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The Effects of Full versus Partial Differentiated Learning on Students' Science Understanding Based on Critical Thinking Skills

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Abstract

This study aims to analyze the differences in the effect of full and partial differentiation learning on students' science understanding, variations based on critical thinking skills, and the interaction effect between differentiation strategies and critical thinking levels. A quasi-experimental method with a 2x3 factorial design was applied to eleventh-grade students at SMAN 1 Karanganyar studying heat transfer. Samples were selected using cluster random sampling, assigning class XI F5 as experimental group 1 (full differentiation) and class XI F6 as experimental group 2 (partial differentiation). Both groups utilized a flipped classroom framework via Google Sites. Data collected from validated tests were analyzed using Two-Way ANOVA via SPSS 27. The results revealed a significant difference in science understanding based on the differentiation model (a Sig. value of <0.001 (sig.<0.05)) where full differentiation outperformed partial differentiation (mean: 90.33 vs 74.33). Significant differences were also found across critical thinking levels (a Sig. value of < 0.001 (sig.<0.05)). However, no significant interaction effect was found between the learning models and critical thinking levels (a Sig. value of>0.407 (sig.>0.05)) indicating full differentiation consistently yields better results across all levels.

Keywords: critical thinking, differentiation learning, flipped classroom, google sites, science understanding

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Introduction

21st-century education demands a transformation in the learning process, particularly in the fields of science and physics. Students are no longer expected to merely memorize mathematical equations; rather, they are required to possess a deep understanding of science and high critical thinking skills to solve contextual problems in daily life. In reality, physics concepts are often considered abstract and difficult for students to comprehend, one of which is heat transfer. Ranging from conduction, convection, to radiation, each heat transfer mechanism exhibits diverse characteristics in everyday life.

The low level of conceptual understanding regarding this topic is frequently caused by conventional, teacher-centered learning processes, which fail to accommodate the diverse learning paces and critical thinking skills of students (Tubagus et al., 2024). This uniform learning approach fails to facilitate the classroom reality where each student possesses different levels of learning readiness, comprehension speed, learning styles, and interests. When educators treat all students with the same method and pace (a one-size-fits-all approach), students with high critical thinking skills will feel unchallenged, while those with slower learning paces will fall further behind in understanding heat transfer concepts.

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One alternative solution to bridge the gap caused by these diverse student characteristics is the implementation of differentiated learning. Differentiated learning is a systematic approach that accommodates students' varying learning needs, interests, and learning profiles. In its implementation, this strategy can be applied through full differentiation, which integrates content, process, and product differentiation simultaneously, or partial differentiation, which only emphasizes one or two components (Kurniawan S Setiawan, 2022; Putri S Sugiarto, 2022). Although differentiated learning is considered effective, its classroom execution is often constrained by limited face-to-face time (Handayani S Purnomo, 2023). Therefore, an innovative learning model capable of optimizing time efficiency is required, one of which is through the flipped classroom model. This model reverses the traditional learning cycle by moving direct instruction outside the classroom through self-directed activities, thereby optimizing in-class time for in-depth discussion, collaboration, and problem-solving (Lestari S Fitriani, 2021; Yusuf, 2025).

Independent learning within a flipped classroom requires integrated and easily accessible digital technology. The use of Google Sites as a web-based learning medium presents instructional content in a structured, flexible, and accessible manner (Abdurrahman S Herlina, 2020; Sari S Utami, 2023). This supports student autonomy in a flipped classroom environment, as it allows them to study the material independently prior to face-to-face sessions at school (Pratama S Wijaya, 2023). Aside from instructional strategy factors, internal student characteristics such as critical thinking skills are also strongly presumed to influence their level of science understanding. Physics problem-solving skills are closely linked to students' critical thinking abilities (Nugraha S Saputra, 2024; Zahroh S Parno, 2018). Students with high critical thinking skills tend to be more independent and capable of exploring differentiated content effectively compared to those with moderate or low critical thinking levels (Ramadhani, 2024; Wafa et al., 2025).

Prior studies have extensively examined the effectiveness of differentiated learning and the flipped classroom model separately. However, research that specifically compares the effectiveness of full differentiation versus partial differentiation within a flipped classroom framework utilizing Google Sites on heat transfer topics remains highly limited. Based on these conditions, this study aims to analyze: (1) the differences in the effect between full differentiation and partial differentiation learning on students' science understanding; (2) the variations in science understanding based on students' critical thinking skill levels (high, medium, and low); and (3) the interaction effect between differentiation strategies and critical thinking skills on students' science understanding.

Methods

This study employed a quasi-experimental research method with a quantitative approach applying a 2x3 factorial design. The research population involved all eleventh-grade students at SMAN 1 Karanganyar in the 2026 academic year. The sampling technique used was cluster random sampling to determine two parallel experimental classes without disrupting the existing classroom structures (Fraenkel et al., 2019). Based on this technique, class XI F5 (30 students) was selected as

experimental group 1, which implemented full differentiated learning, while class XI F6 (30 students) was selected as experimental group 2, which implemented partial differentiated learning. Both experimental classes operated within a flipped classroom framework aided by Google Sites media on heat transfer material

The variables in this study consisted of three types, namely: (1) the independent variable in the form of the type of differentiated learning consisting of two levels (full differentiation and partial differentiation); (2) the dependent variable in the form of students' science understanding; and (3) the moderator variable in the form of students' critical thinking skill levels, which were classified into three categories: high, medium, and low. The classification of critical thinking skill levels was calculated based on critical thinking test scores with reference to the group division according to Azwar (2021).

