

Implementation of the modified free inquiry (MFI) learning model and its influence on students' analytical abilities

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Abstract

Analytical ability is a crucial part of the HOTS thinking element. This ability needs to be optimally trained through the learning process. However, the use of inappropriate learning models can lead to suboptimal analytical abilities in students. The Modified Free Inquiry (MFI) learning model is one of the suitable learning models for training analytical abilities. This study aims to analyze the effect of applying the MFI model on students' analytical abilities concerning the immune system material. This research is a type of quasi-experimental study with a pretest-posttest control group design. The research sample consisted of 72 students, comprising control and experimental classes selected through cluster random sampling technique. The analysis technique used was ANCOVA test with the help of SPSS 24. The research results showed significance value of ANCOVA is 0.000 ($p < 0.05$), indicating that the MFI model has an influence on students' analytical skills. This is also reinforced by the descriptive analysis results showing that the implementation of the MFI syntax can provide a positive trend in each dimension of analytical ability compared to the control class. Thus, the MFI model has a significant effect on improving students' analytical skills. This research is expected to strengthen theoretical studies in the field of analytical skills. Additionally, this study is also hoped to serve as a reference for teachers in choosing the right learning model to optimize students' analytical abilities.

Abstrak. Kemampuan analitis merupakan bagian krusial dari elemen berpikir HOTS. Kemampuan ini perlu dilatih secara optimal melalui proses pembelajaran. Akan tetapi, penggunaan model pembelajaran yang kurang tepat dapat menyebabkan tidak optimalnya kemampuan analitis siswa. Model pembelajaran Modified Free Inquiry (MFI) merupakan salah satu model pembelajaran yang cocok digunakan untuk melatih kemampuan analitis. Penelitian ini bertujuan untuk menganalisis pengaruh penerapan model MFI terhadap kemampuan analitis siswa pada materi sistem imun. Penelitian ini merupakan jenis penelitian kuasi-eksperimen dengan pretest-posttest control group design. Sampel penelitian yang digunakan sebanyak 72 siswa, terdiri dari kelas kontrol dan eksperimen yang dipilih melalui teknik cluster random sampling. Teknik analisis yang digunakan berupa Uji ANCOVA dengan bantuan SPSS 24. Hasil penelitian menunjukkan nilai signifikansi ANCOVA 0.000 ($p < 0.05$), sehingga model MFI memberikan pengaruh terhadap kemampuan analitis siswa. Hal ini juga diperkuat dari hasil analisis deskriptif yang menunjukkan bahwa implementasi sintaks MFI mampu memberikan tren positif terhadap tiap dimensi kemampuan analitis dibanding kelas kontrol. Dengan demikian, model MFI berpengaruh signifikan terhadap peningkatan kemampuan analitis siswa. Adanya penelitian ini diharapkan dapat memperkuat kajian teoritis dalam bidang kemampuan analitis. Selain itu, penelitian ini juga diharapkan dapat menjadi referensi bagi guru dalam memilih model pembelajaran yang tepat guna mengoptimalkan kemampuan analitis siswa.

A. Introduction

The 21st century learning process emphasizes students' ability to master various Higher Order Thinking Skills (HOTS), one of which is analytical thinking. Analytical thinking is the ability of students to describe, detail, and analyze information used to understand relationships from all aspects by using reason and logical thinking (Chonkaew et al., 2016). Analytical thinking is needed in 21st century life as one of the components of learning skills (Laar et al., 2020). Analytical thinking is needed to prepare learners to face life and a complex work environment (Thaneerananon et al., 2016). Analytical thinking is useful for training students in finding relationships between knowledge components through the process of deciphering (Annisa et al., 2016).

Ideally, all learners should possess analytical skills. This ability is crucial and an important aspect of life. However, the current reality shows that the analytical skills of students in Indonesia are still relatively low (Khurniawan & Eza, 2019). This can be seen based on the history of international assessment results conducted by (Program for International Student Assessment) PISA 2022 and 2018, which shows the ability scores of Indonesian students who are still below average. In line with this, the research by Ilma et al. (2017) shows that students' analytical thinking skills are still relatively low. This is reinforced by the study by Tangsakul et al. (2017), which explains that students' skills are significantly weaker at higher levels such as analysis.

