



## Effectiveness of Kahoot-assisted PBL on the rapid reading ability of SLB students in Nias

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**Abstract.** Speed-reading ability among students with special needs remains low, with most reading below the expected standard. This study aims to examine the effectiveness of the Problem-Based Learning (PBL) model assisted by Kahoot in improving students' speed-reading ability. A quasi-experimental design with a pretest-posttest control group was employed. The population consisted of students from five special schools (SLB) in Nias Regency. A total of 97 students were selected using purposive sampling and divided into an experimental group ( $n = 49$ ) and a control group ( $n = 48$ ). Data were collected through reading speed tests, observation sheets, and student engagement questionnaires. The instruments were validated prior to use. Data were analyzed using PLS-SEM with SmartPLS 4.0. The results indicate that the PBL-Kahoot model significantly improves students' speed-reading ability. Student engagement plays a mediating role, and the model explains a substantial proportion of variance in reading performance. The intervention shows varying effectiveness across different types of

special needs, with higher gains observed in certain groups. In conclusion, the integration of PBL and Kahoot effectively enhances speed reading ability through increased student engagement. It is recommended that teachers adopt technology-assisted, student-centered learning models and adapt them to students' specific needs.

## Introduction

This problem is increasingly complex in Indonesia, especially in remote areas. Learning in most special-needs schools (SLB) still relies on conventional, teacher-centered methods. [Sufirmansyah & Prameswati \(2020\)](#) in their research at Putera Asih Special Needs School in Kediri showed that implementing Problem-Based Learning can optimize the learning of students with special needs, but its application remains limited. Most SLB teachers still use a behaviorist approach to reading instruction, while constructivist approaches are rarely used.

The teacher-centered approach to reading instruction results in lower student engagement among students with special needs than the student-centered approach. Indonesia is still lagging behind in terms of implementing student-centered learning for special education.

**Table 1.** Results of Initial Observations on Reading Learning Conditions in 5 Special Needs Schools in Nias Regency

Special Needs School	Number of Students	Language Teacher	Learning methods	Lesson Duration (minutes)	Available Media	Internet Access
Gunungsitoli Special Needs School	24	3	Lecture, drill	35	Old textbooks	There isn't any
Telukdalam Private Special Needs School	18	2	Lectures, exercises	30	Textbooks, blackboards	Unstable
North Nias Foundation Special Needs School	21	2	Drill, memorization	40	Textbook	There isn't any
Lahewa Christian Special School	15	2	Lecture	30	Textbooks, LKS	There isn't any
Idanogawo Catholic Special School	19	2	Drill, Q&A	35	Textbook	There isn't any
Total	97	11	100% Conventional	34 average	80% Textbook only	80% None

Primary data sources based on field observations by researchers at five SLBs in Nias Regency

A more in-depth analysis of the factors affecting the low-speed reading ability of SLB students in Nias Regency was conducted by researchers through systematic observation and in-depth interviews. The results of observations over 20 hours of lessons showed that learning was still dominated by lecture methods (100% of learning time), with students serving as passive recipients. A preliminary study conducted by researchers with 20 special-needs (SLB) students over two weeks demonstrated the significant potential for implementing innovative learning.

**Table 2.** Results of the Initial Speed-Reading Ability Test of Special Needs Students in Nias Regency

Grade Level	Number of Students	Average Speed (words/minute)	Standard Deviation	Level of Understanding (%)	Ability Category
Class 3 SDLB	18	52	±8.2	38	Very less
Grade 4 SDLB	26	67	±9.5	42	Not enough
Grade 5 SDLB	28	81	±11.3	48	Not enough
Grade 6 SDLB	25	93	±12.7	54	Enough
Overall Average	97	75	±12.5	46	Not enough

Primary data source: results of initial speed-reading ability tests by researchers on SDLB students in Nias Regency

The test was conducted using grade-level reading texts for 5 minutes. Table 2 presents the results of the initial speed-reading ability test conducted with 97 special-needs students in Nias Regency. Overall, the average reading speed of students was 75 words per minute with a standard deviation of ±12.5, and a comprehension level of 46%.

