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COMPARATIVE STUDY OF STUDENTS' CRITICAL THINKING SKILLS: GENICS VS DISCOVERY LEARNING MODEL

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ABSTRACT: The purpose of this study was to examine how students' critical thinking skills differed between students learning with the GENICS model and students learning with the Discovery Learning model. It is hoped that this study will provide insight into how well each model improves students' critical thinking skills. This study employed a quantitative approach and employed a non-randomized pretest-posttest control group design. The study used an essay test to assess students' critical thinking skills. The MANCOVA test was used to conduct data analysis using statistic software. The review was conducted through observations of the critical thinking skills of class X students of SMAN Titian Teras. The study shows that the GENICS model produces a higher average post-test score of students' critical thinking skills (84.68) compared to the Discovery Learning model (81.64). Although both models improve critical thinking skills, the GENICS model is more effective in the focus and situation indicators, while Discovery Learning excels in the reasoning and data processing indicators. Significant improvements occurred in both models, with differences in p-values indicating a real impact of the learning strategy. This study provides insights that lie in the direct comparison between the GENICS and Discovery Learning learning models in the context of students' critical thinking skills. This study provides new insights into the effectiveness of both models, as well as their specific contributions in improving students' analytical and reflective skills, which can serve as a reference for the development of more effective learning methods.

ABSTRAK: Tujuan dari penelitian ini adalah untuk melihat bagaimana keterampilan berpikir kritis siswa berbeda antara siswa yang belajar dengan model GENICS dan siswa yang belajar dengan model Discovery Learning. Diharapkan penelitian ini akan memberikan wawasan tentang seberapa baik masing-masing model dalam meningkatkan keterampilan

berpikir kritis siswa. Penelitian ini menggunakan pendekatan kuantitatif dan menggunakan desain kontrol *group pretest-posttest non-randomized*. Penelitian menggunakan tes esai untuk menilai kemampuan berpikir kritis siswa. Uji MANCOVA digunakan untuk melakukan analisis data menggunakan perangkat lunak statustik. Tinjauan dilakukan melalui observasi kemampuan berpikir kritis siswa kelas X SMAN Titian Teras. Penelitian menunjukkan bahwa model GENICS menghasilkan skor rata-rata pasca-tes keterampilan berpikir kritis siswa yang lebih tinggi (84,68) dibandingkan dengan model Discovery Learning (81,64). Meskipun kedua model meningkatkan keterampilan berpikir kritis, model GENICS lebih efektif dalam indikator fokus dan situasi, sedangkan *Discovery Learning* unggul dalam indikator penalaran dan pemrosesan data. Peningkatan signifikan terjadi pada kedua model, dengan perbedaan nilai-p yang menunjukkan dampak nyata dari strategi pembelajaran. Penelitian ini memberikan wawasan yang terletak pada perbandingan langsung antara model pembelajaran GENICS dan *Discovery Learning* dalam konteks keterampilan berpikir kritis siswa. Penelitian ini memberikan wawasan baru tentang efektivitas kedua model, serta kontribusi spesifiknya dalam meningkatkan keterampilan analitis dan reflektif siswa, yang dapat menjadi referensi untuk pengembangan metode pembelajaran yang lebih efektif.

INTRODUCATION

Rapid developments in science and technology in the 21st century require students to master the 4c skills (commucation, collaboration, critical thinking and problem solving and creative and innovative). The application of 4c skills in the teaching and learning process has been proven to provide significant benefits for students including increasing the ability to solve problems, process information critically (Siburian et al., 2022). Improving the quality of education is not a simple matter, because these efforts require a long process and the struggle to support improving the quality of education is by updating the curriculum (Siburian et al., 2023). In line with this perspective, the implementation og the independent curriculum in Indonesia grants teachers greater flexibility in organizing learning activities and selecting appropriate instructional tools to enhance students' learning experiences (Salsabila et al., 2025). To face the challenges of the 21st century, learning that focuses on developing 4C skills is an urgent need (Nurhayati et al., 2024). Although 21st-century skills have been widely emphasized in the curriculum, their implementation in biology learning still faces several challenges. Learning activities are often teacher-centered and focus on memorization, limiting students' opportunities to develop critical thinking skills. As a result, students experience difficulties in understanding complex biological concepts that require deeper analysis. Curriculum updates not only aim to align learning materials with technological developments, but also ensure that students are able to think critically, collaborate effectively, and produce innovative solutions. To face the challenges of the 21st century, learning that focuses on developing 4C skills is an urgent need. Curriculum updates not only aim to align learning materials with technological developments, but also ensure that students are able to think critically, collaborate effectively, and produce innovative solutions. Apart from that, the