Analytical ability is one of the three aspects of science literacy in the PISA assessment. In scientific literacy, students are required to describe, elaborate, and analyze information in order to logically construct knowledge. Analytical skills are fundamental to students' mastery of scientific content and competencies, as measured by PISA. However, fact is that Indonesia's PISA achievement score fluctuates greatly and tends to rank at the bottom (Wahab et al., 2024). In 2015, Indonesia scored 403 and ranked 62nd among 69 countries. The score was still below the average score set by PISA (500). Based on the last assessment in 2018, Indonesia obtained a score of 396 and ranked 71st out of 79 countries. Looking at the data, there was a decrease in Indonesia's score from 2015 to 2018 (OECD, 2019). In the last survey, Indonesia's score in science literacy dropped again. Compared to neighboring countries such as Malaysia and Thailand (Wahab et al., 2024). Indonesia is still lagging behind with a science score of 383, while the two countries scored above 400 points. This indicates that Indonesian students are not yet able to solve problems with HOTS (Prawita et al., 2019).

A similar phenomenon was found in one of the schools located in Magelang Regency. Based on testing 36 students by giving HOTS questions developed by Rizki et al. (2024) it was found that 60% of students scored below 50 for the analytical aspect. This finding

also proves their weak ability to solve analytical problems. The low analytical ability can be caused by students' lack of familiarity with solving HOTS-type problems (Astuti & Adirakasiwi, 2020). In addition, the use of a teacher-centered learning model that does not empower analytical skills is a key factor in their low ability.

This is in line with the results of interviews with high school biology teachers, who revealed that during the learning process the largest percentage of the learning process was still carried out using conventional methods. In the conventional learning, the teacher plays an active role as a source of learning and involves students less in the process of independent knowledge discovery. As a result, students' analytical skills are not optimally developed. Conventional learning tends to promote a passive learning process, making it ineffective in training higher-order thinking skills such as analysis (Ghafar, 2023; Freeman et al., 2014). In addition, the lecture method also causes the class to be monotonous and boring, as a result students are not sufficiently involved in the scientific thinking process and investigation (Li & Arshad, 2015). In line with the research by Areepattamannil et al. (2020), it states that teacher-centered learning limits students from designing and interpreting scientific investigations through the process of inquiry. This lack of student involvement in the learning process leads to the underdevelopment of their analytical skills, especially in biology material, which is closely related to everyday life.

The immune system is an abstract biological material, making it difficult for students to master (Ristanto et al., 2023; Dewi et al., 2016). In the material on the immune system, the physiological mechanisms of the body that are interconnected and cannot be seen with the naked eye are studied. The characteristics of the complex material require a level of student engagement in learning and constructing their knowledge. In constructing knowledge, students need to be actively engaged independently (Altinyelken & Hoeksma, 2021). Students' activity in learning can be carried out through the learning process (Prajoko et al., 2023). A good learning process must be able to train students' analytical skills (Jumini, 2022).

One of the learning models that has the potential to empower students' analytical skills is the Modified Free Inquiry (MFI) learning model. Looking at Raudatun (2021)'s research found that the MFI model had a significant effect on science generic skills and scientific attitudes. In line with this, research by Harahap and Harahap (2021), Rahmi et al. (2020), and Hadi et al. (2018) explained that the MFI learning model had a significant effect on critical thinking skills compared to conventional methods. Thus, the MFI model also has potential as a learning model that can improve other cognitive abilities such as analytical thinking skills. MFI is a learning model that combines

free and guided inquiry models. The MFI syntax includes (1) problem orientation, (2) problem formulation, (3) hypothesis creation, (4) data collection, (5) hypothesis testing, and (6) conclusion drawing. The MFI model allows ideal intervention from educators to provide a problem and provide opportunities for students to solve problems (Fatmawati, 2021). The problem-solving process can be done according to individual or group abilities (Kholilurrohman & Suryadarma, 2019). Education only exist as facilitators during learning activities.

