

How does AI-based Canva enhance cooperative literacy learning? Insight from a CIRC-based PLS-SEM model

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Abstract

The integration of artificial intelligence (AI) into collaborative learning offers new opportunities to enhance literacy education in higher education. However, empirical evidence regarding the role of AI-based tools in supporting collaborative literacy learning remains limited. This study investigates the effect of AI-Based Canva on the effectiveness of the Cooperative Integrated Reading and Composition (CIRC) model. A quantitative explanatory design was employed, involving 243 undergraduate students from Indonesian Language and Literature Education programs across Indonesia. Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The results indicate that AI-Based Canva significantly improves the effectiveness of the CIRC model ($\beta = 0.802$, $p < 0.001$). Self-regulated learning, reading skills, writing skills, and social skills were also found to significantly predict students' use of AI-Based Canva. The findings highlight AI-Based Canva as a key technological mediator that enhances collaborative literacy learning and supports student autonomy and engagement.

L'integrazione dell'intelligenza artificiale (IA) nell'apprendimento collaborativo offre nuove opportunità per migliorare l'insegnamento dell'alfabetizzazione nell'istruzione superiore. Tuttavia, le evidenze empiriche relative al ruolo degli strumenti basati sull'IA nel supportare l'apprendimento collaborativo dell'alfabetizzazione rimangono limitate. Il presente studio indaga l'effetto di Canva, basato sull'IA, sull'efficacia del modello *Cooperative Integrated Reading and Composition* (CIRC). È stato adottato un disegno quantitativo esplicativo, che ha coinvolto 243 studenti universitari iscritti a corsi di laurea in Lingua e Letteratura Indonesiana in tutta l'Indonesia. I dati sono stati analizzati utilizzando il modello di equazioni strutturali con minimi quadrati parziali (PLS-SEM). I risultati indicano che Canva basato sull'IA migliora significativamente l'efficacia del modello CIRC ($\beta = 0,802$, $p < 0,001$). È emerso inoltre che l'apprendimento autoregolato, le competenze di lettura, le competenze di scrittura e le competenze sociali sono variabili predittive significative dell'utilizzo di Canva basato

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sull'IA da parte degli studenti. I risultati evidenziano che Canva basato sull'IA funge da mediatore tecnologico chiave che potenzia l'apprendimento collaborativo dell'alfabetizzazione e sostiene l'autonomia e il coinvolgimento degli studenti.

Keywords: AI assisted learning; Cooperative Integrated Reading and Composition (CIRC); reading skills; self-regulated learning; writing skills

Parole chiave: apprendimento assistito dall'intelligenza artificiale; *Cooperative Integrated Reading and Composition* (CIRC); competenze di lettura; apprendimento autoregolato; competenze di scrittura

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1. Introduction

The rapid advancement of digital technologies has reshaped instructional practices in higher education, particularly within language and literacy learning contexts (Khatib, 2025; Kurniawan, 2024; Rathour & Thakur, 2026; Somabut et al., 2016). Contemporary students are expected not only to develop strong reading and writing competencies but also to demonstrate self-regulated learning, collaborative skills, and digital literacy (Hamzah et al., 2024; Jige, 2025; Mirmotahari et al., 2025; Yadav, 2024). In this regard, the integration of artificial intelligence (AI) into educational platforms has introduced new possibilities for creating more interactive and adaptive learning environments, facilitating collaborative knowledge construction, and supporting higher-order thinking (Aulia & Utami, 2021; Fakhrudin et al., 2025; Pinheiro, 2025; Rathour & Thakur, 2026). These developments have prompted increasing attention toward the alignment of technology-enhanced tools with collaborative pedagogical approaches. Such integration is considered essential for optimizing literacy learning outcomes, as it enables the convergence of cognitive, social, and technological dimensions within a more student-centered learning environment.

The Cooperative Integrated Reading and Composition (CIRC) model is a commonly utilized collaborative learning strategy in language teaching (Durukan, 2011; Ristanto & Darmawan, 2020). CIRC prioritizes collaborative reading and writing exercises that enhance understanding, peer engagement, and critical thinking (Habiddin et al., 2023; Komara, 2019; Susilo et al., 2021). Prior research has shown that the CIRC model can significantly enhance literacy skills and foster collaborative learning engagement. Nevertheless, conventional implementations of CIRC often depend on traditional instructional media, thereby constraining prospects for interactive content creation, multimodal learning, and prompt feedback. As a result, the capacity of digital technology to enhance cooperative literacy learning is frequently underexploited in numerous educational settings. Recent studies underscore the growing role of digital and AI-assisted technologies in enhancing learner engagement and academic outcomes (Manolov, 2025; Moro Ramos, 2024; Vasilev, 2026), particularly through personalized support, adaptive content, and interactive environments that promote student-centered learning (Corbeil, 2025; Gowda et al., 2025; Khosravi et al., 2022; Waladi et al., 2025). Among these, AI-Based Canva stands out as a tool enabling visual content creation, real-time collaboration, and multimodal communication, thereby enriching learning experiences (Alonso-García et al., 2024; Huda et al., 2025; Jige, 2025; Khatib, 2025; Yadav, 2024). At the same time, research on digital tools and cooperative learning consistently shows positive effects on literacy development, comprehension, and communication skills (Hamid et al., 2020; Komara, 2019; Nasim et al., 2024; Saputro et al., 2025). However, prior studies largely examine technology and pedagogy in isolation, with limited integration into a unified framework that captures their combined impact on learning outcomes.

Despite the increasing adoption of AI in education, a significant gap remains in understanding how AI-driven platforms can be effectively integrated with structured cooperative learning models to enhance literacy outcomes. In particular, limited empirical evidence explains how AI-Based Canva supports the implementation of the CIRC model or how student competencies—such as reading, writing, self-regulated learning, and social skills—influence its use. Moreover, prior studies rarely employ comprehensive structural models to capture the complex interplay between learner characteristics, technology adoption, and cooperative learning outcomes, especially within Indonesian higher education contexts (Durukan, 2011; Karafkan & Aghazadeh, 2015; Komara, 2019; Li et al., 2023; Susilo et al., 2021).

To address this gap, the present study proposes an integrated framework that combines AI-Based Canva with the CIRC model, positioning AI as a mediating tool in collaborative literacy learning. The study contributes by

(1) introducing AI integration within the CIRC framework, (2) developing a unified model linking student competencies to technology use, and (3) providing empirical evidence of both direct and indirect relationships using a robust structural approach. This offers a more comprehensive understanding of AI-supported cooperative learning environments.