curriculum plays a crucial role and has a strategic position in the implementation of learning in schools (Devi et al., 2024) .

High-level skills are also one of the skills students need to prepare to produce quality human resources, critical thinking is one aspect of high-level thinking (Sari et al., 2024). According to (Lieung, 2019) critical thinking skills can be interpreted as an individual's ability to think reflectively and rationally in determining the right beliefs or actions. A person who has critical thinking skills is able to evaluate information critically and objectively to make the right decisions, this skill is very important in everyday life, especially in the world of work and in learning (Ariadila et al., 2023). However, when students' critical thinking skills are low, it can cause students to be unable to solve a problem, make students inactive, and not confident and lacking in defining learning theories (Rachmedita et al., 2017).

According to (Taufiq Satria Mukti & Edi Istiyono, 2018) measurement of critical thinking skills is often done through essay tests using indicators developed by Ennis (2015) known as FRISCO. There are several criteria in FRISCO, namely focus, reason, inference, situation, clarity, and overview. Focus refers to the ability to determine the core of the problem, reason involves the ability to provide a reason based on relevant facts, inference relates to the ability to draw the right conclusions based on existing reasons (Prihartini et al., 2016). situation requires individuals to utilize all available sources in solving problems according to context, clarity focuses on the ability to provide clear and smooth explanations, while overview includes the ability to re-check the information that has been conveyed (Setiana et al., 2020). A person is said to be able to think critically, namely with the characteristics, being able to solve problems, being able to analyze and simplify information, and being able to draw conclusions correctly (Cahyono, 2017).

In learning critical thinking skills are trained by applying the GENICS and Discovery Learning models. The GENICS learning model is a group-based learning approach that provides flexibility for students to choose learning methods according to their preferences. Freedom to learn sees unique interests and tendencies, students as a source of self-confidence, students have the freedom to choose learning resources (Mardiyanti & Siburian, 2023). Meanwhile, the Discovey Learning model is a learning approach that emphasizes the discovery of concepts or principles through direct experience by students. Students are faced with problems or situations that encourage them to explore, observe and conduct experiments (Pratiwi et al., 2024).

Based on the results of observations conducted on tenth-grade students at SMAN Titian Teras, the majority of students were categorized at a moderate level (94%), while the remaining 6% were in the low category. The average scores for each critical thinking indicator were focus (60.4), reason (61.3), inference (61.7), situation (62.8), clarity (59.4), and overview (60.9). These findings indicate that students' critical thinking skills are not yet optimal and require further improvement. This condition is consistent with previous research by Hamdani et al., (2019) which states that low critical thinking ability is caused by learning processes that are still dominated by memorization, thereby affecting students' learning outcomes. Therefore, it is important to apply appropriate learning models that can actively involve students in the learning process. One effort that can be made is by comparing the GENICS and Discovery Learning models, as both models offer different approaches in developing students' critical thinking skills. Previous studies have examined the use of innovative learning models to improve students' critical thinking skills. However, most of these studies focus on the implementation of a single learning model and do not directly compare the effectiveness of different models within the same context. Therefore, research is needed not only to examine

the effectiveness of a learning model but also to compare different models with distinct approaches in order to determine which model is more effective. The GENICS learning model emphasizes the integration of clear learning objectives, active interaction, and self-regulation to promote structured critical thinking. In contrast, Discovery Learning focuses on independent exploration and concept discovery through direct learning experiences (Abdurohman et al., 2024). These two models offer different approaches to developing students' critical thinking skills therefore, it is important to compare their effectiveness in the context of biology learning.

