**F**ocus **ACT**ion **O**f **R**esearch **M**athematic
Volume 9, No. 2, 2026
Page 329-351
https:/jurnalfaktarbiyah.iainkediri.ac.id/index.php/factorm/

ISSN: 2655-3511 (print)
ISSN: 2656-307X (online)

# Nearpod interactive media and its association with mathematical conceptual understanding and motivation among junior high school students

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## Abstract

Indonesian junior high school students continue to perform poorly in mathematics, and weak conceptual understanding of abstract topics such as number patterns often accompanies low learning motivation. Students often memorize pattern formulas without understanding why a rule holds, and conventional instruction offers few chances for immediate, individual feedback on their reasoning. Nearpod, an interactive platform that provides quizzes, visualized material, and instant feedback, may support both conceptual understanding and motivation. This quasi-experimental study evaluated post-intervention group differences in mathematical conceptual understanding and internal and external motivation (grounded in Self-Determination Theory) between students using Nearpod-interactive media and those receiving conventional instruction. Thirty-two eighth-grade students from an Islamic junior high school in Padang, Indonesia, were assigned via intact classes to an experimental group (N=16) and a control group (N=16). Data were collected using a 5-item conceptual understanding test and a 24-item motivation questionnaire. The MANOVA indicated no statistically significant multivariate difference across the three dependent variables, Pillai's Trace = 0.217, $F(3, 28) = 2.585$, $p = 0.073$. Subsequent univariate analyses showed unadjusted group differences favoring the experimental class in mathematical conceptual understanding, $F(1, 30) = 4.658$, $p = 0.039$, and external motivation, $F(1, 30) = 5.249$, $p = 0.029$. In contrast, internal motivation did not differ significantly, $F(1, 30) = 0.576$, $p = 0.454$. However, neither unadjusted significant finding remained significant after Bonferroni adjustment (adjusted $p = 0.117$ and 0.087), so these univariate findings are exploratory. Possible explanations are theoretical and untested. Studies with pretests, random assignment, and larger samples are needed.

**Keywords**: Interactive Media, Nearpod, Mathematics Conceptual Understanding, Internal Motivation, External Motivation

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**How to Cite**: Mardika, F., Fitriza, R., & Saputri, B. (2026). Nearpod interactive media and its association with mathematical conceptual understanding and motivation among junior high school students. *Journal Focus Action of Research Mathematic (Factor M), 9*(2), 329–351. https://doi.org/10.30762/f_m.v9i2.9954

## INTRODUCTION

Internationally, Indonesian students' mathematical competence remains a persistent concern. In the 2025 cycle of the Programme for International Student Assessment (PISA), whose results the OECD released in September 2026, Indonesian 15-year-olds scored 364 points in mathematics, far below the OECD average of 463 points, and only 17% reached Level 2, compared with 65% on average across OECD countries (OECD, 2026). Level 2 is the baseline level of proficiency. At this level, students can interpret and recognize situations that require no more than direct inference, extract relevant information from a single source, use a single representation, and apply basic algorithms, formulas, or procedures to problems involving whole numbers (OECD, 2019). Students below this level are classed as low performers (OECD, 2019), so the 2025 results mean that more than four in five Indonesian students had not yet reached the point at which they begin to use mathematics in simple real-life situations. PISA measures mathematical literacy, that is, the capacity to formulate, employ, and interpret mathematics in context; it does not measure conceptual understanding directly. The low result is persistent. Indonesia's mean mathematics score was 360 in 2003 and 386 in 2015, and it then fell to 379 in 2018 and 366 in 2022, one of the lowest results ever measured for the country (OECD, 2019; OECD, 2023). The 2025 score did not differ statistically from that of 2022 and remained below the 2015 level (OECD, 2026). The Trends in International Mathematics and Science Study (TIMSS), which assesses curriculum-based knowledge and therefore differs in construct from PISA, points in the same direction: Indonesian eighth-graders scored 386 in 2011, well below the TIMSS scale center point of 500 (Mullis et al., 2012).

Neither assessment measures conceptual understanding directly, but weak conceptual understanding plausibly contributes to these results, and classroom studies show it is not limited to one topic. Junior high school students' understanding is often weak in algebra and number operations, as reflected in report-card scores (Gunawan et al., 2023). In a study of matrix material, Islamic senior high school students' performance differed across indicators of conceptual understanding. It was lowest in applying procedures, and the authors advised teachers to move beyond memorization (Handayani & Anggraini, 2023). Media development studies have also targeted geometry concepts such as rectangles and squares (Monalisa et al., 2025), suggesting that conceptual

 http://doi.org/10.30762/f_m.v9i2.9954

difficulties extend beyond algebra and number. Conventional instruction centered on memorizing procedures has been argued to leave students' understanding fragmented and easily forgotten, which hinders problem solving (Domu et al., 2022).

