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A Study of Extrovert and Introvert Personality Types on Students' Mathematical Problem-Solving Ability

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ABSTRACT

Purpose of the study: Mathematical problem-solving ability is a crucial skill influenced by various factors, including personality types. This study aims to analyze students' mathematical problem-solving abilities based on extrovert and introvert personality types in the MBTI framework.

Methodology: This research was descriptive qualitative research. Data were collected through an MBTI questionnaire to determine students' personality types and a mathematical problem-solving test to assess their abilities. The participants consisted of 11 undergraduate students from the Mathematics Education Department at Institut Agama Islam Negeri Kerinci, who were enrolled in the Mathematical Statistics course.

Main Findings: Extroverted students tend to excel in understanding problems and planning solutions; however, they are more likely to overlook careful execution. In contrast, introverted students struggle with planning and do not always review the solutions they have produced. It can be concluded that extroverted students have better mathematical problem-solving abilities than introverted students in the mathematical statistics course. These results highlight the role of personality in cognitive strategies and error patterns during problem-solving. Tailored instructional approaches could help both extroverted and introverted students optimize their problem-solving abilities. The small sample size and single-institution context may limit the generalizability of these findings. Future research is recommended to expand on these insights.

Novelty/Originality of this study: This study fills the gap by conducting an in-depth analysis of specific problem-solving behaviors, cognitive strategies, and error tendencies associated with extroverted and introverted students based on the MBTI framework, thereby offering a richer understanding of how personality types affect problem-solving ability.

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1. INTRODUCTION

Mathematical problem-solving ability is crucial in higher education [1], [2]. In mathematics courses, students are expected to engage in complex problem-solving processes that involve abstraction, pattern recognition, and structured decision-making. Enhancing problem-solving skills is one of the most essential aspects for students [3]-[5]. The problem-solving process requires both conceptual and procedural knowledge. Conceptual knowledge involves understanding, skills, and tools essential for solving problems, while procedural knowledge refers to the process skills applied during problem-solving [6]. Problem-solving considers the demands of modern life and work in a 21st Century Mathematics Curriculum [7], [8]. The indicators of mathematics problem-solving ability include understanding the problem, planning the solution, executing the plan, and reviewing the solution [9]. Understanding the problem ensures clarity, and devising the plan, executing the plan by applying mathematical concepts, and reviewing verifies correctness. These stages enhance systematic thinking and problem-solving efficiency. Szabo et al. proved the relevance of the Pólya method in the context of 21st-century problem-solving in their research [10].

However, Indonesian students' problem-solving ability still needs to improve [11]-[14]. Many students struggle with problem-solving [15]-[18] especially in mathematical statistics courses. Students often find it difficult to formulate problems, identify appropriate solution strategies, and validate their answers. This fact was discovered in the field by researchers as lecturers. The student's learning outcomes in the Mathematical Statistics course tend to be low. Based on the test middle semester learning outcome results, the average score across all students is 59.45, which falls into the Low-performance category in problem-solving. This issue is evident in students' responses to statistical problem-solving tasks, where they frequently make errors in selecting the correct approach or applying mathematical concepts appropriately. These difficulties indicate a broader challenge in students' mathematical reasoning and problem-solving abilities, which require further investigation to develop more effective instructional strategies.

The difficulties students face in mathematical problem-solving are also reported in several previous studies. Jensen found that university students often struggle with selecting appropriate problem-solving strategies in advanced mathematical courses [19], particularly in subjects involving statistical reasoning. Similarly, Prambanan et al. observed that many students exhibit a lack of confidence and systematic reasoning when solving mathematical problems, leading to frequent errors and incomplete solutions [20]. Research by Selpiana and Munawir further highlighted that students' problem-solving difficulties are exacerbated by their limited ability to connect abstract mathematical concepts with real-world applications, which is a common issue in statistical mathematics courses [21]. These findings suggest that the challenges in problem-solving are not isolated to a specific group of students but are part of a larger issue in mathematics education.

Personality types play a significant role in shaping students' learning behaviors and cognitive processes. Understanding students' personality types is essential for gaining insight into their approaches to tackling and solving mathematical problems [22]. Each student possesses a unique personality, which influences their learning preferences, methods of absorbing information, and approaches to problem-solving [23]. Educators can provide the best learning methods for students by considering the different personality conditions of each student [24].

The Myers-Briggs Type Indicator (MBTI) is a widely recognized framework that categorizes individuals into 16 personality types based on four dichotomies: Extroversion (E) vs. Introversion (I) as mind dimension, Sensing (S) vs. Intuition (N) as energy dimension, Thinking (T) vs. Feeling (F) as nature dimension, and Judging (J) vs. Perceiving (P) as tactics dimension [25], [26]. Among these, the extroversion-introversion dimension is particularly relevant to learning styles and problem-solving approaches. Significant distinctions between extroversion and introversion indicate the need to explore how these personality traits influence the problem-solving process [27]. Extroverted students tend to be more verbal, collaborative, and quick in generating solutions, while introverted students are often more reflective, analytical, and systematic in their approach. These differences suggest that personality traits may influence how students engage with mathematical problem-solving tasks [28], particularly in courses such as mathematical statistics that require both conceptual understanding and procedural fluency.