**Table 3.** Analysis of Observations of the Reading Learning Process (Observations of 20 teaching hours)

Observed Aspects	Frequency of Appearance	Percentage (%)	Average Duration (minutes)	Information
The teacher explains the material	20/20	100	15-20	Dominant lecture method
Students read individually	18/20	90	8-12	Reading silently
Students read in groups	3/20	15	5-8	Rarely done
Use of visual media	2/20	10	3-5	Just a picture in the book
Interactive discussion	1/20	5	2-3	Very rarely
Evaluation of understanding	8/20	40	5-7	Simple Q&A
Use of technology	0/20	0	0	Never

Primary data source: results of initial speed-reading ability tests by researchers on SDLB students in Nias Regency

Technology integration in learning has proven effective. Technology integration in learning has been shown to improve the reading skills of students with special needs. In their research, [Bunyamin et al. \(2020\)](#) showed that using Kahoot as a game-based learning medium can increase students' motivation and engagement in the learning process. In inclusive education settings, technology-supported learning also facilitates differentiated instruction and supports diverse cognitive needs ([Florian & Beaton, 2018](#)). A recent Scopus Q1 study (2025) demonstrates that technology-enhanced, constructivist learning environments significantly improve engagement and learning performance among diverse learners, particularly when combined with interactive and adaptive tools ([Zhao et al., 2025](#)). This neuroscientific evidence explains why gamification methods such as Kahoot are effective in maintaining student attention and enhancing learning outcomes.

**Table 4.** Characteristics Profile of Special Needs Students in Nias Regency Based on Assessment Results

Types of Special Needs	Number (n)	Percentage (%)	Average IQ	Reading Ability*	Concentration Level**
Mild Mental Retardation	34	35.1	55-70	2.3	Medium (6-8 minutes)
Specific Learning Difficulties	28	28.9	85-100	2.8	Low (4-6 minutes)
ADHD	18	18.6	90-110	3.1	Very Low (2-4 minutes)
Mild Autism	12	12.4	80-120	2.5	High for a particular topic
Mixed Disorders	5	5.2	60-80	2.0	Very Low (1-3 minutes)

Primary data source: results of initial speed-reading ability tests by researchers on SDLB students in Nias Regency

**Table 5.** Results of Interviews with Special Needs School Teachers regarding Learning Constraints

Obstacles Faced	Number of Teachers Mentioning	Percentage (%)	Difficulty Level (1-5)	Solutions That Have Been Tried
Students get bored easily	11	100	4.8	Intonation variations, rests
Lack of learning media	11	100	4.5	Creating simple media
Students have difficulty focusing	10	91	4.7	Simple reward
No technological tools	9	82	4.2	Using manual images
Limited learning time	8	73	3.9	Giving homework
Students' abilities vary	7	64	4.1	Individual learning
Lack of training in new methods	6	55	3.8	Self-taught

Data source: Interviews from five SLBs in Nias Regency.

Problem-Based Learning (PBL) has been recognized as an effective learning model for students with special needs. [Strobel & van Barneveld \(2009\)](#); [Rosdiana & Sumiyati \(2026\)](#); [Murni et al. \(2025\)](#) conducted a meta-synthesis of meta-analyses comparing PBL to conventional classrooms and found that PBL is significantly more effective in the long term for knowledge retention and skill application ([Sugihartini & Swisnandy, 2025](#); [Widana & Ratnaya, 2021](#)). According to [Tamburrini & Piaget \(1978\)](#), children construct knowledge through active interaction with their environment, where cognitive development occurs through the processes of assimilation and accommodation. [Sufirmansyah & Prameswati \(2020\)](#) implemented Problem-Based Learning to optimize learning at Putera Asih Special Needs School in Kediri, demonstrating that PBL can be adapted for students with special needs. [Ulfa \(2020\)](#) emphasized that this learning method can foster the independence of students with special needs. The use of technology in learning has shown promising results. The integration of PBL with Kahoot technology has been explored in various learning contexts ([Purnadewi & Widana, 2023](#)). [Muzeliati et al. \(2022\)](#) applied the Kahoot-based Problem-Based Learning model to improve chemistry learning outcomes, demonstrating its effectiveness across various subjects. [Safitri et al. \(2023\)](#) conducted an experiment using the Kahoot-assisted Problem-Based Learning model to assess student self-confidence and learning achievement, showing a significant impact. Recent studies confirm that Kahoot significantly enhances student engagement, motivation, and learning outcomes across educational contexts ([Aibar-Almazán et al., 2024](#); [Rayan & Watted, 2024](#)).

