

A Comparative Analysis of Discovery Learning, Video-Based Learning, and Direct Instruction Models on The Science Learning Outcomes in the Topic of Food Additives

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Abstract

This study aims to analyze the differences in the effectiveness of the Discovery Learning, Video-Based Learning, and Direct Instruction models on students' cognitive learning outcomes in food additives material. The research approach used a quantitative approach with a posttest-only control group design involving three eighth-grade classes at SMPN 27 Bandung as research subjects selected by purposive sampling. Data were collected through a validated learning outcome test instrument and then analyzed using the Kruskal–Wallis nonparametric test and the Mann–Whitney follow-up test because the normality assumption was not met. The results showed that the highest median learning outcome score was obtained in the Discovery Learning model (90.00), followed by Video-Based Learning (80.00) and Direct Instruction (70.00). The Kruskal–Wallis test showed a significance value of 0.029 ($p < 0.05$), indicating a significant difference in learning outcomes between the three learning models. Specifically, the follow-up test showed that the Discovery Learning model had a significantly different impact compared to Direct Instruction, while the Video-Based Learning model had a different impact compared to Direct Instruction. These findings confirm that knowledge construction through independent discovery activities is more effective in improving science concept understanding. Teachers are advised to integrate exploratory learning to minimize the gap in student learning outcomes.

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Introduction

Science education plays an important role in shaping students' scientific, critical, and creative thinking skills in relation to natural phenomena and their application in everyday life. One relevant SSC topic is Food Additives, which requires students to understand the types, functions, and health impacts of these substances. Studying food additives is important because they are widely used in food products to enhance taste, color, aroma, and shelf life. Literature on community service and health studies indicates the need for education related to additives and the selection of healthier snacks for students (Muzakir et al., 2023), while field studies on food products in circulation also confirm that additives are found in foods on the market, so the public needs to understand the safety of consumption (Rorong & Wilar, 2019). Through science learning, students are expected to be able to understand basic scientific concepts and apply them to solve problems in life (Putri et al., 2017).

However, empirical facts in the field indicate that the implementation of science learning is still dominated by the use of conventional teacher-centered models (teacher-centered). Teachers face obstacles related to understanding and skills in applying creative and innovative learning methods and utilizing available teaching materials and resources (Wijayanti & Tirtoni, 2023), resulting in students becoming passive, easily bored, and lacking understanding of the concepts (Bilqis et al., 2016).

Developments in educational technology offer various learning models to overcome this. The Discovery Learning model has been recognized as a powerful model based on constructivist theory influenced by Piaget and Vygotsky's theory that students are not just recipients of information but are responsible for constructing their knowledge and experiences (Lestari et al., 2024). In addition, the integration of media in the form of Video-Based Learning is also increasingly being used, which is considered effective in visualizing abstract concepts that are difficult to explain, thereby reducing students' cognitive load. (Richard E. Mayer, 2020). The Direct Instruction model is still widely used in learning practices, especially for delivering procedural and factual material (Kardi & Nur, 2005 in Panjaitan, 2016; Suryadi, 2022). This model is still considered effective for deductive information delivery, although it is often criticized for not encouraging student independence (Thanavathi, 2022).

A number of previous studies have examined these models partially. Discovery Learning is effective in improving students' critical thinking skills (Muhamad Akrom et al., 2023), the use of YouTube-based video media can increase student learning motivation (Hendar et al., 2022), and improve critical thinking skills through a combination of problem-based learning (Rizqi et al., 2023). Other studies still compare innovative and conventional learning models, and there are still few studies that conduct a three-way comparative analysis to examine the active discovery model

(Discovery Learning), Video-Based Learning as an interactive media-based model, and the direct instruction model.

Based on this background, this study aims to examine the differences in effectiveness between the three models, namely Discovery Learning, Video-Based Learning, and Direct Instruction. The research questions used in this study are (1) Are there significant differences in science learning outcomes between students who use the Discovery Learning, Video-Based Learning, and Direct Instruction models? (2) Which of the three models contributes the most to students' cognitive learning outcomes on the subject of food additives? This study is expected to provide findings that serve as empirical references for education practitioners, especially science teachers, in designing more effective and meaningful instructional designs.