By comparing these two models, educators can understand the advantages and disadvantages of each approach in various learning situations. This helps in choosing the most effective model to achieve a particular educational goal, for example, to support student engagement, improve analytical skills, or solve problems (Masri, 2024). In addition, according to (Asmal, 2023) this comparative analysis can also inspire the development of new learning models that combine the advantages of both approaches. This study is expected to contribute to the field of biology education by providing empirical evidence regarding the comparative effectiveness of the GENICS and Discovery Learning models in improving students' critical thinking skills. This is the basis for the author to use a learning model that is expected to improve critical thinking skills. Based on the facts that have been described above, it is necessary to conduct research entitled "Implementation of the GENICS Learning Model in Differentiated Learning for Critical Thinking Skills"

RESEARCH METHOD

This study used a non-randomized control group pretest–posttest design as part of a quantitative research methodology. Students in the tenth grade at SMAN Titian Teras participated in the study during the 2024–2025 academic year. All tenth-grade students made up the study's population, and a purposive sampling technique based on class characteristics was used to choose the sample. Two classrooms, each with roughly thirty to thirty-five students, made up the sample: an experimental class that used the GENICS learning model and a control class that used the Discovery Learning model.

The research procedure was carried out in several stages. First, a preliminary study was conducted through classroom observations to identify students' initial critical thinking skills and learning conditions. Second, research instruments and learning tools were developed, including teaching modules, student worksheets (LKPD), and essay test instruments. Third, the instruments were validated by two experts, namely a material expert and a media expert, to ensure content validity, construct validity, and language appropriateness. The validity results indicated that the instruments were categorized as valid and suitable for use in the study. The reliability of the essay test instrument was tested using reliability analysis to ensure consistency of the measurement results. The reliability coefficient obtained indicated that the instrument had high reliability and was appropriate for measuring students' critical thinking skills.

The implementation stage began with administering a pretest to both experimental and control classes to measure students' initial critical thinking skills and cognitive learning outcomes. Then, the experimental class was taught using the GENICS learning model, while the control class used the Discovery Learning model. After the learning process was completed, a posttest was administered to measure the improvement in students' critical thinking skills and learning outcomes.

The data analysis was conducted in a chronological sequence. First, descriptive statistical analysis was used to determine the mean and distribution of students' scores. Second, to make sure the data satisfied the requirements for additional analysis, preparatory tests such as homogeneity and normality tests were carried out. Third, the consistency of the learning model's application was assessed using multiple linear regression analysis. After adjusting for starting abilities, the Multivariate Analysis of Covariance (MANCOVA) test was employed to assess if students' critical thinking abilities differed significantly between the experimental and control groups. The proper significance levels were used for all statistical analyses.

RESULTS AND DISCUSSION

Based on the research that has been conducted, it is known that in the syntax consistency test of the leaning model, multiple regression analysis was carried out with parallelism and compression tests, for further explanation, see Table 1.

Table 1. Consistency test of experimental class of GENICS model

	Sum of Squares	df	Mean Square	F	Sig.
Regression	10.021	3	3.340	,598	0.622
Residual	156.523	28	5.590		
Total	166.544	31			

Based on the results of the multiple linear regression analysis, the implementation of the GENICS learning model syntax was carried out consistently during the learning process $F(3,28) = 0.598$, $p = 0.622$, indicating that the stages of the model were applied systematically without elements of coincidence $t = 4.671$, $p < 0.001$. This finding confirms that all components of the GENICS syntax were implemented as intended in the classroom. The consistent implementation of the GENICS model plays an important role in ensuring the effectiveness of the learning process, particularly in supporting the development of students' critical thinking skills. This is evident from the higher improvement in students' critical thinking scores in the experimental class compared to the control class, indicating that a structured and well-organized learning process can better facilitate students in analyzing and evaluating biological concepts.