Students' low mathematics learning outcomes may also be associated with weak conceptual understanding. Concerning the variable of mathematics conceptual understanding, this study refers to the framework proposed by Kilpatrick et al. (2001) who defined conceptual understanding as the comprehension of mathematical concepts, operations, and relations. Students with such understanding know not only isolated facts and procedures but also why a concept is important and in which contexts it applies, and they can represent mathematical situations in different ways. Conceptual understanding is one of five interwoven strands of mathematical proficiency, together with procedural fluency, strategic competence, adaptive reasoning, and productive disposition. To make the construct measurable, four indicators were used. Representing a concept in different forms is the indicator most directly tied to the framework, which treats the ability to represent situations in different ways as a sign of understanding. The other three indicators, restating a concept, classifying objects according to their properties, and giving examples and non-examples, are operationalizations commonly used in Indonesian research on conceptual understanding (Handayani & Anggraini, 2023). They express the framework's emphasis on knowing what a concept means and what its properties are, and not only how to apply a procedure, in forms that can be assessed in writing. This mapping is the authors' operationalization; it is not a validated measurement model of the Kilpatrick et al. (2001) framework.

Number patterns are a suitable context for examining conceptual understanding at this level. The topic is taught across several levels of schooling, and solving pattern questions requires students to recognize regularities, state a rule, and generalize it (Firnanda & Susiswo, 2024). In a case study of two 10th-grade students, Firnanda and Susiswo (2024) found that students tended to rely on automatic, intuitive processes when solving number pattern questions, errors arose from this tendency, and that scaffolding through the researcher's questions and instructions helped them correct their mistakes. These findings suggest that number pattern learning benefits from timely prompts that push students to check rules and representations, a function that interactive questions with immediate feedback could potentially serve in a whole-class setting.

 http://doi.org/10.30762/f_m.v9i2.9954

Motivation is the second factor. Learning motivation has been linked to mathematics learning outcomes and problem solving in several contexts (Doño & Mangila, 2021; Hutajulu et al., 2019). Studies in Indonesian junior high schools relate low learning outcomes to weak motivation, whether it arises from the student, such as interest and self-confidence, or from the learning environment, such as support from teachers, parents, and the classroom atmosphere (Agus et al., 2024; Fatimah et al., 2024; Kurniawan et al., 2025). A review at the elementary level stresses that internal and external motivation both need to be strengthened (Pangestu et al., 2026).

Self-Determination Theory (SDT), as developed by Deci and Ryan (1985) and Ryan and Deci (2020), provides the framework for interpreting motivation in this study. Intrinsic motivation is engagement in an activity for its inherent interest, curiosity, and satisfaction. Extrinsic motivation is engagement for separable outcomes such as grades, praise, rewards, or the demands of the learning environment. SDT does not treat extrinsic motivation as a single, uniformly controlled state: its forms range from externally regulated to well-internalized, depending on the extent to which students accept the value of the activity, and internalization is fostered when the needs for autonomy, competence, and relatedness are satisfied (Niemiec & Ryan, 2009; Ryan & Deci, 2020). In the present study, 'internal motivation' refers to intrinsic motivation (interest, curiosity, personal satisfaction, and self-confidence), and 'external motivation' refers to extrinsic motivation driven by grades, praise, and support from teachers, parents, and the classroom atmosphere. The questionnaire did not separate the regulation subtypes of extrinsic motivation, and the three psychological needs were not measured.

The conventional instruction in the participating school consisted of teacher explanation, worked examples, and exercises. In this approach, feedback on an individual student's pattern rule depends on the teacher checking the student's written work, so feedback may reach each student late, and opportunities for choice and peer interaction depend on how the teacher organizes the exercises. Nearpod is a technology-based interactive platform that delivers slides, videos, and questions to students' devices and shows the teacher students' responses in real time; its quiz activities provide immediate feedback and include game-like elements. In SDT terms, responding on one's own device may support autonomy, immediate feedback may support competence, and shared activities may support relatedness (Niemiec & Ryan, 2009). Technology-based

 http://doi.org/10.30762/f_m.v9i2.9954

interactive media such as Nearpod provide live quizzes, polls, drawing tasks, instant feedback, collaborative features, and game-like elements. In theory, responding individually on one's own device may support autonomy, immediate feedback may support competence, and shared activities may support relatedness. At the same time, the same features may scaffold the conceptual understanding described by Kilpatrick et al. (2001). The present study does not directly test these theoretical expectations.

Several empirical studies have examined the effectiveness of Nearpod as an interactive learning medium. In higher education, Nearpod combined with Blum modeling was associated with stronger academic performance in mathematics courses (Carrillo-Yalán et al., 2023)Nearpod has been described as a tool for promoting active learning in bring-your-own-device classrooms (Hakami, 2020). At the elementary level, a Nearpod study and a systematic review reported links with motivation and achievement (Bintoro et al., 2024; Pangestu et al., 2026)and a social studies study reported a significant increase in learning interest with a very strong effect size (Rahmadani & Khusna, 2026). At the junior high school level, a development study using the 4-D model reported an N-gain of 80.19% in seventh-grade students' critical thinking in algebra (Kurniati et al., 2026). Some studies show a similar development orientation. Syaikhu et al. (2022) Developed a game-based Snake and Ladder media that was valid and practical, and junior high school students' motivation questionnaire scores rose from 76.38% to 85.78% after use. Rani et al. (2024) Developed science-based interactive multimedia for polyhedra and reported excellent product quality and positive student feedback. A systematic review of 188 articles found that interactive multimedia has been studied at all educational levels, that research and development designs were the most frequently found, and that its use in Indonesian mathematics education is still limited (Sutomo & Turmudi, 2024).

