Mandalika Mathematics and Education Journal
Volume 8 Nomor 2, Juni 2026
e-ISSN 2715-1190| |p-ISSN 2715-8292
DOI: http://dx.doi.org/10.29303/jm.v8i2.11902

Analysis of civil engineering students' mathematical thinking skills in calculus based on personality type

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Abstract
Mathematical thinking skills are crucial competencies for civil engineering students in dealing with increasingly complex infrastructure problems, one of the foundations of which is laid by basic calculus. However, students show varying abilities, indicating the influence of internal factors such as personality. This study aims to describe the relationship between students' personality types, as measured by the Myers–Briggs Type Indicator (MBTI) framework, and the mathematical thinking abilities of civil engineering students in calculus learning. This study uses a descriptive qualitative approach involving civil engineering students at Samudra University. Personality types were determined using the MBTI questionnaire, while mathematical thinking skills were measured by analyzing students' written answers to calculus problems compiled based on mathematical thinking indicators. Data were analyzed descriptively and qualitatively to identify patterns in mathematical thinking skills across personality types. The results of the study indicate that students with ESFJ or SFJ tendencies tend to show strength in applying concrete procedures (specializing), while students with ENFJ or NFJ tendencies tend to demonstrate greater flexibility in developing intuitive ideas. This study suggests that students' personalities should be taken into account when designing calculus learning. The application of adaptive and differentiated learning strategies tailored to individual personality characteristics may be considered.

Keywords: mathematical thinking; Myers–Briggs Type Indicator (MBTI); calculus learning

Abstrak
Kemampuan berpikir matematis merupakan kompetensi krusial bagi mahasiswa teknik sipil dalam menghadapi persoalan infrastruktur yang semakin kompleks. Salah satu fondasinya dibangun melalui pembelajaran kalkulus dasar. Namun, mahasiswa menunjukkan kemampuan yang bervariasi, yang mengindikasikan adanya faktor internal yang berpengaruh, seperti kepribadian. Penelitian ini bertujuan untuk mendeskripsikan hubungan antara tipe kepribadian mahasiswa berdasarkan kerangka Myers–Briggs Type Indicator (MBTI) dan kemampuan berpikir matematis mahasiswa teknik sipil dalam pembelajaran kalkulus. Penelitian ini menggunakan pendekatan kualitatif deskriptif dengan melibatkan mahasiswa Program Studi Teknik Sipil di Universitas Samudra. Penentuan tipe kepribadian dilakukan melalui kuesioner MBTI, sedangkan kemampuan berpikir matematis diukur melalui analisis jawaban tertulis mahasiswa pada soal kalkulus yang disusun berdasarkan indikator berpikir matematis. Data dianalisis secara deskriptif kualitatif untuk mengidentifikasi pola kemampuan berpikir matematis pada tiap tipe kepribadian. Hasil penelitian menunjukkan bahwa mahasiswa dengan kecenderungan ESFJ atau SFJ cenderung memiliki keunggulan dalam menerapkan prosedur konkret (*specializing*), sedangkan mahasiswa dengan kecenderungan ENFJ atau NFJ cenderung menunjukkan

fleksibilitas yang lebih besar dalam mengembangkan ide-ide yang intuitif. Penelitian ini menunjukkan bahwa kepribadian mahasiswa perlu dipertimbangkan dalam merancang pembelajaran kalkulus. Penerapan strategi pembelajaran yang adaptif dan terdiferensiasi sesuai dengan karakteristik kepribadian individu dapat dipertimbangkan

Kata Kunci: berpikir matematis; myers–briggs type indicator (MBTI); pembelajaran kalkulus

1. INTRODUCTION

The increasing complexity of issues in various fields today requires mathematical thinking skills, enabling individuals to solve problems systematically and effectively. Abidin et al. (2024) state that mathematical thinking skills have proven to be an essential aspect in solving complex problems. This is reinforced by the statements of Schoenfeld (1992) and Mason et al. (2010), which demonstrates a strong relationship between mathematical thinking skills and a person's ability to solve mathematical problems successfully. Furthermore, according to Isoda (1999)Mathematical thinking enables individuals to develop the proper perspective, ask critical questions, and use relevant data to understand and solve problems. Devlin (2012) notes that mathematical thinking enables individuals to present, understand, and think about facts and mathematical relationships through internal imagination or external representations. Thus, in the context of increasingly complex infrastructure development, mathematical thinking skills are a key competency that students need to have.

