



Development of Brain-Based Learning Innovations to Enhance Thai Reading and Writing Skills in Non-Formal Education: A Case Study of the Special Non-Formal Education Center in Chonburi Province

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Received 13/10/2025

Revised 21/10/2025

Accepted 20/12/2025

Abstract

Background and Aim: The advancement of brain-based learning innovations is crucial because it enhances the reading and writing abilities of learners in non-formal education by aligning instructional strategies with how learners' brains naturally process language. Additionally, it helps diverse learners close literacy gaps and attain more successful lifetime learning outcomes by boosting engagement and retention. This study aimed to (1) develop and evaluate a brain-based learning innovation to enhance Thai reading and writing skills among primary learners, targeting an efficiency criterion of 80/80, and (2) compare learners' reading and writing performance before and after the intervention.

Materials and Methods: The research employed a one-group pretest–posttest quasi-experimental design with research and development (R&D) product development. The participants were 41 Grade 3 learners enrolled at a Special Non-Formal Education Center in Chonburi Province during the 2023 academic year, selected through purposive sampling. Instruments included Thai reading and writing skill tests validated for content and reliability. Data were analyzed using descriptive statistics (percentage, mean, standard deviation) and a paired-samples t-test, along with E_1/E_2 efficiency analysis to evaluate instructional effectiveness against the predetermined 80/80 criterion.

Results: The BBL innovation achieved high efficiency, with process efficiency $E_1 = 84.64\%$ and outcome efficiency $E_2 = 83.13\%$, exceeding the 80/80 benchmark. Students' mean reading and writing scores improved significantly from $M_{pre} = 12.81$, $SD = 1.03$ to $M_{post} = 23.84$, $SD = 2.33$, $t(40) = 21.57$, $p < .001$, Cohen's $d = 3.36$, 95% CI [2.64, 4.09], indicating a substantial effect.

Conclusion: The brain-based learning innovation was associated with significant gains in Thai reading and writing skills among primary learners in non-formal education settings. These findings suggest that brain-based instructional approaches can enhance literacy development and may be applicable in similar educational contexts.

Keywords: Development of learning innovation, development of Thai reading and writing skills, Interdisciplinary, Humanities, Social Sciences, learning innovation

Introduction

Literacy, particularly reading and writing, is a foundational skill for lifelong learning and personal development. In Thailand's non-formal education system, many learners continue to struggle with reading fluency and writing accuracy, which limits their capacity for self-directed learning and overall academic progress (Jensen, 2008). These challenges are especially pronounced among learners in primary-level equivalency programs, where instructional time and access to literacy-rich environments are often limited (Kangkha et al, 2023). Addressing this gap requires innovative teaching approaches that align with how the brain naturally learns.

Brain-Based Learning (BBL) offers a neuroscience-informed pedagogical framework that emphasizes emotional engagement, multisensory stimulation, and contextualized learning experiences (Min & Worapongpat, 2023). According to BBL principles, learning occurs most effectively when instruction activates both cognitive and affective neural systems, particularly the limbic system, which mediates motivation and emotional memory (National Reading Panel, 2000). In literacy instruction, enjoyable and emotionally positive learning contexts enhance learners' attention and cognitive receptivity, supporting long-term retention and skill transfer (Ning et al, 2023). Reading aloud and silent reading activities stimulate different neural pathways: the former externalizes linguistic knowledge, while the latter promotes comprehension and visualization (Institute of Language and Mathematics; Parker & Kapoor, 2024). Similarly, writing tasks integrate motor, linguistic, and executive functions,





reinforcing neural connections related to language production and organization (Pressley & McCormick, 1995).

Within non-formal education contexts, BBL-based instruction may be particularly beneficial because it encourages active, experiential learning through tasks that are emotionally engaging and personally meaningful. Prior research indicates that structured, progressive activities—ranging from concrete to abstract, and from guided to independent practice—can improve literacy outcomes among learners with diverse backgrounds. The present study applies the principles of Brain-Based Learning to develop and test a learning innovation aimed at improving Thai reading and writing skills among primary-level learners enrolled in a Special Non-Formal Education Center in Chonburi Province. The study seeks to evaluate both the efficiency and effectiveness of this instructional model.