In the MFI learning process, students are given the freedom to search for and find solutions to the problems presented (Eristya & Aznam, 2019). Students must actively participate in seeking answers to these problems. The teacher acts as a facilitator and provides minimal assistance if students encounter difficulties. The minimal guidance from the teacher encourages the formation of independent exploration by students, creating meaningful learning experiences (Asmarini et al., 2017). This is very important to ensure that students can acquire basic ideas, analyze, and conclude fundamental concepts in the learning material (Bhardwaj et al., 2025).

This research specifically examines the impact of the MFI learning model on students' analytical thinking skills regarding the immune system material. The immune system is a complex topic that requires analytical skills to understand the mechanisms and interrelations among immune components that influence each other (Lestari et al., 2024; Yulianis et al., 2019). However, currently, these analytical skills have not been optimally developed. In fact, analytical skills are very important to master and need to be improved. Therefore, this study aims to analyze the extent to which the MFI model influences and has the potential to train students' analytical skills regarding the immune system material. Thus, this study is expected to provide an alternative for teachers in choosing learning models that can optimize students' analytical thinking skills.

B. Material and method

This research is a type of quasy experiment study with a pretest-posttest control group design. This method is used to determine the effect of treatment on the experimental class using the MFI model. Meanwhile, the control group uses a conventional learning by lecturing. The research design is presented in Table 1.

The population in this study is Phase F students at SMAN 1 Bandongan which amounted to 144 students and was spread across four classes. The research sample consists of 72 students. Consists of 36 students from the experimental class and 36 students from the control class. The sample selection was determined by cluster random sampling technique with the following steps (1) Tabulation of summative assessment scores of the entire population; (2) One way anova test and the results obtained that the four

classes did not have significant differences in ability. To determine which class was the research sample, a draw was made using a card. The rules in the draw were the first and second draws for the first and second draws for the experimental and control classes respectively; (3) Two cards were drawn randomly to obtain the control and experimental classes. Random sampling was applied since the classrooms were already established, allowing each class an equal chance to be selected and ensuring greater objectivity.

The instruments used in this research were test and non-test instruments. Non-test instruments in the form of observation sheets of learning syntax implementation. The syntax implementation observation sheet was used to measure the implementation of the learning process in the control and experimental classes. This sheet consists of "Implemented" and "Not Implemented" statements that are filled in by the observer. The calculation results were then interpreted using the syntax implementation score in Table 2.

Table 1 Research design

Class	Pretest	Treatment	Posttest
Experiment	O ₁	X ₁	O ₂
Control	O ₁	-	O ₂

Description:

O₁ = Pretest

O₂ = Posttest

X₁ = Implementation of the MFI model

- = Implementation of the Conventional model

Table 2 Interpretation of syntax implementation

Score	Criteria
80 ≤ X ≤ 100%	Very good
60% ≤ X < 80%	Good
40% ≤ X < 60%	Simply
20% ≤ X < 40%	Bad
0% ≤ X < 20%	Very bad

(Source: Firdausichuuriyah & Nasrudin, 2017)

The test instrument consisted of seven descriptive questions aligned with the aspects of analytical thinking based on Marzano's New Taxonomy. These aspects, adapted from Marzano and Kendall (2007, are presented in Table 3.

The aspects are distributed across the instrument as follows: matching (item 1), classifying (items 2 and 5), analyzing errors (item 4), generalizing (item 3), and specifying (items 6 and 7). Before use, the instrument was reviewed using content and construction validity tests. The results of the content validity test showed that the value of r count was greater than r table, so the instrument was declared valid. Meanwhile, the results of the reliability test show, α value > 0.6 so it can be categorized as a reliable instrument. Based on expert assessment, the instrument obtained a score of 0.9, indicating that it is classified as a valid and reliable instrument. In terms of

difficulty level, all items in the instrument were classified as moderate. Meanwhile, based on differentiating power, two questions met the criteria of very good, and five questions had good differentiating

power. In addition, based on the construction validity test, the test instrument developed met the expert's criteria. Thus, the instrument developed can be used as a tool to measure students' analytical skills.