In the context of higher education, particularly in civil engineering study programs, calculus plays a crucial role as the foundation for advanced courses related to structural analysis, mechanics, and other disciplines. The broad role of calculus in mathematics makes it a valuable tool for assessing students' mathematical thinking skills. Learning calculus requires not only mastery of procedures, but also an understanding of abstract concepts, the ability to interpret and analyze mathematical statements, and the ability to relate various representations and relationships involving the quantization process (Dubinsky & Yiparaki, 1996). However, in reality, many students still struggle to master calculus. Several findings indicate that students' achievement in calculus courses still needs improvement (Pardede & Sitorus, 2021) and that many students continue to experience difficulties in learning calculus (Desriyati & Rahmi, 2021; Hidayah et al., 2021; Saputri et al., 2024; Susilo et al., 2022).

Students' difficulties in learning calculus are not only related to their weak grasp of concepts, but also indicate challenges in their mathematical thinking skills. Stacey (in Saefuloh et al., 2023) revealed that mathematical thinking requires a person to have in-depth mathematical abilities, the ability to generalize, and knowledge of the strategies to be used. In addition, mathematical ability is one of the essential goals in learning (OECD, 2023). Even Oers (2010) states that mathematical thinking is the way to learn mathematics. Thus, mathematical thinking becomes one of the keys to understanding abstract mathematical concepts, including in the Basic Calculus course.

Although mathematical thinking plays a vital role in learning calculus, this ability may develop differently among students due to variations in individual characteristics. One internal factor that may relate to students' ways of processing information and solving problems is personality (Sutiawati et al., 2025; Tiana & Purwanto, 2022). Previous studies suggest that personality is associated with motivation and cognitive outcomes (Purwanto et al., 2021). In addition, personality tendencies may relate to students' learning interests and learning experiences (Tamba et al., 2020). Setiani & Budiarso (2025) also emphasized the relationship between emotional intelligence and personality development. Another opinion is that of Ismajli (2018), who reveal that effective learning strategies are designed based on the unique needs of students. Thus, effective learning must be able to cover a variety of psychological profiles in a class (Ain et al., 2024; Ardenlid et al., 2025; Preston et al., 2025). In this regard, personality may provide insights into how students process information, approach mathematical tasks, and develop mathematical thinking processes. Therefore, a framework is needed that can describe personality differences systematically.

In this context, personality frameworks such as the Myers-Briggs Type Indicator (MBTI) can be used as a conceptual approach to help understand individual learning tendencies and how they process information and make decisions. The application of MBTI in learning design may facilitate the creation of a more personalized learning experience tailored to students' individual characteristics (Putro & Rosmansyah, 2020; Rinjeni et al., 2024; Samonte et al., 2023). Personality emphasizes that personality may relate to adaptability (Ulfah & Akmal, 2019), speaking ability (A. D. Putri et al., 2023), and independence (Istichori et al., 2021). Research conducted by Roslan et al. (2021) indicates that personality traits are associated with students' systems thinking skills. Another study conducted by Korkut & Nalbantoğlu (2023) suggests that the MBTI framework may help students address learning challenges.

The MBTI framework describes personality dimensions that may relate to students' cognitive preferences in learning. In calculus learning, these preferences may influence how students interpret information, recognize patterns, organize problem-solving strategies, and construct mathematical reasoning. Therefore, MBTI is not intended to determine students' mathematical abilities, but rather to provide a conceptual perspective for understanding variations in students' mathematical thinking processes. However, research specifically examining mathematical thinking processes in relation to MBTI personality types in calculus learning remains limited. Therefore, this study aims to explore how students with different MBTI personality tendencies demonstrate mathematical thinking processes in solving calculus problems, providing insights for designing learning that considers students' diverse personality characteristics.

Although numerous studies have been conducted on mathematical thinking abilities (Bintoro et al., 2021; Drijvers et al., 2019), research specifically linking these abilities to MBTI personality types remains limited. Studies have examined mathematical problem-solving skills in relation to extrovert-introvert personality types (W. A. Putri & Masriyah, 2020; Sari & Kurniasari, 2022; Satya et al., 2022). Another study, conducted by Sulastri et al. (2021), examined mathematical problem-solving abilities from the perspective of extrovert, introvert, and ambivert personalities. However, these studies have not yet linked these abilities to aspects of student personality as described in the Myers-Briggs Type Indicator (MBTI) framework, particularly in the context of calculus learning. Based on this description, this study aims to describe the relationship between MBTI personality types and students' mathematical thinking abilities in calculus learning. This study is expected to contribute to the development of the learning process.

2. METHODS

2.1 Design

This research employs a qualitative case study approach to explore students' mathematical thinking abilities in relation to their personality types. In qualitative research, as explained by Aspers & Corte (2019), the analysis process is carried out iteratively, allowing researchers to gain a deeper understanding of the phenomenon being studied and uncover new insights. The case study approach was chosen because it enables researchers to explore phenomena in depth within a specific group. This aligns with Schoch (2020), who states that case studies enable researchers to focus their attention on a particular case and collect data from multiple sources, thereby facilitating a comprehensive understanding of the events under study.