By embedding AI-Based Canva within the CIRC framework, this study offers a refined perspective on leveraging digital technologies to strengthen cooperative learning in language education. It contributes to the AI-in-education literature by emphasizing the critical alignment between technological innovation, pedagogical design, and learner competencies. The findings provide actionable insights for educators, curriculum developers, and policymakers in designing more effective, engaging, and technology-enhanced learning environments that foster students' literacy development and collaborative skills.

2. Literature review

The present study is grounded in an integrative theoretical framework that combines constructivist learning theory, social interdependence theory, and technology-enhanced learning perspectives to explain how AI-based tools support cooperative literacy learning. Constructivist theory emphasizes that knowledge is actively constructed through interaction with content, peers, and the learning environment, highlighting the roles of meaningful engagement, reflection, and collaboration in literacy development (Sukkamart et al., 2025; Fernando & Marikar, 2017; Zajda, 2021). The Cooperative Integrated Reading and Composition (CIRC) model reflects these principles by promoting active learning through integrated reading and writing tasks, peer interaction, and shared responsibility (Durukan, 2011; Komara, 2019; Li et al., 2023).

This study is based on an integrative theoretical framework that merges constructivist learning theory, social interdependence theory, and technology-enhanced learning models to elucidate the role of AI-based learning tools in facilitating cooperative literacy learning. The constructivist theory posits that knowledge is actively constructed through interactions with learning content, peers, and the learning environment (Sukkamart et al., 2025; Fernando & Marikar, 2017; Zajda, 2021). This perspective in literacy education emphasizes the significance of meaningful engagement, reflection, and collaborative knowledge construction (Ristante & Darmawan, 2020; Thompson & Coffey, 2017). The CIRC model exemplifies these principles by facilitating peer interaction and active learning via integrated reading and writing activities (Durukan, 2011; Komara, 2019; Li et al., 2023). Social interdependence theory supports the notion that collaborative learning environments enhance outcomes when learners collectively pursue shared goals (Frykedal & Chiriac, 2018; Saputro et al., 2025; Surjawan et al., 2025). In CIRC, students participate in collaborative reading discussions and writing activities that promote cognitive growth and social engagement. Within this framework, AI-based tools function as enabling technologies that facilitate interaction, support collaboration, and enhance learning processes, thereby strengthening the effectiveness of cooperative literacy models such as CIRC.

The effectiveness of cooperative learning environments is shaped by both instructional design and students' individual competencies. Prior research consistently identifies reading and writing skills, social skills, and self-regulated learning as critical factors in supporting effective collaborative literacy learning (Chen et al., 2025; Huda et al., 2025; Hwang et al., 2021; Li et al., 2023; Raitskaya & Tikhonova, 2025; van de Wiel & van den Bossche, 2013). Strong reading and writing abilities enable students to comprehend texts, organize ideas, and actively contribute to group tasks, while social skills facilitate communication and collaboration. In addition, self-regulated learning plays a central role by allowing students to plan, monitor, and evaluate their learning, thereby optimizing the use of available resources within cooperative settings.

From a technological perspective, AI-driven digital tools have progressively been incorporated into educational settings to facilitate interactive and student-centered learning. Technology-enhanced learning frameworks emphasize that digital platforms facilitate collaboration, multimodal knowledge representation, and immediate feedback, thus enhancing learning engagement and outcomes (Moro Ramos, 2024; Vasilev, 2026). AI-Based Canva provides features including automated design support, visual content creation, and collaborative workspaces, which can enhance reading and writing activities. These features enable students to visually organize ideas, collaborate on content development, and present information using multimodal formats. AI-Based Canva serves as a mediating learning technology that aligns students' competencies with the application of cooperative learning strategies.