Based on this body of prior research, several clear gaps can be identified. First, the Nearpod evidence comes from contexts that differ from the present one: university courses in which Nearpod was combined with another approach, so its own contribution was not isolated (Carrillo-Yalán et al., 2023); elementary schools (Bintoro et al., 2024; Pangestu et al., 2026); and a different subject (Rahmadani & Khusna, 2026). The only junior high school Nearpod study reviewed here is a development study of algebra that reported gains in critical thinking and did not address conceptual understanding or

 http://doi.org/10.30762/f_m.v9i2.9954

motivation (Kurniati et al., 2026). Second, studies in Indonesian junior high schools and in this journal are mostly development studies that report product quality and student response (Rani et al., 2024) or a change in a single motivation score (Syaikhu et al., 2022), which is consistent with a review of 188 articles that found development designs to be the most frequent and the use of interactive multimedia in Indonesian mathematics education to be still limited (Sutomo & Turmudi, 2024). Third, motivation is usually treated as one construct, so these studies cannot show whether interactive features relate differently to intrinsic and to extrinsic motivation.

These patterns leave an unresolved question that is more specific than the absence of a study with three outcomes. Interactive features such as immediate feedback and game-like quizzes could plausibly relate differently to conceptual understanding, to extrinsic motivation, and to intrinsic motivation. Feedback may help students check and revise their pattern rules, and game-like rewards may readily raise externally driven motivation, but intrinsic motivation is expected to depend on need satisfaction sustained over time, and rewards can undermine it when they are experienced as controlling (Niemiec & Ryan, 2009; Ryan & Deci, 2020). Reviews of gamification likewise describe mixed results and insufficient evidence for long-term benefits (Dichev & Dicheva, 2017). What remains unexplained is whether a short Nearpod-supported unit on number patterns in junior high school is associated with differences in all three outcomes or only in some of them. The studies reviewed here cannot answer this question because they examined other levels, other subjects, or a single motivation score.

This study primarily explored the use of Nearpod as an interactive tool to support junior high school students' learning of number patterns by comparing post-intervention outcomes between a class taught with Nearpod and a class taught with conventional instruction. The study addressed three research questions: (RQ1) Do students who learn number patterns with Nearpod differ in mathematical conceptual understanding from students who receive conventional instruction only? (RQ2) Do they differ in internal and external motivation? (RQ3) Do the three outcomes differ jointly between the two groups? Because the design is posttest-only and one class was assigned to each condition, the results are interpreted as differences between the classes after instruction, not as improvement and not as effects of Nearpod. The study is expected to inform teachers' use of Nearpod as a supplement to conventional number pattern instruction and to show

 http://doi.org/10.30762/f_m.v9i2.9954

what a small posttest-only comparison can and cannot support.

## METHODS

This study used a posttest-only quasi-experimental design with a non-equivalent control group. The school has only two eighth-grade classes, with 32 students in total, so total sampling was applied, and both intact classes were used. One class (n = 16) was assigned to the experimental condition (conventional instruction supplemented by Nearpod) and the other (n = 16) to the control condition (conventional instruction only), based on the fixed school timetable; students were not grouped individually. The experimental and control classes met according to the school's existing timetable. The independent variable was instructional condition. The dependent variables were mathematical conceptual understanding, internal motivation, and external motivation. No pretest was administered, so the study compares outcomes after instruction and cannot establish change within either class. Both classes followed the same curriculum. Because the intervention was delivered at the class level, with one class per condition, differences between classes after instruction may reflect pre-existing class characteristics, such as prior achievement, class climate, or timetable, rather than Nearpod itself. Statistical tests that treat students as independent cannot remove this class-level confounding, so the inferential statistics reported below are interpreted cautiously.

The research instruments were Nearpod interactive media content on Number Patterns, a mathematics conceptual understanding test, and motivation questionnaires. Both classes studied Number Patterns, specifically focusing on arithmetic and geometric sequences. The instruction was delivered over three meetings (Table 1), with each meeting lasting 80 minutes, and both classes were taught by the same mathematics teacher. The control class received conventional instruction as practiced in the school, consisting of teacher explanation, examples, and exercises. This business-as-usual condition served as the comparison and is not presented as optimal. In the experimental class, the same lesson structure was retained, and Nearpod was used from the start to the end of each meeting. Nearpod activities included instructional slides, a video, multiple-choice and open-ended questions, and the game-like quiz Time to Climb (Figure 1). Students opened the Nearpod lesson through a link on their smartphones, and the teacher

 http://doi.org/10.30762/f_m.v9i2.9954

saw responses in real time. Before the first meeting, students were introduced to Nearpod through a teacher explanation and a brief simulation. After the final meeting, both classes completed the conceptual understanding test and the motivation questionnaire on paper. The classes were taught at different times according to the school schedule, but the Nearpod link remained active at all times so that students could review the material at home. No restriction on sharing the link or the materials is documented, so students in the control class could have opened the experimental materials; this was not controlled and is acknowledged as a limitation of the study. The control class was not asked to open the link. Contamination between classes and additional exposure to Nearpod outside the lessons therefore cannot be ruled out, and this is treated as a limitation.

