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THE EFFECT OF THE DIRECT INSTRUCTION LEARNING MODEL ASSISTED BY INTERACTIVE LEARNING VIDEOS ON CONCEPT UNDERSTANDING AND INDEPENDENCE IN LEARNING MATHEMATICS

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Abstract

Conceptual understanding and learning independence are two important aspects of mathematics education that still need to be improved. This study aims to examine the effect of the Direct Instruction learning model assisted by interactive learning videos on students' understanding of concepts and mathematical learning independence. The research uses a quantitative approach with a quasi-experimental method and a Pretest-Posttest Control Group Design. The research sample consists of an experimental class with 36 students and a control class with 36 students from the XI grade at SMA Negeri 1 Binjai. Data were collected through concept understanding tests and learning independence questionnaires that met valid and reliable criteria. Data analysis was conducted using Multivariate Analysis of Covariance (MANCOVA) with the help of IBM SPSS Statistics. The results indicate that the learning model significantly affects on mathematical concept understanding ($F = 111.114$; $p < 0.001$) and mathematical learning independence ($F = 71.052$; $p < 0.001$). Additionally, the learning model also has a significant simultaneous effect on both variables (Pillai's Trace = 0.628; $F = 56.544$; $p < 0.001$).
Keywords: Direct instruction, interactive learning videos, concept understanding, learning independence.

INTRODUCTION

Mathematics has become one of the disciplines that significantly support the advancement of science and the resolution of various life problems. This is reflected in the status of mathematics as a subject taught during every educational level, beginning with elementary school to higher education.(Anzani et al., 2024) The effectiveness of the learning process that teachers create has a direct impact on students' comprehension of the subject matter and achievement of learning objectives. (Herlina et al., 2022). In other words, the quality of learning provided by educators is the main factor in enhancing students' understanding of mathematics in a sustainable and meaningful way during the learning process.

High school mathematics education also faces challenges, as reflected in the results of the TIMSS international assessment, which show that Indonesian students' achievement in mathematics has been low across several assessment cycles. This situation indicates that students' ability to understand, analyze, and apply mathematical concepts in various contexts (Siregar, 2023). The findings indicate that in mathematics learning, students have not yet developed optimally. The lack of optimal development in mathematics learning indicates fundamental problems in the mathematics education process, regarding conceptual understanding.

The Programme for International Student Assessment (OECD, 2022) results demonstrate that Indonesian students' arithmetic proficiency is still below the OECD average. The OECD average was 470, whereas Indonesia's math score was just 366. There is an urgent need to improve the quality of learning, especially in terms of conceptual comprehension, as this situation shows that pupils are still having difficulty comprehending, reasoning through, and

applying mathematical concepts.According to the (OECD, 2023) Interviews with public high school math professors in the eleventh grade suggest that pupils' conceptual comprehension is still lacking. Many kids are still unable to summarize what they have learnt in their own words, according to the teachers. Without comprehending the logic behind each stage of the solution, students frequently imitate the given examples. This suggests that kids have not yet attained a deep level of comprehension and that their understanding is still mechanical (Mandasari et al., 2021).

In mathematics learning, it does not only depend on conceptual understanding but is also influenced by students' learning independence.(Utami et al., 2022). Several studies show that learning independence has a significant contribution to the understanding of mathematical concept, where an increase in learning independence is directly proportional to an increase in students' conceptual understanding (Daulay & Sitorus, 2022). In other words, learning independence significantly The ability of students to actively and responsibly manage their learning process is known as learning independence. (Wati et al., 2025). In actuality, a teacher centered approach still predominates in the classroom. Due to this circumstance, pupils are more likely to be passive, depend on the teacher's explanations, lack initiative when learning, and be unaccustomed to using their own learning methodologies. When addressing difficult or contextual math issues, this lack of learning independence leads to a deficient conceptual comprehension. (Utami et al., 2022).