Objectives

1. To evaluate the process efficiency (E_1) and outcome efficiency (E_2) of a Brain-Based Learning (BBL) activity set for enhancing Thai reading and writing skills among elementary-level learners in non-formal education, against a predetermined 80/80 efficiency benchmark.

2. To compare students' Thai reading and writing achievement scores before and after participation in the BBL-based learning program using a paired-samples t-test.

Literature review

1. Brain-Based Learning (BBL) Theory

Brain-Based Learning (BBL) is grounded in educational neuroscience and cognitive psychology, emphasizing that learning occurs most effectively when instructional design aligns with the brain's natural functioning (Seesun et al, 2023). BBL posits that learning is influenced by the brain's emotional, social, and physiological states, highlighting the importance of multisensory experiences, positive emotions, and meaningful contexts (Sousa, 2017). Emotional engagement activates the limbic system, which strengthens attention and memory encoding (Tianshu & Worapongpat, 2023). In classroom practice, this translates into activities that integrate motivation, movement, and reflection, promoting deeper conceptual understanding rather than rote memorization (Thammajai et al, 2024).

2. Applications of BBL in Early Literacy Development

Research on early literacy indicates that emotionally engaging, experience-based learning environments enhance phonological awareness, reading fluency, and written expression (Weiyi et al, 2024). Within BBL frameworks, reading aloud externalizes linguistic processing and reveals comprehension gaps, whereas silent reading cultivates concentration and visualization (Institute of Language and Mathematics [ILM], n.d.). Similarly, writing tasks integrate motor, linguistic, and executive functions, supporting learners in organizing thoughts and constructing meaning (Worapongpat, 2023). Empirical studies in both formal and non-formal Thai education contexts have demonstrated that brain-compatible instruction—characterized by interactive, emotion-rich activities—significantly improves reading comprehension and written communication skills (Worapongpat, 2024). However, few studies have systematically examined the efficiency and measurable learning outcomes (E_1/E_2) of BBL interventions in non-formal education settings, where learners often vary in age, background, and motivation (Worapongpat, 2025).

3. Learning Innovation and Instructional Design

Instructional innovation involves designing learning activities that integrate theory, practice, and evaluation to produce measurable skill gains (Worapongpat & Chayboonkrong, 2024; Zhou et al, 2024). Effective literacy interventions employ multimodal tasks, scaffolded instruction, and iterative feedback to promote transfer and retention (Worapongpat & Junsuk, 2024). In the context of Thailand's educational reform, BBL-based innovations have been developed to align with the Ministry of Education's emphasis on competency-based learning (Worapongpat & Kumla, 2024). The present study extends this line of inquiry by developing a structured BBL learning activity set focused on Thai reading and writing skills for learners at a Special Non-Formal Education Center, evaluating both process and outcome efficiency against the 80/80 criterion (Worapongpat & Nipapon, 2024).