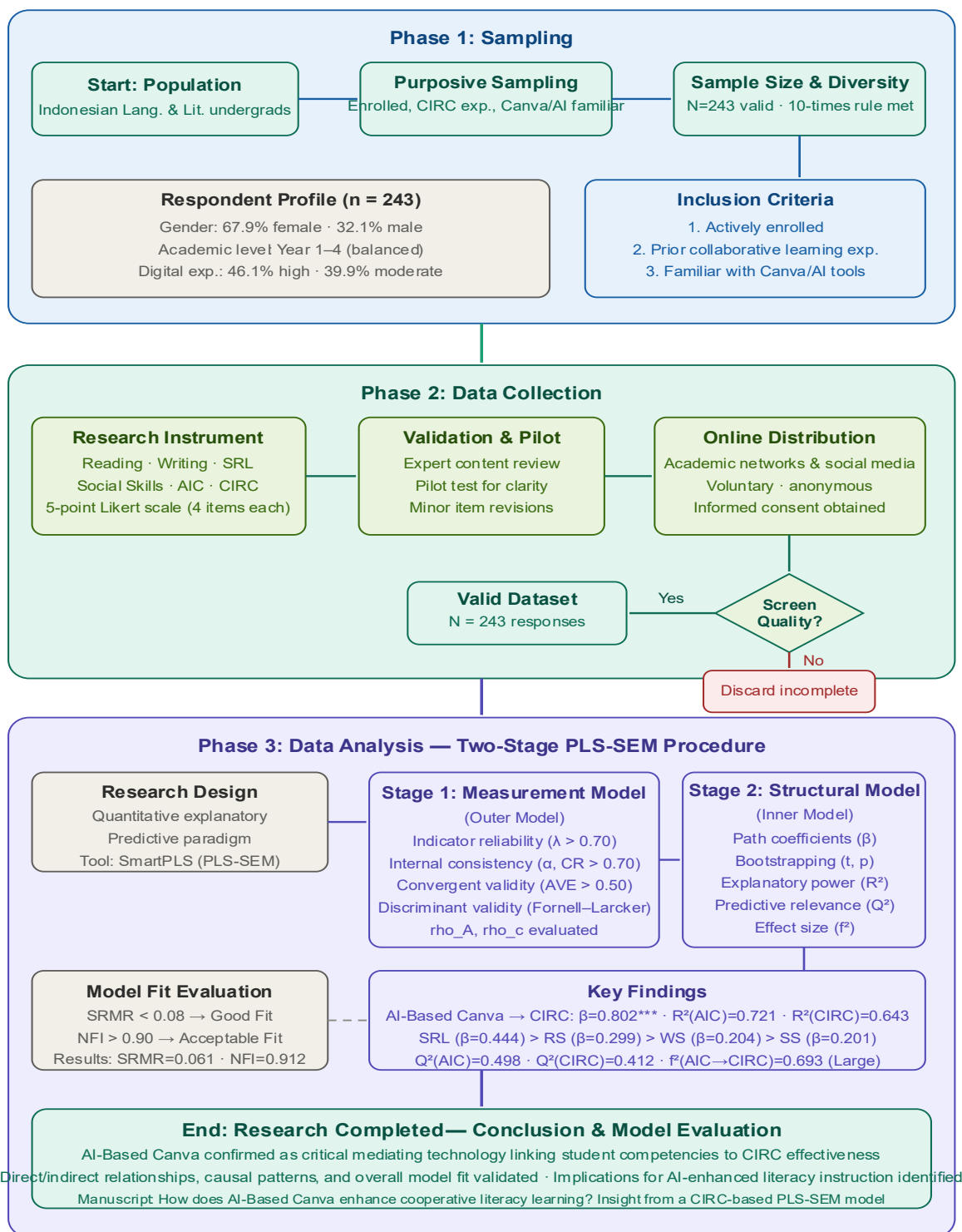
3. Methodology

3.1 Research design

This study adopts a quantitative cross-sectional survey design to examine the relationships between AI-based learning technology and cooperative literacy outcomes in higher education (Baumeister et al., 2026; Bloomfield & Fisher, 2019; Creswell & Guetterman, 2024; Dei, 2025; Ziauddin et al., 2023). Grounded in a predictive-explanatory framework, it analyzes both direct and indirect relationships among latent constructs representing student competencies and technology-enhanced learning processes. The conceptual model integrates constructivist learning theory, social interdependence theory, and technology-enhanced learning perspectives, emphasizing the role of collaborative interaction, student-centered learning, and digital innovation. Within this framework, AI-Based Canva is positioned as a mediating technological tool, while reading skills, writing skills, self-regulated learning, and social skills are specified as antecedents influencing technology use and the effectiveness of the CIRC model.

Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM), which is well-suited for examining complex models with multiple constructs and mediating relationships, particularly under non-normal data conditions and moderate sample sizes (Hair et al., 2022). The analysis followed a two-stage procedure: first, the measurement model was evaluated in terms of indicator reliability, internal consistency, convergent validity, and discriminant validity; second, the structural model was assessed through path coefficients, significance testing via bootstrapping, and predictive power. In this model, AI-Based Canva serves as a mediator linking student competencies to cooperative learning effectiveness, with the conceptual framework and research process illustrated in Figure 1.

Figure 1
Research process and procedure



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3.2 Sample and respondents

3.2.1 Sampling techniques

The population of this study consists of undergraduate students enrolled in Indonesian Language and Literature Education programs across universities in Indonesia. This group was selected due to their intensive involvement in literacy-related activities, including reading, academic writing, and collaborative learning, which align closely with the focus of this research on cooperative literacy and AI-supported learning environments. A purposive sampling technique was employed to ensure that participants possessed relevant academic and technological experience (Campbell et al., 2020; Memon et al., 2025). The inclusion criteria required participants to (1) be actively enrolled in the program, (2) have prior experience in collaborative reading and writing activities, and (3) be familiar with digital learning platforms, particularly Canva or similar AI-assisted tools. This sampling approach ensures that respondents have sufficient exposure to both literacy learning and technology-enhanced environments, thereby increasing the relevance and validity of the data. By focusing on participants with direct experience in cooperative learning and AI-supported platforms, the study enhances content validity and ensures that the findings are applicable to the context of technology-integrated literacy instruction in higher education.

3.2.2 Sample size

A total of 243 valid responses were retained for analysis. This sample size meets and exceeds the commonly accepted requirements for Partial Least Squares Structural Equation Modeling (PLS-SEM). Following the “10-times rule,” the minimum sample should be at least ten times the maximum number of structural paths pointing to any endogenous construct. Given the complexity of the proposed model and the number of predictors involved, the current sample provides sufficient coverage to ensure stable parameter estimation and robust model performance (Jobst et al., 2021; Williamson, 2018). Beyond heuristic guidelines, recent methodological literature emphasizes the importance of statistical power in variance-based SEM. In this regard, the sample of 243 observations offers adequate power to detect meaningful structural relationships, including mediation effects, within the model. Consequently, the sample size is considered appropriate for rigorous PLS-SEM analysis and supports the reliability and interpretability of the findings within the context of higher education in Indonesia.

3.2.3 Respondents

The sample consisted of 243 undergraduate students enrolled in Indonesian Language and Literature Education programs across multiple universities in Indonesia. This cohort reflects diverse academic backgrounds, regional contexts, and levels of exposure to digital learning environments, thereby enhancing the representativeness and external validity of the study. The demographic profile of participants, summarized in Table 1, includes gender, academic level, and digital learning experience. As shown in Table 1, the sample is predominantly female (67.9%), consistent with the typical gender composition of language and literature programs. Participants are relatively evenly distributed across academic levels, ranging from first-year (21.4%) to fourth-year students (25.5%), ensuring representation across different stages of study. In terms of digital learning experience, most respondents report moderate to high familiarity with digital tools, with 46.1% indicating frequent use and 39.9% occasional use, while only 14.0% report limited exposure. This distribution suggests that most participants possess adequate experience with digital learning environments, which is particularly relevant for examining the integration of AI-Based Canva in cooperative literacy learning.

Table 1

Demographic of respondents (n = 243)

Aspect	Category	Freq.	(%)
Gender	Male	78	32.1
	Female	165	67.9
Academic Level	1st year	52	21.4
	2nd year	61	25.1
	3rd year	68	28.0
	4th year	62	25.5
Digital Learning Experience	Low (Rarely use digital tools)	34	14.0
	Moderate (Occasionally use digital tools)	97	39.9
	High (Frequently use digital tools)	112	46.1

3.3 Data collection

Data were collected through a structured online questionnaire distributed through academic networks, institutional channels, and social media platforms, enabling efficient participation from respondents across different regions of Indonesia and enhancing sample diversity. Prior to participation, respondents were informed about the study’s objectives, procedures, and ethical considerations. Participation was voluntary, and anonymity and confidentiality were guaranteed, with informed consent obtained from all participants before completing the survey. To ensure data quality, responses were screened for completeness and consistency (Kalkbrenner, 2023). Only fully completed questionnaires were retained, resulting in 243 valid responses for analysis. The overall data collection procedure adheres to established ethical standards in educational research, ensuring the integrity and reliability of the dataset.