2.2 Time and Location

This research was conducted at the Civil Engineering Study Program, Faculty of Science and Technology, Samudra University, Langsa. Data collection was carried out in the odd semester of the 2025 academic year, specifically during the Midterm Examination period.

2.3 Participants

The participants in this study were civil engineering students at Samudra University who took two calculus courses with a total of 39 students. These classes were chosen because they received the same treatment in terms of material, teaching methods, and lecturers, thus ensuring equal conditions in the learning process (Lahdenperä et al., 2018).

The personality types of all participants were identified using the Myers-Briggs Type Indicator (MBTI) instrument. Based on the MBTI measurement results in this class, the distribution of student personality types was uneven, with some types having a minimal number of respondents. Only one or two students represented some MBTI types. Therefore, the general analysis in this study focused on four dominant and representative MBTI personality types, namely ESTJ, ENFJ, ENTJ, and ESFJ. This stage aimed to describe variations in students' mathematical thinking abilities based on MBTI tendencies.

Therefore, for an in-depth analysis of mathematical thinking processes, subjects were selected using purposive sampling techniques. Friday & Leah (2024) state that the purposive sampling technique is a method of deliberately selecting participants based on specific characteristics relevant to the research objectives, so that the chosen subjects can represent the phenomenon being studied in greater depth. In line with the qualitative nature of this study, not all student responses were analyzed in equal depth. Therefore, several student responses were selected purposively based on their ability to provide rich and relevant information regarding mathematical thinking processes during calculus problem solving. These selected responses were then analyzed in greater detail to explore students' mathematical thinking processes across the stages of specializing, generalizing, conjecturing, and convincing.

2.4 Instruments

The main instrument in this study is the researcher himself. Bahrami et al. (2016) argue that in qualitative research, the researcher plays a central role, especially in the data collection process. Furthermore, the supporting instruments used are midterm exam answer sheets, which represent mathematical thinking abilities, and the MBTI test.

To categorize students into personality types, a questionnaire based on the MBTI framework was employed. The data obtained were further analyzed to examine the relationship between students' personality tendencies and their mathematical thinking processes. The MBTI is one of the commonly used frameworks for identifying personality tendencies. Yang (2022) states that the MBTI helps teachers recognize students' strengths, enabling them to better integrate with each student's learning style. Li et al. (2023) also noted that researchers have begun to utilize personality tests, such as the MBTI, to assess personality. Another opinion is expressed by Zhao et al. (2020), who assert that the MBTI remains relevant for understanding individual differences.

The MBTI questionnaire used in this study has undergone a validation process, as it refers to the Myers–Briggs Type Indicator developed by Myers and Briggs. The questionnaire used was adapted from Aryanto's research (2019) by adjusting the wording and context to be more relevant to the reality of lectures and student experiences. The instrument consists of 40 items in the form of paired statements, with 10 items measuring each of the four MBTI dimensions, namely Extroversion–Introversion, Sensing–Intuition, Thinking–Feeling, and Judging–Perceiving. Reliability and validity testing were not included in this study because the MBTI has been validated by several previous researchers, such as Myers et al. (1998).

Mathematical thinking ability in this study refers to the mathematical thinking process framework, as outlined by Stacey, which involves specializing, generalizing, conjecturing, and convincing. The indicators of mathematical thinking processes in this study were adapted from those developed by Primasatya (2016) with reference to Stacey's framework. In this study, MBTI dimensions were used as a conceptual framework to help interpret variations in students' mathematical thinking processes. Certain MBTI dimensions may relate to particular aspects of mathematical thinking. Sensing-oriented students may tend to approach mathematical problems through concrete examples and systematic procedures, particularly during specialization processes (Dewiyani et al., 2017).

Students' midterm exam answer sheets were used as data to measure their mathematical thinking abilities. The course lecturer compiled the midterm exam questions. They had undergone a process of discussion and review to ensure the quality of the content and instrument construction before being administered, so that academically it was considered appropriate to evaluate student learning outcomes and mathematical thinking skills (Luque-vara et al., 2020).

2.5 Analysis

Data analysis was conducted using a descriptive qualitative approach to examine students' mathematical thinking abilities. After all participants were identified by their personality type using the MBTI instrument, their answers on the mathematical thinking ability test were classified based on a rubric adapted from Widoyoko (in Susanti & Hartono, 2019). The rubric is presented in the table below.