4. Conceptual Framework and Research Gap

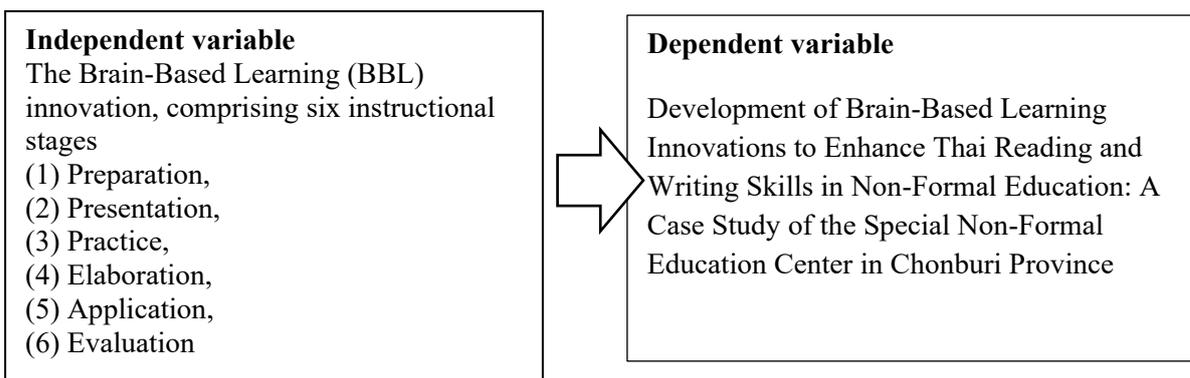




Synthesizing prior research, the conceptual model for this study integrates Brain-Based Learning (BBL) principles, emotional engagement, multisensory learning, and contextualization with instructional design theory, including goal alignment, feedback, and performance measurement. This study addresses two key gaps in the literature. First, there is limited empirical evidence on the measurable efficiency (E_1/E_2) of BBL innovations in non-formal Thai education (Yasuttamathada & Worapongpat, 2025). Second, comparative data on learners’ reading and writing achievement before and after BBL-based interventions remain scarce. Accordingly, the study posits the following hypotheses: H_1 : Students’ posttest reading and writing scores will be significantly higher than pretest scores ($p < .05$). H_2 : The developed BBL learning innovation will achieve efficiency levels meeting or exceeding the 80/80 criterion ($E_1/E_2 \geq 80/80$) (Yun & Worapongpat, 2023).

Conceptual Framework

This study is grounded in the Brain-Based Learning (BBL) approach, which emphasizes aligning instructional design with natural brain functions through emotionally engaging and multisensory learning experiences (Worapongpat & Sriaroon, 2024; Worapongpat, Cai, & Wongsawad, 2024; Worapongpat, Purisuttamo, & Lormanenoprat, 2024). The conceptual framework integrates BBL principles, structured learning activities, and cognitive–affective mediators to produce measurable literacy outcomes in Thai reading and writing. Specifically, the framework illustrates how BBL-based learning activities (independent variable) influence students’ reading and writing performance (dependent variables) through cognitive–emotional engagement (mediators), while accounting for contextual factors inherent to the non-formal education environment (Worapongpat, Wongkumchai, & Anuwatpreecha, 2024; Xunan & Worapongpat, 2023).



Methodology

Research Design

This study employed a research and development (R&D) design to create and evaluate a Brain-Based Learning (BBL) activity set for enhancing Thai reading and writing skills among elementary learners in a non-formal education context. The evaluation phase adopted a one-group pretest–posttest quasi-experimental design, allowing comparison of literacy performance before and after the intervention.

Ethical approval was obtained from the Human Research Ethics Committee of [Name of Institution] (Approval Code: EDU-HREC-2023-CHB-021). Parental consent and student assent were secured before data collection. All data were anonymized, and participation was voluntary.

Setting and Participants

The research was conducted at the Special Non-Formal Education Center, Chonburi Province, which provides equivalency programs for primary-level learners outside the formal school system.

The population comprised students in Grades 1–3 enrolled during the 2023 academic year. The sample consisted of 41 Grade-3 learners (ages 8–10 years; 22 females, 19 males) selected by purposive





sampling because Grade 3 marks the transition from basic decoding to reading-to-learn skills—an appropriate stage for applying BBL to literacy development.

Eligibility criteria included:

Enrollment in the Grade 3 non-formal primary program; Regular attendance (≥ 80 % of sessions); and No diagnosed learning disabilities affecting reading or writing.

This sample size aligns with prior Thai literacy studies using within-subject designs that reported large effect sizes (d ≈ 0.8); thus, a power level of > 0.80 was anticipated at α = .05. Generalizability is limited to similar non-formal contexts and learner profiles.

Intervention: BBL Activity Set

The intervention comprised 10 BBL-based activities delivered over 15 hours (13 instructional + 2 testing sessions). Activities were structured according to the six BBL stages—Preparation, Presentation, Practice, Elaboration, Application, and Evaluation—and aligned with the Thai Basic Education Core Curriculum literacy standards.

Table 1 Learning activity schedule for developing creative reading and writing skills.

Table with 3 columns: Activity, Focus, Duration (hours). Rows include activities like 'Blending words according to spelling rules' and 'Writing blended words according to spelling rules', totaling 15 hours.

Fidelity of implementation was supported through a 3-hour teacher orientation on BBL principles and session objectives. Classroom observations using a 10-item checklist verified adherence (> 90 % compliance).