In line with the theory proposed by Ennis (2015), critical thinking skills can develop optimally when students are actively involved in structured learning activities that require them to focus, reason, and draw conclusions. The GENICS model, which emphasizes clear learning objectives, interaction, and self-regulation, provides a learning environment that supports these processes. Furthermore, this finding is consistent with previous research (Khasinah, 2021), which states that the consistent application of learning models can enhance student engagement and promote higher-order thinking skills. This result is further supported by the pattern of the multiple linear regression lines, which are parallel and do not intersect, indicating the stability of the model implementation throughout the learning process. This stability suggests that the GENICS model can be reliably applied in classroom settings to support the development of students' critical thinking skills. The results of the consistency test of the GENICS learning model syntax using multiple linear regression are presented in Figure 1.

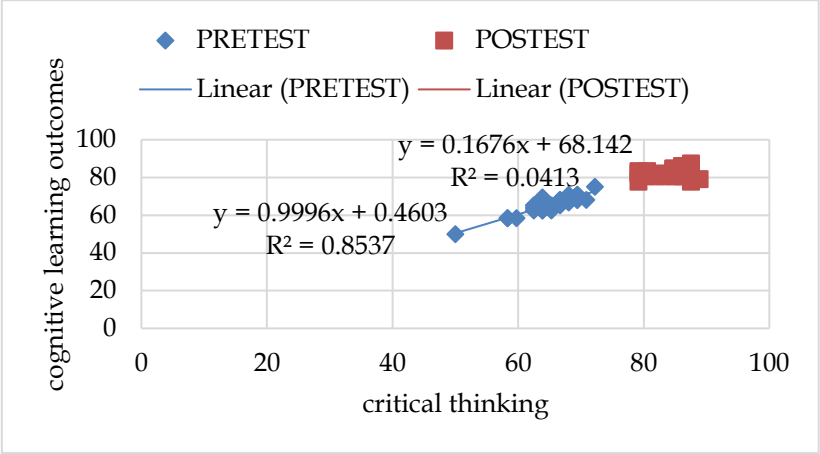

Figure 1. GENICS Model Syntax Execution Graph

Then, a syntactic consistency test was carried out on the learning model in the Discovery learning class, a multiple regression analysis was carried out with a parallelism test and a compression test, for further explanation, see Table 2.

Table 2. Consistency test of the control class of the discovery learning model

	Sum of Squares	df	Mean Square	F	Sig.
Regression	13.404	3	4.468	,998	0.408
Residual	125.315	28	4.476		
Total	138.719	31			

The results of the multiple linear regression analysis indicate that the syntax of the Discovery Learning (DL) model was implemented consistently during the learning process [F(3,28) = 0.998, p = 0.408], suggesting that the stages of the model were applied systematically without elements of chance [t = 7.038, p = 0.001]. This finding confirms that the implementation of the Discovery Learning model followed the intended learning procedures in the classroom. The consistent application of the Discovery Learning model plays an important role in supporting the learning process, particularly in encouraging students to actively explore and construct knowledge independently. However, compared to the GENICS model, the improvement in students' critical thinking skills in the Discovery Learning class was relatively lower, indicating that although this model promotes independent learning, students may require additional guidance to optimize their critical thinking processes.

In line with the theory proposed by Ennis (2015), the development of critical thinking skills requires structured guidance in addition to active engagement, especially in helping students to analyze, evaluate, and draw conclusions effectively. Therefore, while Discovery Learning supports exploration, the lack of structured direction may limit its effectiveness in developing certain aspects of critical thinking skills. This finding is also consistent with previous research (Khasinah, 2021), which suggests that well-structured learning models tend to provide better support for higher-order thinking skill development. This interpretation is further supported by the pattern of the multiple linear regression lines, which appear parallel and do not intersect, indicating the stability of the model implementation during the learning activities. The results of the consistency test of the Discovery Learning model syntax using multiple linear regression are presented in Figure 2.