**Table 1.** Research Procedure by Stage and Condition

| Stage | Experimental class (conventional instruction + Nearpod) | Control class (conventional instruction only) | Duration |
|---|---|---|---|
| Preparation | Nearpod lesson on number patterns prepared; instruments validated | Instruments validated | – |
| Orientation | Teacher's explanation and brief simulation of Nearpod | Regular lesson opening | 10min |
| Meeting 1 | Content: Number Patterns. Teacher-led lesson with Nearpod slides, video, and questions | Same content: teacher explanation, examples, and exercises | 80 min |
| Meeting 2 | Content: Arithmetic Sequences. Teacher-led lesson with Nearpod activities | Same content: teacher explanation, examples, and exercises | 80 min |
| Meeting 3 | Content: Geometric Sequences. Teacher-led lesson with Nearpod activities | Same content: teacher explanation, examples, and exercises | 80 min |
| Posttest | Conceptual understanding test and motivation questionnaire (paper) | Same instruments under the same conditions | 80 min |
| Analysis | MANOVA, then univariate ANOVAs, with Bonferroni sensitivity criterion | Same | – |

The mathematics conceptual understanding test consists of 5 essay questions related to the four indicators (Table 2). Each answer was scored from 0 to 3 using a scoring rubric, so the raw score ranged from 0 to 15, and totals were converted to a 0 to 100 scale for analysis.


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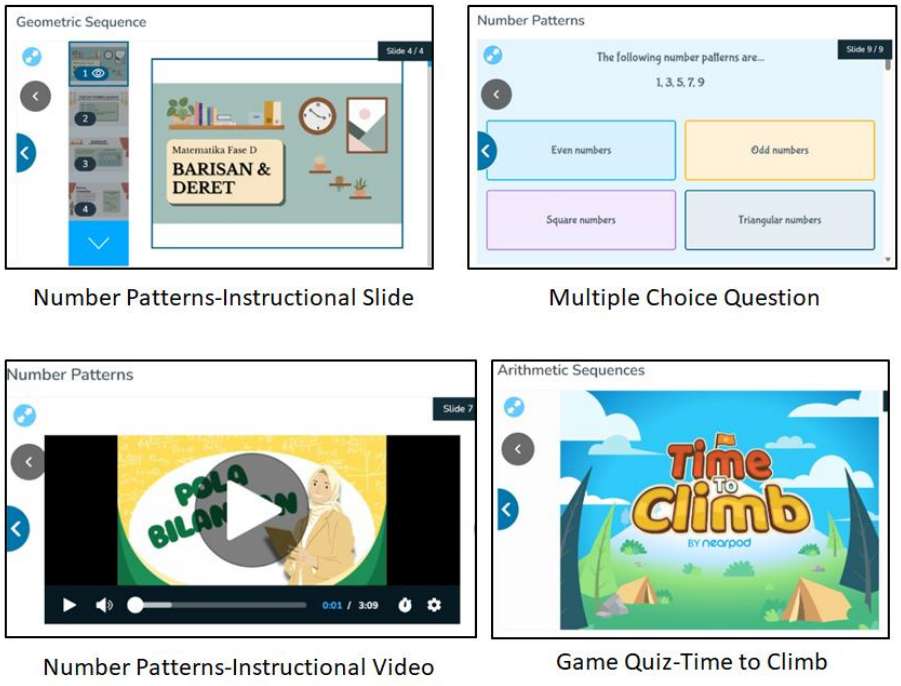


**Figure 1.** The Screenshot of Nearpod-Interactive Media

**Table 2.** Indicators of Conceptual Understanding, Operational Definitions, and Alignment with Nearpod Activities

| Indicator | Operational definition for number patterns | Example Nearpod activity | Test Item(s) |
|---|---|---|---|
| Restating a concept | States in own words what a number pattern is and how its rule works | Slides and video followed by a poll or short question | 1 |
| Classifying objects | Decides which type of pattern a given sequence represents and explains why | Multiple-choice classification item (Figure 1) | 2 |
| Giving examples and non-examples | Writes sequences that do and do not follow a given rule | Open-ended question or Draw It | 3 |
| Representing a concept in different forms | Moves between verbal rule, table, picture, and symbolic expression | Draw It and visual pattern slides | 4,5 |

The motivation questionnaires consist of 24 items. The items represent external motivation (12 items) and internal motivation (12 items). The questionnaires were developed based on the indicators in Deci and Ryan (1985) and Ryan and Deci (2020). The analysis used a Likert scale, converting students' responses into scores ranging from 1 to 4. For positive items, a score of 1 represents an answer of "never", a score of 2 represents an answer of "rarely", a score of 3 represents an answer of "often", and a score of 4 represents an answer of "always" and negatively worded items were reverse-scored. Each subscale total therefore ranged from 12 to 48.