Method

This study used a quantitative associative design with a survey approach to examine the relationships between work discipline, work stress, job satisfaction, and educator performance in a special needs school context. This approach is suitable for testing causal relationships among variables through statistical analysis (Sugiyono, 2019). The study population consisted of all teachers at Talenta Center Special Needs Schools. A total of 134 teachers were selected as respondents using purposive sampling, with criteria including active teaching status, a minimum of one year of teaching experience, and direct involvement in instructional planning and classroom activities. This ensured that participants had sufficient professional experience to provide valid responses. Data were collected using a structured questionnaire adapted from previous studies and relevant theories, adjusted to the context of special needs education. The instrument consisted of 48 items measured on a five-point Likert scale, covering work discipline (10 items), work stress (12 items), job satisfaction (13 items), and educator performance (13 items). Validity testing using Corrected Item–Total Correlation showed that all items met the minimum criterion ($r \geq 0.30$). Reliability analysis using Cronbach's alpha indicated strong internal consistency, with coefficients of 0.83 for work discipline, 0.86 for work stress, 0.88 for job satisfaction, and 0.91 for educator performance. Data analysis was conducted using multiple linear regression to examine the partial and simultaneous effects of the independent variables on educator performance. Prior to hypothesis testing, assumption tests for normality, multicollinearity, and homoscedasticity were performed, and all results met the required criteria. Statistical analysis was carried out using SPSS software to ensure accuracy and objectivity.

Results and Discussion

Results

The learning outcomes in the form of students' posttest scores between the Discovery Learning, Video-Based Learning, and Direct Instruction models are

presented in Table 1 regarding student learning outcome data.

Table 1. Student Learning Outcomes

Sample	DCL	VBL	DI	Sample	DCL	VBL	DI
<i>s1</i>	100	80	60	<i>s16</i>	90	60	90
<i>s2</i>	90	70	70	<i>s17</i>	60	70	60
<i>s3</i>	90	90	100	<i>s18</i>	60	90	80
<i>s4</i>	90	90	70	<i>s19</i>	100	70	90
<i>s5</i>	80	50	60	<i>s20</i>	70	100	50
<i>s6</i>	80	70	90	<i>s21</i>	90	90	60
<i>s7</i>	100	60	70	<i>s22</i>	100	90	90
<i>s8</i>	100	70	60	<i>s23</i>	90	80	70
<i>s9</i>	80	90	90	<i>s24</i>	100	80	50
<i>s10</i>	50	70	90	<i>s25</i>	90	90	90
<i>s11</i>	70	50	70	<i>s26</i>	80	80	70
<i>s12</i>	90	100	50	<i>s27</i>	80	70	80
<i>s13</i>	70	80	80	<i>s28</i>	80	77	70
<i>s14</i>	80	80	80	<i>s29</i>	90		74
<i>s15</i>	80	70	90				

Student learning data, as shown in Table 2, was first processed using prerequisite tests, namely data normality and homogeneity tests.

Table 2. Normality Test Outcomes

	Kolmogorov-Smirnova			Shapiro Wilk		
	Statistik	df	Sig.	Statistik	df	Sig.
Model Discovery Learning	0.220	29	0.002	0,864	29	0.002
Model Video Based Learning	0.151	28	0.100	0,936	28	0.090
Model Direct Instruction	0.175	29	0.023	0,923	29	0.036

The data from the normality test using the Shapiro-Wilk method presented in Table 1 shows that the video-based learning model group obtained a significance value of 0.09 ($p > 0.05$), indicating that the data is normally distributed. In contrast, the results for the Discovery Learning model group had a significance value of 0.002, and the Direct Instruction group had a value of 0.036, which are both below 0.05, indicating that the data for these two groups are not normally distributed. Given that the normality assumption is not met in all treatment groups, the comparative analysis for hypothesis testing cannot be performed using parametric statistics but must instead use nonparametric statistics (Ghozali & H. Imam, 2018).

Table 3. Homogeneity Test Outcomes

	Levene Statistic	df1	df2	Sig.
Based on Mean	0,285	2	81	0,753
Based on Median	0,219	2	81	0,804
Based on Median and with adjusted df	0,219	2	80.122	0,804
Based on trimmed mean	0,299	2	81	0,742

Based on the results of the homogeneity of variance test as presented in Table 3, a significance value based on the mean was obtained, namely 0.753 ($p > 0.05$), which indicates that the variance of the cognitive learning outcomes data of the students from the three groups is the same or homogeneous. (Sianturi, 2022). Although the data is homogeneous, the normality assumption was not met in all groups, so hypothesis testing was performed using nonparametric analysis, namely the Kruskal-Wallis H test (Field, 2018). This test was used to determine whether there were significant differences in students' cognitive learning outcomes between the groups that applied the Discovery Learning, Video-Based Learning, and Direct Instruction models.