At Binjai 1 Public High School, eleventh-grade students still lack complete independence in their learning process. The kids' degree of autonomous learning is still relatively low, according to the findings of the first interviews with the math teacher. Pupils typically simply study in class and don't take the initiative to go over the content again after class. The adoption of a full-day school system, which implies that pupils seldom participate in independent learning activities at home because the school does not assign homework, makes this situation worse. Students' lack of independent learning is made worse by this circumstance. Students will find it difficult to learn more complex mathematics material and will be less able to develop the higher-order thinking skills required by the Merdeka Curriculum and international assessments if the problems of poor conceptual understanding and lack of independent learning are not promptly addressed (Syakroni et al., 2026). As a result, there is a need for instructional innovations that support students' continuous independent learning while simultaneously enhancing learning outcomes.

Direct Instruction is one educational approach thought to be appropriate for dealing with this problem. This approach helps students gradually develop conceptual knowledge by delivering instruction in a methodical manner through content delivery, demonstrations, guided practice, feedback, and independent practice. However, the teacher's capacity to provide interesting education is a major factor in this model's efficacy (Asyva et al., 2025) Learning materials that fit the learners' characteristics must be used to assist this model's implementation in order to make learning more dynamic and engaging. (Machrani et al., 2023).

One example of educational media that is relevant to current technological developments is interactive educational videos(Azmi et al., 2021). Interactive educational videos are highly useful when teaching mathematics, especially when it comes to abstract and complicated subjects. This is due to the fact that these videos may show how to solve problems step-by-step, give instances of how ideas are used in different situations, and provide instant feedback through interactive features created especially to gauge students' comprehension(Ali et al., 2024). The Ruangguru app supplied the interactive educational videos used in this study. Ruangguru was selected due to its National Curriculum-aligned instructional videos, captivating audiovisual content, and interactive exercises that facilitate students' self-directed learning(Amanda et al., 2023). Students can study visually, review content independently, and engage with the instructional material through interactive

instructional videos (Wardika & Putri, 2021).

Various prior research have indicated that Direct Instruction is beneficial in boosting students' knowledge of math topics (Hanum & Fitri, 2023; Krismolita et al., 2022). According to other research, students' enthusiasm and independence in learning can be improved by using interactive instructional videos (Laoli et al., 2025; Muliana et al., 2023). These studies, however, typically still examine the two methods independently or concentrate on a single dependent variable. There hasn't been much study done to date that combines interactive instructional video with Direct Instruction to examine their simultaneous effects on students' conceptual understanding and independence in learning mathematics while using MANCOVA analysis to control for prior aptitude. This gap shows that there is currently insufficient empirical evidence to demonstrate the efficacy of combining learning models and learning media on students' cognitive and affective elements.

The novelty of this study lies in three aspects. First, the study integrates the Direct Instruction model with interactive instructional videos as a unified learning strategy. Second, the study examines the simultaneous effect of this model on two learning outcomes: students' understanding of mathematical concepts and their learning independence. Third, the study uses MANCOVA analysis while controlling for students' prior ability through pretest scores, thereby providing a more accurate estimate of the treatment's effect compared to previous studies that used only univariate analysis. Based on this research gap, this study aims to analyze the effect of the Direct Instruction model, supplemented by interactive educational videos, on students' conceptual understanding and independent learning in mathematics both partially and simultaneously while controlling for students' prior knowledge. This study was conducted with 11th-grade students at Binjai 1 Public High School on the topic of regression statistics, using an empirical and measurable approach.

METHOD

This study employed a quantitative approach using a quasi-experimental design because the grouping of students at Binjai State High School No. 1 had already been determined by the school, making it impossible for the researcher to randomly assign the research subjects.(Iswadi, 2022). The experimental group was the intact class, and a pretest and covariate analysis using MANCOVA were used to control the students' starting abilities. A pretest-posttest control group design, which comprises two groups an experimental group and a control group was employed in the study. Before the intervention, both groups completed a pretest to gauge their students' starting skills. After the intervention, they completed a posttest to gauge how their learning outcomes had changed (A. Wicaksono, 2022).

