

## The Effect of Flipped Classroom Learning Model on Psychomotor Learning Outcomes in Prototype Design for Class X Students at SMK Negeri 1 Sawit Boyolali

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### ABSTRACT

This study examines the effect of the Flipped Classroom learning model on psychomotor learning outcomes (prototype design skills) of Class X Automotive Engineering students at SMK Negeri 1 Sawit Boyolali. This research employed a quasi-experimental method with a nonequivalent control group design. The sample consisted of 71 students: Class X TO 2 (n=35) as the experimental group receiving Flipped Classroom instruction, and Class X TO 4 (n=36) as the control group using Guided Discovery. Data were collected through performance assessment using a rubric covering five aspects of prototype design: tools usage, layout, element selection, innovation, and theme suitability. Data analysis included descriptive statistics, normality and homogeneity tests, Independent Sample t-Test, and Cohen's d effect size. Results indicated that the experimental group achieved a higher average post-test score (78.57) and N-Gain (0.391) compared to the control group (76.81; N-Gain 0.334). However, the Independent Sample t-Test yielded  $t = 0.675$  ( $p = 0.502 > 0.05$ ), indicating no statistically significant difference. Cohen's  $d = 0.160$  revealed a small effect size. Despite this, descriptive analysis showed that the Flipped Classroom model produced more evenly distributed improvements, with 54.29% of experimental students achieving moderate N-Gain compared to only 30.56% in the control group. This study concludes that although the Flipped Classroom model has not produced statistically significant differences, it demonstrates promising potential in enhancing the quality and equity of psychomotor learning outcomes in vocational education.

**Keywords:** *Canva, Flipped Classroom, Prototype Design, Psychomotor Learning Outcomes, SMK*



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### INTRODUCTION

Vocational education in Indonesia, particularly through Sekolah Menengah Kejuruan (SMK), faces the dual challenge of meeting industry-ready competency standards while integrating 21st-century digital learning approaches. The Revitalization of Vocational Education Policy (Republik Indonesia, 2022) mandates competency-based learning aligned with the world of work, emphasizing practical skills, curriculum alignment, and technology-based learning innovations. Concurrently, the Merdeka Belajar curriculum framework (Kemdikbudristek, 2022) promotes student learning autonomy, digital literacy, and the use of open educational resources as the core of the learning experience.

At SMK Negeri 1 Sawit Boyolali, the Informatics subject serves as a strategic vehicle to develop students' 21st-century competencies, including computational thinking, problem-solving, and proficiency in technology applications. However, classroom observations and preliminary questionnaire data involving 52 students revealed several critical challenges: 62% reported low interest in teacher-centered instruction; 55% felt that material was delivered too fast; and 73% admitted difficulty understanding Informatics concepts without additional practice opportunities. Furthermore, analysis of daily test scores showed that 13 out of 33 students (39%) scored below the Minimum Competency Criterion (KKM = 75), indicating significant inequality in learning outcomes.

These challenges point to a fundamental problem: insufficient class time for hands-on practice due to the time consumed by direct instruction. The Flipped Classroom model (Lage et al., 2000) addresses this by inverting the traditional learning sequence. Students access instructional materials videos, digital modules independently before class (pre-class phase), while in-class time is entirely devoted to practice, discussion, and collaborative problem-solving. This restructuring extends effective practice time within the same instructional hours while enabling the teacher to provide personalized feedback during practice activities.

Previous studies confirm the model's potential. Herlambang & Rachmadi (2024) demonstrated higher procedural and psychomotor outcomes in vocational students under Flipped Classroom. Wang et al. (2022) showed significant psychomotor skill improvements in nursing education. Meta-analyses by Liu (2025) further validated Flipped Classroom's positive impact on motor skill performance. However, most prior research focused on cognitive outcomes or was conducted in general education contexts. The novelty of this study lies in applying Flipped Classroom specifically to psychomotor outcomes in SMK Informatics, targeting prototype design skills using Canva a context combining technical procedural skills with digital creativity under the vocational education framework.

This study therefore aims to examine the effect of the Flipped Classroom learning model on the psychomotor learning outcomes (prototype design skills) of Class X Automotive Engineering students at SMK Negeri 1 Sawit Boyolali, with the hypothesis that Flipped Classroom produces significantly better psychomotor outcomes compared to Guided Discovery.