Table 1. Criteria for mathematical thinking

Category	Criteria
$x > 90$	Very high
$75 < x \leq 90$	High
$60 < x \leq 75$	Average
$45 < x \leq 60$	Low
$x \leq 45$	Very Low

After the initial classification, a general analysis was conducted to describe students' mathematical thinking ability levels across different MBTI personality groups. Subsequently, an in-depth qualitative analysis was carried out on selected student responses to explore their mathematical thinking processes in greater detail. These responses were chosen purposively based on their richness and relevance in representing variations in problem-solving strategies.

The analysis focused on identifying patterns in students' mathematical thinking processes during problem solving. Students' thinking processes were then compared across personality groups to identify similarities and differences in their approaches. To enhance the credibility of the findings, triangulation was conducted by comparing test results, observation notes, and students' written responses. The final stage involved drawing conclusions based on the identified patterns and relating them to MBTI personality tendencies and students' mathematical thinking processes.

3. RESULTS AND DISCUSSION

3.1 Result

The results of this study describe the relationship between student personality as measured by the MBTI test and students' higher-level mathematical thinking abilities.

Based on the results of personality type measurements using the Myers–Briggs Type Indicator (MBTI) instrument on 39 students, the results are as shown in Table 2 below. Criteria for mathematical thinking skills

Table 2. The MBTI Personality Type Distribution

Personality Type	Frequency	Percentage(%)
ESTJ	12	30,8
ENFJ	5	12,8
ENTJ	4	10,3
ESFJ	4	10,3
ISTJ	2	5,1
ISTP	2	5,1
ISFJ	2	5,1
ESTP	2	5,1
INFJ	1	2,6
ENTP	1	2,6
INTJ	1	2,6
ESFP	1	2,6
ENFP	1	2,6
INFP	1	2,6
Total	39	100

Based on Table 2 above, the distribution of student personalities is varied and uneven. The most dominant personality type is ESTJ, with 12 students (30.8%) in total. The ESTJ personality type is typically characterized by a tendency to be practical, realistic, and decisive. Next, the ENFJ type ranks second with five students (12.8%). The ENFJ type generally tends to be warm, empathetic, and responsive. Then followed by ENTJ and ESFJ, each with four students (10.3%). The ENTJ personality type tends to be decisive, confident, and have strong leadership skills, while the ESFJ personality type is generally warm, responsible, and cooperative. Most other personality types have a relatively small frequency. The ISTJ, ISFJ, ISTP, and ESTP types each had two students (5.1%), while the INFJ, ENTP, INTJ, INFP, ENFP, and ESFP types were represented by only one student (2.6%).

To provide a more detailed picture of student personality tendencies, the analysis then focused on the average of each MBTI dimension, which includes Mind, Energy, Nature, and Tactics. The presentation of this data aims to show the direction of dominance in each personality dimension based on the MBTI type of each student. The indicators for each personality type are presented in Table 3 below.

Table 3. MBTI Indicators Based on Personality Type

No	Dimension	Category	Total	Percentage (%)	Dominant
1	Mind	Ekstrovert (E)	30	76,9	Ekstrovert (E)
		Introvert (I)	9	23,1	
2	Energy	Sensing (S)	24	61,5	Sensing (S)
		Intuiting (N)	15	38,5	
3	Nature	Thinking (T)	24	61,5	Thinking (T)

4	Tactics	Feeling (F)	15	38,5	Judging (J)
		Judging (J)	31	79,5	
		Perceiving (P)	8	20,5	

Table 3 above shows that in the Mind dimension, most students fall into the Extrovert (E) category with a percentage of 76.9%, while students with Introvert (I) tendencies account for 23.1%. This suggests that the majority of students actively engage in social environments and discussion activities. In the Energy dimension, the majority of students are in the Sensing (S) category, at 61.5%, while the Intuition (N) category comprises 38.5%. This shows that students tend to process information through concrete details and clear sequences rather than abstract concepts. In the Nature dimension, students with a Thinking (T) tendency predominate, accounting for 61.5%, while the Feeling (F) category comprises 38.5%. This shows that most students tend to evaluate tasks logically and objectively rather than judging based on personal feelings. Furthermore, in the Tactics dimension, the Judging (J) category is the most dominant, with a percentage of 79.5%, while the Perceiving (P) category accounts for 20.5%. This dominance suggests that students tend to be structured and planned rather than flexible in their approach to several possibilities (Myers et al., 1998).

The results show that, in general, this class consists of students who tend to show a preference for social interaction and structured learning environments where material is presented in a clear sequence with systematic steps and well-defined procedures. However, this does not imply that all students share identical characteristics; rather, it reflects general tendencies based on MBTI classification results.