3.4 Instruments

The instrument was developed based on an extensive review of literature in technology-enhanced learning, cooperative learning, and literacy education to ensure strong theoretical grounding. Measurement items were adapted from previously validated scales and refined to fit the context of AI-supported cooperative literacy learning in higher education. All items were rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree), which is widely used to capture perceptions and attitudes in educational research. All constructs were specified as reflective latent variables, with each construct measured by four indicators to ensure adequate coverage and reliability. To ensure content validity and clarity, the instrument was reviewed by experts in educational technology and language education prior to data collection. A pilot test with a small group of students was also conducted to assess item readability and comprehensibility, leading to minor revisions. The final instrument, including operational definitions and measurement items for each construct, is presented in Appendix 1.

To ensure the robustness of the measurement model, several reliability and validity criteria were applied. Indicator reliability was assessed through outer loadings, with values above 0.70 considered acceptable. Internal consistency was evaluated using Cronbach’s alpha and composite reliability (CR), both required to exceed 0.70. Convergent validity was examined using the Average Variance Extracted (AVE), where values above 0.50 indicate adequate construct representation. Discriminant validity was assessed using the Fornell–Larcker criterion, ensuring that each construct is empirically distinct from others. Collectively, these procedures confirm that the measurement model meets established PLS-SEM standards for reliability and validity.



3.5 Data analysis

The data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with SmartPLS, selected for its suitability in handling complex models involving multiple latent constructs and mediating relationships. PLS-SEM is particularly appropriate for predictive research, accommodates moderate sample sizes, and does not require strict normality assumptions, making it well-suited for examining the proposed pedagogical–technology framework (Hair et al., 2017, 2022; Sarstedt et al., 2022).

The analysis followed a two-stage procedure. First, the measurement model was evaluated in terms of indicator reliability (outer loadings > 0.70), internal consistency (Cronbach's alpha, CR, and rho_A > 0.70), convergent validity (AVE > 0.50), and discriminant validity using the Fornell–Larcker criterion. Second, the structural model was assessed using path coefficients (β) and bootstrapping to test significance ($t > 1.96$; $p < 0.05$), along with explanatory power (R^2), predictive relevance ($Q^2 > 0$), and effect size (f^2). Model fit was examined using SRMR (< 0.08) and NFI (> 0.90), ensuring a rigorous evaluation of both measurement quality and structural relationships.

4. Results

4.1 Measurement model evaluation

4.1.1 Indicator reliability (outer loadings)

Indicator reliability was assessed through outer loadings, with values above 0.70 indicating that each item adequately represents its latent construct (Hair et al., 2022; Sarstedt et al., 2022). As shown in Table 2, all indicators meet this criterion, with loadings ranging from 0.722 to 0.913, confirming strong measurement quality. The Self-Regulated Learning (SRL) construct exhibits the highest loadings (0.832–0.913), particularly SRL1 (0.913), suggesting that goal-setting is a central dimension of students' self-regulation. Similarly, Reading Skills (0.832–0.888) and Writing Skills (0.753–0.890) demonstrate consistently high loadings, indicating that the items effectively capture students' abilities in comprehension, analysis, and written expression. Indicators for AI-Based Canva (0.750–0.882) and CIRC (0.809–0.876) also show strong reliability, reflecting the importance of visual design, collaboration, and integrated literacy activities in the learning process.

The Social Skills construct presents acceptable loadings (0.722–0.865), with SS3 showing the lowest value yet remaining within acceptable limits, possibly reflecting variability in students' confidence in providing peer feedback. Overall, the consistently high outer loadings across all constructs indicate that the measurement items are well aligned with their respective latent variables and reliably operationalize key concepts, including student competencies, AI-supported learning, and cooperative literacy practices. These results confirm that the indicators are suitable for inclusion in the measurement model, providing a solid foundation for subsequent structural analysis, as illustrated in Figure 2.