The selection of extroversion and introversion in this study is based on their fundamental influence on cognitive processing and learning behaviors. Extroversion and introversion are the most highlighted personality in the learning process [29]. Unlike other MBTI dichotomies, the extroversion-introversion dimension directly affects how students approach problem-solving. Extroverted students often engage in rapid ideation and discussion, preferring interactive and dynamic learning environments, while introverted students tend to analyze problems deeply and work independently with a more structured approach [19]. Previous studies, such as those conducted by Juliansa et al., indicate that differences in extroverted and introverted tendencies may result in varied problem-solving strategies [30]. However, most research has focused on general learning behaviors rather than their direct impact on mathematical problem-solving. By focusing on these two personality types, this study aims to provide a clearer understanding of how cognitive tendencies influence students' problem-solving processes, ultimately contributing to more effective teaching strategies in mathematical education.

Although previous research has explored the correlation between personality traits and general academic performance, few have thoroughly investigated how extrovert and introvert personality types shape students' cognitive processes. There remains a gap in understanding how extroverted and introverted students engage in mathematical problem-solving at a cognitive and strategic level. Most studies focus on broad academic achievement, such as participation in discussions, group activities, and general learning preferences, rather than problem-solving in mathematics, which requires distinct cognitive processes such as abstraction, logical reasoning, and structured decision-making [31]. This gap underscores the urgency to explore the interplay between personality and problem-solving, especially as 21st-century education demands more personalized learning approaches.

This study fills this gap by conducting an in-depth analysis of mathematical problem-solving abilities through the lens of MBTI personality types, particularly extroversion and introversion. Unlike prior studies that merely classify students into personality groups, this research investigates specific problem-solving patterns, cognitive strategies, and error tendencies exhibited by extroverted and introverted students. Furthermore, this study employs qualitative methods to explore the reasoning processes behind students' solutions, providing deeper insights into how personality traits influence mathematical problem-solving. By addressing this research gap, the findings of this study will contribute to the development of more adaptive and personalized instructional strategies in mathematics education. The results will offer practical implications for educators in designing problem-solving tasks, adjusting teaching methods, and fostering inclusive learning environments tailored to students' cognitive and personality differences.

The existing gaps and the importance of understanding how extrovert and introvert personality types influence mathematical problem-solving, this study formulates the research questions: (1) how do extroverted and introverted students differ in understanding, planning, executing, and evaluating mathematical problems? (2) what specific challenges and errors are most commonly observed among extroverted and introverted students? and (3) how can insights into these differences be leveraged to develop more effective teaching strategies for mathematical problem-solving? The research objectives are: (1) to examine the distinct problem-solving patterns of extroverted and introverted students across the stages of problem-solving; (2) to identify the primary challenges and error patterns associated with each personality type in mathematical problem-solving; and (3) to propose instructional strategies tailored to extroverted and introverted learners, aimed at enhancing overall problem-solving performance. These questions and objectives guide the investigation into the distinct problem-solving patterns, challenges, and instructional implications associated with each personality type. By analyzing these stages, this study offers insights into how extroverted and introverted learners differ in their approach, and how educators can leverage such differences to enhance teaching effectiveness.

2. RESEARCH METHOD

This study employs a qualitative descriptive method. The research participants consisted of 11 undergraduate students from the Mathematics Education Department at Institut Agama Islam Negeri Kerinci, who were enrolled in the Mathematical Statistics course during the odd semester of the 2024/2025 academic year. We chose the Mathematical Statistics course because statistics play a significant role in various human activities [32], [33] and are essential in developing high-quality human resources in Indonesia [34]. The selection of participants was based on purposive sampling to ensure the representation of both extroverted and introverted student's personality categories according to the MBTI framework. Additionally, not all students in a given class or program possessed the required personality traits for this study, making purposive sampling essential to include only those who met the criteria. This method also ensured efficiency and enabled a more in-depth analysis of problem-solving patterns within each personality group without dealing with an excessively large and heterogeneous sample.

The primary instrument in this study is the researcher. In qualitative, the researcher serves as the primary instrument in data collection, interpretation, and analysis [35]. One of the characteristics of qualitative research is that the researcher serves as both an instrument and a data collector [36]. Data were collected using two supported instruments: the MBTI questionnaire and a mathematical problem-solving ability test. The MBTI questionnaire follows the standardized model developed by Myers [25] and adopted from Aryanto's research that contains 10 statements with opposing item choices to determine extrovert and introvert personality types [37]. The MBTI questionnaire has been widely validated and does not require further reliability testing. This questionnaire was administered to categorize students into extroverted and introverted personality types.

The mathematical problem-solving test was designed based on established indicators of mathematical problem-solving ability [38]. The test items underwent an item analysis to ensure their validity and suitability for measuring students' problem-solving abilities. The analysis of the test item and the grid are presented in Table 1.

Table 1. The Grid and The Analysis of the Test Item of Mathematics Problem-Solving Ability.

Indicator	Item	r_{xy}		Reliability	Difficulty Index		Discrimination Power	
Understanding the Problem, Planning the Solution, Executing the Plan, and Reviewing the Solution	a	0,709	Valid	0,80 (high)	75,00	Easy	40	Enough
	b	0,450	Valid		30,00	Hard	71	Very Good
	c	0,569	Valid		51,39	Moderate	67	Good
	d	0,564	Valid		50,00	Moderate	65	Good

This problem effectively measures students' problem-solving ability by assessing their performance across four key indicators: understanding the problem, planning the solution, executing the plan, and reviewing the solution. The analysis of test items further confirms the validity, reliability, difficulty index and discrimination power of the test, making it suitable for use in research.