These characteristics may be related to how students engage with basic calculus learning, where they tend to show a preference toward structured learning approaches that provide clear procedures and step-by-step guidance compared to less structured exploratory approaches. Understanding these tendencies may provide insight for lecturers in designing learning strategies that better align with students' cognitive preferences. In line with this, students' personality tendencies may also be reflected in variations in their mathematical thinking processes in basic calculus learning.

To obtain a more comprehensive picture, this study further analyzes students' mathematical thinking skills based on predetermined indicators. The analysis includes both dominant and representative MBTI personality types (ESTJ, ENFJ, ENTJ, and ESFJ) to capture variations in students' mathematical thinking processes during calculus problem solving. The classification is presented in Table 4 below.

Table 4. The Classification of Students' Mathematical Thinking Ability Based on Personality

Personality Type	**Freq**	**Klasifikasi**				**Average**
		Low	**Average**	**High**	**Very High**	
ESTJ	12	57	61, 69, 73 65, 69, 61, 65, 69, 73	77, 81	-	68
ENFJ	5	-	69, 61, 61, 73	77	-	68
ENTJ	4	-	65, 73, 73	-	93	76
ESFJ	4	-	61, 73	81, 89	-	76

Based on Table 4 above, students with ESTJ personality types had scores ranging from 57 (Low) to 81 (High). Students with ENFJ personality types also showed relatively similar results, with midterm scores ranging from 61 (Moderate) to 77 (High). For the ENTJ personality type, the midterm exam score range is between 65 (Average) and 93 (Very High). Furthermore, students with the ESFJ personality type have midterm exam scores ranging from 61 (Average) to 89 (High). Overall, the descriptive analysis results show that each personality type has internal variations in mathematical thinking abilities. No single personality type was consistently found to be in the highest or lowest category. A summary of students' mathematical thinking abilities, based on their personality type, is presented in Table 5.

Table 5 The summary of students' Mathematical Thinking Abilities Based on Personality

Personality	Average test score	Category
ESTJ	57 – 81	Low – High
ENFJ	61 – 77	Average – High
ENTJ	65 – 93	Average – Very High
ESFJ	61 – 89	Average – High

Table 5 above shows that students with ENTJ personality types had the highest score range, from 73 to 93, falling into the moderate to very high category. Furthermore, ESFJ, ENFJ, and ESTJ types showed relatively similar score ranges, falling into the moderate to high category. However, no single personality type consistently dominates all achievement categories, as each type still shows internal variation in student midterm exam scores. Only four MBTI personality types are presented in Table 5 because these types dominate the distribution of students in this study.

Table 5 shows that the Judging (J) dimension appeared consistently across all MBTI personality types analyzed. This dimension was reflected in students' tendency to approach mathematical problems in a structured, organized manner, particularly through clear procedures and sequential steps in problem solving. The Thinking (T) dimension was observed in students' tendency to emphasize logical reasoning and objective analysis, with attention to the accuracy and consistency of mathematical procedures. Meanwhile, the Sensing (S) dimension appeared in students' use of concrete examples, step-by-step procedures, and repetitive exercises when working on calculus problems. These findings describe patterns observed in this study and should be interpreted as contextual tendencies within the sample, rather than fixed or deterministic characteristics of students.

The Mind (Extrovert–Introvert) dimension in this study did not show a significant impact on mathematical thinking ability. This suggests that students' level of social activity or reflective tendencies does not directly determine the quality of their mathematical thinking, but instead influences how they interact and participate in the learning process.

Discussion

Following the general analysis of students' mathematical thinking abilities across MBTI personality types, an in-depth qualitative analysis was conducted on selected student responses. Several responses were selected purposively based on their ability to provide rich and relevant information regarding students' mathematical thinking processes during calculus problem solving.

Students' MBTI personality types are used to analyze their mathematical thinking abilities. Below is one of the mathematical thinking questions, along with two student answers. Student answers will be analyzed using Stacey's mathematical thinking process, namely, specializing, generalizing, conjecturing, and convincing. This analysis aims to investigate how students' mathematical thinking processes are employed in solving mathematical problems.

Student answers are analyzed based on indicators developed by (Primasatya, 2016) with reference to Stacey's framework. The following is one of the questions used to analyze student answers.

Consider the following function $f(x) = \frac{x^3+2x^2}{x^2+4}$

a. *Determine the domain of the function.*
b. *Determine whether the function is odd, an even function, or neither*

The mathematical thinking process and relevant indicators for the above question are 1) the specializing process with indicators of identifying problems and selecting solution strategies, 2) generalizing with indicators of selecting solution strategies, and 3) the convincing process with indicators of reflecting on the problem-solving steps taken. The three processes are explained in more detail below.