Figure 2

Results of the PLS SEM analysis

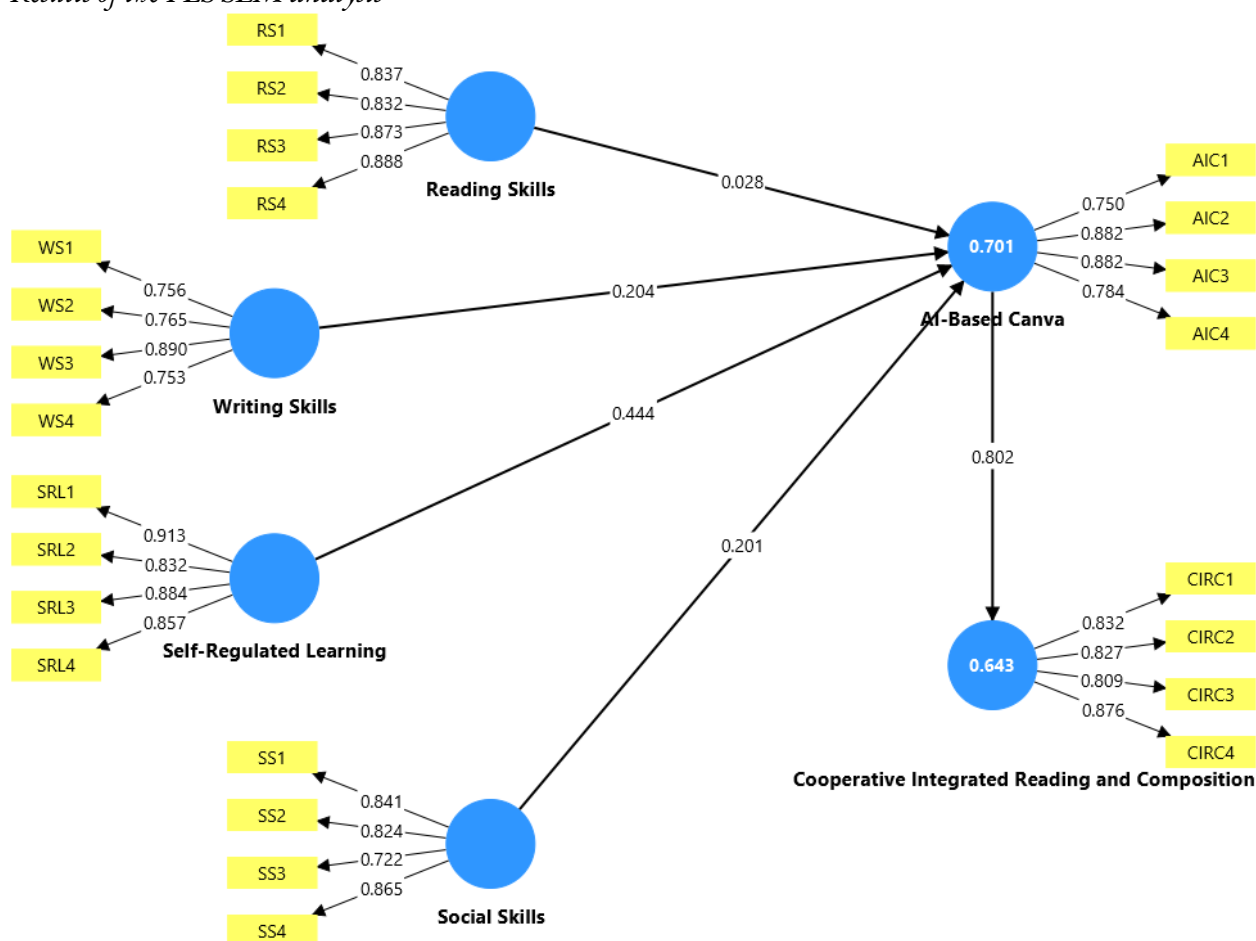


Table 2

Outer Loadings

	AI-Based Canva	Cooperative Integrated Reading and Composition	Reading Skills	Self-Regulated Learning	Social Skills	Writing Skills
AIC1	0.750					
AIC2	0.882					
AIC3	0.882					
AIC4	0.784					
CIRC1		0.832				
CIRC2		0.827				
CIRC3		0.809				
CIRC4		0.876				
RS1			0.837			
RS2			0.832			
RS3			0.873			

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	AI-Based Canva	Cooperative Integrated Reading and Composition	Reading Skills	Self-Regulated Learning	Social Skills	Writing Skills
RS4			0.888			
SRL1				0.913		
SRL2				0.832		
SRL3				0.884		
SRL4				0.857		
SS1					0.841	
SS2					0.824	
SS3					0.722	
SS4					0.865	
WS1						0.756
WS2						0.765
WS3						0.890
WS4						0.753

4.1.2 Internal consistency reliability and convergent validity

Internal consistency reliability was assessed using Cronbach’s alpha, rho_A, and composite reliability (CR), while convergent validity was evaluated through Average Variance Extracted (AVE). Following established PLS-SEM criteria, all reliability values exceeded the recommended threshold of 0.70, indicating satisfactory to excellent reliability (Kalkbrenner, 2023; Trizano-Hermosilla & Alvarado, 2016). As shown in Table 3, Cronbach’s alpha ranges from 0.802 to 0.895 and rho_A from 0.827 to 0.904, confirming stable internal consistency across constructs. Composite reliability values (0.871–0.927) further support the robustness of the measurement model, with Self-Regulated Learning (CR = 0.927) demonstrating the highest reliability, followed by Reading Skills (CR = 0.918) and CIRC (CR = 0.903).

Convergent validity is also well established, with AVE values ranging from 0.629 to 0.760, all exceeding the 0.50 threshold. Self-Regulated Learning shows the strongest convergence (AVE = 0.760), indicating that a substantial proportion of indicator variance is captured by the construct. Similarly, Reading Skills (AVE = 0.736) and CIRC (AVE = 0.699) exhibit strong validity. These results confirm that the constructs are both reliable and valid, with measurement items adequately representing their underlying theoretical dimensions, thereby providing a solid basis for structural model evaluation.

Table 3

Measurement model evaluation

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
AI-Based Canva	0.844	0.844	0.896	0.684
Cooperative Integrated Reading and Composition	0.857	0.859	0.903	0.699
Reading Skills	0.881	0.888	0.918	0.736
Self-Regulated Learning	0.895	0.904	0.927	0.760

	Cronbach h's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Social Skills	0.831	0.848	0.887	0.664
Writing Skills	0.802	0.827	0.871	0.629

4.1.3 Discriminant validity

Discriminant validity was assessed using the Fornell–Larcker criterion, which requires that the square root of the AVE for each construct exceeds its correlations with other constructs (Afthanorhan et al., 2021; dos Santos & Cirillo, 2023). As presented in Table 4, the diagonal values (0.793–0.872) are consistently higher than the corresponding inter-construct correlations, confirming adequate discriminant validity across the model. For instance, AI-Based Canva (0.827) demonstrates greater variance with its own indicators than with other constructs, indicating that it captures a distinct conceptual domain. Similarly, Self-Regulated Learning (0.872) shows strong discriminant validity despite its relatively high correlations with related constructs, reflecting conceptual proximity without empirical overlap.

Although certain correlations are notably high—particularly between Reading Skills and CIRC (0.932)—the Fornell–Larcker criterion remains satisfied, as the square root of AVE for both constructs exceeds their inter-correlation. This pattern suggests that while these variables are theoretically related within cooperative literacy learning, they remain empirically distinct. Overall, the results confirm that all constructs are sufficiently differentiated, supporting the validity of the measurement model and providing a solid foundation for subsequent structural analysis.

Table 4

Discriminant Validity (Fornell–Larcker Criterion)

Construct	AIC	CIRC	RS	SRL	SS	WS
AI-Based Canva	0.827					
CIRC	0.802	0.836				
Reading Skills	0.763	0.932	0.858			
Self-Regulated Learning	0.818	0.848	0.870	0.872		
Social Skills	0.781	0.852	0.862	0.863	0.815	
Writing Skills	0.782	0.857	0.860	0.865	0.847	0.793

4.2 Structural Model Evaluation

4.2.1 Hypothesis testing

Hypothesis testing was conducted using path coefficients (β), t-statistics, and p-values obtained from bootstrapping, with significance determined at $t > 1.96$ and $p < 0.05$ (Hair et al., 2022). As shown in Table 5, all hypothesized relationships are positive and statistically significant, providing strong support for the proposed model. The strongest effect is observed between AI-Based Canva and CIRC ($\beta = 0.802$, $t = 34.423$, $p < 0.001$), indicating that AI-supported tools play a central role in enhancing cooperative literacy learning. This substantial coefficient suggests that AI-Based Canva functions not merely as a supplementary tool but as a key enabler that transforms collaborative reading and writing activities through interactive and visual features.

Among the antecedents of AI-Based Canva, self-regulated learning emerges as the strongest predictor ($\beta = 0.444$), followed by reading skills ($\beta = 0.299$), while writing skills ($\beta = 0.204$) and social skills ($\beta = 0.201$) show smaller yet significant effects. These results indicate a hierarchical pattern in which metacognitive regulation

and cognitive literacy skills are primary drivers of effective technology use, whereas writing and social competencies play supporting roles. The findings highlight that AI-based learning technology acts as a mediating mechanism, translating students' competencies into improved cooperative literacy outcomes, and underscore the importance of aligning pedagogy, learner readiness, and digital tools in higher education contexts. The results of the hypothesis testing based on bootstrapping are presented in Figure 3.