Table 4. Nonparametric Test Results

	MDLP-PBM	N	Mean Rank
SKOR-HB	Discovery Learning Model	29	52,98
	Video Based Learning Model	28	41,05
	Direct Instruction Model	29	36,38
	Total	86	

Based on the results of the analysis using the Kruskal-Wallis test, as shown in Table 4, there was a significant difference in the mean rank between the three learning models. The Discovery Learning group obtained the highest mean rank compared to the other treatment groups. Conversely, the lowest mean rank was found in the Direct Instruction group. This indicates that active student involvement in independent concept discovery contributes more to learning outcomes than one-way information delivery (Hosnan, 2014). The dominance of mean rank in the application of the Discovery Learning model is in line with constructivist theory, which states that knowledge acquired through discovery activities tends to be more lasting and meaningful in students' memories. (Ulya, 2024)

Table 5. Kruskal-Wallis Nonparametric Test Results

Learning Outcome Scores	
Kruskal-Wallis H	7.112
df	2
Asymp. Sig.	0.029

Based on the results of the Kruskal-Wallis statistical test as shown in Table 5, a significance value (Asymp. Sig) of 0.029 ($p < 0.05$) was obtained, so the null hypothesis (H_0) was rejected and the alternative hypothesis (H_1) was accepted. These results indicate that there are statistically significant differences in cognitive learning outcomes among groups of students who use the Direct Instruction, Video-Based Learning, and Discovery Learning models for learning about food additives. This shows that the learning model variable has a different impact on students' level of understanding and mastery of concepts, so a post-hoc test needs to be conducted to identify the group of students with the most striking score differences based on the learning model applied. (Ghozali & H. Imam, 2018)

Table 6. Mann-Whitney Significance Results

No.	Method	Significance Value	Significance Value
1	Discovery Learning	Video based Learning	0,055
		Direct Instruction	0,012
2	Video based Learning	Discovery Learning	0,055
		Direct Instruction	0,424
		Discovery Learning	0,012
3	Direct Instruction	Learning	
		Video based Learning	0,424

Based on Table 6, which presents the results of the post-hoc test using the Mann-Whitney U Test to identify the significance of differences between treatment groups, it was found that significant differences in learning outcomes were only found in the comparison between the Discovery Learning Model and Direct Instruction ($p < 0.05$). Meanwhile, the Video-Based Learning model did not show any statistically significant differences ($p > 0.05$). These findings indicate that the Discovery Learning model has the most proven effectiveness in improving students' cognitive learning outcomes in food additive material compared to the Direct Instruction method (Pallant, 2020). The absence of significant differences in the group of students who used Video-Based Learning was likely due to the role of audio-visual media as a visual supplement, whereas Discovery Learning involved a more in-depth cognitive process through the stages of independent knowledge reconstruction. (Belay, 2022). Based on the results of posttest data processing from the three groups, a general picture of the average learning outcomes of students was obtained, as presented in Table 7.

Table 7. Descriptive Analysis

Statistik	Discovery Learning	Video Based Learning	Direct Instruction
Sample Size (N)	29	28	29
Mean Score	86,56	77,39	74,28
Minimum Score	60	50	50
Maximum Score	100	100	100
Variance	168.795	174.766	203,064
Standar Deviation	12.992	13.220	14,25

Median value analysis was conducted as a more representative indicator of data in nonparametric statistics when the data was not normally distributed. Based on Table 7, it can be seen that there was a significant difference in the mean achievement scores of students, namely the mean in the Discovery Learning model, which was 90, followed by Video-Based Learning with a mean of 80, and Direct Instruction with the lowest mean of 70. The high median value in the group of students who used the Discovery Learning model shows that half of the students in that group have achieved excellent mastery of the concept of food additive substances (Ghozali, 2018). The use of the median value in the Kruskal-Wallis test has provided a more accurate picture of the relative position of these groups in a population with an asymmetric data distribution.

**Figure 2.** Learning Process Using the Discovery Learning Model

Thus, pedagogically, the high median value in the Discovery Learning model reflects the success of the process of independent knowledge construction by students and shows that this model is able to encourage the majority of students to exceed the minimum competency threshold with satisfactory results. This indicates that learning

that actively involves students through discovery activities and places students at the center of the cognitive process can give students a deeper understanding. (Sugrah, 2020). Thus, learning with the discovery learning model is able to facilitate various levels of student abilities more effectively so that it can reduce the gap in students' cognitive learning outcomes in the classroom. (Slavin, 2025)

The implementation of learning procedures in each experimental and control group was documented to provide a visual overview of the activities carried out by students during the study, which are presented sequentially in Figures 2, 3, and 4.



Figure 3. Learning Process Using the Video-Based Learning Model



Figure 4. Learning Process Using the Direct Instruction Model

Discussion

The Discovery Learning model can be said to be more effective in improving students' cognitive learning outcomes on food additive material compared to other learning models, namely Video-Based Learning and Direct Instruction. This learning model provides students with ample opportunity to observe and analyze food additives encountered in everyday life in depth, in line with the principles of constructivist learning theory. This process triggers a greater response of curiosity from students so that the understanding of abstract science concepts can become more concrete and meaningful. The principle of meaningful learning is in line with the objectives of the national curriculum through a deep learning approach that emphasizes a comprehensive, contextual, and relevant learning experience for students (Rosiyati et al., 2025). Students are able to actively explore by integrating chemistry concepts into their daily food consumption, thereby forming a more substantial understanding that is stored in their memory compared to the Direct Instruction model, which tends to result in temporary rote learning. This is in line with the results of research (Mawardi & Mariati, 2016) which shows that Discovery Learning can significantly improve conceptual understanding and science learning outcomes compared to conventional methods. Similar research by Putri et al. (2017) also concluded that Discovery Learning can improve learning activities and outcomes because students are actively involved in the process of discovering concepts through observation and discussion.