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Before data collection, all instruments underwent validation. Content validity was conducted by two expert validators with expertise in mathematics education, both of whom are active associate professors at UIN Imam Bonjol Padang. The validators assessed whether the test items matched the learning objectives and indicators of conceptual understanding, whether the language was understandable, and whether the questionnaire statements were clear and consistent with the motivation indicators. No validity index, such as Aiken's V, was calculated; the judgments were qualitative comments. For the test, the validators advised aligning the items with the learning objectives and the conceptual understanding indicators. For the questionnaire, two validators had no suggestions and confirmed that the statements were understandable and matched the indicators.

Both instruments were then tried out on 21 eighth-grade students of another Islamic junior high school in Padang who were not part of the research sample. For the test, item analysis showed that all five items discriminated significantly between higher- and lower-scoring students and were of moderate difficulty (difficulty indices from 53.3% to 70%), so all items were retained. For the questionnaire (Field, 2018)Pearson item-total correlations (uncorrected correlations between each statement and the total score) ranged from 0.460 to 0.839. With N = 21, the critical value of r at the 0.05 level is 0.433 (df = 19), so all 24 statements were retained.

Internal consistency was measured with Cronbach's alpha. In the trial (N = 21), alpha was 0.59 for the test, which falls in the moderate band (0.40 to 0.60) of the criteria used in the trial analysis and below the conventional 0.70 benchmark, and 0.953 for the questionnaire as a whole, with 0.919 for the 12 internal and 0.898 for the 12 external motivation statements (computed from the trial data). The test alpha is reported as obtained. This is a substantial limitation: with five items, test scores contain considerable measurement error, which weakens the precision of the group comparison. Reliability is a separate issue from validity.

After learning with Nearpod, students are then given the mathematics conceptual understanding and motivation questionnaires. MANOVA was chosen because the three outcomes are conceptually related and were measured in the same students; it tests group differences jointly and limits the inflation of Type I error that arises from separate tests. Its limitations here are the small samples and the single class per condition. With

 http://doi.org/10.30762/f_m.v9i2.9954

16 students per class, each cell exceeded the number of dependent variables (3), the minimum recommended by Tabachnick and Fidell (2019), but power is low, and covariance estimates are unstable. Normality (Shapiro-Wilk, suited to small samples), homogeneity of variances (Levene's test), and homogeneity of covariance matrices (Box's M) were checked before the multivariate test. Pillai's Trace was used as the multivariate criterion because it is most robust to assumption violations (Tabachnick & Fidell, 2019). Pillai's Trace does not remove the consequences of non-normality or the limitations of the single-class design. Therefore, it is not considered to resolve all assumption violations. Univariate ANOVAs were then examined for each outcome. We computed partial eta squared and Cohen's d with 95% confidence intervals for the mean differences from the reported means, standard deviations, and mean squares. Because three follow-up tests were run, a Bonferroni-adjusted alpha of 0.017 (0.05 divided by 3) was applied as a sensitivity criterion alongside the conventional alpha of 0.05.

## RESULT AND DISCUSSION

This study involved 32 students divided into two groups: The Experimental Class (N=16, using Nearpod-based media) and the Control Class (N=16, without using Nearpod-based media). Three dependent variables were measured: Internal Motivation, External Motivation, and Mathematical Concept Understanding.

**Table 3.** Descriptive Statistics and Standardized Differences (n=16 per Class)

| Variable | Class | Mean | SD | Mean difference [95% CI] | Cohen's d |
|---|---|---|---|---|---|
| Internal Motivation (12-48) | Experimental | 39.69 | 5.003 | 1.25 [-2.11, 4.61] | 0.27 |
| | Control | 38.44 | 4.289 | | |
| External Motivation (12-48) | Experimental | 39.88 | 4.193 | 3.00 [0.33, 5.67] | 0.81 |
| | Control | 36.88 | 3.138 | | |
| Mathematics Conceptual Understanding (0-100) | Experimental | 80.38 | 13.028 | 11.25 [0.60, 21.90] | 0.76 |
| | Control | 69.13 | 16.280 | | |

Table 3 shows the posttest scores of the 32 students. The conceptual understanding score is on a 0-to-100 scale. Each motivation subscale total ranges from 12 to 48, and the observed means fall within this range. The experimental class scored

 http://doi.org/10.30762/f_m.v9i2.9954

higher than the control class on all three outcomes. These are observed differences between classes after instruction; without baseline data and with one class per condition, they cannot be interpreted as improvement or as demonstrated effects of Nearpod. The standard deviation shows how widely scores spread around the mean; the larger value in the control class for conceptual understanding (16.28 vs. 13.03) indicates greater variability in that class. The standardized differences were medium to large for conceptual understanding (d = 0.76) and external motivation (d = 0.81) and small for internal motivation (d = 0.27). The confidence intervals were wide, indicating limited precision with 16 students per class.

Before conducting the MANOVA, its prerequisite assumptions were tested. Normality was assessed with the Shapiro-Wilk test, which is suitable for small samples because each class had only 16 students. Homogeneity of variances was assessed with Levene's test (both results are shown in Table 4), and homogeneity of covariance matrices was assessed with Box's M test (Figure 2).