## METHODS

### *Research Design*

This study employed a quasi-experimental method (Campbell & Stanley, 1963) with a Pre--Post-test Nonequivalent Control Group Design, appropriate when random assignment of individuals is not possible in real school settings. Two naturally formed classes served as research samples: Class X TO 2 (n=35) as the experimental group receiving the Flipped Classroom model, and Class X TO 4 (n=36) as the control group continuing with the Guided Discovery model. The research design is presented in Table 1.

*Table 1. Quasi-Experimental Research Design*

<b>Group</b>	<b>Pre-test</b>	<b>Treatment</b>	<b>Post-test</b>
Experimental	O <sub>1</sub>	X (Flipped Classroom)	O <sub>2</sub>
Control	O <sub>3</sub>	– (Guided Discovery)	O <sub>4</sub>

### *Participants*

The population consisted of all Class X Automotive Engineering (TO) students at SMK Negeri 1 Sawit Boyolali in the 2025/2026 academic year (N=142, across four classes). Sampling used cluster sampling (Sugiyono, 2022; Fraenkel et al., 2019), selecting two classes with comparable prior academic achievement. The experimental group comprised 35 students and the control

group 36 students, totaling 71 participants. Both classes used the same curriculum, teaching schedule, and subject teacher, ensuring baseline equivalence.

### *Learning Intervention*

The Flipped Classroom intervention was implemented across multiple meetings on the topic of Application UI Design Prototype using Canva. In the pre-class phase, students independently accessed teacher-prepared instructional videos, digital modules, and step-by-step tutorial materials at home. In the in-class phase, all classroom time was dedicated to direct practice, discussion, collaborative problem-solving, and individualized teacher feedback. The control group followed the standard Guided Discovery model, where the teacher delivered new material in class before practice activities, following the school's established approach (Bergmann & Sams, 2012; Bishop & Verleger, 2013).

### *Instrument and Assessment*

Learning outcomes were measured using a performance assessment instrument a psychomotor skills rubric administered as both pre-test and post-test. The pre-test required students to create a simple login/front-page design without prior instruction. The post-test required a more complex prototype design applying the learned design principles. The rubric assessed five aspects on a 1-4 scale: (1) Tools Usage, (2) Layout, (3) Element Selection, (4) Innovation/Creativity, and (5) Theme Suitability. Total maximum score was 20, converted to a 0–100 scale. Instrument validity was established through expert judgment (content validity) by an Informatics subject matter expert and an educational evaluation expert. Reliability was confirmed using Cronbach's Alpha ( $\alpha > 0.7$ ), ensuring internal consistency of the rubric (Arikunto, 2019; Creswell, 2018). The rubric was grounded in Dave's (1970) psychomotor taxonomy, targeting development from Level 2 (Manipulation) to Level 3 (Precision).

### *Data Analysis*

Data analysis followed three stages: (1) Descriptive statistics mean, standard deviation, maximum and minimum values, and N-Gain scores using Hake's (1999) formula; (2) Prerequisite tests normality (Shapiro-Wilk, appropriate for  $n < 50$ ) and homogeneity of variance (Levene's Test); (3) Hypothesis testing using Independent Sample t-Test at  $\alpha = 0.05$ , supplemented by Cohen's d effect size calculation. Student response data were analyzed using percentage descriptive statistics. All analyses were conducted using SPSS.

## **RESULTS AND DISCUSSION**

### *Results*

#### *1. Descriptive Statistics*

*Table 2. Comparative Descriptive Statistics of Both Groups*

<b>Component</b>	<b>Experimental (X TO 2)</b>	<b>Control (X TO 4)</b>
N	35	36
Mean Pre-test	65.43	66.53
Mean Post-test	78.57	76.81
SD Pre-test	8.94	8.93
SD Post-test	10.26	11.72
Mean Gain Score	13.14	10.28
Mean N-Gain	0.391	0.334
N-Gain Category	Moderate	Moderate

The experimental and control groups demonstrated comparable prior ability with pre-test means of 65.43 and 66.53, respectively (difference = 1.10 points). This baseline equivalence is

essential for attributing post-test differences to the learning model rather than prior ability (Creswell, 2012). After the intervention, the experimental group achieved a mean post-test score of 78.57 (gain = 13.14; N-Gain = 0.391, moderate category), while the control group reached 76.81 (gain = 10.28; N-Gain = 0.334, moderate category). Table 2 presents the complete comparative descriptive statistics.