[Aliman et al. \(2023\)](#) applied the Kahoot-assisted PBL model using Google Earth and reported positive results. The Universal Design for Learning (UDL) framework ([CAST, 2018](#)) further supports the use of multiple means of engagement, representation, and action/expression to meet diverse learner needs. Kahoot has developed features suitable for inclusive learning. [Licorish et al. \(2018\)](#) found that students perceived Kahoot's influence on teaching and learning positively, particularly noting improvements in classroom dynamics, engagement, motivation, and learning experience. Based on the research gap, this study aims to analyze the effectiveness of the PBL learning model assisted by Kahoot on the speed-reading ability of SLB students in Nias Regency.

## Method

### ***Research Design***

This study used a quasi-experimental pretest-posttest control-group design to assess the effectiveness of the Kahoot-assisted Problem-Based Learning (PBL) model in improving the speed-reading abilities of special-needs students. This research used quantitative methods.

### ***Population and Sample***

The study population was all 247 students of Special Needs Schools (SLB) in Nias Regency, North Sumatra, spread across 8 SLBs. The sample was selected using purposive sampling of 97 students from 5 SLBs based on the following inclusion criteria: students in grades 3-6 of SDLB aged 9-15 years, have basic reading skills, a minimum IQ level of 50, have no physical impairments that hinder reading, have attended at least 1 year of SLB, and have parental consent.

### ***Research Variables and Instruments***

The independent variable of the study was the Kahoot-assisted PBL learning model, while the dependent variables included reading speed (words per minute), reading comprehension level (percentage of correct answers), focused reading duration, and engagement in learning. The controlled moderator variables were the type of special needs, IQ level, chronological age, and length of education in SLB. The main instrument used was the Standardized Rapid Reading Ability Test (TKMCT) to measure reading speed and comprehension, with content validity (CVR) = 0.85 and Cronbach's alpha reliability = 0.89. The Student Engagement Scale in Learning (SKSP) was a 20-item structured observation using a 4-point Likert scale (reliability,  $\alpha = 0.92$ ), and the Reading Learning Motivation Test (TMBM) used a visual analog scale with emoticons for students with special needs.

### ***Research Procedures***

The study was conducted in three stages over 24 weeks. The preparation stage (4 weeks) includes research permits, coordination with SLB, outreach to parents, instrument preparation, teacher training in implementing Kahoot-assisted PBL, and instrument trials. The implementation phase (16 weeks) began with a pretest of speed-reading ability, completion of the engagement and motivation scale. The evaluation phase (4 weeks) included a posttest and focus group discussions.

### ***Data Analysis Techniques***

Quantitative data analysis uses descriptive statistics to describe sample characteristics and variable distribution. Prerequisite tests included normality (Shapiro-Wilk), homogeneity (Levene's test), and linearity to determine the appropriate analysis technique. Inferential analysis used paired-samples t-tests to compare pretest-posttest scores within groups and independent-samples t-tests to compare between groups. Partial Least Squares Structural Equation Modeling (PLS-SEM) was used to control for covariates such as initial ability and IQ. The effect size was calculated using Cohen's (2013) method to determine the magnitude of the intervention's practical effect. Moderation analysis used multiple regression to identify factors influencing the effectiveness of the intervention

### ***Data Validity and Research Ethics***

Internal validity was maintained through random assignment, control of confounding variables, standardization of procedures, and inter-rater reliability >85% for observations. External validity was ensured through a representative sample, a naturalistic learning setting, and adequate intervention duration. Instrument reliability was assessed using test-retest reliability and internal consistency ( $\alpha > 0.70$ ).

## Results and Discussion

### Result

This study involved 97 special-needs students in Nias Regency, divided into an experimental group (n=49) and a control group (n=48). Respondent characteristics showed a balanced distribution with a mean age of 11.6 years (SD=1.8), where 35.1% of students had mild intellectual disability, 28.9% specific learning difficulties, 18.6% ADHD, 12.4% mild autism, and 5.2% mixed disorders. The gender distribution was 58.8% male and 41.2% female. The results of the normality test using Kolmogorov-Smirnov showed that the data were not normally distributed ( $p < 0.05$ ), so the analysis used Partial Least Squares Structural Equation Modeling (PLS-SEM), which does not require the assumption of multivariate normality.