Figure 3
Hypothesis

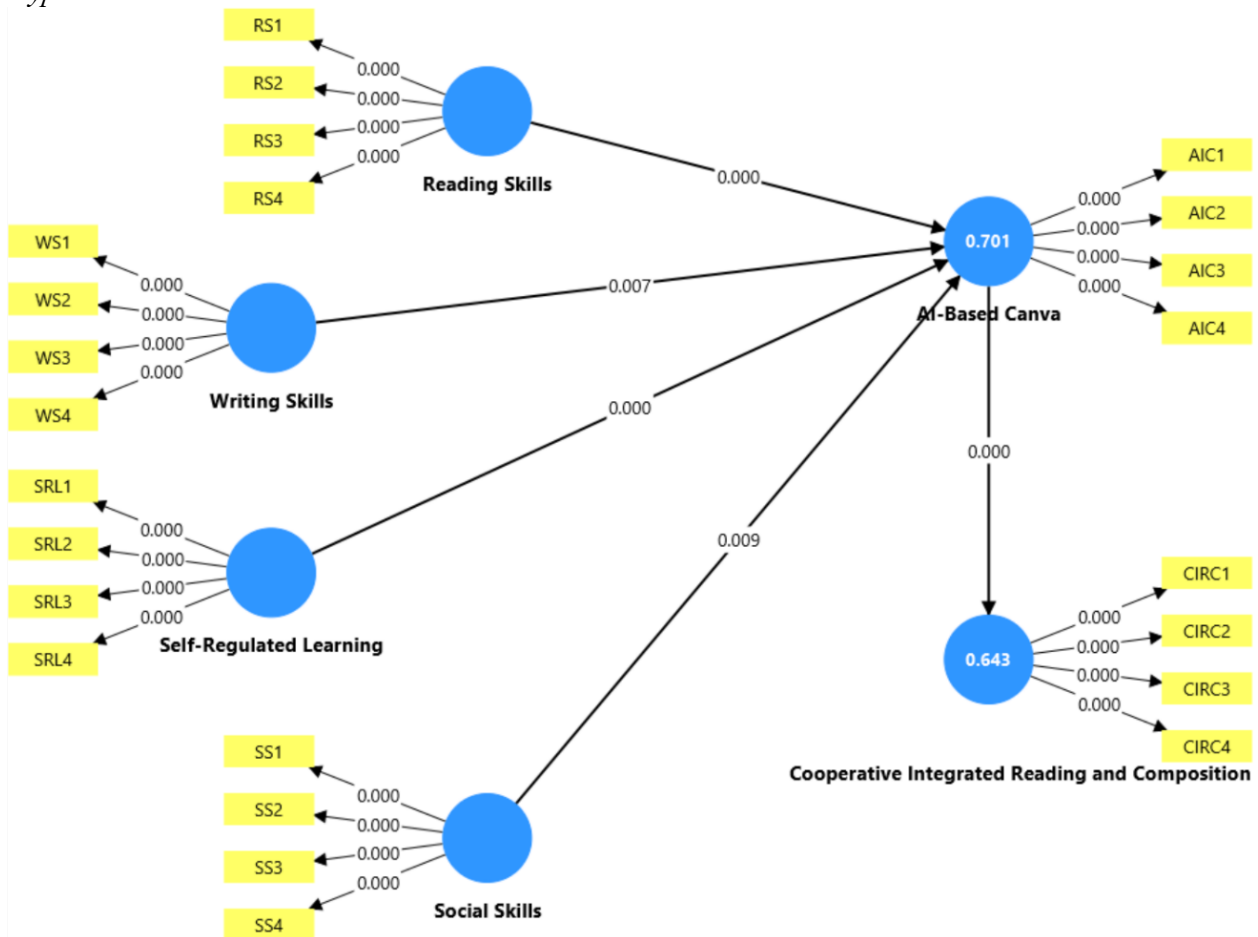


Table 5
Path coefficients and hypothesis testing

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
AI-Based Canva → Cooperative Integrated Reading and Composition	0.802	0.807	0.023	34.423	0.000
Reading Skills → AI-Based Canva	0.299	0.299	0.078	3.809	0.000

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Self-Regulated Learning → AI-Based Canva	0.444	0.440	0.104	4.282	0.000
Social Skills → AI-Based Canva	0.201	0.203	0.077	2.613	0.009
Writing Skills → AI-Based Canva	0.204	0.206	0.076	2.680	0.007

4.3 Model fit

Model fit was evaluated using the Standardized Root Mean Square Residual (SRMR) and the Normed Fit Index (NFI), both commonly recommended in PLS-SEM. The SRMR assesses the discrepancy between observed and model-implied correlations, with values below 0.08 indicating good fit, while the NFI reflects model improvement over a null model, with values above 0.90 considered acceptable (Sarstedt et al., 2022). As shown in Table 6, the SRMR value of 0.061 indicates a good fit, suggesting minimal discrepancy between the empirical data and the proposed model. The NFI value of 0.912 further confirms an acceptable level of fit. Together, these indices demonstrate that the structural model is well specified and adequately represents the underlying data structure. The results provide strong evidence that the relationships among student competencies, AI-based learning technology, and cooperative literacy outcomes are appropriately modeled, supporting the robustness and theoretical consistency of the proposed framework for subsequent analysis.

Table 6

Model fit results and predictive relevance

Fit Index	Value	Threshold	Interpretation
SRMR	0.061	< 0.08	Good Fit
NFI	0.912	> 0.90	Acceptable Fit

4.4 Coefficient of Determination (R²)

The coefficient of determination (R²) was used to evaluate the explanatory power of the structural model, indicating the proportion of variance in endogenous constructs explained by their predictors. As shown in Table 7, the R² value for AI-Based Canva is 0.721, suggesting that reading skills, self-regulated learning, social skills, and writing skills collectively explain 72.1% of the variance, reflecting substantial explanatory power. This result indicates that the proposed competency-based framework effectively captures students’ engagement with AI-supported learning platforms. Similarly, the R² value for CIRC is 0.643, indicating that AI-Based Canva explains 64.3% of the variance in cooperative literacy learning outcomes. This demonstrates that AI integration plays a significant role in enhancing the effectiveness of the CIRC model. Overall, the findings confirm that the structural model has strong explanatory capability, highlighting the combined influence of student competencies and AI-based learning technology on collaborative literacy learning.