1) In the specialization process, the first indicator is identifying the problem. Students can identify that the domain is determined by the denominator, which is not equal to zero, and the odd/even property is determined by comparing the values of and. In the second indicator, which involves formulating and trying strategies, students can check the denominator value for the domain and substitute it into the function to test the odd/even property. 2) The generalizing process in the first indicator, namely reflecting on the ideas created, students realize that, for all, and realize that the numerator contains odd and even powers that affect the nature of the function. And 3) The convincing process, students can provide logical reasons that the function is an even function, an odd function, or neither.

Figure 1 below is one of the answers from a student with an ESFJ personality, who generally tends to process information concretely, follow clear procedures, and is greatly influenced by the classroom atmosphere and feedback from educators.

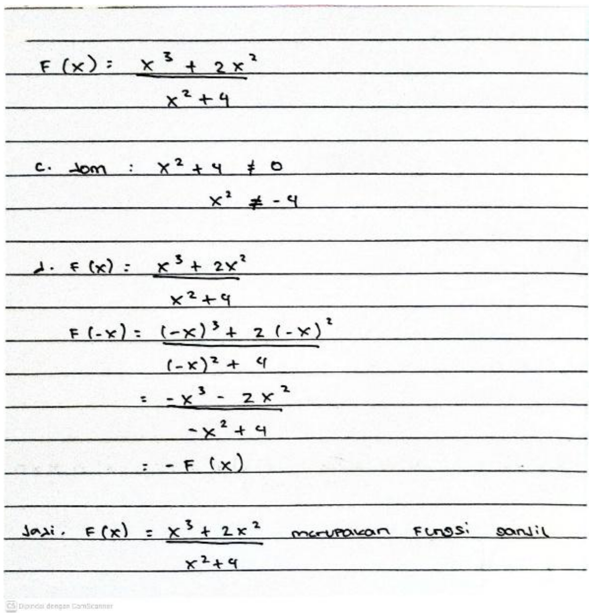

Figure 1. The ESFJ Student's (A) Answer Sheet

Figure 1 above shows that student A is in the process of specializing. On the indicator of identifying problems, he has written down $(x^2 + 4) \neq 0$ and explicitly stated that $f(-x)$. This answer demonstrates that student A understands the question and the general steps required to solve it. Then, in the indicator for developing and trying strategies, he has also begun to operate on the denominator, which cannot be zero under the domain conditions for fractional functions. He has also substituted values $(-x)$ into the function to test whether the function is odd/even, or neither. This indicates that the strategy employed is correct despite errors in the algebraic execution.

During the generalization process, the student was unable to accurately reflect on the results of the calculations. This can be seen from the simplification process, where he wrote $(-x)^2 + 4$ to be $-x^2 + 4$ (incorrect answer). Then, he also did not verify whether the function remained the same as the initial function, so he immediately concluded that $f(-x) = -f(x)$. Therefore, it can be said that Student A did not attempt to check the consistency of the algebra, so reflection did not occur.

In the convincing process, the student tried to give a reason by writing, "because $f(-x) = -f(x)$, then the function is odd." This reason arose based on an incorrect calculation. The denominator should not be $-x^2 + 4$. Thus, the student was able to identify the problem and choose the appropriate solution strategy, both in determining the domain and in testing the function's properties. However, the student did not yet show the ability to reflect on the solution steps taken. Errors in algebraic manipulation led to incorrect conclusions. This indicates that the students' mathematical thinking process still stops at applying procedures and has not yet progressed to reflection and convincing justification.

This finding suggests that the student relied primarily on procedural application during the specializing stage but had not yet developed sufficient reflective reasoning to evaluate the consistency of algebraic operations. As a result, the transition from procedural execution to conceptual verification in the generalizing and convincing stages was not fully achieved.

Based on the ESFJ personality type, students tend to exhibit a dominant mathematical thinking process in the specialization process. This is reflected in the students' ability to identify problems and determine solution strategies in accordance with the question's requirements. However, during the generalization process, students have not fully reflected on the solution steps taken, so errors in algebraic manipulation go undetected. Furthermore, at the convincing stage, students are not yet able to present the correct mathematical justification for their conclusions. This suggests that students with ESFJ personality types place a greater emphasis on applying solution procedures and the reflective process. However, there is still room for improvement in mathematical reasoning. These findings align with Prapita et al. (2017), which indicates that the majority of students with the ESFJ personality type exhibit less optimal analogical reasoning ability. This tendency may be explained by the dominance of the specializing process among ESFJ students, while the generalizing and convincing processes have not yet developed optimally. However, analogical reasoning requires the ability to generalize patterns.