The research process involved several stages. First, students completed the MBTI questionnaire to determine their personality type. Based on the results, students were categorized into extrovert and introvert groups. Two extroverted (E) and two introverted (I) students were selected for further examination of their mathematical problem-solving test results. The selection was made using purposive sampling, ensuring that the chosen participants represent distinct personality types for an in-depth comparative analysis. These stages follow Faradilla and Nasution, who said that to represent both analyzed personality groups, four respondents were selected for an in-depth analysis [24]. Furthermore, Vrasetya et al. did similar steps that chose two students in every personality type for a deeper analysis [22]. In the next step, they were given a mathematical problem-solving test, during which they were encouraged to verbalize their thought processes (think-aloud protocol). Their responses were recorded and transcribed for further analysis, such as their problem-solving ability category, their performance in every problem-solving ability indicator, and the problem-solving patterns between extroverted and introverted students

The collected data were analyzed using thematic analysis based on Polya's problem-solving framework, understanding the problem, planning the solution, executing the plan, and reviewing the solution. Thematic coding was applied to examine patterns in students' problem-solving approaches. Extroverted students were analyzed based on their verbal reasoning, collaborative problem-solving tendencies, and responsiveness, while introverted students were evaluated for their independent reasoning and structured cognitive strategies. The results were interpreted to identify key differences in problem-solving approaches and their implications for instructional strategies.

Davita and Pujiastuti categorize students' mathematical problem-solving skills based on specific performance criteria [39] presented in Table 2 below:

Table 2. The Category of Mathematics Problem-Solving Ability.

Score	Category
$80 \leq x \leq 100$	High
$60 \leq x < 80$	Moderate
$x < 60$	Low

Analyzing students' mathematical problem-solving skills based on specific performance criteria involves evaluating how they understand, plan, execute, and review solving mathematical problems. This assessment typically considers accuracy and problem-solving strategies. A structured rubric is used to measure these aspects on a defined scale. Data collection methods are problem-solving ability tests to observe students' problem-solving processes. By analyzing patterns in their responses, identifying common errors, and comparing performance across different student personality types, educators can gain insights into students' strengths and weaknesses. This analysis helps in developing targeted instructional strategies to enhance mathematical problem-solving abilities based on students' personality types.

Ethical considerations were taken into account, including obtaining informed consent from participants and ensuring confidentiality. The findings from this study are expected to provide insights into how students' personality types influence their mathematical problem-solving processes and how educators can adapt their teaching methods accordingly.

3. RESULTS AND DICUSSION

This section presents the findings of the study based on the analysis of data collected using two main instruments: the MBTI questionnaire and a mathematical problem-solving ability test. The MBTI questionnaire was used to classify students into extroverted and introverted personality types, while the problem-solving test assessed their performance across different stages of problem-solving. The data were analyzed using a qualitative descriptive method, focusing on identifying patterns in students' problem-solving approaches, challenges, and errors. The results are structured according to the research questions, highlighting key differences between extroverted and introverted students. Each subsection provides interpretations of the findings, comparisons with previous studies, and discussions on the instructional implications.

The results of this study describe the differences in mathematical problem-solving abilities between extroverted and introverted students based on the analysis of their performance in the problem-solving test. The findings are presented according to the key stages of problem-solving: understanding the problem, planning a solution, executing the solution, and evaluating the results. Each stage is analyzed to highlight distinct patterns, strengths, and weaknesses observed in both personality types. Additionally, common errors and challenges faced by extroverted and introverted students are identified to provide deeper insights into their problem-solving approaches.

The relationship between personality types and mathematical problem-solving abilities among students enrolled in the Mathematics Statistics course optain by categorizing participants based on their extroversion and introversion tendencies using the MBTI questionnaire, the study aims to explore how these personality types influence their approach to solving mathematical problems. The data obtained from personality assessments and problem-solving tests were analyzed to identify patterns, differences, and potential correlations between cognitive styles and performance in mathematical problem-solving. The visualization of extrovert (E) and introvert (I) scores among the respondents based on the MBTI questionnaire presented in the radar chart below:

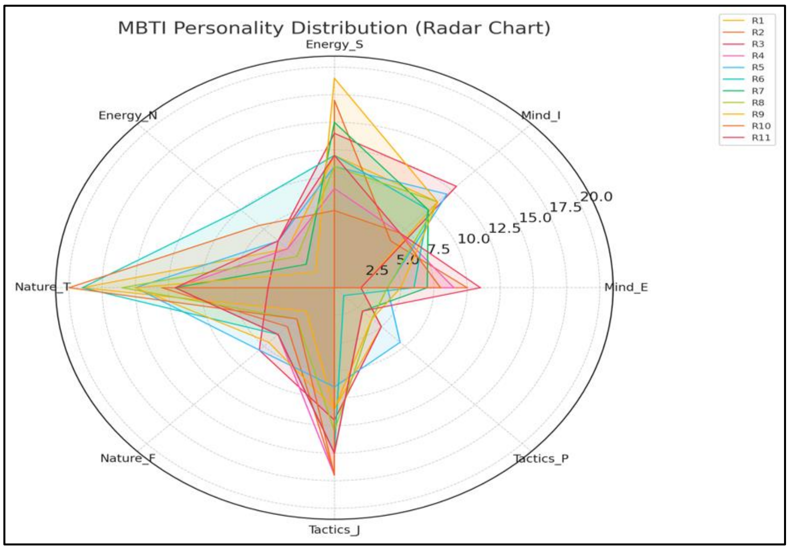


Figure 1. MBTI Questionnaire Result.