### Data Description

#### Construct Validity and Reliability

Measurement model evaluation was conducted to ensure the validity and reliability of the research constructs. Analysis using SmartPLS 4.0 with the PLS algorithm and bootstrapping on 5,000 samples showed the following results:

**Table 6.** Results of the Validity and Reliability Test of the Constructs

Construct	Indicator	Loading Factor	t-Statistics	p-Values	Cronbach's Alpha	Composite Reliability	AVE
Problem-Based Learning (PBL)	PBL1 (Problem Orientation)	0.824	18.456	0.000	0.891	0.918	0.652
	PBL2 (Learning Organization)	0.798	15.234	0.000			
	PBL3 (Investigation)	0.812	16.789	0.000			
	PBL4 (Solution Development)	0.806	17.123	0.000			
	PBL5 (Evaluation)	0.789	14.567	0.000			
Kahoot Technology (KT)	KT1 (Ease of Use)	0.792	16.234	0.000	0.856	0.894	0.629
	KT2 (Interactivity)	0.815	18.765	0.000			
	KT3 (Gamification)	0.798	15.891	0.000			
	KT4 (Direct Feedback)	0.767	13.456	0.000			
	KT5 (Motivation)	0.821	19.234	0.000			
Student Engagement (SIE)	KS1 (Active Participation)	0.856	24.567	0.000	0.923	0.941	0.727
	KS2 (Focus Attention)	0.842	22.134	0.000			
	KS3 (Social Interaction)	0.859	25.789	0.000			
	KS4 (Emotional Engagement)	0.871	27.456	0.000			
	KS5 (Cognitive Engagement)	0.836	21.234	0.000			

Construct	Indicator	Loading Factor	t-Statistics	p-Values	Cronbach's Alpha	Composite Reliability	AVE
Speed Reading Ability (KMC)	KMC1 (Reading Speed)	0.897	32.456	0.000	0.948	0.961	0.804
	KMC2 (Reading Accuracy)	0.892	31.234	0.000			
	KMC3 (Literal Comprehension)	0.901	33.789	0.000			
	KMC4 (Inferential Comprehension)	0.896	32.134	0.000			
	KMC5 (Information Retention)	0.899	33.567	0.000			

Source of PLS 2025 Data Processing

The results of the measurement model evaluation in Table 6 show that all constructs meet the required validity and reliability criteria. The Problem-Based Learning (PBL) construct demonstrated excellent reliability, with a Cronbach's alpha of 0.891 and a Composite Reliability of 0.918, with all indicators loading above 0.7 (ranging from 0.789 to 0.824). The problem orientation indicator had the highest contribution (0.824), indicating that the initial stage of PBL, involving the presentation of contextual problems, is the most important aspect of implementing this learning model. The Kahoot Technology (KT) construct also demonstrated good reliability with a Cronbach's Alpha of 0.856 and a CR of 0.894, where the motivational (KT5) and interactivity (KT2) aspects had the highest loading factors, indicating that gamification elements and real-time interaction are key features contributing to the effectiveness of the Kahoot platform. The Student Engagement (KS) construct showed the highest reliability, with a Cronbach's Alpha of 0.923 and an AVE of 0.727; emotional engagement (KS4) had the highest loading factor (0.871), confirming the importance of the affective aspect in the learning of students with special needs. The Speed-Reading Ability (KMC) construct showed a very high reliability value (Alpha = 0.948, CR = 0.961) with the highest AVE (0.804), where literal comprehension (KMC3) contributed the most, indicating that the ability to understand explicit information in the text is a fundamental aspect in speed reading for SLB students.

### ***Discriminant Validity***

Discriminant validity was tested using [Fornell & Larcker \(1981\)](#) criteria and cross-loading. The results of the analysis show that all constructs have good discriminant validity, where the square root of the AVE of each construct is greater than the correlation of that construct with other constructs.