**Table 4.** Normality and Homogeneity of Variance Test

| Variable | Class | Shapiro-Wilk p | Levene's F(1, 30) | Levene's p |
|---|---|---|---|---|
| Internal Motivation | Experimental | 0.005 | 0.432 | 0.516 |
| | Control | 0.031 | | |
| External Motivation | Experimental | 0.211 | 3.768 | 0.062 |
| | Control | 0.062 | | |
| Mathematics Conceptual Understanding | Experimental | 0.411 | 2.015 | 0.166 |
| | Control | 0.149 | | |

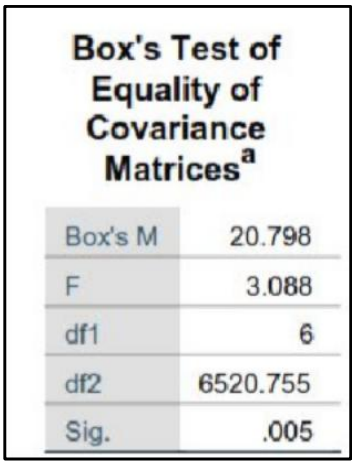


**Figure 2**. Box's M Test

 http://doi.org/10.30762/f_m.v9i2.9954

Based on Table 4, the Shapiro-Wilk test indicated that internal motivation scores were not normally distributed in either class (p = 0.005 and 0.031), which violates the normality assumption for this outcome. External motivation and conceptual understanding did not depart significantly from normality in either class. The non-normality of internal motivation scores must be acknowledged as a limitation when interpreting the MANOVA and univariate results for internal motivation; visual inspection of Q-Q plots, if used, does not override the Shapiro-Wilk results. Levene's tests were not significant for any outcome, although the result for external motivation (p = 0.062) was close to the threshold. However, Box's M (Figure 2) was significant at the 0.05 level, M = 20.798, F (6, 6520.755) = 3.088, p = 0.005, but not at the more conservative 0.001 level recommended for this sensitive test (Tabachnick & Fidell, 2019). Because the classes were of equal size, Pillai's Trace was used. No sensitivity analysis (for example, permutation or bootstrap) was conducted. The assumption problems are therefore not resolved by the use of Pillai's Trace; they are carried forward as limitations of the inferential results.

**Table 5.** Multivariate Test (Pillai's Trace)

| Effect | Pillai's V | F | Hypothesis df | Error df | p | Partial eta squared |
|---|---|---|---|---|---|---|
| Class | 0.217 | 2.585 | 3.000 | 28 | .073 | 0.217 |

The multivariate effect of class was not statistically significant at the 0.05 level (Table 5). The p-value of .073 is not interpreted as evidence of an effect; the multivariate effect size (V = 0.217) suggests a non-trivial joint difference that a sample of 32 may have been too small to detect.

To examine the post-intervention group differences of the Nearpod media treatment on each dependent variable separately, a Univariate ANOVA (Tests of Between-Subjects Effects) was used (Tabel 6).

**Table 6.** Tests of Between-Subjects Effects

| Outcome | Type III Sum of Squares | Df | Mean Square | F | Sig. | Bonferroni-adjusted p | Partial eta squared |
|---|---|---|---|---|---|---|---|
| Internal Motivation | 12.500 | 1 | 12.500 | 0.576 | 0.454 | 1.000 | 0.019 |
| External Motivation | 72.000 | 1 | 72.000 | 5.249 | 0.029 | 0.087 | 0.149 |
| Mathematical Conceptual Understanding | 1012.500 | 1 | 1012.500 | 4.658 | 0.039 | 0.117 | 0.134 |

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RQ1: The Nearpod class scored 11.25 points higher in conceptual understanding (d = 0.76). The unadjusted univariate test was significant, F(1, 30) = 4.658, p = 0.039, partial $\eta^2$ = 0.134, but it was not significant after Bonferroni adjustment (adjusted p = 0.117). The interval is wide, and its lower bound is close to zero, so the size of the difference is uncertain. RQ2: For internal motivation, the experimental and control classes did not differ significantly, F (1, 30) = 0.576, p = 0.454, partial $\eta^2$ = 0.019. Because internal motivation scores were not normally distributed, this result is interpreted with caution. For external motivation, the experimental class scored 3.00 points higher than the control class. The unadjusted test was significant, F (1, 30) = 5.249, p = 0.029, partial $\eta^2$ = 0.149, but it was not significant after Bonferroni adjustment (adjusted p = 0.087). RQ3: The multivariate test did not show a statistically significant joint difference between the classes, Pillai's Trace = 0.217, F (3, 28) = 2.585, p = 0.073. This non-significant result does not show that a joint difference exists. With 32 students and only one class per condition, the precision and the generalizability of the multivariate result are limited.

The multivariate and univariate results must be read together. The omnibus test was not significant, and the two univariate differences that were significant at 0.05 (conceptual understanding and external motivation) were not significant at the Bonferroni-adjusted level of 0.017. The univariate results are therefore exploratory. They describe where the observed differences between the two classes were largest; they do not establish that Nearpod improved conceptual understanding or motivation.