The research data were collected using two types of test instruments that had been validated by experts (expert judgment) and tested for their reliability. The first instrument was a critical thinking skill test consisting of multiple-choice questions arranged based on Ennis's critical thinking indicators. The second instrument was a science understanding test in the form of reasoned multiple-choice questions developed based on indicators of students' science understanding. The data collection process was carried out by administering a pre-test prior to the treatment to determine initial capabilities, and a post-test at the end of the learning period to measure students' science understanding achievement.

Before conducting hypothesis testing, the post-test data of science understanding were first subjected to prerequisite tests. The normality test was performed using the Lilliefors method, while the homogeneity of variance test between groups was conducted using Levene's test (Sugiyono, 2019). After all prerequisite tests were met and the data were declared normally distributed and homogeneous, data analysis was carried out quantitatively using inferential statistics, specifically the Two-Way ANOVA with Unequal Cell Sizes (Sel Tak Sama). This statistical analysis was calculated using IBM SPSS Statistics 27 software at a significance level of α=0,05.

Results and Discussion

This study presents the data of students' science understanding post-test scores after receiving treatment through the flipped classroom model aided by Google Sites. The treatment was distinguished into two strategies, namely full differentiation in class XI F5 and partial differentiation in class XI F6. Prior to hypothesis testing using Two-Way ANOVA, all data were declared to have passed the analysis prerequisite tests, including the distribution normality test and the homogeneity of variance test between groups. The summary of the statistical hypothesis testing results using the Two-Way ANOVA test assisted by SPSS 27 software is presented in detail in Table 1.

Source	Sum of Squares	df	Mean Square	F	Sig.
Learning Model (A)	2347.834	1	2347.834	102.062	< .001
Critical Thinking (B)	2952.050	2	1476.025	64.164	< .001
Inter-action (A*B)	42.067	2	21.034	0.914	0.407
Error	1242.221	54	23.004		

Total	416200.000	60
Corrected Total	7825.000	59

Source: IBS SPSS 27

Based on the statistical analysis in Table 1, the F-value for the learning model variable is 102.062 with a significance value of <0,001 (sig.<0.05). This result indicates that the null hypothesis (H_0) is rejected, meaning that there is a highly significant difference in the effect between the implementation of full and partial differentiated learning models on students' science understanding. Empirically, experimental group 1, taught using full differentiation, demonstrated superior science understanding achievement with a mean score of 90.33, while experimental group 2, with partial differentiation, obtained a mean score of 74.33.

The superiority of full differentiation occurs because the simultaneous integration of content, process, and product differentiation components is capable of comprehensively accommodating the diverse learning needs of students regarding heat transfer material. Through the Google Sites platform, students are not only given the freedom to choose the format of supporting materials (infographics, physics simulations, or videos) but are also encouraged to produce independent laboratory reports that align with their interests. In line with the findings of Yusuf (2025), the efficiency of delivering material outside of face-to-face hours via the flipped classroom model provides a rich collaborative space inside the classroom, allowing the understanding of macroscopic and microscopic concepts of conduction, convection, and radiation to be thoroughly constructed.

Furthermore, the Two-Way ANOVA test results for the critical thinking skill variable show an F-value of 64.164 with a significance level of <0,001 (sig.<0.05). This proves that the null hypothesis (H_0) is rejected, meaning that there is a significant difference in the level of science understanding among students who possess high, medium, and low categories of critical thinking skills. Individuals with high critical thinking characteristics tend to be more systematic and independent in exploring the Google Sites digital ecosystem during the independent learning phase outside the classroom. This finding reinforces the research by Wafa et al. (2025), which states that students' internal cognitive and critical thinking levels play a crucial role as key predictors in determining the success rate of mastering complex physical concepts.

Although both main variables show significant independent effects, the interaction effect test results between the learning model and critical thinking skills yield an F-value of 0.914 with a significance value of 0.407 (sig.>0.05). Since the significance value is greater than 0.05, the null hypothesis (H_0) is accepted. This indicates that there is no significant interaction effect between differentiated learning strategies and students' critical thinking skill levels in influencing their science understanding. The absence of this interaction implies that the full differentiated learning model is consistently proven to provide a better impact on students' science understanding compared to partial differentiation, across high, medium, and low critical thinking groups alike. The lack of interaction confirms that the flexibility offered by full differentiation within a flipped classroom framework is inclusive of the entire spectrum of student abilities.

Students with low critical thinking skills are still supported by content adaptability and scaffolding in the full differentiated learning process, while high-ability students continue to receive proportional enrichment challenges. Therefore, the effectiveness and superiority of full differentiation over partial differentiation apply universally, without depending on the high or low initial critical thinking modalities possessed by the students.

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Conclusion

Based on the results of data analysis and discussion, it can be concluded that the implementation of the flipped classroom model aided by Google Sites is proven effective in improving students' science understanding of heat transfer material. Specifically, this study yields three main conclusions: (1) there is a significant difference in the effect between differentiated learning strategies, where the implementation of full differentiation consistently provides a superior impact on enhancing students' science understanding compared to partial differentiation; (2) there is a significant difference in science understanding based on students' critical thinking skill levels, where the group of students with high critical thinking skills demonstrates the most optimal science understanding achievement; and (3) there is no significant interaction effect between differentiated learning strategies (full vs. partial) and critical thinking skill levels (high, medium, low) on students' science understanding. The absence of this interaction confirms that the superiority of the full differentiated learning model applies universally and inclusively across all levels of students' critical thinking skills.

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