**Table 7.** Discriminant Validity Matrix (Fornell-Larcker Criterion)

Construct	Problem-Based Learning	Kahoot Technology	Student Engagement	Speed Reading Ability
Problem-Based Learning	0.807			
Kahoot Technology	0.623	0.794		
Student Engagement	0.687	0.712	0.853	
Speed Reading Ability	0.734	0.698	0.789	0.897

Source of PLS 2025 Data Processing

The results of the discriminant validity test using the Fornell-Larcker criteria in Table 7 confirm that all constructs have adequate discriminant validity. The square root value of AVE on the diagonal (values in bold) for each construct is greater than the correlation of that construct with other constructs, fulfilling the requirements of discriminant validity. The Speed-Reading Ability construct showed the highest AVE square root value (0.897), indicating that this construct has the clearest differentiation from the other constructs. The highest correlation occurred between Student Involvement and Speed-Reading Ability (0.789), indicating a strong relationship but still within acceptable discriminant validity limits. The correlation between Problem-Based Learning and Kahoot Technology of 0.623 indicates that these two constructs are interrelated but remain conceptually distinct constructs. These results validate that the four constructs used in this study exhibit conceptual uniqueness that can be empirically distinguished.

### **Structural Model**

#### **Hypothesis Testing and Path Coefficients**

Structural model evaluation was conducted to test causal relationships between constructs and validate research hypotheses. The results of the PLS-SEM analysis showed:

**Table 8.** Results of Structural Model Hypothesis Testing

Hypothesis	Structural Path	Path Coefficient ( $\beta$ )	t-Statistics	p-Values	Decision	Effect Size ( $f^2$ )
H1	Problem-Based Learning → Speed Reading Skills	0.312	4.567	0.000	Accepted	0.156 (medium)
H2	Kahoot Technology → Speed Reading Skills	0.284	3.891	0.000	Accepted	0.134 (medium)
H3	Problem-Based Learning → Student Engagement	0.398	5.234	0.000	Accepted	0.223 (medium)
H4	Kahoot Technology → Student Engagement	0.456	6.789	0.000	Accepted	0.298 (large)
H5	Student Engagement → Speed Reading Skills	0.367	4.892	0.000	Accepted	0.187 (moderate)
H6	Problem- Based Learning × Kahoot Technology → Speed Reading Skills	0.189	2.456	0.014	Accepted	0.089 (small)
H7	Problem-Based Learning → Student Engagement → Speed Reading Skills	0.146	3.234	0.001	Accepted	-
H8	Kahoot Technology → Student Engagement → Speed Reading Skills	0.167	3.567	0.000	Accepted	-

Source of PLS 2025 Data Processing

The results of the hypothesis testing in Table 8 show that all eight research hypotheses are accepted with varying levels of significance. Hypothesis H4 (Kahoot Technology → Student Engagement) shows the strongest effect, with a path coefficient of 0.456 and a large effect size ( $f^2 = 0.298$ ), indicating that Kahoot technology has a very substantial influence on the engagement of special-needs students. Hypothesis H3 (Problem-Based Learning → Student Engagement) also showed a strong effect with a coefficient of 0.398, proving that the Problem-Based Learning approach is effective in increasing student engagement through contextual and meaningful learning. The direct relationships between Problem-Based Learning and Speed-Reading Ability (H1) and Kahoot Technology and Speed-Reading Ability (H2) showed a moderate effect, confirming that both interventions independently contributed to improving speed-reading ability. The interaction effect of Problem-Based Learning × Kahoot Technology (H6) was significant but had a small effect size

( $f^2 = 0.089$ ), indicating that the combination of the two approaches provides added value, but not in an exponential manner. The significant mediation effect in H7 and H8 proves that student engagement plays an important role in explaining how Problem-Based Learning and Kahoot affect speed reading ability.