The two classes did not differ significantly on the three outcomes taken together. Unadjusted univariate tests favored the Nearpod class for conceptual understanding and external motivation but not for internal motivation, and neither favorable result survived correction for multiple tests. The groups were not shown to be equivalent before instruction, and there was one class per condition so that some observed differences may reflect pre-existing class characteristics. The following interpretation is therefore offered as a possible explanation, not an established effect.

In the experimental class, the lessons on arithmetic and geometric sequences were delivered through Nearpod slides, an instructional video, multiple-choice questions, and the game-like quiz Time to Climb. For example, students classified a given number sequence through a multiple-choice question (Figure 1), and the teacher could see their responses in real time. Students' responses during these activities were not recorded for

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analysis, so how students responded to each activity is unknown. Because only total test scores were analyzed, the findings cannot show which indicators of conceptual understanding were affected, and Nearpod is not claimed to enhance any single indicator. Theoretically, the activities used could relate to the indicators in Table 2: classification questions to classifying objects, slides and a video that present a rule in words and visual patterns to restating and representing a concept, and open-ended questions to giving examples and non-examples. These links are theoretical and are discussed below together with possible mechanisms.

The higher conceptual understanding scores in the Nearpod class, an exploratory finding that did not remain significant after Bonferroni adjustment, are directionally consistent with studies that link Nearpod to better achievement-related outcomes, such as academic performance in university mathematics courses (Carrillo-Yalán et al., 2023) and critical thinking in junior high school algebra (Kurniati et al., 2026). The comparison is indirect: neither study measured conceptual understanding, the first combined Nearpod with Blum modeling, and the second was a development study. The result also fits the broader view that interactive multimedia can support mathematical understanding (Sutomo & Turmudi, 2024). One possible explanation is that instant feedback after quiz items prompted students to re-examine their pattern rules. This parallels the observation that question-based scaffolding helped students correct errors arising from automatic, intuitive reasoning in number pattern problems (Firnanda & Susiswo, 2024), and it aligns with the general importance of feedback for learning (Hattie & Timperley, 2007). Whether this occurred in the present classes was not examined. Instruction that emphasizes memorization has been criticized for leaving understanding fragmented (Domu et al., 2022; Handayani & Anggraini, 2023); the value of a digital tool likely depends on whether its tasks target concepts rather than procedural drill. The result also fits the broader view that interactive multimedia can contribute to understanding in mathematics (Sutomo & Turmudi, 2024) and Indonesian studies that applied Nearpod to improve engagement, motivation, and mathematical ability (Pramesti & Camellia, 2024; Risky et al., 2023).

Three mechanisms may explain such a difference, but none was investigated in this study, so they remain theoretical possibilities. First, immediate feedback after quiz items may have prompted students to re-examine their pattern rules, which parallels the

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finding that question-based scaffolding helped students correct errors arising from automatic, intuitive reasoning in number pattern problems (Firnanda & Susiswo, 2024) and agrees with the general importance of feedback for learning (Hattie & Timperley, 2007). Second, combining slides, a video, and visual patterns may have helped students connect verbal rules with visual and symbolic representations (Sutomo & Turmudi, 2024). Third, repeated short question-and-response cycles may have increased active participation (Hakami, 2020). Instruction that emphasizes memorization has been criticized for leaving understanding fragmented (Domu et al., 2022; Handayani & Anggraini, 2023), so the value of a digital tool likely depends on whether its tasks target concepts rather than procedural drill.

External motivation in the Nearpod class was higher in the unadjusted comparison. In SDT terms, a possible explanation is that Time to Climb and immediate right-or-wrong feedback provided performance information and game-like incentives, which are largely external. Such feedback can support the need for competence when it is experienced as informative (Ryan & Deci, 2020). The external motivation subscale covers rewards in learning, interesting learning activities, and a conducive learning environment. Because Nearpod is designed to provide interesting activities and a lively environment, a higher score on this subscale may partly reflect the lesson format itself rather than a change in students' motivation to learn mathematics. If the teacher used the real-time responses to support individual students, which was not recorded, this could have made the learning environment feel more supportive and could relate to the need for relatedness (Niemiec & Ryan, 2009). Meta-analytic evidence suggests that gamification can have positive effects on learning outcomes, including motivational ones (Sailer & Homner, 2020)and similar patterns have been reported for Nearpod and other game-based media in elementary, social studies, and junior high school settings (Bintoro et al., 2024; Rahmadani & Khusna, 2026; Syaikhu et al., 2022). The difference in means did not remain significant after Bonferroni adjustment, meaning a difference of this size could plausibly arise by chance when three outcomes are tested. The result should therefore be treated as a hypothesis for replication.