The study was conducted at Binjai State High School 1 during the even semester of the 2025/2026 academic year. All 11th graders from Binjai State High School 1 made up the study's population. Sampling was undertaken via purposive sampling, as individual randomization was not practicable in an experimental study conducted within a classroom context. Therefore, classes were selected based on considerations of equality in academic features, math teachers, learning materials, number of students, and pretest scores, ensuring that both classes matched the criteria to serve as a comparison group(Sugiyono, 2023). Based on these considerations, Grade 11 Science Class 1 was selected as the experimental class and Grade 11 Science Class 3 as the control class, each with 36 students, resulting in a total research sample of 72 students.These two classes were selected because they were both taught by the same math teacher, utilizing the same curriculum, teaching materials, time allocation, and subject, resulting in reasonably similar learning characteristics. In addition, both classes had the same number of students, which decreased variation coming from factors other than the research treatment. The equality of the two classes' beginning abilities was examined using pretest results. The analytical results showed no significant difference between the two classes before the treatment ($p > 0.05$), hence both groups were regarded to have similar beginning abilities.

In the experimental class, the Direct Instruction model was executed with the use of interactive educational videos from the Ruangguru app, while the control class got the conventional instruction generally employed by teachers at the school. The content taught in both classes was regression statistics. The instruction took place across six sessions, consisting of one pretest, four instructional sessions, and one posttest. Each session lasted 2 x 45 minutes, in accordance with the school's mathematics schedule. The Direct Instruction syntax involves stating the objective and preparing students, demonstrating knowledge and skills, providing guided practice, checking for understanding and providing feedback, and offering additional practice.

The research instruments consisted of a mathematical concept comprehension test and a learning independence questionnaire. The concept comprehension test was designed based on indicators of the ability to restate concepts, present concepts in various mathematical representations, apply concepts or algorithms to problem-solving, classify objects based on specific properties, and provide examples and non-examples of a concept. Meanwhile, the self-directed learning questionnaire was developed based on indicators of learning initiative, the ability to self-monitor and self-evaluate, setting learning goals, taking responsibility for learning tasks, and not relying on others. The content validity of the instrument was assessed by five experts, consisting of two mathematical education professors and three experienced mathematics instructors. Subsequently, a brief pilot test was conducted with students outside the research sample to acquire evidence of the instrument's validity, difficulty level, discriminative power, and reliability before it was employed in the main study.

Before the study was conducted, the researcher got consent from the school and authorization from the subject instructors. All student data was kept confidential and utilized strictly for research reasons. The research data were then analyzed using descriptive and inferential statistics. The prerequisite tests conducted included tests of normality and homogeneity. Next, hypothesis testing was performed using Multivariate Analysis of Covariance (MANCOVA) with the aid of the SPSS program (Prastowo, 2021). MANCOVA was chosen since this study contained two dependent variables mathematical concept knowledge and independent learning as well as one covariate, the pretest score. This methodology enables for the simultaneous testing of the treatment's effect on both dependent variables while adjusting for the effects of initial ability, hence producing more accurate estimates of the treatment's effect than a univariate analysis.

RESULTS AND DISCUSSION

Before use, the instrument was first tested to assess the items' discriminative strength, validity, reliability, and degree of difficulty. According to the findings of the conceptual understanding instrument's validity test, all seven of the examined items were deemed legitimate and appropriate for usage. A coefficient of 0.807, which is in the high reliability range, was obtained from the reliability test. Additionally, the difficulty level analysis results showed that most of the questions were in the moderate category, while the discrimination power analysis results indicated that the majority of the questions were able to differentiate students' conceptual understanding abilities. Next, a trial was conducted to determine the validity, reliability, and student learning independence questionnaire. The validity test results showed that out of the 25 items tested, 22 These items are considered valid and can be used. The very high reliability category is represented by a reliability test coefficient of 0.902. Therefore, this research instrument is deemed suitable for collecting research data.

Before the learning process is carried out, both groups are first given a pretest to determine their initial understanding of mathematical concepts and the level of student learning independence. Next, in the experimental class, the Direct Instruction model is applied with the aid of interactive learning videos, while the control class receives the conventional teaching method usually applied by the teacher. The learning process was conducted over four meetings

according to the predetermined material. After all the learning activities are completed, both groups are given a posttest and a learning independence questionnaire to determine the changes in students' mathematical concept understanding and learning independence after the treatment.