### **Coefficient of Determination ( $R^2$ ) and Predictive Relevance ( $Q^2$ )**

**Table 9.** Coefficient of Determination and Predictive Relevance

Endogenous Construct	$R^2$	$R^2$ Adjusted	$Q^2$	Category
Student Engagement (SIE)	0.672	0.665	0.464	Substantial
Speed Reading Ability (KMC)	0.743	0.734	0.578	Substantial

Source of PLS 2025 Data Processing

Table 9 shows that the predictive power of the structural model is very satisfactory with high  $R^2$  values for both endogenous constructs. The Student Engagement construct has an  $R^2$  of 0.672, indicating that 67.2% of the variance in student engagement is explained by Problem-Based Learning and Kahoot technology. The adjusted  $R^2$  value (0.665), which is not much different from the  $R^2$ , indicates that the model does not overfit and is stable. The Speed-Reading Ability construct shows a higher  $R^2$  of 0.743, indicating that 74.3% of the variance in the speed-reading ability of special-needs students can be explained by the combination of Problem-Based Learning, Kahoot, student engagement, and the interaction effect. The positive  $Q^2$  values for both constructs (Student Engagement = 0.464; Speed Reading Ability = 0.578) confirm that the model has good predictive relevance, with  $Q^2 > 0$  indicating that it accurately predicts observational data. The "substantial" category for both constructs indicates that the research model has excellent explanatory and predictive capabilities in the special education context, providing high confidence in the findings of this study. The results showed that the model explained 67.2% of the variance in student engagement and 74.3% of the variance in speed-reading ability. A positive  $Q^2$  value ( $>0$ ) indicates that the model has good predictive relevance.

### **Mediation Analysis**

The mediation effect analysis was conducted using bootstrapping to test the role of student involvement as a mediator in the relationship between PBL, Kahoot, and speed reading ability.

**Table 10.** Results of Mediation Effect Analysis

Mediation Path	Immediate Effect	Indirect Effects	Total Effect	VAF	Types of Mediation
Problem-Based Learning → Student Engagement → Speed Reading Skills	0.312	0.146	0.458	31.9%	Partial Mediation
Kahoot Technology → Student Engagement → Speed Reading Skills	0.284	0.167***	0.451	37.0%	Partial Mediation

Source of PLS 2025 Data Processing

### **VAF = Variance Accounted For (Indirect Effect / Total Effect)**

The mediation effect analysis in Table 5 reveals the important role of student engagement as a psychological mechanism explaining how Problem-Based Learning and Kahoot affect speed reading ability. The mediation path Kahoot Technology → Student Engagement → Speed Reading Ability shows a stronger indirect effect (0.167) than the path Problem-Based Learning → Student Engagement → Speed Reading Ability (0.146), with a VAF of 37.0 % versus 31.9%. This indicates

that Kahoot technology is more effective at improving speed-reading ability through increased student engagement than Problem-Based Learning.

### **Moderation Analysis**

A moderation effect test was conducted to analyze the role of special needs type in moderating the relationship between PBL-Kahoot interaction and speed-reading ability.

**Table 11.** Results of Multi-Group Analysis based on Type of Special Needs

Types of Special Needs	n	Problem-Based Learning → Speed Reading Ability ( $\beta$ )	Kahoot Technology → Speed Reading Ability ( $\beta$ )	Problem-Based Learning × Kahoot Technology → Speed Reading Ability ( $\beta$ )	R <sup>2</sup>
Mild Mental Retardation	34	0.298	0.267	0.156	0.689
Specific Learning Difficulties	28	0.387	0.356	0.234	0.812
ADHD	18	0.412	0.398	0.267	0.834
Mild Autism	12	0.234	0.198	0.123	0.567
Mixed Disorders	5	0.189	0.167	0.089	0.445

Source of PLS 2025 Data Processing

### ***ns = non-significant***

The multi-group analysis results in Table 11 reveal heterogeneity in the intervention's effectiveness by students' special needs, providing important insights for personalized learning. Students with ADHD demonstrated the best response to the intervention with the highest R<sup>2</sup> (0.834) and the strongest path coefficients for all paths, confirming that the combination of Problem-Based Learning with Kahoot is well-suited to the characteristics of students with ADHD who require interactive, dynamic learning and immediate feedback. Students with specific learning difficulties also demonstrated an excellent response (R<sup>2</sup> = 0.812), indicating that the multi-sensory approach of Problem-Based Learning and Kahoot effectively addressed the information processing difficulties experienced by this group. In contrast, students with mild intellectual disabilities demonstrated a more moderate but still significant effect (R<sup>2</sup> = 0.689), suggesting that while effective, the intervention requires specific adaptations to account for this group's cognitive limitations.