Table 3 Components of analytical thinking

Components of analytical thinking	Indicator
Matching	The involvement of identifying similarities and differences between knowledge components can be in the form of concepts or theories.
Classifying	Identifying characteristics and organizing concepts or ideas into meaningful categories.
Analysing errors	Evaluate the validity of knowledge based on explicit criteria and identify errors in thinking
Generalizing	Look for patterns or relationships in the information.
Specifying	Identifying inferences or making predictions.

(Source: Marzano & Kendall, 2007)

Table 4 Classification of analytical skills

Intervals	Criteria
$M + 1,5SD < X$	Very high
$M + 0,5SD < X \leq M + 1,5SD$	High
$M - 0,5SD < X \leq M + 0,5SD$	Medium
$M - 1,5SD < X \leq M - 0,5SD$	Low
$X \leq M - 1,5SD$	Very low

(Source: Azwar, 2012)

Description:

M = Mean

SD = Standard deviation

Research hypothesis testing was carried out using the ANCOVA test on SPSS version 24 software. Before testing the hypothesis, a prerequisite test was conducted using the following steps.

1. The normality test was, carried out using the Kolmogorov-Smirnov test, if the sig value was ≥ 0.05 then the data were normally distributed. Conversely, if the sig value < 0.05 , then the data are not normally distributed.
2. The next stage was the homogeneity test using Levene's test. If the sig value ≥ 0.05 then the variance of the two data groups is homogeneous. Conversely, if the sig value < 0.05 then the variance of the two data groups is not homogeneous.
3. Furthermore, a linearity test was, carried out using to determine whether the data tested had a distribution that fitted the linear line. If the sig value > 0.05 then the data is linear, and if the sig value < 0.05 then the data is not linear.

If the data met the prerequisite assumptions in the form of normal, homogeneous, and linear data, hypothesis testing was performed using the ANCOVA test. If the sig value is > 0.05 then H_0 is accepted, meaning that there is no effect of the MFI model on students' analytical skills. Meanwhile, if the sig value is < 0.05 , then H_1 is accepted, meaning that there is an effect of the MFI model on students' analytical thinking skills.

To determine the categories of students' analytical ability levels, we calculated the grade data of

students in the control and experimental classes. The analysis is conducted based on the intervals shown in Table 4.

C. Results and discussion

Implementation of the MFI learning model

The MFI model consists of six learning syntaxes: (1) problem orientation, (2) problem formulation, (3) making hypotheses, (4) data collection, (5) hypothesis testing, and (6) drawing conclusions. Syntax is a learning model stage that can support the achievement of learning outcomes and desired goals (Setiawati & Corebima, 2017). Learning syntax then becomes the flow that students must follow during the learning process. Based on the results of the syntax implementation analysis, it is known that the average implementation of the MFI learning process was 98,75%. The results of the analysis are presented in Table 5.

Table 5 Implementation of MFI syntax

Meeting	Applicability (%)	Description
First	95	Very good
Second	100	Very good
Third	100	Very good
Fourth	100	Very good
Average	98,75	Very good

Based on Table 5, the MFI syntax meets the very good criteria. Learning activities took place over four meetings, with two additional meetings used for pretest and posttest data collection. Meanwhile, the results of descriptive analysis of pretest and posttest data in each class are presented in Table 6.

Based on the descriptive analysis, as shown in Table 6, the initial ability of students in the control class had an average of 55.36 with a low category. Meanwhile, after the post-test the final ability of students increased to 71.81 with a moderate category. In contrast to the control class, in the experimental class, the initial ability of students had an average score of 54.86 with a low category and the final ability of

students increased to 79 with a high category after treatment. This data is an initial indication that there is an effect of treatment that underlies the surge in the increase in final ability in the experimental group. Thus, the analysis continued with a prerequisite test. Based on the prerequisite assumption analysis, the

data in this study were normally distributed, homogeneous and linear. Thus, hypothesis testing can be performed using the ANCOVA test using SPSS version 24. The basis for decision making H_0 is accepted if the significance value (2-tailed) < 0.05 . The ANCOVA test results are presented in Table 7.