Figure 1 visualizes the MBTI personality scores of 11 respondents based on different dimensions: Mind (Introvert/Extrovert), Energy (Sensing/Intuition), Nature (Thinking/Feeling), and Tactics (Judging/Perceiving). Each cell represents the score obtained by a respondent in a specific category, with a color gradient indicating the intensity of the scored for higher values and blue for lower values. From the visualization, we can observe variations in personality traits among students. Some respondents exhibit strong tendencies in specific dimensions, such as high Thinking (T) and Judging (J) scores, while others display more balanced characteristics. The heatmap effectively highlights patterns in personality distribution, which can be analyzed further to explore potential correlations between MBTI types and students' mathematical problem-solving abilities.

The results of the MBTI questionnaire reveal distinct distributions of extrovert (E) and introvert (I) among the 11 respondents. A majority of students exhibit introverted tendencies, with seven out of eleven respondents scoring higher in introversion than extroversion. This suggests that most students prefer introspective thinking, structured work environments, and independent problem-solving approaches. On the other hand, four respondents demonstrate a stronger inclination toward extroversion, indicating a preference for interactive learning, verbal expression, and engagement in collaborative problem-solving. The visualization specifically for the Extrovert (E) and Introvert (I) scores of the 11 respondents is presented in Figure 2 below:

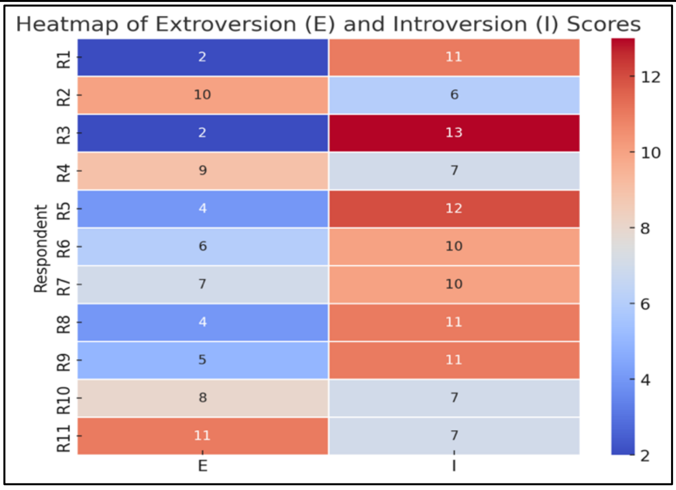


Figure 2. The Extrovert (E) and Introvert (I) MBTI scores

The visualization of extroversion (E) and introversion (I) scores among the respondents provides an overview of their personality tendencies based on the MBTI questionnaire. From the extroverted group, R2 and R11 were selected. These students were chosen because they exhibit strong extroverted characteristics, with R2 scoring E = 10 and R11 scoring E = 11. Both individuals indicate strong extrovert tendencies. From the introverted group, R3 and R5 were chosen. R3 has a high score of 13, while R5 has a score of 12, indicating strong introverted tendencies. The purposive selection of these four participants allows for a controlled comparison of how extroverts and introverts engage in mathematical problem-solving tasks. As noted by Creswell, purposive sampling is essential in qualitative research to ensure that the selected individuals provide rich, relevant data for analysis [35]. This method facilitates a deeper exploration of cognitive and behavioral differences in approaching mathematical challenges.

By focusing on these selected students, the study aims to uncover whether extroverted individuals approach mathematical problem-solving differently compared to their introverted counterparts, particularly in aspects such as verbal reasoning, structured problem-solving, and reflective thinking. The comparison will provide insights into how personality traits influence cognitive strategies in mathematical contexts, contributing to a deeper understanding of individual differences in learning and problem-solving. The following table presents the test results of students' mathematical problem-solving abilities, categorized based on their personality type as either extroverted or introverted. This classification follows the MBTI questionnaire results, which determined each respondent's personality type. The test scores reflect individual performance in solving mathematical problems, providing insight into potential differences in problem-solving abilities between extroverted and introverted students presented in Table 3 below:

Tabel 3. The Student's Problem-Solving Ability Test Score

Personality Types	Respondent	Score	Category
Introvert (I)	R1	85	High
	R3	8	Low
	R5	10	Low
	R6	79	Moderate
	R7	76	Moderate
	R8	68	Moderate
	R9	55	Low
Average (I)		54.43	Low
Extrovert (E)	R2	100	High
	R4	51	Low
	R10	35	Low
	811	87	High
Average (E)		68.25	Modarete

Table 3 summarizes problem-solving ability test scores categorized by personality types: introverts (I) and extroverts (E). Among introverts, the highest score recorded is 85 (High), while the lowest is 8 (Low). The average score for this group is 54.43, which falls under the Low-performance category. Several introverts performed at a Moderate level, but the majority had scores categorized as Low. For extroverts, the highest score is 100 (High), while the lowest is 35 (Low). The average score for this group is 68.25, which is categorized as moderate. Unlike introverts, extroverts had a slightly higher proportion of participants scoring in the high category.

