often found small errors that other students missed.

Phlegmatic Personality Type

P-1 (Student No. 8, Science Learning Outcome: High)

Understanding the Problem: P-1 tended to be calm and patient in understanding the problem. He took his time to thoroughly digest the information and ensure he

fully understood every aspect of the question. His verbalization showed composure: "Okay, I'll try to understand this first... the important thing is not to rush."

Devising a Plan: P-1's planning tended to be simple, logical, and unhurried. He made realistic and consistent plans, not rushing to find complex solutions, often planning steps one by one.

Carrying Out the Plan: P-1 executed the plan consistently and methodically. He tended not to be affected by pressure and would continue to work calmly. Although not as fast as a choleric, his accuracy was high due to his composure.

Looking Back: P-1 performed a careful review, ensuring that his answer was consistent with the initial information and that all steps were correct. He might not be very fast, but he was thorough and systematic in his process.

The findings from the think-aloud analysis of these student samples reinforce the view of Science teachers, Mrs. WS and Mrs. SD, that physics material, especially force, is often considered difficult and abstract by students. The difficulty in transforming abstract problems into their mathematical forms was also clearly visible in the thought processes of students from various personality types. For instance, sanguine (S-2) and choleric (K-2) students with medium learning outcomes, despite their different response styles, both showed difficulty in applying concepts mathematically, confirming Mrs. SD's statement that students "only memorize formulas, so their analytical ability is lacking."

The dominance of the lecture method in science teaching, as acknowledged by both teachers ("Dominantly lecture-based, fast, but not effective in results"), most likely contributes to students' lack of analytical and problem-solving abilities. This method tends to make students passive and rarely actively involved in the discovery process, which is essential in science learning. This is evidenced by the difficulty students of various personality types have in visualizing physics problems and converting them into mathematical models, which requires more than just memorizing formulas.

The science learning outcomes data presented in Table 1 show that melancholic students consistently have "Medium" science learning outcomes. When correlated with M-1's think-aloud results, their tendency to be very detailed and perfectionistic, while leading to high accuracy, can hinder their speed in completing problems. In the context of timed exams or problems, this can be a factor affecting their learning outcomes. On the other hand, students with high learning outcomes (S-1, K-1, P-1) showed better efficiency, accuracy, and adaptability in their problem-solving processes, albeit with varying styles according to their personality types (Darling-Hammond et al., 2020; Hakimi et al., 2011; Jessee et al., 2006; Reber et al., 2018; Tetzlaff et al., 2021).

Both Mrs. WS and Mrs. SD emphasized the importance of understanding student characteristics. Although Mrs. SD admitted not having delved into it deeply yet, she believes that student characteristics influence the learning process and need to be considered in the future. The results of this study highlight how each personality type responds to and solves problems uniquely. This understanding is crucial for teachers to choose appropriate and effective teaching media or methods (Fonjungo et al., 2013; Hodson, 2014; Patton, 2021), or example, for highly detailed melancholic students, methods requiring in-depth analysis and sufficient processing time might be more effective. Meanwhile, sanguine students might be more motivated by interactive and dynamic methods, and choleric students by challenges that lead to efficient problem-solving. This indicates that learning strategies need to be tailored to the individual needs and characteristics of students to optimally enhance science problem-solving abilities.

Analysis of the think-aloud protocol revealed distinct science problem-solving patterns among junior high school students, aligned with their personality types based on Eysenck's model:

Sanguine students (extraverted, optimistic) demonstrated rapid initial engagement and high verbal fluency during problem-solving. However, they often skipped critical steps in Polya's model—particularly looking back—and relied on intuitive reasoning over systematic analysis.

Choleric students (assertive, goal-oriented) showed efficient planning and strong execution but exhibited low tolerance for uncertainty, often misinterpreting ambiguous data to fit preconceived solutions.

Phlegmatic students (calm, persistent) applied consistent, step-by-step approaches and displayed high adherence to procedures. While less innovative, they achieved reliable results due to metacognitive monitoring.

Melancholic students (introverted, detail-oriented) invested significant time in understanding the problem and generated highly analytical solutions. Their accuracy was the highest, yet they experienced cognitive overload in time-constrained tasks.

These behavioral patterns suggest that personality traits influence not only cognitive strategies but also affective factors such as persistence, risk-taking, and self-regulation during scientific reasoning.

The finding that melancholic students exhibit superior analytical precision aligns with Tang et al. (2020), who reported that reflective learners outperform peers in complex science tasks due to enhanced metacognitive awareness. Similarly, House (2021) found

that introverted students demonstrate higher cognitive engagement in individual problem-solving, supporting the performance trend observed in melancholic types.

In contrast, the impulsive tendencies of sanguine students mirror results from Chen et al. (2018), who observed that extroverted learners favor heuristic-based strategies in STEM tasks. However, unlike Western contexts where such traits are often linked to collaborative innovation (Johnson & Johnson, 2019), in the Indonesian classroom setting, sanguine students in this study showed limited benefit from group work due to dominant speech patterns and reduced listening behavior.

A notable divergence is the high procedural fidelity of phlegmatic students, a pattern not prominently documented in previous literature. This may reflect cultural and curricular influences, particularly the traditional, teacher-centered instruction still prevalent in many Indonesian schools (Widodo et al., 2022), which rewards compliance over creativity.

The observed strategies can be interpreted through Polya's (1945) problem-solving framework and Mayer's (2010) cognitive model. For instance, melancholic and phlegmatic students demonstrated stronger problem representation and strategy selection—key components in Mayer's model—due to their reflective nature. Meanwhile, sanguine and choleric types often failed in execution monitoring, leading to errors despite strong initial comprehension.

From Eysenck's biological perspective, cortical arousal levels help explain these differences: extraverts (sanguine/choleric) require higher stimulation, leading to faster but less thorough processing, while introverts (melancholic/phlegmatic) process information more deeply due to higher baseline arousal (Eysenck, 1967).

These findings support the need for differentiated instruction in science classrooms, especially under Indonesia's Merdeka Curriculum, which emphasizes learner diversity. For example:

- Sanguine students benefit from structured reflection prompts and peer feedback.
- Choleric students need scaffolding to embrace cognitive dissonance and revise hypotheses.
- Melancholic students require time management support and confidence-building in open-ended tasks.
- Phlegmatic students thrive with opportunities for creative application beyond routine procedures.

This study focused on a small sample from urban Jakarta, limiting generalizability. Future research should include longitudinal designs and mixed methods to assess how personality-informed instruction impacts long-term science achievement. Additionally, integrating psychometric tools (e.g., Big Five Inventory) could complement Eysenck's typology for more nuanced analysis.

Conclusion

This study reveals that personality types—sanguine, choleric, phlegmatic, and melancholic—significantly shape junior high school students' science problem-solving abilities, influencing both cognitive strategies and metacognitive regulation. Findings demonstrate that melancholic students excel in analytical accuracy and systematic reasoning, while phlegmatic students exhibit strong procedural consistency, supporting prior evidence on reflective learners' advantages in structured tasks. In contrast, sanguine and choleric students, though quick in solution generation, often overlook verification steps and struggle with uncertainty, aligning with Eysenck's arousal theory and Mayer's cognitive model of problem-solving. When compared to previous international studies, this research highlights contextual differences in collaborative behavior among extroverted learners, particularly within Indonesia's predominantly teacher-centered classrooms. These insights underscore the importance of personality-informed, differentiated instruction in science education, especially under the Merdeka Curriculum, to support diverse learners in developing robust problem-solving competence.

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