Table 6 Descriptive analysis of students' analytical ability

	Initial ability		Final ability	
	Control	Experiment	Control	Experiment
Highest score	70	74	83	91
Lowest score	35	35	52	59
Mean	55,36	54,86	71,81	79
Median	56	55,5	73	79,5
Mode	58	59	74	78
Standard deviation	8,21	8,37	7,71	7,51
Category	Low	Low	Medium	High

Criteria $x < 46$ = Very Low, $46 < x \leq 59$ = Low, $59 < x \leq 72$ = Medium, $72 < x \leq 85$ = High, $x > 85$ = Very High

Table 7 Hypothesis test results

Class	df	F	Sig.	Description
Experiment-Control	1	39,800	0,000	There is an influence

Based on Table 7, it is known that the significance value of ANCOVA is 0.000 ($p < 0.05$). This not only indicates the presence of an effect but confirms that the guided structure of the MFI model is fundamentally superior to the control class approach in developing analytical skills. The significant difference in final averages between the experimental class (79.00) and the control class (71.81) is not just a number, but a reflection of different cognitive processes. In the experimental class, students actively construct knowledge through the problem formulation cycle to conclusion drawing. Meanwhile, the control class has a less structured process, resulting in a smaller increase in skills compared to the experimental class.

The first syntax of the MFI model is problem orientation. After group formation, the teacher presents problems relevant to the learning objectives. The problem cases were presented in the form of pictures and narratives through PowerPoint slides and student worksheets. In addition, the teacher occasionally provided triggering questions accompanied by follow-up questions. This process is useful for maximizing students' interest in learning a particular topic. This is also reinforced by Eggen & Kauchak (2012) that one way to make students think actively in learning is to increase their curiosity.

The next stage in the MFI syntax is problem formulation. This stage focuses on encouraging students to identify and define existing problems in more detail. Proper problem formulation can be a focal point and a means of developing problem-solving skills in learning as well as providing direction in the next stage. When formulating a problem, many questions come to mind. The curiosity formed during

apperception is further strengthened by the emergence of such questions. The emergence of questions in the minds of students is an indication of a cognitive process where the brain tries to think and identify the relationship between the problems presented (Dawati et al., 2015). In this situation, teachers are required to be more creative in creating situations that can make students discover their knowledge (Sigit et al., 2024).

After students formulate the problem, the next stage is hypothesis formulation. Hypothesis formulation encourages students to make predictions based on their initial understanding. Early understanding becomes the basic foundation in forming meaningful predictive hypotheses (Kuang et al., 2020). Students are required to collaborate and exchange ideas among group members. The process of exchanging ideas then encourages students to form a group hypothesis. To build a more active learning atmosphere, the teacher can pit hypotheses between groups and give skeptical statements on the hypotheses that they propose. Thus, students can be more determined to prove the truth of the hypothesis that their group proposes (Nurhadi et al., 2023).

The next syntax is the data collection. This stage involves students in the process of exploring and searching for information to support or reject the hypothesis that has been formulated. According to Datun et al. (2019) the data collection stage can train students in building arguments based on empirical evidence. At this stage, the teacher gives each group the freedom to find arguments and truth for the hypothesis they propose. Students not only learn to understand concepts but also develop analytical skills in evaluating and processing information.

During the research process, it was found that some groups consisted of students with high cognitive abilities and a good level of learning independence. Students with these characteristics tend to act as group leaders. Students with these characteristics usually direct the course of the discussion and the implementation of tasks in the group (Özgen et al., 2019). On the one hand, the presence of independent students can trigger enthusiasm and be a source of motivation for other group members who tend to be passive. However, students with better mastery of the material also have the potential to dominate the group. This dominance can cause dependence on other members and reduce the level of individual participation in the inquiry process. As a result, the findings or results of group discussions become less representative of collective work and only reflect the contribution of one individual (Kholilurrohman & Suryadarma, 2019).