Table 1. Descriptive Statistics of Students' Conceptual Understanding Ability

	N	Range	Min	Max	Mean	Std. Deviation
Control Pretest	36	60	4	64	23.33	13.980
Control Posttest	36	36	39	75	63.44	9.530
Experimental Pretest	36	67	4	71	23.28	15.188
Experimental Posttest	36	39	61	100	84.94	7.456
Valid N (listwise)	36					

According to descriptive statistics, the two groups' mean pretest scores were almost comparable, indicating that their initial abilities were relatively similar. Both groups' conceptual comprehension improved following the intervention, but the experimental group's improvement was noticeably higher than the control group's. When compared to traditional instruction, the Direct Instruction model combined with interactive educational videos produced a higher improvement in conceptual understanding, as seen by the difference in posttest averages of 21.50 points. In addition, the smaller posttest standard deviation in the experimental class indicates that the improvement in students' abilities occurred more evenly, so that the effectiveness of the intervention is reflected not only in the increase in the mean score but also in the consistency of learning outcomes across students.

Table 2. Descriptive Statistics of Learning Independence

	N	Range	Min	Max	Mean	Std. Deviation
Control Pretest	36	34	30	64	45.22	10.023
Control Posttest	36	38	52	90	69.14	7.925
Experimental Pretest	36	34	30	64	44.81	8.451
Experimental Posttest	36	37	63	100	84.42	7.205
Valid N (listwise)	36					

Prior to the intervention, the students' initial levels of independent learning in both groups were roughly equal, according to descriptive statistics. Following the teaching, learning independence increased more in the experimental class than in the control group. The posttest averages differed by 15.28 points. These results show that combining interactive instructional video with Direct Instruction enhances students' academic performance while also empowering them to take charge of their own learning. The lower posttest standard deviation in the experimental class indicates that the increase in learning independence occurred more consistently among students, meaning that the benefits of the intervention were felt by the majority of students, not just by a few specific students.

The normality test must be calculated after the pretest and posttest results have been obtained. The normality test is conducted as a prerequisite test.

Table 3. Normality Test Results

Data	N	Statistics	Sig.
Control Pretest	36	0,095	0,200
Control Posttest	36	0,141	0,067
Experimental Pretest	36	0,143	0,061
Experimental Posttest	36	0,140	0,074

All pretest and posttest data for both groups satisfy the assumption of a normal distribution, according to the normality test results. The reason for this is that every significance value is higher than 0.05. The fulfillment of this assumption indicates that the distribution of scores does not exhibit any deviations that could affect the estimation of statistical parameters; therefore, parametric analysis using MANCOVA can be conducted without the need for data transformation. Consequently, the results of subsequent tests can be interpreted with a higher level of confidence. The homogeneity of variance test on concept understanding and learning independence was conducted using Levene's Test and SPSS software.

Table 4. Homogeneity Results

Indicator criteria	Levene statistic	df1	df2	Sig.
Pretest of concept understanding	0,041	1	70	0,839
Posttest of Concept Understanding	3,411	1	70	0,117
Pretest of Learning Independence	3,394	1	70	0,070
Posttest of Learning Independence	0,451	1	70	0,504

To ascertain whether the variances between groups were identical, a homogeneity test was performed prior to employing MANCOVA to test the hypotheses (Nurrohmah et al., 2026). With the aid of the SPSS software, Levene's Test was used to conduct the homogeneity test. The findings demonstrated that the variances of all the research data were homogeneous. It may be inferred that the variances of the data in the experimental and control classes were homogeneous because all of the significant values in the computation table above were higher than the significance level of 0.05. In other words, the variation in scores within the experimental and control groups is relatively comparable, so the differences in the results obtained are more likely due to the treatment than to differences in data variability between the groups. Thus, one of the prerequisites for conducting MANCOVA analysis has been met, allowing the hypothesis testing to proceed.