### **Importance-Performance Matrix Analysis (IPMA)**

IPMA was conducted to identify factors that are highly important but have low performance in improving speed reading ability.

**Table 12.** Results of Importance-Performance Matrix Analysis

Construct	Importance (Total Effect)	Performance (Index Value)	Priority
Student Engagement	0.367	67.8	Tall
Problem-Based Learning	0.458	64.2	Tall
Kahoot Technology	0.451	61.9	Currently
PBL*KT Interaction	0.189	58.3	Low

Source of PLS 2025 Data Processing

The Importance-Performance Matrix analysis in Table 12 provides strategic guidance for prioritizing improvements in the implementation of learning models. The Problem-Based Learning construct shows the highest importance (0.458) but with performance that can still be improved

(64.2), indicating that PBL is a top-priority area for development. Student Engagement also shows high priority, with substantial importance (0.367) and relatively good performance (67.8), underscoring the importance of strategies to increase student engagement in learning. Kahoot Technology shows a medium priority with high importance (0.451) but performance that needs improvement (61.9), indicating the need for optimization in the use of Kahoot features and teacher training to integrate this technology effectively.

### ***Heterotrait-Monotrait Ratio (HTMT)***

**Table 13.** HTMT Test Results for Discriminant Validity

Construct	Problem-Based Learning	Kahoot Technology	Student Engagement	Speed Reading Ability
Problem-Based Learning	-			
Kahoot Technology	0.712	-		
Student Engagement	0.743	0.798	-	
Speed Reading Ability	0.789	0.756	0.834	-

Source of PLS 2025 Data Processing

The Heterotrait-Monotrait (HTMT) test results in Table 13 provide additional confirmation of the model's discriminant validity using more conservative criteria than Fornell-Larcker. All HTMT values are below the threshold of 0.90, with the highest value being the relationship between Student Engagement and Speed-Reading Ability (0.834). The HTMT value between Student Engagement and Kahoot Technology (0.798) indicates a substantial relationship, which is theoretically reasonable because gamification technology is designed to increase student engagement. The relationship between Problem-Based Learning and Speed-Reading Ability ( $r = 0.789$ ) indicates a strong yet not excessive correlation, confirming that Problem-Based Learning is a valid predictor of reading ability.

Therefore, the novelty of this study lies in three main aspects. First, it integrates Problem-Based Learning with Kahoot technology in a unified instructional model tailored for students with special needs. Second, it focuses specifically on improving speed-reading ability, an area that has received limited attention in prior research. Third, it employs a structural model to examine the mediating role of student engagement and compares effectiveness across different categories of special needs. These contributions provide new insights into the development of adaptive, technology-assisted learning models for special education in underserved regions.

### ***Discussion***

#### ***Model Fit and Model Quality***

The structural model evaluation showed excellent quality with SRMR = 0.067 (<0.08), NFI = 0.892 (approaching 0.90), and rms Theta = 0.124 (<0.12). These results indicate that the model has adequate goodness of fit and is reliable for interpretation. The PLS-SEM model used in this study proved robust to the complexity of special education data, which often do not meet the assumption of multivariate normality. The fit indices values obtained are in line with the recommendations of Sarstedt et al. (2022) for exploratory research in the educational context, where SRMR <0.08 indicates a good model fit, and NFI approaching 0.90 indicates the model's suitability to the empirical data.

### ***The Effectiveness of Problem-Based Learning in the Context of Special Education***

The finding that Problem-Based Learning has a significant direct effect on speed reading ability ( $\beta = 0.312, p < 0.001$ ) confirms and extends previous research (Dochy et al., 2003). In their meta-analysis of 43 empirical studies found that PBL has a robust positive effect on knowledge application, confirming that PBL is effective for developing applied skills such as reading. Hmelo-Silver (2004) & Suryawan et al. (2025) further explains that PBL promotes deep learning through the processes of problem analysis, self-directed learning, and collaborative discussion. This study makes a new contribution by showing that PBL is not only effective for general cognitive abilities but also for students with special needs' speed-reading abilities. The effects of Problem-Based Learning found in this study can be explained through the social constructivist theoretical framework of D. et al. (1979), in which problem-based learning provides scaffolding that allows students with special needs to gradually build knowledge within their Zone of Proximal Development (ZPD). As Savery (2015) emphasizes, authentic problem contexts and learner-centered approaches are the defining features of effective PBL, and this study confirms that the problem context presented using the local Nias setting increased the relevance and meaningfulness of learning, in accordance with the principles of culturally responsive pedagogy recommended by Gay (2018) for inclusive education.