Therefore, teacher must ensure that exploration activities are carried out equally by all group members. During the data collection process, the teacher monitored each group member. Teachers can provide assistance so that each student has the same opportunity and responsibility in the process of searching and processing data (Pedaste et al., 2015). In addition, anticipation can also be done by analyzing the initial abilities of students to group high and low-ability students. After grouping, group division can be done to ensure that each group has high and low-ability students so that all groups are heterogeneous.

Although the overall average of the experimental class is high, observations regarding the presence of dominant students indicate potential variability in individual mastery. This implies that without teacher intervention to ensure equal participation, the effectiveness of the MFI model at the individual level may not be uniform. This is a limitation that needs to be considered in the implementation of this model.

The fifth phase, in the MFI syntax, is hypothesis testing. This phase is crucial in inquiry-based learning. At this stage, students compare the data obtained with the hypothesis that was made before. According to Chinn and Malhotra (2002) this process requires students to evaluate the suitability of existing data and theory. At times, students were unable to propose a simple hypothesis formulation properly. Therefore, teachers need to provide guidance in efforts to formulate hypotheses (Susanti et al., 2017). The matching process can be performed by discussing with group members. Each member explained what they understood from the exploration activities that had been carried out. The exposure of each group member encourages discussion. The discussion between members can provide insights and different points of view in finding the truth of the conjecture that has been made. The occurrence of discussions between students

and teachers can improve analytical skills because it makes students active learners (Sigit et al., 2024).

The final stage of the MFI syntax is the formulation of conclusions. This stage aimed to formulate generalizations based on the results of the data analysis. According to Bybee et al. (2006), a good conclusion should be based on a valid interpretation and supported by empirical evidence. This stage helps students hone their analytical thinking skills by systematically connecting the various concepts they have learned. Through the formulation of conclusions, students are invited to attribute the information obtained by compiling the relationship between data, theory, and observed phenomena. The MFI model is able to foster students' ability to learn to make decisions with appropriate and responsible strategies (Sigit et al., 2024). This process not only reflects conceptual understanding but also shows students' ability to evaluate and communicate their learning outcomes logically (Pedaste et al., 2015).

MFI implications for each analytical dimension

Analytical thinking consists of five aspects which include (1) Matching, (2) Classifying, (3) Analyzing Errors, (4) Generalizing, and (5) Specifying (Marzano & Kendall, 2007). The syntax in MFI is closely related to these aspects, so it has a positive influence on students' analytical skills. The implementation of the MFI model has been proven to influence students' analytical skills in general. To determine the impact of MFI implementation on each aspect of analytical thinking, the final ability scores of each class were analyzed and are presented in Figure 1.

Based on Figure 1, it can be seen that the analytical ability score of the experimental class shows a higher average than the control class. This difference is inseparable from the learning process and syntax that is differs in each class. The problem orientation and data analysis stages in the MFI syntax can encourage students to link known information with the data they obtain. In line with the research by Cairns (2019) the ability to connect cause and effect as well as the relationships between variables can be formed through the process of data analysis. Students are accustomed to comparing their findings with their initial theory or hypothesis. that they propose. Thus, students find a "matching" match between what they understand in the syntax of problem orientation and what actually happens or the science facts they know from the syntax of hypothesis testing.

The research results in Figure 1, show that students' ability to match has the highest percentage score compared to other analytical dimensions. This can mean that the matching dimension has a low level of difficulty, so that students are able to solve problems with precise and correct analysis (Rahmawati, 2017). Matching is the simplest component in the domain of analysis (Marzano & Kendall, 2007). Thus, it can be concluded that matching is the lowest level of

analytical thinking. Although it is the lowest level, the very high score on the matching dimension in the experimental class indicates that the foundation for

the analysis of the ability to identify similarities and differences has been successfully built very strongly through problem-oriented syntax.