The N-Gain distribution reveals a more pronounced difference between groups. In the experimental group, 54.29% of students achieved moderate N-Gain, compared to only 30.56% in the control group. Conversely, the control group was dominated by low N-Gain (52.78%) versus 31.43% in the experimental group, as detailed in Tables 3 and 4.

*Table 3. N-Gain Distribution – Experimental Group (X TO 2)*

Category	Criterion	N	%
High	$g \geq 0.70$	5	14.29
Moderate	$0.30 \leq g < 0.70$	19	54.29
Low	$g < 0.30$	11	31.43
Total	–	35	100.00

*Table 4. N-Gain Distribution – Control Group (X TO 4)*

Category	Criterion	N	%
High	$g \geq 0.70$	6	16.67
Moderate	$0.30 \leq g < 0.70$	11	30.56
Low	$g < 0.30$	19	52.78
Total	–	36	100.00

## 2. Per-Aspect Rubric Analysis

Analysis of rubric scores per aspect, referenced against Dave's (1970) psychomotor taxonomy levels, reveals that all pre-test scores (range 2.22–2.89) aligned with Level 2 (Manipulation) indicators students could perform tasks following instructions but without independence or consistency. After the intervention, all post-test scores moved to the range 2.61–3.37, indicating achievement of Level 3 (Precision) indicators. Table 5 presents the per-Aspect comparison.

*Table 5. Mean Rubric Score per Aspect – Both Groups*

Aspects	Experimental			Control		
	Pre	Post	$\Delta$	Pre	Post	$\Delta$
Tools Usage	2.80	3.23	+0.43	2.72	3.11	+0.39
Layout	2.23	2.83	+0.60	2.22	2.61	+0.39
Element Selection	2.80	3.37	+0.57	2.69	3.28	+0.58
Innovation	2.71	3.20	+0.49	2.89	3.22	+0.33
Theme Suitability	2.54	3.09	+0.54	2.78	3.14	+0.36

The layout aspect showed the most notable difference: the experimental group advanced from Level 2 (2.23) to Level 3 (2.83,  $\Delta+0.60$ ), while the control group remained at Level 2 (2.61,  $\Delta+0.39$ ). This is the only aspect where the two groups occupied different psychomotor levels post-intervention the strongest evidence that Flipped Classroom more effectively facilitates the Level 2→Level 3 transition in aspects requiring direct practice and visual concentration. The innovation/creativity aspect also demonstrated a faster progression rate in the experimental group ( $\Delta+0.49$  vs.  $\Delta+0.33$ ), reflecting the more conducive environment for creative exploration enabled by independent pre-class learning (Salsabela, 2025; Liu, 2025).

### 3. Pre-requisite Tests

Shapiro-Wilk normality tests (appropriate for  $n < 50$ ; Field, 2009) confirmed normal distribution for all four datasets (Sig.  $> 0.05$ ): pre-test control (SW = .960,  $p = .236$ ), post-test control (SW = .943,  $p = .068$ ), pre-test experimental (SW = .951,  $p = .124$ ), post-test experimental (SW = .963,  $p = .275$ ). Levene's Test for equality of variances yielded  $F = 1.778$  ( $p = .187 > 0.05$ ), confirming homogeneous variances between groups. These results validated the use of parametric Independent Sample t-Test.

### 4. Hypothesis Testing

The Independent Sample t-Test with equal variances assumed yielded  $t = -0.675$  ( $|t| = 0.675$ ),  $df = 69$ ,  $p = 0.502$ . Since  $|t|$  ( $0.675$ )  $<$   $t$ -table ( $1.995$ ) and  $p$  ( $0.502$ )  $>$   $\alpha$  ( $0.05$ ),  $H_0$  is accepted: there is no statistically significant difference in psychomotor learning outcomes between the Flipped Classroom and Guided Discovery groups at the 95% confidence level. The 95% CI ( $-6.987$  to  $3.455$ ) encompasses zero, confirming this result.