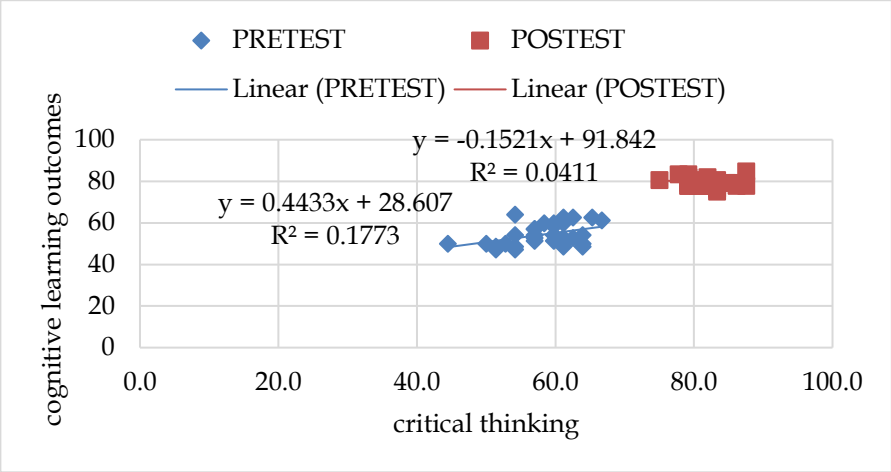

Figure 2. Discovery Learning Model Syntax Implementation Graph

Both learning models showed positive results in terms of the consistency of syntax implementation, indicating that each model was applied according to its designed procedures. The consistent application of learning syntax is important because it can enhance students' motivation, promote active engagement, and support independent learning, thereby creating a more interactive and productive learning environment (Khasinah, 2021).

However, the differences in statistical results between the two models provide deeper insight into how each model functions in the learning process. The GENICS model demonstrated more stable implementation, which was reflected in better improvements in students' critical thinking skills compared to the Discovery Learning model. This suggests that the integration of clear learning objectives, structured stages, and active interaction in the GENICS model enables students to participate more effectively in analyzing and evaluating biological concepts. The collaborative nature of the GENICS model also supports discussion and the exchange of ideas, which are essential components in developing critical thinking skills.

In contrast, the Discovery Learning model emphasizes independent exploration and concept discovery through direct experience (Burais et al., 2023). While this approach encourages student autonomy, the findings of this study indicate that students may require additional guidance to fully benefit from the learning process. Without sufficient direction, some students may experience difficulties in exploring concepts deeply, which can limit the development of their critical thinking skills. This is consistent with the theory proposed by Ennis (2015), which highlights that critical thinking development requires not only active engagement but also structured guidance.

Overall, both the GENICS and Discovery Learning models have the potential to improve students' critical thinking skills, as reflected in the consistency of their implementation. However, the GENICS model appears to provide a more optimal learning structure for supporting these skills. These findings are also supported by previous research (Laeni et al., 2022), which suggests that structured and interactive learning models tend to be more effective in promoting higher-order thinking skills.

Therefore, the results of this syntax consistency analysis are important in understanding how different learning models contribute to student learning outcomes, particularly in the development of critical thinking skills. Further research is needed to explore other factors that may influence the effectiveness of these models and to optimize their

implementation in various learning contexts. A comparison of students' critical thinking scores from pretest to posttest for each learning model is presented in Table 3.

Table 3. Comparison of corrected scores of critical thinking ability

Class	Number of students	Average Pre	Average Post	Corrected	Mean Difference*	Percentage Improvement
GENICS	30	65.0175	84.6784	19.6609	84.918	30.23945476%
DL	30	58.2406	81.6406	23.4000	81.401	40.17814026%

* Corrected by the average of the Critical Thinking pretest = 61.6291

The results of this study indicate a comparison of students' critical thinking skills between the GENICS and Discovery Learning models. Based on the score comparison, the class implementing the GENICS model obtained a higher average posttest score (84.68) compared to the Discovery Learning class (81.64), with a difference of 3.04 points. This finding suggests that although both models contribute to improving students' critical thinking skills, the GENICS model provides a more effective learning approach in facilitating these skills.