Nevertheless, the students' answers show that the reflection process and strengthening of mathematical reasoning have not been carried out optimally. Students tend to conclude immediately after applying the solution procedure, without re-evaluating the accuracy of the calculations or the consistency of the results. Additionally, the presentation of answers is not yet accompanied by visual representations or more detailed explanations of the calculation steps, which could improve the clarity of the solutions. The analysis of the relationships among elements of the problem has also not been developed in depth. In general, the students' answers were well-organized. They demonstrated adequate procedural understanding, but strengthening reflection, mathematical justification, and mathematical communication is expected to improve the overall quality of their problem-solving.

The second analyzed answer is presented in Figure 2 and comes from a student with an ENFJ personality tendency, who tends to be warm, empathetic, and responsive.

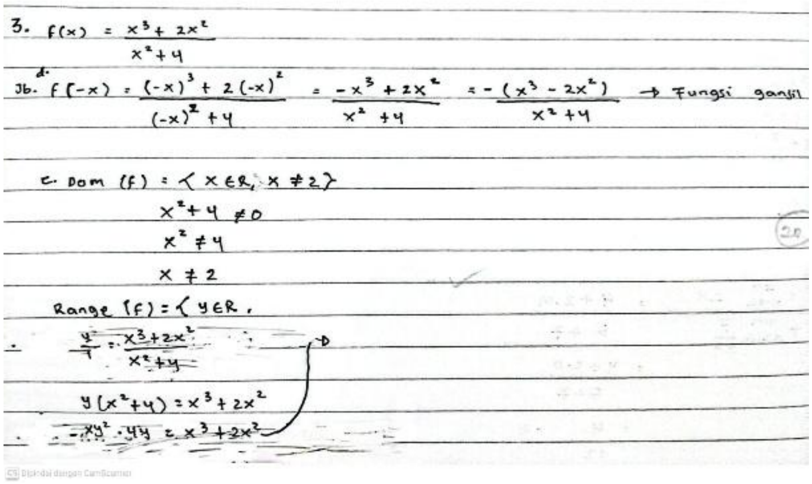

Figure 2. The ENFJ Student's (B) Answer Sheet

Based on Figure 2 above, the student is already in the process of specializing, meaning that the student can identify problems by writing domain rules for functions that cannot be equal to zero, "$x^2 + 4 \neq 0$". The student also writes explicit function property tests $f(-x)$. This shows that the student understands what is being asked and the first steps to solving the problem. Then, in the strategy development indicator, students substituted values $-x$ to test the properties of the function, performed checks on the domain, and even attempted advanced strategies by finding the range of the function. However, the execution was not yet correct.

During the generalizing process, student B did not accurately reflect on the calculations. This is evident in the errors in the conclusions. He wrote something that was not equivalent $-x^3 + 2x^2 = -(x^3 - 2x^2)$. Another error occurred when stating the domain; he wrote $x \neq 2$ yet $x^2 + 4 \neq 0$ for $x \epsilon \mathbb{R}$. Furthermore, he also did not recheck the suitability of the results with the definition of an odd function. Thus, it can be said that student B continued the solution without verifying the algebraic and mathematical logic processes. The convincing process was also not fulfilled because the reasons given were based on incorrect algebraic manipulation, and he did not show valid mathematical arguments. This indicates that the student's mathematical thinking process still primarily focuses on the application of procedures, while the reevaluation and strengthening of mathematical reasoning have not developed optimally.

The student's attempt to expand the solution beyond the requirements of the problem may reflect a tendency toward broader exploration of mathematical ideas. However, the lack of verification suggests that idea expansion was not consistently accompanied by reflective evaluation and mathematical justification.

Judging from the ENFJ personality type, students tended to think systematically in the early stages of problem solving, particularly in identifying the function's form, determining the domain through the denominator condition, and testing the function's properties using substitution. This process demonstrates a notable ability to specialize, characterized by applying procedures in accordance with the question's requirements. However, during the generalizing and convincing stages, students did not consistently demonstrate adequate mathematical reflection and justification, as evidenced by errors in algebraic manipulation and conclusions lacking strong mathematical reasoning. On the other hand, the students' efforts to expand the solution by determining the function's range—although not requested—indicate an orientation towards a solution considered complete, which aligns with ENFJ characteristics. These findings suggest that, although students have been able to follow the solution procedure systematically, reinforcement is still needed in aspects of concept evaluation and mathematical argumentation to ensure that the thinking process formed becomes more profound and valid. This finding aligns with Aini et al. (2025), who reported that individuals with the ENFJ personality type tend to be less thorough in exploring multiple possibilities and may not optimally evaluate and generalize strategies. This is consistent with the present study, where ENFJ students demonstrated strong specialization ability but showed limited development in the generalizing and convincing stages.