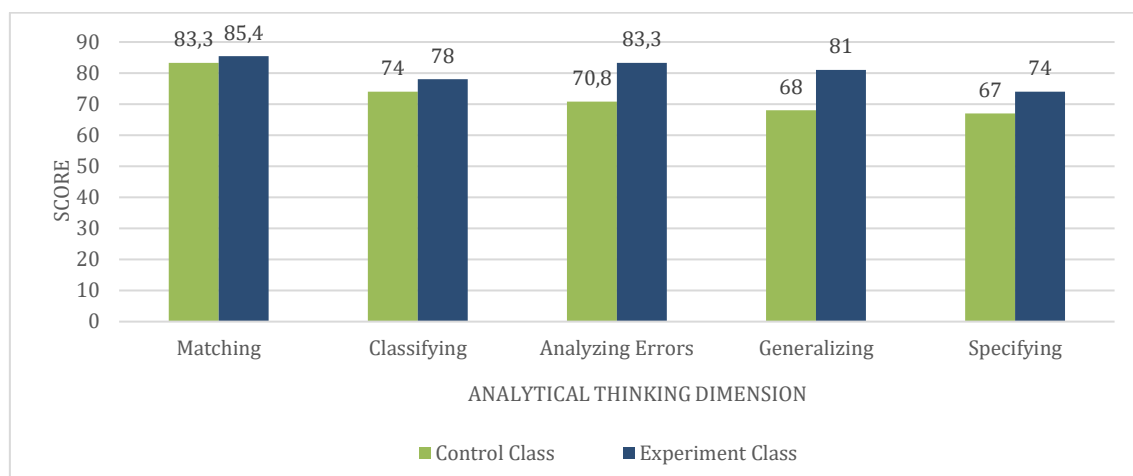


Figure 1 Average score of each dimension of analytical thinking

In Figure 1, it is evident that the classifying aspect in the experimental class has a higher score. The average classifying score in the experimental class is 78, which is higher than the control class that only received an average of 74. Although the average difference is not very large, this finding indicates that the implementation of the MFI model can provide a positive contribution to improving students' skills in classifying information. The classifying aspect emphasizes students' ability to group information based on characteristics, categories, or certain relationships. The initial syntax in the MFI model, namely problem orientation, plays a crucial role in encouraging students to identify, sort, and group data or information relevant to the issues raised. This process makes students not only passively receive information but also practice organizing and systematically structuring knowledge.

In the classifying dimension, students are used to classifying in the problem formulation process (Sigit et al., 2024). This is reinforced by Suyatman et al. (2021) who explained that the problem orientation process gives a positive trend towards analytical skills, especially in the matching and classifying aspects. At these stages' students are required to compare, examine, and classify the problems being studied. In this syntax, students are trained to classify information into certain categories. Students are required to actively classify the data relevant to the problem they are solving. This activity directly strengthens the classifying ability because students must create a logical structure from diverse information (Syafitri, 2021).

In line with the views of Marzano and Kendall (2007), which state that classifying can develop when students are given the opportunity to engage in the process of categorization and independently

determine classification criteria. The conventional learning model in the control class tends to focus more on direct material delivery, so students play a more passive role as information receivers. As a result, opportunities to practice classifying skills become limited.

Although the problem-oriented MFI syntax has a positive effect on the classifying dimension in the experimental class, the average results for the classifying dimension are relatively low compared to other dimensions such as matching. To form classifying, students need explicit guidance in the form of directions for creating comparison tables, making categories, or organizing criteria. If the teacher gives too much freedom without organizational strategies, students may skip the classification stage. According to Anderson and Krathwohl (2001), analytical skills in the classification dimension do not automatically develop just through inquiry activities, but require instructional support.

The next dimension, analyzing errors, is closely related to data collection and hypothesis testing stages. In the dimension of error analysis, the experimental class showed an average score of 83.3 (figure 1) while the control class showed an average score of 70.8 (figure 1). The significant difference in both classes provides evidence that the MFI syntax has a real effect on students' ability to analyze errors. The MFI model encourages students to think systematically and reflect on their knowledge so that errors in thinking can be identified. The MFI model can improve students' ability to analyze errors due to the syntax of planning and data collection (Sigit et al., 2024). Unlike the conventional model in the control class, the data validation and search process is not conducted in the class. This results in the inability to validate the findings and knowledge obtained.