The higher improvement in the GENICS model can be explained by its collaborative and structured learning approach, which encourages active student involvement throughout the learning process. As stated by (Mardiyanti & Siburian, 2023) ,the GENICS model provides flexibility for students to choose learning methods according to their preferences, thereby increasing their engagement in learning activities. This active involvement allows students to develop critical analysis and reflection skills more effectively. In addition, during active learning, students are required to utilize higher-order thinking skills to understand concepts, solve problems, and apply knowledge, which directly contributes to the development of critical thinking skills (Kariadi & Suprapto, 2018).

On the other hand, although the Discovery Learning model also showed positive results, the improvement in students' critical thinking skills was relatively lower compared to the GENICS model. This indicates that while Discovery Learning supports independent exploration, students may face challenges in directing their learning process effectively. According to (Sukreni et al., 2024), this model emphasizes independent exploration; however, without sufficient guidance, students may experience difficulties in understanding concepts deeply. This is supported by (Lieung, 2019), who stated that the Discovery Learning model can improve critical thinking skills but requires adequate guidance to maximize learning outcomes.

The comparison of corrected scores further confirms that the GENICS model, with its integrative approach and clear learning objectives, is more effective in creating a learning environment that supports interaction and discussion. Students tend to be more active and engaged, which in turn enhances their critical thinking skills. In contrast, although Discovery Learning provides opportunities for experiential learning, the lack of structured guidance may limit its effectiveness in developing certain aspects of critical thinking. Therefore, this study highlights that learning models combining structure, interaction, and student engagement tend to produce better outcomes in developing critical thinking skills in biology learning. A more detailed comparison of students' critical thinking skills based on each indicator is presented in Table 4.

Table 4. Comparison of critical thinking ability data of students in the experimental class (GENICS Model) and control class (Discovery Learning Model) for each indicator.

Critical Thinking Indicators	Model	Number of students	Syntax Model	Average pretest	Average postest	difference	Percentage increase
Fokus	GENICS	30	*Explorating*	61.9	4.8	22.9	36.9%
	DL	30	*Problem statement*	58.8	81.3	22.5	38.2%
Reason	GENICS	30	*Discussion*	67.2	86.7	19.5	29.1%
	DL	30	*Data collection*	55.5	86.7	31.3	56.3%
Inference	GENICS	30	*Individual Activity*	66.4	83.3	16.9	25.5%
	DL	30	*Data prosessing*	57.0	81.8	24.7	43.4%
Situation	GENICS	30	*Grouping*	64.8	90.1	25.3	39.0%
	DL	30	*Simulasion*	60.7	82.6	21.9	36.1%
Clarity	GENICS	30	*Combining*	64.1	80.5	16.4	25.6%
	DL	30	*Verification*	54.7	86.3	31.6	57.9%
Overview	GENICS	30	*Sharing*	66.6	82.6	16.0	24.0%
	DL	30	*Generalization*	55.2	82.1	26.8	48.6%

The comparison of critical thinking skills between the experimental class implementing the GENICS model and the control class implementing the Discovery Learning model shows meaningful differences across several indicators. Although both models improved students' critical thinking skills, each model demonstrated strengths in different aspects. The GENICS model showed better performance in the Focus and Situation indicators, indicating that structured learning stages and collaborative activities support students in identifying problems and relating concepts to real contexts. In contrast, the Discovery Learning model performed better in the Reason, Inference, and Clarity indicators, suggesting that independent exploration encourages students to construct arguments, draw conclusions, and articulate their understanding more clearly.

These findings indicate that different learning approaches influence how specific components of critical thinking skills are developed. The structured syntax in the GENICS model provides clear guidance, enabling students to systematically analyze problems and engage in meaningful discussions. This is particularly evident in the Situation indicator, where group-based activities help students connect theoretical knowledge with contextual applications. On the other hand, the Discovery Learning model emphasizes student autonomy, allowing learners to explore concepts independently. This approach is beneficial for developing reasoning and inference skills, as students are required to gather and interpret data on their own (Sartono, 2019).