Four respondents were selected for an in-depth analysis of their mathematical problem-solving abilities, consisting of two extroverted (E) and two introverted (I) students. The study focused on their problem-solving performance across different indicators, including understanding the problem, planning the solution, executing the plan, and reviewing the solution. The following table summarizes the problem-solving abilities of these four respondents based on their responses and written solutions. Table 4 below summarizes the problem-solving skills of the four students (R2, R3, R5, and R11) based on problem-solving indicators:

Tabel 4. The Summarize of Student's Problem-Solving Ability

Respondent	Understanding the Problem	Planning the Solution	Executing the Plan	Reviewing the Solution
R3 (I1)	X	X	X	X
R5 (I2)	X	V	X	X
R2 (E1)	V	V	V	V
R11 (E2)	V	V	X	X

From Table 4 above, R2 demonstrates perfect problem-solving skills by correctly solving all parts. R11 has a good understanding but makes mistakes in points c and d. R11 fail in executing the plan and reviewing the solution. This result follows Purnamasari and Ismail's research results, which found that in implementing the plan, extroverted students checked only part of the steps and only rechecked some of their solutions [40]. R3 and R5 show weaknesses in understanding and applying solutions, resulting in incorrect answers. On the other hand, R5, as an introvert, can plan the solution similarly to R11 and R2, who are extroverts. This result follows Halima's research results that found that both extroverted and introverted students can determine the type of method used to solve the problem [41]. Based on the analysis of the four students, it can be stated that extroverted students tend to be more active in verbally developing ideas and trying various problem-solving strategies, although they may sometimes lack precision in execution. On the other hand, introverted students demonstrate a more systematic and in-depth approach when analyzing problems before determining a solution, although they tend to be less flexible in exploring alternative strategies. These results follow Setyadi et al. research results that found students' mathematical problem-solving with extrovert personalities is greater than students with introverted personalities [42].

The findings of this study reveal distinct differences in mathematical problem-solving approaches between extroverted and introverted students. This section provides an in-depth interpretation of these results, examining how the observed patterns align with or differ from existing research. The discussion focuses on understanding the cognitive and behavioral tendencies of each personality type in problem-solving, analyzing the underlying reasons for their strengths and weaknesses. Additionally, the implications of these findings for mathematics education are explored, emphasizing how tailored instructional strategies can enhance students' problem-solving abilities. The discussion also considers the limitations of this study and provides recommendations for future research.

In this study, R2 and R11 were selected for extroverted students, while R3 and R5 were chosen for introverted students based on MBTI questionnaire scores that demonstrated the strongest tendency. Their problem-solving test results will be analyzed to examine differences in mathematical problem-solving abilities based on personality types. Their responses were analyzed based on the four indicators of mathematical problem-solving ability: understanding the problem, planning the solution, executing the plan, and reviewing the solution. The problem-solving ability test questions given are as follows:

Indonesian Version:

Diketahui fungsi padat gabungan berikut:

$$f(x) = \begin{cases} \frac{2}{5}(2x + 3y), & 0 \le x \le 1,\ 0 \le y \le 1 \\ 0, & \text{untuk x yang lain} \end{cases}$$

a. Tunjukkan bahwa $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)dx\ dy = 1$ **(Skor 20)**

b. Hitung P (X,Y) dengan $0 \le x \le \frac{1}{2}$, $\frac{1}{4} \le y \le \frac{1}{2}$ **(Skor 15)**

c. Tentukan Fungsi Marginal X **(Skor 15)**

d. Tentukan Fungsi Marginal Y **(Skor 15)**

English Version:

The following joint density function is given:

$$f(x) = \begin{cases} \frac{2}{5}(2x + 3y), & 0 \le x \le 1,\ 0 \le y \le 1 \\ 0, & \text{for other values of x} \end{cases}$$

a. Show that $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)dx\ dy = 1$ **(Score 20)**

b. Calculate P (X,Y) with $0 \le x \le \frac{1}{2}$, $\frac{1}{4} \le y \le \frac{1}{2}$ **(Score 15)**

c. Determine the Marginal Function of X **(Score 15)**

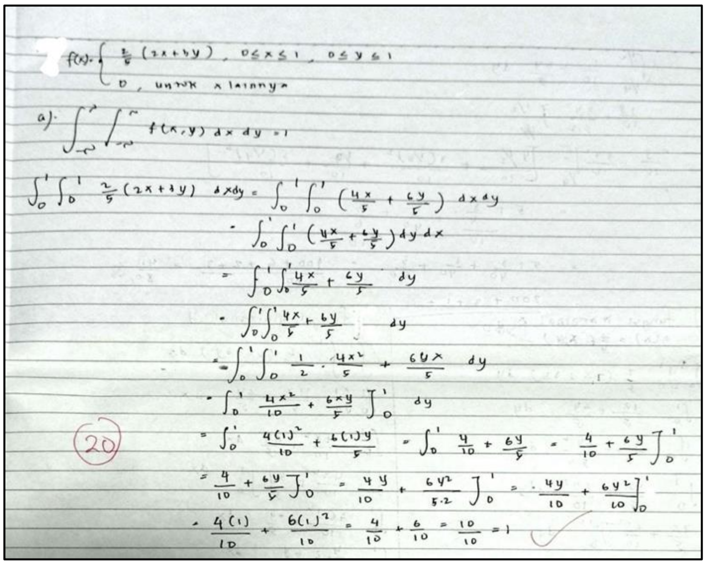
d. Determine the Marginal Function of Y **(Score 15)**

Figure 3. The Problem-Solving Ability Test Question

The given problem is a mathematical problem-solving test that students must complete. It assesses their ability to apply concepts of joint probability distributions, including verifying a probability density function, calculating probabilities over a given range, and determining marginal distributions. To solve it, students need to understand integral calculus, probability theory, and mathematical reasoning. Completing this test demonstrates their ability to analyze and solve problems systematically using the four key indicators of problem-solving: understanding the problem, planning the solution, executing the plan, and reviewing the solution.