Internal motivation did not differ significantly between the classes. This non-significant result should not be read as equivalence between the groups. The confidence interval (−2.11 to 4.61 points) is wide, and the estimate's precision is limited by the small

 http://doi.org/10.30762/f_m.v9i2.9954

sample, the single class per condition, and the non-normal distribution of internal motivation scores. Scores were also already high in both classes, at about 77% (experimental) and 73% (control) of the possible range of 12 to 48, which leaves little room for a difference. SDT predicts that intrinsic motivation depends on satisfying autonomy, competence, and relatedness over time (Niemiec & Ryan, 2009; Ryan & Deci, 2020). A short unit in which Nearpod mainly provides feedback and game-like challenge may not change these conditions. Gamification may also produce short-lived novelty effects, and a critical review concluded that evidence for its long-term benefits is insufficient (Dichev & Dicheva, 2017). Research on habit formation likewise indicates that new behaviors become automatic only after extended repetition (Lally et al., 2010). However, that evidence comes from outside education and is offered only as an analogy. Because autonomy, competence, and relatedness were not measured, the SDT mechanisms discussed here remain theoretical.

The findings are preliminary, but they suggest practical uses of Nearpod within number pattern lessons. Teachers can use students' real-time responses to identify errors in determining pattern rules, compare different representations of the same pattern, and provide feedback while the lesson is still in progress. Questions can be written to match specific indicators (restating, classifying, exemplifying, representing), and game-like quizzes can supplement the lesson rather than serve as its core. Nearpod supports learning; it is not a substitute for the teacher's pedagogical understanding and instructional design, which determine whether tasks target concepts rather than procedures (Handayani & Anggraini, 2023; Kilpatrick et al., 2001). Because internal motivation did not clearly differ, teachers who wish to foster it should pair the tool with practices that satisfy the needs described by SDT, such as letting students choose and justify solution strategies (autonomy), calibrating tasks so that students experience success on challenging items (competence), and building collaborative tasks (relatedness) (Niemiec & Ryan, 2009). They should do so over a longer period than the present unit. For researchers, the predominance of development studies in this area (Sutomo & Turmudi, 2024) shows a need for controlled evaluations of the media that are being developed.

Several limitations restrict the conclusions. The sample was small (N = 32) and drawn from one school, which limits power and generalizability to one grade level and

 http://doi.org/10.30762/f_m.v9i2.9954

one topic. The posttest-only design lacks a pretest, so it is not possible to confirm that the two classes had equivalent initial ability, and, because each condition was a single intact class, statistical tests conducted at the student level cannot eliminate confounding at the class level. Any difference associated with Nearpod therefore cannot be separated from class-level characteristics, and the MANOVA and univariate results should be interpreted with caution. Students in the same school could have shared the Nearpod link, and the link remained available at home, so contamination and additional exposure cannot be excluded. The conceptual understanding test had modest reliability (alpha = 0.59) and only five items, and the motivation questionnaire did not separate regulation types of extrinsic motivation or measure psychological need satisfaction. Non-normality of internal motivation scores and a significant Box's M at the .05 level call for caution, no sensitivity analysis was conducted, and the loss of significance after Bonferroni correction weakens the univariate results. The intervention was short, and novelty effects cannot be excluded.

Future studies should use pretest-posttest designs with random or matched assignment, larger and more diverse samples, and longer interventions with delayed posttests. They should validate longer concept tests with indicator-level reporting, measure autonomy, competence, and relatedness directly, separate regulation types of extrinsic motivation, and combine outcome data with classroom observation or student interviews to identify which Nearpod features support which outcomes.

## CONCLUSION

This study explored Nearpod as an interactive tool to support learning number patterns among junior high school students by comparing post-intervention outcomes between a class taught with Nearpod and a class taught with conventional instruction. Its contribution is specific. It examined Nearpod for the topic of number patterns at the junior high school level, assessed conceptual understanding alongside internal and external motivation as distinguished by Self-Determination Theory, and shows what a small posttest-only comparison can and cannot support. The joint difference was not significant, and the unadjusted univariate differences in conceptual understanding and external motivation did not remain significant after adjustment, so the study does not show that Nearpod enhances conceptual understanding or motivation. It suggests, as a

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hypothesis for further testing, that Nearpod may be a useful supplement in number pattern lessons when teachers use real-time responses to identify and correct errors in pattern rules, and that fostering intrinsic motivation likely requires longer instruction that supports autonomy, competence, and relatedness.

The conclusions are limited by the small sample from a single school, the posttest-only design without a pretest, which prevents confirmation of equivalent initial ability, the assignment of one class to each condition, the limited reliability of the conceptual understanding test (alpha = 0.59), and the operationalization of motivation, which does not capture the full complexity of the SDT construct. Future research should use pretest-posttest designs with several classes per condition and random or matched assignment, larger samples, and longer interventions. It should directly measure psychological need satisfaction and indicator-level learning outcomes.

## ACKNOWLEDGMENTS

The authors thank the expert validators from UIN Imam Bonjol Padang for their valuable input on the research instruments, as well as the school and students who participated in this study.

## FUNDING STATEMENT

This work received no specific grant from any public, commercial, or not-for-profit funding agency.

## AUTHOR CONTRIBUTIONS

**First Author:** Conceptualization, writing - original draft, editing, and visualization;

**Second Author:** Writing - review and editing, formal analysis, and methodology;

**Third Author:** Data collection, framework, conceptualization.

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**Conflict of Interest Statement**: The authors declare that the research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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