Table 7.

Coefficient of determination (R²)

Endogenous Variable	R ²	Interpretation
AI-Based Canva	0.721	Substantial
CIRC	0.643	Moderate to Substantial



4.5 Predictive Relevance (Q^2)

Predictive relevance was assessed using the Stone–Geisser Q^2 statistic obtained through the blindfolding procedure, where values greater than zero indicate predictive capability (Hair et al., 2022). As shown in Table 8, both endogenous constructs demonstrate strong predictive relevance, with Q^2 values of 0.498 for AI-Based Canva and 0.412 for CIRC, indicating substantial predictive performance. These results confirm that the model not only explains the relationships among constructs but also has strong capability in predicting future outcomes. Specifically, it reliably estimates how student competencies influence the use of AI-based tools and how such use translates into cooperative literacy learning outcomes, reinforcing the predictive validity and robustness of the proposed framework.

Table 8

Predictive relevance (Q^2)

Construct	Q^2	Interpretation
AI-Based Canva	0.498	Large Predictive Relevance
CIRC	0.412	Large Predictive Relevance

4.6 Effect Size (f^2)

Effect size (f^2) was calculated to determine the relative contribution of each exogenous construct to the endogenous variables, with values of 0.02, 0.15, and 0.35 indicating small, medium, and large effects, respectively (Lovakov & Agadullina, 2021; Zhao et al., 2020). As shown in Table 9, AI-Based Canva has a large effect on CIRC ($f^2 = 0.693$), indicating that it plays a critical role in enhancing the effectiveness of cooperative literacy learning. This substantial effect confirms that AI-supported tools are not merely complementary but significantly transform collaborative reading and writing activities.

Among the predictor variables, self-regulated learning shows a moderate effect on AI-Based Canva ($f^2 = 0.238$), making it the most influential student competency in technology use. In contrast, reading skills ($f^2 = 0.124$), writing skills ($f^2 = 0.087$), and social skills ($f^2 = 0.082$) exhibit smaller yet meaningful effects. These findings suggest that while cognitive and social competencies contribute to AI-based learning engagement, self-regulation serves as the primary driver, with other skills providing complementary support in cooperative learning contexts.

Table 9

Effect size (f^2)

Path	f^2	Effect Size
Reading Skills → AI-Based Canva	0.124	Small
Self-Regulated Learning → AI-Based Canva	0.238	Medium
Social Skills → AI-Based Canva	0.082	Small
Writing Skills → AI-Based Canva	0.087	Small
AI-Based Canva → CIRC	0.693	Large

5. Discussion

This study examines the effect of AI-Based Canva on the effectiveness of the Cooperative Integrated Reading and Composition (CIRC) model by considering key student competencies, including reading skills, writing skills, self-regulated learning, and social skills. The findings provide strong empirical support for the proposed

framework, indicating that cooperative literacy learning in technology-enhanced environments is shaped by the interaction between learner competencies and AI-supported tools.

The results reveal that AI-Based Canva exerts a substantial and significant effect on CIRC ($\beta = 0.802$, $p < 0.001$), confirming its central role in enhancing collaborative reading and writing activities. This large effect demonstrates that AI-assisted design and collaboration tools meaningfully improve how students engage in integrated literacy tasks. Consistent with prior research, AI-Based Canva facilitates multimodal learning, real-time collaboration, and content organization, effectively bridging reading comprehension and writing production within the CIRC framework.

From a constructivist perspective, AI-Based Canva supports active knowledge construction through collaborative and multimodal engagement. It enables students to synthesize information, co-construct understanding, and produce shared learning outputs more effectively. The model's substantial explanatory ($R^2 = 0.643$) and predictive power further underscores the role of AI-Based Canva as a key technological mediator that transforms traditional cooperative learning into a more interactive, adaptive, and student-centered process, thereby extending current literature on AI-integrated cooperative literacy learning (Hinchcliff & Mehmet, 2023; Li et al., 2023; Moro Ramos, 2024; Vasilev, 2026).

Self-regulated learning emerges as the strongest predictor of AI-Based Canva use ($\beta = 0.444$; $f^2 = 0.238$), indicating that students' ability to plan, monitor, and evaluate their learning substantially determines effective engagement with AI tools. In technology-rich environments, self-regulated learners demonstrate greater autonomy in navigating platforms, organizing tasks, and adapting strategies, aligning with self-regulated learning theory that emphasizes metacognitive control as a key driver of success in digital learning (Berglas-Shapiro et al., 2017; Broadbent, 2017; Du et al., 2025; Pionera et al., 2020; Xu et al., 2023). This finding underscores that effective AI integration depends not only on technological access but also on learners' readiness and autonomy. Reading ($\beta = 0.299$) and writing skills ($\beta = 0.204$) also significantly influence AI-Based Canva, confirming that foundational literacy competencies remain essential in technology-enhanced contexts (Adipat, 2025; Bhimavarapu, 2025; Karataş et al., 2024; Raitskaya & Tikhonova, 2025; Sutrisno et al., 2025). These skills enable students to interpret, synthesize, and transform information into coherent multimodal outputs, particularly in platforms that integrate visual and textual elements. Social skills ($\beta = 0.201$) contribute positively, though with a smaller effect, reflecting their supportive role in facilitating collaboration, communication, and shared content creation within the CIRC framework (Li et al., 2023; Nasim et al., 2024; Ristanto & Darmawan, 2020; Suresh Babu et al., 2025a; Vasilev, 2026).

The special AI features integrated into Canva significantly enhance the impact of student competencies inside the CIRC framework. The AI-generated layout recommendations in Canva alleviate cognitive burden by automating visual design choices, enabling students to concentrate their cognitive efforts on content creation and collaborative interpretation throughout reading and writing activities. This function is especially advantageous for students with little writing talent, as it supports the organization of ideas without necessitating extensive design abilities. The Text-to-Image creation capability facilitates multimodal representation of textual content, allowing students to visually encode reading materials and produce more enriched, communicative outputs that correspond with the multimodal requirements of the CIRC model. Collectively, these AI capabilities serve as pedagogical enhancers that facilitate the amalgamation of reading comprehension and writing production, thereby enriching collaborative literacy endeavours and rendering the advantages of AI-Based Canva more attainable across diverse levels of student proficiency (Budiman et al., 2025; Moro Ramos, 2024; Suresh Babu et al., 2025b; Vasilev, 2026).