Table 5. Homogeneity of Variance Test

	F	df1	df2	Sig.
Understanding concepts	2.737	1	70	.103
Learning independence	.655	1	70	.421

To ascertain whether the variances of the data in each research group had the same degree of variability, a test of homogeneity of variances was performed. The significant values for the mathematical concept understanding and mathematical learning independence variables were 0.103 and 0.421, respectively, based on the test results shown in Table 5. The significance criterion of 0.05 was exceeded by both significance values. The data variances in the experimental and control groups are relatively similar, according to the homogeneity test results. This suggests that the differences in learning outcomes observed are not due to differences in the level of data variability between groups but are more likely attributable to the treatment administered.

The fulfillment of the homogeneity assumption reinforces the appropriateness of using MANCOVA as an analytical technique to evaluate the effect of the learning model on the two dependent variables.

Table 6. Box's M Test Results

Statistics	Box's M	F	Dfl	Df2	Sig.
Value	79,233	25,590	3	882000.000	$< .001$

The hypothesis used is H_0 (The covariance matrix of the control group and the experimental group are the same), and H_1 (The covariance matrix of the control group and the experimental group are not the same). Based on the table above, a A significance level of less than 0.001 was attained. H_1 is rejected because the significance value is less than 0.05. This suggests that the two groups' covariance matrices are not homogeneous. The two groups have the same sample sizes, thus even though the assumption of homogeneity of the covariance matrices is not met, using MANCOVA is still possible. In order to ensure that the analysis results may still be correctly interpreted, the interpretation concentrates on Pillai's Trace, which is known to be more resilient to violations of this assumption (Rabiatul et al., 2025). Therefore, the study's conclusions still possess an adequate level of validity despite a violation of one of the MANCOVA assumptions.

The first hypothesis test was conducted to determine the effect of the Direct Instruction learning model assisted by interactive learning videos on students' understanding of mathematical concepts, based on the Tests of Between-Subjects Effects.

Table 7. Test of Influence on Concept Understanding

Source of Variation	Variable Dependen	F	Sig.	Partial Eta Squared
Pretest of concept understanding	Posttest of Concept Understanding	0,573	0,452	0,004
Pretest of Learning Independence	Posttest of Concept Understanding	0,124	0,726	0,002
Learning Model	Posttest of Concept Understanding	111.14	<0,001	0,620

After adjusting for students' prior ability through pretest scores, the learning model variable had a substantial impact on mathematical concept understanding, according to the Tests of Between-Subjects Effects results in Table 7 ($F = 111.114$; $p < 0.001$). This result suggests that students' initial aptitude had less of an impact on disparities in conceptual understanding at the conclusion of the learning process than the treatment given.

On the other hand, posttest conceptual knowledge was not significantly impacted by the covariates of pretest conceptual understanding ($F = 0.573$; $p = 0.452$) or pretest learning independence ($F = 0.124$; $p = 0.726$). These findings show that students' starting skills were no longer a major factor in predicting the diversity in conceptual comprehension at the end of the learning process following the intervention. Therefore, the implementation of the learning model is more strongly linked to advances in conceptual comprehension than the initial conditions of the pupils.

After adjusting for the impact of prior ability, the learning model explained 62% of the variance. of the variation in conceptual comprehension, according to a partial Eta-squared value of 0.620. This number falls into the "large effect" category according to the interpretation of effect sizes, suggesting that the learning model's influence is not only statistically significant but also has considerable practical consequences for enhancing students' comprehension of math topics.

The effect size's magnitude indicates that using interactive instructional video in conjunction with the Direct Instruction methodology significantly enhances students' comprehension of mathematical ideas. These findings suggest that the progress was caused by the features of the teaching strategy used during the learning process rather than just variations in the students' starting skills. Almost every conceptual This improvement is reflected in nearly all indicators of conceptual understanding. Students are able to restate concepts in their own words, present concepts in various mathematical

representations, connect related concepts, apply algorithms accurately to solve problems, and distinguish between examples and non-examples of a concept. Progress across these indicators demonstrates that students not only master problem-solving procedures but also understand the conceptual meaning underlying each step of the solution.