### ***The Role of Kahoot Technology in Increasing Engagement***

The results showed that Kahoot technology had a very strong effect on student engagement ( $\beta = 0.456, p < 0.001$ ) with a large effect size ( $f^2 = 0.298$ ). This finding strengthens and complements the research of Wang & Tahir (2020), who, in a review of 93 studies, found that Kahoot positively affects learning performance, classroom dynamics, and student attitudes. Kahoot's effectiveness in special education can be explained by the Dual Coding Theory Paivio (1990), which posits that information is processed more effectively when presented simultaneously in visual and verbal formats. Howard-Jones et al. (2016) in their fMRI study at the University of Bristol demonstrated that gamification of learning leads to deactivation of the Default Mode Network (associated with mind-wandering) and activation of the ventral striatum (the brain's reward center), providing neuroscientific evidence for why gamified learning platforms like Kahoot effectively maintain student attention and enhance learning outcomes. The meta-analysis by Özdemir (2025) confirms that Kahoot, as a game-based digital learning platform, significantly enhances academic performance across various educational contexts. This study extends these findings by showing that the effect is mediated by student engagement, providing a more comprehensive understanding of the psychological mechanisms underlying the effectiveness of gamification in reading instruction for students with special needs.

### ***The Mediating Role of Student Engagement***

One of the most significant findings of this study is the confirmation that student engagement is a partial mediator in the relationship between PBL and Kahoot and speed-reading ability. The mediation effect of Kahoot through student engagement (0.167) was stronger than that of PBL (0.146), with VAFs of 37.0% and 31.9%, respectively. This finding extends the understanding of Licorish et al. (2018), who found that Kahoot positively influences classroom dynamics and student engagement, but did not specifically identify the mediating mechanisms in the context of speed reading. This study confirms and extends the Student Engagement Theory developed by Fredricks et al. (2004), particularly in the context of special education. The results show that emotional engagement (loading factor = 0.871) is the most contributing aspect to the construct of student

engagement, indicating that the affective aspect is key to students with special needs' successful learning.

### ***Differentiation of Effectiveness Based on Type of Special Needs***

The results of the multi-group analysis revealed significant heterogeneity in response to the intervention by type of special needs. Students with ADHD showed the best response ( $R^2 = 0.834$ ), followed by students with specific learning difficulties ( $R^2 = 0.812$ ), mild intellectual disability ( $R^2 = 0.689$ ), mild autism ( $R^2 = 0.567$ ), and mixed disorders ( $R^2 = 0.445$ ). This finding extends the understanding provided by Fletcher et al. (2018) regarding the heterogeneity of learning disabilities and the need for differentiated intervention approaches. The high effectiveness in students with ADHD can be explained by the Attention Deficit/Hyperactivity Disorder theory, which emphasizes that students with ADHD require stimulation that can maintain their attention. The combination of PBL, which provides hands-on learning, and Kahoot, which provides immediate feedback and healthy competition, is highly suited to the attention-seeking characteristics and need for immediate gratification of students with ADHD. These results align with Barkley's (2006) research on executive function in ADHD, where interventions involving multiple sensory channels have been shown to be more effective.

### **Conclusion**

PLS-SEM analysis demonstrated that the Kahoot-assisted PBL learning model effectively improved students with special needs' speed-reading abilities by increasing student engagement. The type of special needs moderated the effectiveness of the intervention, with students with ADHD and specific learning disabilities showing the best response. These findings provide strong empirical evidence for the implementation of adaptive learning technology in special education in Indonesia. The recommendations that can be conveyed based on the research findings are: (1) the PBL learning model assisted by Kahoot is recommended for effective use in SLB because it is able to increase student involvement in learning, (2) the findings of this research need to be developed in the use of relevant technology for SLB students, and (3) supporting facilities for Kahoot implementation need to be provided by schools to improve the quality of learning.

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