First, in the understanding the problem stage, students must comprehend the given probability density function, its domain, and the conditions that must be satisfied, such as verifying that the total probability sums to one. Item (a) aligns with this stage and has a high difficulty index (75.00, Easy) and enough discrimination power (40), indicating that most students were able to grasp the fundamental concepts but with a moderate level of differentiation between high and low performers. Its reliability score (0.709) confirms its validity in assessing this aspect. Next, in the planning the solution stage, students must develop a clear strategy for solving each part of the problem. This is strongly reflected in Item (b), which requires students to determine the correct integration limits and formulate a structured solution approach. The difficulty index (30.00, Hard) and discrimination power (71, Very Good) suggest that this item effectively distinguishes between students who can systematically approach problem-solving and those who struggle with planning. In the executing the plan stage, students apply their mathematical knowledge to compute required integrals. This is represented by Item (c) (difficulty index: 51.39, Moderate; discrimination power: 67, Good) and Item (d) (difficulty index: 50.00, Moderate; discrimination power: 65, Good). These results indicate that both items have an appropriate difficulty level and can effectively measure students' ability to perform the necessary calculations and derive meaningful results from their solutions.

Finally, in the reviewing the Solution stage, students must validate their answers to ensure they align with probability principles. The overall reliability and validity of the problem items confirm that they encourage students to critically analyze their solutions. The varying difficulty levels across the four items ensure that different levels of student ability are measured effectively, making the test a comprehensive tool for assessing problem-solving ability. Extrovert (E) R2 achieved a perfect score of 100, indicating that they possess strong mathematical problem-solving skills across all indicators. This suggests that R2 was able to understand the problem, plan an appropriate solution, execute the plan effectively, and review the solution thoroughly. The R2 answer sheet is presented in Figure 4 below:



$$f(x) = \begin{cases} \frac{2}{5}(2x+3y), & 0 \le x \le 1,\ 0 \le y \le 1 \\ 0, & \text{untuk } x \text{ lainnya} \end{cases}$$

a). $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\, dx\, dy = 1$

$$\int_0^1\int_0^1 \frac{2}{5}(2x+3y)\, dx dy = \int_0^1\int_0^1 \left(\frac{4x}{5} + \frac{6y}{5}\right) dx\, dy$$
$$= \int_0^1\int_0^1 \left(\frac{4x}{5} + \frac{6y}{5}\right) dy\, dx$$
$$= \int_0^1\int_0^1 \frac{4x}{5} + \frac{6y}{5}\ dy$$
$$= \int_0^1\int_0^1 \frac{4x}{5} + \frac{6y}{5}\ dy$$
$$= \int_0^1\int_0^1 \frac{1}{2} \cdot \frac{4x^2}{5} + \frac{6yx}{5}\ dy$$
$$= \int_0^1 \frac{4x^2}{10} + \frac{6xy}{5} \Big]_0^1\ dy$$
20
$$= \int_0^1 \frac{4(1)^2}{10} + \frac{6(1)y}{5} = \int_0^1 \frac{4}{10} + \frac{6y}{5} = \frac{4}{10} + \frac{6y}{5}\Big]_0^1$$
$$= \frac{4}{10} + \frac{6y}{5}\Big]_0^1 = \frac{4y}{10} + \frac{6y^2}{5 \cdot 2}\Big]_0^1 = \frac{4y}{10} + \frac{6y^2}{10}\Big]_0^1$$
$$= \frac{4(1)}{10} + \frac{6(1)^2}{10} = \frac{4}{10} + \frac{6}{10} = \frac{10}{10} = 1$$

Figure 4. The R2 (E1) Answer Sheet

R2's answer demonstrates problem-solving ability based on four key indicators. First, R2 understands the problem by recognizing that the task requires proving the given joint probability density function satisfies the total probability condition, ensuring the integral over its entire domain equals 1. Next, R2 devises a plan by setting up the correct double integral with appropriate limits for x and y. In executing the plan, R2 systematically computes the integral step by step, using proper substitutions and algebraic manipulations, leading to the correct result. Finally, R2 reviews the solution by confirming that the final result satisfies the required probability condition. The full score awarded indicates accuracy and a clear understanding of the problem-solving process. Additionally, R2 successfully solves parts (b), (c), and (d) correctly, demonstrating proficiency in calculating probabilities and marginal functions. As a result, R2 achieves a perfect score, reflecting a strong understanding of mathematical problem-solving. This finding follows the Juliansa et al. research results: extroverted students tend to demonstrate a higher ability to solve mathematical problems compared to introverted students [30]. Furthermore, Ginevra et al., in their research results found that the extroversion trait shows a positive correlation with problem-solving abilities [43].