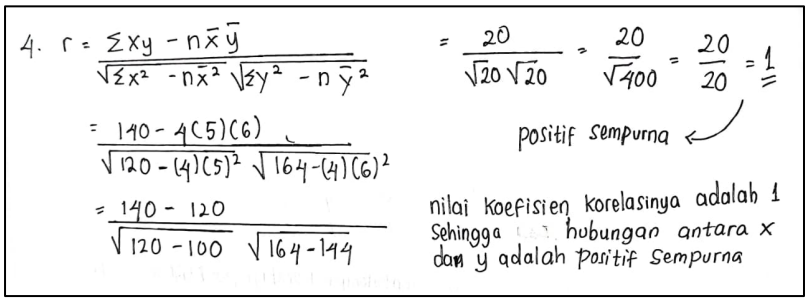

Figure 1. Example of student's answer demonstrating conceptual understanding.

The pupils' work on the Pearson correlation material also demonstrates this. In addition to obtaining accurate correlation coefficients, the students were also able to grasp the significance of the relationships between variables and offer pertinent justifications based on the statistical ideas they had studied. These findings indicate that the students have achieved a deeper conceptual understanding, as they were able to explain the reasoning behind their answers rather than merely performing calculations mechanically. The fact that pretest scores had no discernible impact on posttest results indicates that, following the intervention, students' starting skills were no longer a major factor.

This result suggests that the Direct Instruction model, which is bolstered by interactive educational videos, can offer students with different starting abilities relatively equal learning opportunities; consequently, improvements in conceptual understanding are more influenced by the quality of instruction than by students' starting conditions. The Direct Instruction model's features, which teach content step-by-step through the presentation of learning objectives, demonstrations, guided practice, feedback, and autonomous practice, can account for this outcome. Before taking on more difficult tasks, a methodical presentation aids pupils in making connections between ideas. Conversely, interactive educational videos support this process by providing contextual examples, audio and visual presentations, and the ability for students to review the content based on their own needs. This makes abstract concepts easier to comprehend(Dermawan & Salisah, 2025).

The findings of this study are in line with research by (Krismolita et al., 2022), which discovered that using multimedia-based Direct Instruction can enhance students' comprehension of mathematical ideas. According to that study, students' learning outcomes improved when they were taught utilizing an interactive media-integrated learning model. In addition, the results of this study are consistent with research (Hanum & Fitri, 2023) that suggests that the Direct Instruction model has a significant impact on students' ability to understand mathematical concepts when compared to traditional teaching methods. However, this study makes a significant contribution because it shows that integrating Direct Instruction with interactive learning videos not only produces statistically significant differences, but also produces large effect sizes after students' initial abilities are determined through MANCOVA analysis. This proves empirically that the combination of interactive media and learning models can have a positive impact on students' understanding of mathematical concepts.

The second hypothesis test was conducted to determine the effect of the Direct Instruction model supplemented with interactive educational videos on students'

independence in learning mathematics, based on the Tests of Between-Subjects Effects.

Table 8. Test of Influence on Learning Independence

Source of Variation	Dependent Variable	F	Sig.	Partial Eta Squared
Pretest of concept understanding	Posttest Learning Independence	0,076	0,784	0,001
Pretest of Learning Independence	Posttest Learning Independence	0,155	0,695	0,002
Learning Model	Posttest Learning Independence	71,052	<0,001	0,511

After adjusting for students' prior ability through pretest scores, the learning model variable had a substantial impact on mathematics learning independence, according to the Tests of Between-Subjects Effects results in Table 8 ($F = 71.052$; $p < 0.001$). These results suggest that the application of the learning model has a greater impact on variations in the degree of learning independence at the conclusion of the learning process than do the beginning conditions of the students before the treatment.

In contrast, the pretest covariates of conceptual understanding ($F = 0.076$; $p = 0.784$) and learning independence ($F = 0.155$; $p = 0.695$) did not show a significant effect on posttest learning independence. These results indicate that after the intervention was administered, students' initial abilities were no longer a significant factor explaining the variation in learning independence at the end of the learning process. Thus, the increase in learning independence can be better explained by the effectiveness of the implemented learning model than by the students' initial characteristics.