*Table 6. N-Gain Distribution – Control Group (X TO 4)*

Component	Value
Levene's F	1.778
Sig. Levene (homogeneity)	.187
t-value	-0.675
df	69
Sig. (2-tailed) / p-value	.502
Mean Difference	-1.766
Std. Error Difference	2.617
95% CI Lower	-6.987
95% CI Upper	3.455
t-table ( $\alpha=0.05$ ; $df=69$ )	1.995

Cohen's  $d = 0.160$  indicates a small effect size (Cohen, 1988). Post-hoc power analysis estimated statistical power at approximately  $0.20$ – $0.25$ —well below the recommended threshold of  $0.80$  (Cohen, 1988). This low power suggests insufficient sample size to detect a small effect ( $d \approx 0.2$ ), estimating a requirement of approximately 250 students per group for adequate detection. These findings are consistent with Hew & Lo (2018), whose meta-analysis found that Flipped Classroom generally produces better outcomes but with varying effect sizes depending on implementation context and sample size.

*Table 7. Effect Size (Cohen's d) Calculation*

Component	Value
Mean Post-test Experimental	78.57
Mean Post-test Control	76.81
Mean Difference	1.766
Pooled SD	11.06
Cohen's d	0.160
Effect Size Category	Small ( $d < 0.2$ )

### Discussion

The absence of statistically significant differences does not negate the practical potential of Flipped Classroom. Three contextual factors require consideration. First, the limited intervention duration (one teaching unit) was insufficient for students to fully adapt to the independent pre-class learning pattern. Flipped Learning Network (2014) emphasizes that effectiveness is contingent on students consistently completing pre-class materials a habit requiring sustained practice. Second, the small sample size ( $n = 35$  and  $36$ ) produced inadequate

statistical power, limiting the test's ability to detect small but real effects. Third, unmeasured mediating variables pre-class video access frequency, self-directed motivation, and device availability outside school may have moderated the effect.

Despite statistical non-significance, the descriptive advantage of Flipped Classroom is consistent across all measured indicators: higher mean post-test, larger gain score, higher N-Gain, and most importantly more equitable distribution of learning improvement. The shift of 54.29% of experimental students to moderate N-Gain versus 30.56% in control, and the reduction of students with low N-Gain (31.43% vs. 52.78%), reflects the mechanism described by Bergmann & Sams (2012): pre-class exposure enables students to arrive at practice sessions with prior understanding, maximizing direct practice time and enabling more personal teacher feedback. This addresses two of the three root problems identified in the preliminary study insufficient practice time and unequal learning outcomes (Bishop & Verleger, 2013).

The layout aspect's unique finding the experimental group achieving Level 3 (Precision) while the control group remained at Level 2 (Manipulation) provides concrete empirical support for the cognitive load reduction mechanism. By separating conceptual acquisition (pre-class) from skill application (in-class), Flipped Classroom allows students to dedicate full working memory capacity to the visual concentration and trial-and-error required for layout refinement (Piaget, 1972; Fosnot, 2013). This finding is particularly relevant for vocational education, where psychomotor skill development progressing through Dave's (1970) taxonomy from Imitation through Articulation requires repeated practice with immediate corrective feedback.

From a broader vocational education policy perspective, these findings align with the Merdeka Belajar framework's (Kemdikbudristek, 2022) emphasis on learning independence, digital literacy, and student-centered pedagogies. The Flipped Classroom model structurally operationalizes these principles, making it a contextually appropriate and theoretically sound innovation for SMK.

## **CONCLUSION**

This study concluded that the Flipped Classroom learning model did not produce statistically significant differences in psychomotor learning outcomes in prototype design compared to the Guided Discovery model among 10th-grade Automotive Engineering students at SMK Negeri 1 Sawit, Boyolali. However, descriptive analysis consistently favored the Flipped Classroom: the experimental group achieved higher average post-test scores, greater gain scores, higher N-Gain, and a more even distribution of gains among experimental students in the medium N-Gain category compared to the control group. The statistically insignificant results were due to the limited duration of the intervention, the small sample size resulting in insufficient statistical power, and the students' adaptation phase to self-paced pre-class learning.

These findings suggest that the Flipped Classroom has promising potential to improve the quality and equity of psychomotor learning in vocational education, particularly when implemented over a full semester with a larger sample size and a gradual introduction of students to self-paced pre-class learning. Future research should utilize a larger sample size, a longer intervention period, and measurement of mediating variables such as frequency of pre-class video access, intrinsic motivation, and out-of-school digital access.

## **CONFLICT OF INTEREST**

The authors declare no conflict of interest in the preparation and publication of this research article.

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