Science learning from a constructivist perspective provides students with scientific knowledge in such a way that they not only understand scientific concepts and principles but also the significance of science learning in constructing internal illustrations of knowledge through the interpretation of personal experiences (Sugrah, 2020), which is in line with Jean Piaget's view of cognitive adaptation through the processes of assimilation and accommodation. When students discover a new fact about food additives that contradicts their prior knowledge, a cognitive imbalance occurs, which encourages them to seek equilibrium or a new, more stable understanding (Slavin, 2025).

This is different from the use of the Video-Based Learning model, which provides a learning experience with visual dimensions that help students abstract chemical concepts in additives that are difficult to observe directly, making explanations simpler and more interesting. However, its effectiveness, which tends to be lower than Discovery Learning, shows the need for more intensive inquiry activities to transform visual understanding into the cognitive domain of students. The success of multimedia-based learning is highly dependent on students' ability to integrate visual information into their cognitive schemas, rather than simply receiving passive information (Richard E. Mayer, 2020). The development of more specific interactive content and teachers' ability to integrate technology in the creation of interactive media are among the

practical implications for increasing student participation. (Hasnawiyah & Maslena, 2024)

The highest learning gap is found in the application of the Direct Instruction learning model, which places students as static recipients of information, resulting in lower retention of students' understanding of concepts. Theoretically, this model has limitations in terms of space for students to explore ideas independently, and learning motivation tends to be extrinsic. Direct Instruction learning can be effective for factual material, but it is less optimal in fostering conceptual understanding that requires reasoning and active student involvement (Suryadi, 2022). Teacher-centered strategies are more effective for introducing basic knowledge, while student-centered methods are effective for encouraging deeper understanding, strengthening motivation, and enhancing students' metacognition (Mahliyo Kukiboyeva, 2025).

The results of this study enrich previous findings by presenting a comparison of three learning approaches (Discovery Learning, Video-Based Learning, and Direct Instruction) in the same context, namely food additives. This material requires students not only to understand the terms and types of additives but also to be able to relate them to real examples in packaged foods/snacks and consider their impact on health, as emphasized in the literature on additive education and healthy snacks for students (Muzakir et al., 2023) and studies on the presence of additives in food products on the market (Rorong & Wilar, 2019). Thus, the findings of this study confirm that learning that provides space for exploration and discovery of concepts is more suitable for building meaningful understanding on the topic of additives, while also suggesting that the use of videos will be more optimal when accompanied by active cognitive activities (e.g., label analysis, classification of additives, provoking questions, formative quizzes, and case discussions), so that videos function as triggers for reasoning, not merely as presenters of information.

In implication, the comparison of these three models confirms that for contextual material related to health and the environment, such as food additives, a learning strategy is needed that encourages students to think critically and discover facts actively and independently. Although video media has advantages in terms of attractive visualization, it will be more effective if audiovisual elements are combined in the Discovery Learning syntax, which will be one of the stronger alternative strategies for teachers in their efforts to optimize student learning outcomes in science subjects in general.

Conclusion

The transformation of students' roles to become active and independent in the process of discovering knowledge has a significant impact on their mastery of science concepts. The Discovery Learning model has proven to be the most effective strategy in creating meaningful learning experiences compared to Video-Based Learning and

Direct Instruction. Students are able to reconstruct a deeper and more stable understanding. This model is able to facilitate diversity in student abilities so that academic gaps in the classroom can be minimized effectively. Although this study has shown empirical evidence regarding the learning model, there are limitations that need to be considered in interpreting the results, including the limited scope of the study to one school with specific material on food additives, so that the results of this study cannot be fully generalized. Furthermore, the effectiveness of Video-Based Learning is highly dependent on the quality of visual content and the readiness of facilities at the school, so that technical obstacles that arise during the research intervention have the potential to affect the focus and attention of students. Based on these limitations, further research is expected to expand the scope of the subject and integrate other variables, including critical thinking skills and science literacy, to obtain a more comprehensive picture of the impact of the Discovery Learning model on improving student competence. More interactive video content can be developed to address the weaknesses of the Video-Based Learning model so that it can compete with the active discovery model in increasing students' mental engagement, accompanied by exploratory and collaborative worksheets.

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Authors' Note

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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