The characteristics of students' mathematical thinking abilities in relation to ESFJ and ENFJ personality tendencies are reviewed, based on Stacey's mathematical thinking process, which includes specializing, generalizing, conjecturing, and convincing. In ESFJ students, their main strengths are seen in the specializing and generalizing stages. The sensing (S) tendency in ESFJ encourages students to focus on concrete information and clear procedural steps, enabling them to identify essential elements in a problem and translate them into relevant mathematical forms. Meanwhile, the judging (J) character supports regularity in following the rules and procedures of the learned solution. This combination makes ESFJ students relatively consistent in developing solution steps. However, there is still room for improvement in the conjecturing and convincing stages, particularly in developing more critical assumptions and thoroughly verifying results.

Students with an SFJ (Sensing–Feeling–Judging) personality tendency show their main strength in the specializing stage, particularly in identifying relevant information and applying solution procedures coherently. Sensing encourages SFJ students to focus on concrete data that appears in the question, such as determining the domain of a function and direct value substitution. Meanwhile, the judging aspect tends to lead students to follow familiar, safe solution steps. However, in the generalizing and convincing stages, SFJ students have not fully reflected on the correctness of the results obtained or provided in-depth mathematical justifications. The conclusions drawn are generally still procedural and lack strong conceptual reasoning, particularly in their reevaluation of the steps taken. This condition aligns with some studies that state that reflection and mathematical justification are higher-order thinking processes that often do not emerge when problem-solving is overly focused on applying procedures.

In contrast to SFJ, students with NFJ (Intuiting – Feeling – Judging) personality tendencies tend to view problems more comprehensively and meaningfully. This is reflected in their efforts to expand on the solution to the problem, such as adding further discussion that is not actually required in the question. Intuiting encourages NFJ students to develop ideas and generalizations, while the feeling aspect influences the desire to produce answers that are considered complete and satisfactory. However, this tendency is not always balanced with accuracy in algebraic manipulation and verification of the correctness of the results. At the generalizing and convincing stages, NFJ students still show weaknesses in providing consistent mathematical reasoning and ensuring the validity of the conclusions drawn. These findings align with a study indicating that individuals with intuitive preferences tend to emphasize global meaning and idea development but may neglect the detailed examination and validation of results unless explicitly directed.

Overall, the differences between SFJ and NFJ students indicate that SFJs are more attuned to procedural regularity and accuracy in following steps. At the same time, NFJs excel in expanding ideas and the meaning of solutions. However, both personality types need reinforcement in reflection and mathematical justification so that the thinking process is oriented not only towards the final solution but also towards the logical and conceptual validity of each step taken.

These findings may provide practical implications for calculus instruction. Students with SFJ tendencies may benefit from learning activities that emphasize structured procedures, guided examples, and gradual verification of solution steps to strengthen reflective reasoning. Meanwhile, students with NFJ tendencies may benefit from open-ended problem-solving activities that encourage idea exploration while also requiring explicit mathematical justification and verification of results. Therefore, calculus instruction may be designed to balance procedural understanding, conceptual reflection, and mathematical argumentation across different student tendencies. Nevertheless, the personality tendencies identified in this study should be interpreted as contextual patterns within the analyzed sample rather than as fixed characteristics that determine students' mathematical thinking abilities.

4. CONCLUSIONS

Based on the analysis results, differences in SFJ and NFJ personality tendencies were associated with variations in students' mathematical thinking processes. SFJ tendencies were evident in students' emphasis on structured procedures and step-by-step approaches during the specializing stage, whereas NFJ tendencies were reflected in more flexible, pattern-oriented approaches during the generalizing stage. However, these findings should be interpreted as contextual tendencies within this study, and not as fixed classifications of students' mathematical thinking abilities. Both tendencies still require further support, particularly in the stages of reflection and mathematical justification

This study also contributes to research on mathematical thinking in higher education by providing a contextual perspective on how personality tendencies may be reflected in students' mathematical thinking processes during calculus problem solving. The findings extend the application of Stacey's mathematical thinking framework by showing that differences in students' approaches to specializing, generalizing, and convincing may be associated with variations in personality tendencies within calculus learning contexts.

5. SUGGESTION

Based on these findings, mathematics instruction should be designed to accommodate differences in personality tendencies by integrating structured reflection and explicit mathematical justification into problem-solving activities. Instructional interventions need to balance procedural accuracy and intuitive idea generation by incorporating guided reasoning prompts, metacognitive questioning, and systematic verification tasks that support both SFJ and NFJ students in strengthening their generalizing and convincing stages. Future research is recommended to include broader personality classifications and larger participant groups, and to examine the effectiveness of personality-responsive instructional models in fostering deeper mathematical reasoning and conceptual validity.

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