R11's answer demonstrates a good understanding of the problem, particularly in parts (a) and (b), which were solved correctly. R11 successfully verified the given joint probability density function by correctly setting up and computing the double integral, ensuring that it sums to 1. Additionally, R11 correctly determined the probability for the given range in part (b), showing the proper application of integration techniques and probability concepts. However, R11 made errors in parts (c) and (d) while determining the marginal probability density functions. In part (c), an error occurred in integrating for y, leading to an incorrect expression for the marginal function of x. Similarly, in part (d), while integrating for x, some mistakes in algebraic manipulation resulted in an incorrect final expression for the marginal function of y. The presence of incorrect terms and miscalculations suggests a lack of careful verification in these steps. The R11 answer sheet is presented in Figure 5 below:

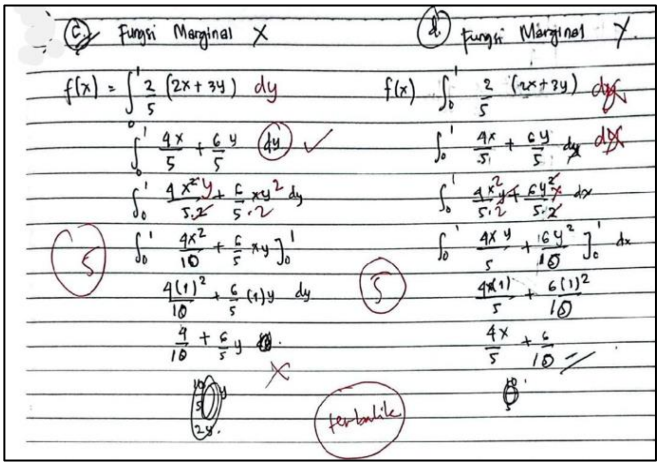


Figure 5. The R11 (E2) Answer Sheet

R11 demonstrated a strong understanding of the problem, as evidenced by the correct approach in parts (a) and (b). R11 correctly recognized the necessity of verifying the given probability density function by integrating over its domain and accurately computed the probability in part (b), indicating a solid grasp of probability concepts. In the planning stage, R11 devised an appropriate strategy by correctly setting up the necessary integrals for solving each part. The approach taken in part (a) was methodical, showing an awareness of the need to integrate over the entire given range. Similarly, in part (b), R11 set up the correct limits and integrand, indicating a structured problem-solving plan. Engaging in problem-solving and constructing new knowledge can foster the development of strong problem-solving skills [44] because students are encouraged to examine problems and identify solutions during the problem-solving process [45].

During execution, R11 successfully computed the integrals in parts (a) and (b), demonstrating fluency in applying integration techniques. However, in parts (c) and (d), errors emerged in the calculations for the marginal functions. Mistakes in algebraic manipulation and integration suggest a lack of accuracy in executing the steps, which ultimately led to incorrect final expressions. In the review stage, R11 did not appear to verify the correctness of the solutions in parts (c) and (d), as errors in integration and algebra were left uncorrected. A more thorough review could have helped detect miscalculations and refine the marginal functions correctly. Overall, R11 shows strong competency in understanding problems and planning solutions, but there is a need for more careful execution and verification in complex calculations, particularly in algebraic manipulation and marginal probability computations. These findings are consistent with the study by Indrayani, which indicates that extroverted students tend to be less meticulous and rush when solving problems [46]. Furthermore, Anwar et al., in their research result, found that extrovert students tend to skip rechecking the results they have calculated [47].

R3, as Introvert 1 (I1), has a mathematical problem-solving ability score of 8, which falls into the Low category. This indicates that R3 may struggle with certain aspects of problem-solving. Table 3 presents R3 failure in all aspects of problem-solving ability: understanding the problem, planning the solution, executing the plan, and reviewing the solution. The low score suggests a need for targeted support or instructional interventions to enhance their mathematical reasoning and problem-solving skills. The R3 answer sheet is presented in Figure 6 below:

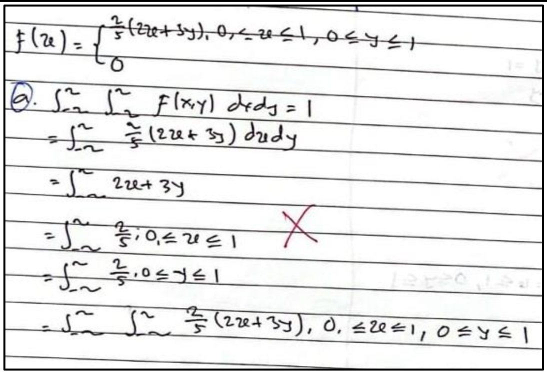


Figure 6. The R3 (I1) Answer Sheet

R3 understands the problem and recognizes the need to integrate the function over the given domain. However, there is a conceptual error in setting up the integral, as R3 incorrectly writes 2x + 3y instead of maintaining the full function 2/3 (2x + 3y), and there is also a mistake in the notation of the domain. These errors indicate weaknesses in structuring the solution plan. During execution, the omission of the coefficient and incorrect integral limits affect the correctness of the solution. There is no indication that R3 reviewed the work, as the errors remain throughout the solution. The same mistakes are also found in parts b, c, and d, where the misapplication of integral setup and incorrect limits lead to incorrect results. This suggests that R3 struggles with execution and verification across multiple steps, highlighting the need for better accuracy and validation in mathematical problem-solving. This finding follows Rohmah and Rona's research results that found that introvert's weaknesses are hard to understand mathematics questions therefore, they seem careless in answering the questions [29]. Furthermore, this research finding also follows Selpiana and Munawir's research found that introverts had difficulty understanding a mathematical presentation [21].