After adjusting for the impact of prior ability, the learning model can account for around 51.1% of the variation in learning independence, according to the partial Eta-squared value of 0.511. This number falls into the "large effect" category according to the interpretation of effect sizes, suggesting that the learning model's influence is not only statistically significant but also has considerable practical consequences for improving students' independence in learning mathematics.

The results of the study show that students' freedom in learning mathematics is greatly enhanced by the use of the Direct Instruction approach, which is backed by interactive instructional videos. The magnitude of the effect size found suggests that changes in students' learning behaviors were widespread throughout the experimental group rather than just occurring in a small subgroup of students. This implies that the use of interactive learning materials in conjunction with organized content delivery produces a learning environment that motivates students to take a more active part in overseeing their own learning process.

This improvement is reflected in various indicators of learning independence used in the study, namely the ability to take the initiative in learning, control and evaluate the learning process, set learning goals, take responsibility for completing tasks, and reduce dependence on teachers and peers. Changes in these indicators show that students no longer act as passive recipients of information but are beginning to be able to adjust their learning strategies according to their own needs and abilities. These findings suggest that the implemented learning model is capable of providing relatively equal learning opportunities to students with varying initial levels of independence. In other words, the increase in learning independence is more influenced by the quality of the learning experiences gained during the study than by the students' initial characteristics.

These findings can be explained by the

characteristics of the Direct Instruction model, which provides a systematic sequence of learning steps, ranging from the presentation of objectives, demonstrations, guided practice, and feedback to independent practice (Khosiyono et al., 2022). In order to help students understand what they need to learn and how to accomplish the learning objectives, these phases offer a clear learning structure. By enabling students to go over the content again, go over parts they still don't understand, and evaluate their own comprehension without depending entirely on the teacher's explanations, the use of interactive instructional videos strengthens this process even more (Wati et al., 2025).

The beginning conditions of the preliminary study at Binjai 1 Public High School, when the majority of pupils tended to study mainly during class time and were still heavily dependent on their professors, are similarly compatible with the results of this study. Students started to exhibit changes in their learning behavior once the learning model was put into practice, including revisiting content outside of class, looking for extra learning materials, and finishing tasks independently. The results of this investigation align with previous studies (Muliana et al., 2023) which shows that the use of instructional videos has a positive effect on students' independence in learning mathematics. The study (Laoli et al., 2025) It also reports that technology-based learning media can improve students' ability to manage their own learning process. However, this study makes a broader contribution by demonstrating that the increase in learning independence is not only statistically significant but also has a large effect size after controlling for students' initial abilities through MANCOVA analysis. Thus, the results of this study strengthen the empirical evidence that integrating Direct Instruction with interactive instructional videos is an effective strategy for developing students' autonomy in learning mathematics.

To determine the simultaneous effect of learning models on students' understanding of mathematical concepts and their independence in learning mathematics, the results of multivariate tests were used. Since the results of the Box's Test previously indicated that the covariance matrix was not homogeneous, the interpretation was based on Pillai's Trace, which is suitable for use with small samples or when the assumptions are not fully met (Rabiatul et al., 2025).

Table 9. Test of Influence on Concept Understanding and Learning Independence

Source of Variation	*Pillai's Trace*	F	Sig.	Partial Eta Squared
Pretest of concept understanding	0,010	0,328	0,721	0,010
Pretest of Learning Independence	0,002	0,083	0,920	0,002
Learning model	0,628	56,544	<0,001	0,628

The instructional approach had a significant simultaneous impact on students' comprehension of mathematical ideas and their learning independence, according to the findings of the multivariate tests in Table 9 (Pillai's Trace = 0.628; F = 56.544; $p < 0.001$). These results show that using the Direct Instruction approach in conjunction with interactive instructional videos significantly affects both dependent variables at the same time, even after adjusting for students' starting skills.