However, the findings also suggest that the lack of structured guidance in Discovery Learning may limit its effectiveness in certain aspects, particularly in helping students build a comprehensive understanding of the material. This is reflected in the Overview indicator, where students may struggle to integrate information holistically. Similarly, although the GENICS model provides strong guidance, it may offer fewer opportunities for independent exploration, which could influence the development of certain analytical skills. Therefore, the

differences in outcomes between the two models highlight the importance of balancing structure and autonomy in the learning process (Asmal, 2023).

These results are supported by previous studies, which indicate that critical thinking skills are influenced by the suitability of the learning model and the level of student engagement during the learning process (Avivi et al., 2023). In addition, external factors such as student participation, attention during learning, and the availability of learning resources may also contribute to differences in critical thinking performance between groups. Students with higher engagement and better learning support tend to show stronger critical thinking abilities.

From an educational perspective, low critical thinking skills can hinder students in solving complex problems and adapting to real-world challenges, whereas higher critical thinking skills enable students to analyze information and make appropriate decisions (Ulfa et al., 2023). Therefore, the selection of appropriate learning models becomes crucial in supporting the development of these skills.

Furthermore, the results of the hypothesis testing indicate that there is a significant difference in students' critical thinking skills and cognitive learning outcomes between those taught using the GENICS model and those taught using the Discovery Learning model, after controlling for initial abilities [$F(1,60) = 11.254$, $p = 0.001$, $\eta p^2 = 0.158$]. The effect size indicates a moderate to strong influence, suggesting that the choice of learning model has a meaningful impact on students' learning outcomes.

Overall, these findings suggest that both GENICS and Discovery Learning models have their respective strengths in developing critical thinking skills. However, the GENICS model appears to provide a more balanced approach by combining structured guidance and interaction. Therefore, integrating elements of both models or adapting their implementation may offer a more effective strategy for enhancing students' critical thinking skills in biology learning. A more detailed comparison of these results is presented in Table 5.

Table 5. Hypothesis test results

Dependent Variable			Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Postest	Critical thinking	Contrast	87.699	1	87.699	11.254	<,001	,158
		Error	467.556	60	7.793			

The significant improvement observed in this study indicates that students' critical thinking skills can be enhanced through the implementation of both the GENICS and Discovery Learning models. This finding suggests that the use of appropriate learning strategies plays an important role in facilitating the development of higher-order thinking skills. The improvement in students' performance reflects how learning activities that actively involve students can support their ability to analyze, evaluate, and draw conclusions effectively.

However, the results also show that the GENICS model provides more optimal outcomes compared to the Discovery Learning model. This can be attributed to its structured and guided learning approach, which helps students engage more effectively in the learning process. In contrast, although Discovery Learning encourages independent exploration, students may require additional guidance to fully develop their critical thinking skills. This finding is consistent with previous research (Alqorana et al., 2025), which emphasizes that

structured learning strategies tend to produce better learning outcomes in developing students' analytical abilities.

Overall, this study highlights that structured and interactive learning approaches are more effective in improving students' critical thinking skills compared to less structured approaches. In addition, this study provides new insights by directly comparing two different learning models within the same learning context, which is still limited in previous studies. Therefore, the GENICS model can be considered a more effective alternative in biology learning to enhance students' analytical and critical thinking abilities. These findings also strengthen the importance of selecting appropriate learning models to support the development of higher-order thinking skills in biology education.

CONCLUSION

This study shows that both learning models, genics and discovery learning, have a significant impact on students' critical thinking skills. The genics model, which emphasizes a collaborative approach and integration of clear objectives, is proven to be effective in improving students' critical thinking skills. The average post-test scores of students using the genics model were higher than those using discovery learning, although both models showed significant improvements. On the other hand, although the discovery learning model is also effective in improving critical thinking skills, this study revealed that students need more guidance to optimize the process of exploration and discovery of concepts. The differences in approach between the two models provide valuable insights for educators in choosing the appropriate model to improve student engagement and learning outcomes. Therefore, this study recommends the use of the genics model as a superior choice in developing students' critical thinking skills, while still considering the combination of elements from both models to achieve more optimal results**.**

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