R5 as Introvert (I2) obtained a score of 10, categorized as Low. This indicates that R5 struggled with mathematical problem-solving in almost all indicators, specifically the first, third, and fourth indicators. These challenges suggest difficulties in understanding the problem, executing the solution, and reviewing the final answer, which significantly impacted overall problem-solving performance. However, R5 performed well in the second indicator, suggesting they were able to plan a solution effectively despite difficulties in understanding the problem, executing the solution, and reviewing the final answer. Introverted students, with their quiet nature, can formulate problem-solving plans effectively, but they struggle with executing the plans they have devised, which affects their overall problem-solving performance [48]. The R5 answer sheet is presented in Figure 7 below:

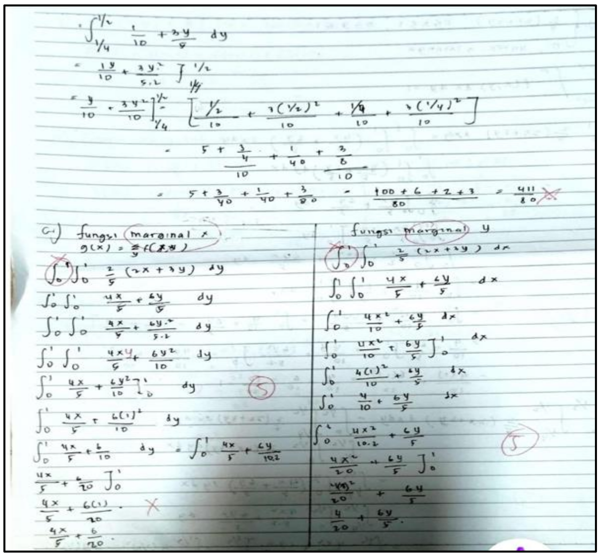


Figure 7. The R5 (I2) Answer Sheet

R5 demonstrates an attempt to solve the problem systematically by following a structured process. However, in point (a), similar to R3, R5 makes an error in setting up the integral and defining the limits, which affects the correctness of the solution. Despite showing a lengthy process, the fundamental mistake suggests a lack of conceptual understanding rather than a simple miscalculation. In points (b), (c), and (d), R5 continues to make similar mistakes, particularly in applying integration rules and managing coefficients. Although the steps are written in detail, they do not lead to the correct final result. This indicates a tendency to construct a solution without fully verifying the correctness of each step. The errors show weaknesses in planning and execution, as well as a lack of reflection on the obtained results. R5 needs to improve in structuring the problem-solving approach, ensuring that the formulation aligns with the given conditions, and validating each step to avoid unnecessary errors. This finding follows Nurhayati and Nurandini's research results that found that introverts can understand problems in their language but are less able in the expansion stage and tend to be slow in the problem-solving process [49], [50]. Furthermore, Yolawati et al. in their research found that introverts also lack justification for generalization in the investigation of problem-solving [50]. Furthermore, student's activities and attitudes are effective in transforming students' problem-solving [51].

Teaching methods should be adapted to accommodate both extroverted and introverted students. Encouraging structured discussions can help extroverted students refine their precision while providing written reflections or individual problem-solving sessions can support introverted students. Extroverted students should work on improving accuracy and avoiding rushed conclusions, while introverted students should practice verbalizing their thought processes and considering multiple solution paths. Further studies could explore how specific instructional strategies impact mathematical problem-solving abilities based on personality traits.

This study was conducted with only four students as representatives, which may not fully capture the diversity of problem-solving approaches among all extroverted and introverted students. The analysis was limited to the mathematical problem-solving aspect without considering other cognitive factors such as working memory or mathematical anxiety. The research focused on one specific subject, Mathematical Statistics, which may not be generalizable to other mathematical topics.

Future research could involve a larger sample size to improve generalizability. Additional personality dimensions beyond extroversion and introversion could be explored for a more comprehensive analysis. The study could also be extended to different mathematical disciplines to determine whether problem-solving tendencies vary across subjects.

4. CONCLUSION

Based on the data analysis, it can be concluded that extroverted students have better mathematical problem-solving abilities than introverted students in the mathematical statistics course. There are significant differences in the problem-solving patterns between extroverted and introverted students. Extroverted students tend to be more verbally active in developing ideas, experimenting with various problem-solving strategies, and making quick decisions. However, they often lack precision in execution and evaluation. In contrast, introverted students take a more systematic and in-depth approach when analyzing problems before determining a solution. They are more meticulous and precise in execution but less flexible in exploring alternative strategies. In the evaluation stage, introverted students tend to review their answers more thoroughly, whereas extroverted students rely more on intuition and discussion to assess their solutions.

Regarding common challenges and errors, extroverted students are more likely to make computational errors and overlook details as they focus more on exploring strategies. On the other hand, introverted students struggle to adapt their strategies when their initial approach fails, making them more prone to stagnation in problem-solving. Conceptual errors are more frequent among extroverted students, whereas introverted students are more likely to make procedural mistakes due to their limited flexibility in modifying their approach.

These findings have important implications for mathematics instruction, particularly in accommodating students with different personality types. Interactive and discussion-based learning approaches can help extroverted students improve their accuracy, while introverted students may benefit from teaching strategies that allow more time for reflection and gradual practice to enhance their flexibility in selecting strategies. By understanding these differences, educators can design more adaptive and effective teaching methods, ultimately improving students' overall problem-solving abilities.

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