Conversely, the pretest covariates of learning independence (Pillai's Trace = 0.002; $p = 0.920$) and conceptual understanding (Pillai's Trace = 0.010; $p = 0.721$) did not significantly affect the combination of the two dependent variables. These findings show that following the intervention, students' beginning skills were no longer important in predicting the combined difference in conceptual understanding and learning independence. Therefore, the learning model that was used had a greater impact on changes in these two skills than the initial conditions of the students. After adjusting for the impact of prior ability, the learning model can account

for around 62.8% of the combined variation in mathematical concept understanding and learning independence, according to the partial Eta-squared value of 0.628. This number falls into the "large effect" category according to the interpretation of effect sizes, suggesting that the learning model's influence is both statistically significant and has considerable practical consequences for concurrently increasing both talents. The amount of the impact size found indicates that the learning model can simultaneously build students' cognitive and affective skills in addition to improving one aspect of learning.

These results can be explained by the characteristics of Direct Instruction, which presents learning systematically through the presentation of objectives, demonstrations, guided practice, feedback, and independent practice. These stages help students build conceptual understanding gradually, making it easier to integrate new concepts with their existing knowledge. (Khosiyono et al., 2022). Interactive instructional videos, on the other hand, provide students the freedom to go over the content again, go over parts they still don't understand, and evaluate their own learning. Together, these two elements enable the development of self-regulation abilities, which are the cornerstone of independent learning, as well as enhanced conceptual comprehension (Wulandari et al., 2024).

These findings reinforce the view that conceptual understanding and academic autonomy are two interrelated skills. Students who have a strong grasp of concepts tend to be more confident in managing their own learning process, while students with a high degree of academic autonomy are more motivated to explore the material in greater depth. This reciprocal relationship explains why improvements in both skills can occur simultaneously during the learning process (Anzani et al., 2024). The results of this study are consistent with the findings of (Wardani T.T et al., 2024) and (Rahmatyas, 2024) which shows that the use of interactive learning media can improve understanding of mathematical concepts. In addition (Supriyatin, 2024) Additionally, it states that pupils' comprehension of mathematical topics is positively impacted by autonomous learning. This study, however, contributes more broadly because it not only looks at how the learning model affects each variable independently but also uses MANCOVA to investigate their simultaneous effects while accounting for students' past knowledge. This method offers more thorough empirical proof of the learning model's impact on cognitive and affective aspects of math learning.

Although the results of this study indicate that the Direct Instruction model supplemented by interactive educational videos has a significant effect on students' conceptual understanding and independent learning in mathematics, this study still has several limitations. The study was conducted at only one school with a relatively small sample size and focused on regression statistics. Furthermore, the interactive instructional videos used were sourced from a single learning platform; therefore, the findings of this study cannot yet be generalized to all math topics or different learning conditions. Therefore, future research is expected to involve a larger sample size, more diverse materials, and the use of various types of interactive learning media in order to obtain more comprehensive results. Based on the above discussion, it can be concluded that the Direct Instruction model, supported by interactive instructional videos, has a simultaneous effect on students' conceptual understanding and independent learning in mathematics.

CONCLUSION

This study shows that the implementation of the Direct Instruction model, supported by interactive educational videos, has a significant effect on students' understanding of mathematical concepts and their independence in learning, as well as on both variables simultaneously, after controlling for students' initial abilities using MANCOVA analysis. The magnitude of the effect size indicates that this instructional model makes a strong contribution to the improvement of both abilities in the context of this study. From a scientific standpoint, this study advances the field of math learning research by showing how the Direct

Instruction model and interactive instructional videos can improve both cognitive and affective features at the same time. By using MANCOVA analysis, which enables the evaluation of the treatment impact while controlling for students' past abilities and produces more precise estimates of the effect than univariate analysis, this study additionally broadens the empirical evidence.

The novelty of this study lies in its examination of the effect of the Direct Instruction model, supplemented by interactive educational videos, on both conceptual understanding and independent learning in the context of regression statistics. Thus, this study provides additional empirical evidence regarding the effectiveness of integrating instructional models and digital media in mathematics education. However, the findings of this study should be understood in light of the research context, which is regression statistics being studied by 11th grade students at Binjai 1 State Senior High School. As a result, it is not possible to immediately extrapolate these results to other educational levels, school features, or mathematical subjects. To improve the external validity and generalizability of the results, it is advised that future studies include a bigger sample size, a variety of school characteristics, and a wider range of math topics.

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