In the syntax of data collection and hypothesis testing, students are trained to detect discrepancies in data or procedures to improve their error analysis skills. The high error analysis ability of students in the experimental class compared to the control class was due to the exploration and observation process in groups to find various sources of information to design and collect data (Sigit et al., 2024). These activities encourage students to be more critical in assessing the validity of the data collected and strengthen analytical thinking skills in terms of analyzing errors. The ability to analyze errors is an important key to the next stage of analytical thinking. Analytical thinking involves cognitive processes such as analyzing errors which become the foundation for the next stage of cognitive processes (Bilgin & Kala, 2022). In addition, Fatmawati (2021) also shows that the MFI learning model can improve students' cognitive abilities, including in the aspect of error analysis. In the MFI model, students are encouraged to be active in the learning process through data collection and analysis which helps them identify and correct errors that occur during the learning process.

The next dimension of analytical thinking is generalization. A significant improvement occurred in the dimension of generalization, where the experimental class achieved an average score of 81 (Figure 1), far surpassing the control class with an average score of 68 (Figure 1). This reflects that this improvement is directly related to the attribution on MFI syntax. The high average score in the experimental class in the generalizing aspect is because in the MFI model students analyze the findings by discussing them in groups. Through discussion activities, students directly interact and exchange ideas with their friends, causing students to gain experience in learning to increase their knowledge (Susanti et al., 2017). In addition, the final stage in the MFI syntax, namely summarizing the results, requires abstraction from concrete data in to general principles. This can directly develop generalization skills. Discussion and conclusion activities in MFI syntax can stimulate students' creativity and analysis in the form of new ideas and ideas in solving a problem (Karyadi, 2017). In contrast to the control class, where students did not conduct group discussions, the conclusions they had depended on what they understood and what the teacher conveyed. In line with this, Vickrey et al. (2023) without any discussion, the main mechanism to facilitate knowledge construction does not occur. Group discussions encourage students to think analytically and scientifically, and encourage the collection of opinions, all of which contribute to the development of generalization ability.

In addition to contributing to the generalization aspect, group discussions and drawing conclusions also made a positive contribution to the specification aspect. This is reinforced by Sigit et al. (2024) who explained that specification skills can be trained with

presentations and class discussions. Discussions between students and teachers can increase student activity during learning. Students' involvement in discussions allows them to express opinions, question information, and clarify concepts that have not been understood. This process directly stimulates analytical thinking skills, including the specifying aspect because students are required to identify information in more detail and relevance in answering a problem. In addition, discussions also open up opportunities for students to get new perspectives from classmates and teachers, so that they are encouraged to be more thorough in classifying and describing the information needed.

A quality class discussion can increase students' contributions to specifying a problem. This is a reflection of students' ability to convey detailed and relevant information (Lugini & Litman, 2019). In line with this, according to Rahmawati (2017), learning that involves two-way interaction can create a learning environment that supports the development of higher order thinking skills. Thus, class discussion activities are not only a means of sharing information, but also an effective tool for training students to develop specifying abilities sustainably.

The results of this study imply that the application of the MFI model can be one alternative for biology learning that encourages students to more actively explore concepts through the inquiry process. Although the MFI model significantly has a positive impact on improving analytical skills, in some dimensions of analytical ability, it has not been maximally formed. Therefore, teacher intervention and modification of the learning model syntax are necessary so that the dimensions that have not been maximally formed can be trained and improved as expected. Additionally, further studies are also needed to determine whether the positive trend of the MFI model also occurs in other aspects of HOTS.

D. Conclusion

Based on the discussion above, it can be concluded that the Modified Free Inquiry (MFI) learning model affects the analytical thinking skills of students at SMAN 1 Bandongan. This can be proven by the result of the ANCOVA test, which shows sig. $0.00 < 0.05$ that H_1 is accepted. This finding is also reinforced by the increase in the mean score of the pretest and posttest in the experimental class from 54.86 to 79 after treatment. The increase in the score is evidence that the MFI model positively influenced each dimension of analytical thinking. Therefore, the MFI learning model can be considered an alternative for teachers to enhance students' analytical thinking skills. Further research is needed to prove whether the MFI model has the same effect on other HOTS abilities.

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