A key contribution of this study is the identification of AI-Based Canva as a mediating mechanism linking student competencies to CIRC effectiveness. All competencies significantly predict AI use, which in turn strongly impacts cooperative literacy outcomes, with substantial explanatory power ($R^2 = 0.721$). This highlights technology as an active pedagogical enabler that translates individual capabilities into collaborative performance (Corbeil, 2025; Komara, 2019; Koukaras et al., 2025; Mayanti & Widiyatmoko, 2025; Suresh Babu et al., 2025a; Susilo et al., 2021; Waladi et al., 2025). The findings reveal a hierarchical structure in which self-regulation plays a dominant role, followed by reading skills, while writing and social skills provide complementary support. This reinforces the importance of aligning learner competencies, pedagogical design, and AI technologies to optimize cooperative learning outcomes.

5.1 Implications for theory and practice

This study advances the literature by integrating cooperative learning, self-regulated learning, and AI-supported learning into a unified explanatory framework. The findings demonstrate that technology-enhanced learning is inherently multidimensional, shaped by the interaction of cognitive, metacognitive, and social competencies. Importantly, the study positions AI-based tools as mediating mechanisms that translate individual competencies into collaborative learning outcomes, highlighting their role not as supplementary tools but as integral pedagogical enablers within cooperative learning environments.

The results suggest that integrating AI platforms such as Canva into cooperative literacy instruction can enhance engagement, creativity, and collaboration through multimodal learning. However, effective implementation requires parallel development of self-regulated learning skills, particularly goal-setting, monitoring, and reflection, as these are the strongest predictors of technology use. In addition, foundational literacy skills remain critical, serving as the cognitive basis for meaningful participation in AI-supported environments. Therefore, instructional design should combine AI integration with strategies that strengthen literacy, foster learner autonomy, and promote collaborative interaction.

Although the present study is situated within the Indonesian higher education context, the theoretical mechanisms that underlie the findings are of broader cross-cultural and cross-linguistic relevance. The constructivist learning theory and self-determination theory, which have been validated across diverse educational contexts globally, are the foundations of the central predictors identified: self-regulated learning, reading skills, writing skills, and social skills. These theories are not limited to specific cultural or linguistic settings. Consequently, the proposed model provides a theoretically generalisable framework for comprehending the manner in which AI-enhanced tools mediate the relationship between cooperative literacy outcomes and learner competencies. Simultaneously, it is crucial to recognise that Indonesia's unique contextual factors, such as cooperative learning traditions that are ingrained in the local pedagogical culture, multilingual language environments, and varying levels of digital infrastructure equity, may mitigate the extent of the effects that are observed in other contexts. For instance, cultures with more individualistic learning orientations or distinct norms regarding peer collaboration may generate varying effect sizes for social skills as a predictor. Similarly, the importance of self-regulated learning may differ across educational systems due to varying levels of learner autonomy and metacognitive scaffolding. Future research is explicitly encouraged to replicate and test the boundary conditions of this model across diverse international contexts, including East Asian, Middle Eastern, European, African, and Latin American higher education systems, in order to advance a more comprehensive and culturally inclusive understanding of AI-supported cooperative literacy learning, taken into account these considerations.

6. Conclusion

This study examined the role of AI-Based Canva in enhancing the effectiveness of the Cooperative Integrated Reading and Composition (CIRC) model by considering key student competencies: reading, writing, self-regulated learning, and social skills. Using PLS-SEM, the findings provide strong empirical support for the proposed model, confirming that AI-Based Canva functions as a critical mediating mechanism linking student competencies to cooperative literacy outcomes. The significant effect of AI-Based Canva on CIRC indicates that AI-supported visual and collaborative tools substantially enhance engagement in integrated reading and writing activities, transforming cooperative learning into a more interactive, adaptive, and student-centered process. Among the predictors, self-regulated learning emerges as the most influential factor in AI tool utilization, followed by reading and writing skills, while social skills play a complementary role. The model also demonstrates substantial explanatory and predictive power, reinforcing the importance of aligning learner competencies with AI-supported pedagogical strategies.

This study integrates constructivist, social constructivist, and self-regulated learning perspectives within an AI-enhanced cooperative learning framework. Practically, the findings highlight that effective AI integration requires not only technological adoption but also the development of learner autonomy, foundational literacy, and collaborative competencies. Despite its contributions, the study is limited by its cross-sectional design and reliance on self-reported data. Furthermore, as this study relies on self-reported measures, the risk of social desirability bias should be acknowledged, participants may have overstated their competencies. Future research is encouraged to triangulate these findings using objective performance indicators, such as actual writing scores, reading comprehension assessments, or digital analytics from learning platforms, to further validate the proposed model. In addition, future research should employ longitudinal or experimental approaches and incorporate additional variables, such as motivation, digital literacy, and cognitive load, to further validate and extend the model.

Author Contributions

Dwi Viora: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. Anwar Efendi: Data curation, Formal analysis, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. Kastam Syamsi: Formal analysis, Methodology, Project administration, Software, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Appendix 1

Measurement Items of Research Constructs

Construct	Code	Measurement Item
Reading Skills (RS)	RS1	I can understand the main ideas of the texts I read.
	RS2	I can analyze the content of reading materials critically.
	RS3	I can interpret information from various reading sources.
	RS4	I can identify important information from texts effectively.
Writing Skills (WS)	WS1	I can organize my ideas clearly in writing.
	WS2	I can write coherent and well-structured texts.
	WS3	I can express my ideas effectively in written form.
	WS4	I can develop creative and engaging written content.
Self-Regulated Learning (SRL)	SRL1	I set clear goals before starting my learning activities.
	SRL2	I monitor my own learning progress regularly.
	SRL3	I manage my time effectively during learning tasks.
	SRL4	I evaluate my learning outcomes and make improvements.
Social Skills (SS)	SS1	I communicate effectively with my peers during group activities.
	SS2	I actively participate in collaborative learning tasks.
	SS3	I can give and receive constructive feedback.
	SS4	I can resolve conflicts effectively in group work.
AI-Based Canva (AIC)	AIC1	AI-Based Canva is easy to use for learning activities.
	AIC2	AI-Based Canva helps me create learning materials effectively.
	AIC3	AI-Based Canva enhances my understanding through visual content.
	AIC4	AI-Based Canva supports collaboration in learning tasks.
Cooperative Integrated Reading and Composition (CIRC)	CIRC1	Learning through CIRC improves my understanding of reading materials.
	CIRC2	CIRC helps me develop better writing skills.
	CIRC3	CIRC encourages active collaboration with peers.
	CIRC4	CIRC effectively integrates reading and writing activities.

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