Research Instruments

1. Learning Activity Set Validation

The activity set underwent expert review by three Thai-language and instructional-design specialists. Item-objective congruence (IOC) indices ranged from 0.80 to 1.00. A pilot with 10 comparable learners confirmed clarity and engagement.

2. Reading and Writing Skills Tests

Two parallel 30-point assessments (pretest and posttest) measured literacy outcomes across five constructs: Reading accuracy (word and sentence level)

Reading and analytical thinking

Reading-writing integration

Writing and idea organization

Reading, writing, and analytical synthesis

Both forms contained equivalent items to mitigate practice effects, separated by a two-week instructional interval. Internal consistency reliability was α = 0.86 for reading and α = 0.88 for writing. Writing tasks were scored by two trained raters using a 5-category rubric (content, organization, vocabulary, grammar, mechanics). Inter-rater reliability was ICC = 0.92.

Data Collection Procedure

Data were collected during the first semester of 2023 over 15 one-hour sessions.





The process included:

Preparation phase – instrument development, teacher briefing, and pilot test.

Pretest administration – 1 hour.

Instructional phase – 13 hours across 10 BBL activities following the six stages.

Posttest administration – 1 hour.

Observation and documentation – ongoing fidelity monitoring and student engagement notes.

A summary flow is shown below.

Recruitment → Consent → Pretest → 13 BBL Sessions → Posttest → Data Analysis

Data Analysis

Analyses were defined a priori: Descriptive statistics (mean ± SD, percentages) for performance and efficiency.

E_1/E_2 efficiency computation against the 80/80 criterion.

Paired-samples t-test comparing pre- and posttest scores.

Effect size (Cohen's d for paired data) with 95 % CIs.

Assumption checks: normality of difference scores (Shapiro–Wilk), outliers (± 3 SD).

Significance was set at $\alpha = .05$ (two-tailed).

The resulting E_1/E_2 values were compared to the 80/80 benchmark to determine whether the developed learning innovation met the predetermined efficiency criterion.

Results

Table 2 Effectiveness of the Brain-Based Learning (BBL) Innovation in Enhancing Reading and Writing Skills (n = 41)

Activity Set	Full Score	Process (E_1)		Outcome (E_2)	
		Mean (\bar{X})	SD	% of Mean	Mean (\bar{Y})
1	10	8.05	0.76	80.50	24.94
2	10	8.33	0.56	83.30	—
3	10	8.23	0.70	82.30	—
4	10	8.36	0.84	83.60	—
5	10	8.19	0.68	81.80	—
6	10	8.68	0.66	86.80	—
7	10	8.65	0.76	86.50	—
8	10	8.29	0.98	82.80	—
9	10	8.97	0.76	89.70	—
10	10	8.81	0.74	88.10	—
Overall Mean	—	—	—	84.64	—

Note. Full score = maximum obtainable points per activity (10) and posttest (30). E_1 = in-class process efficiency; E_2 = posttest outcome efficiency. The overall efficiency values were $E_1 = 84.64$ (95% CI [83.12, 86.16]) and $E_2 = 83.13$ (95% CI [81.67, 84.59]), exceeding the 80/80 benchmark criterion.

Summary: Across the ten activities, the mean in-class process efficiency (E_1) was 84.64%, and posttest outcome efficiency (E_2) was 83.13%, both surpassing the predetermined 80/80 criterion. Variability across sets was minimal (SDs < 1.0), indicating consistent performance and stable learning engagement throughout implementation.





Table 3 Comparison of Reading and Writing Achievement Before and After BBL-Based Instruction

Test	Full Score	Mean (\bar{X})	SD	t(40)	p	Cohen's d
Pretest	30	12.81	1.03	—	—	—
Posttest	30	23.84	2.33	21.57	< .001***	3.36

Note. * $p < .001$ (two-tailed). Cohen's d was calculated for paired data using the pooled SD of difference scores.

Narrative summary: Students' mean reading and writing achievement increased from 12.81 (SD = 1.03) before instruction to 23.84 (SD = 2.33) after participating in the BBL program. The difference was statistically significant, $t(40) = 21.57$, $p < .001$, indicating a large effect size ($d = 3.36$, 95% CI [2.64, 4.09]). These results suggest that engagement in the BBL learning activities was associated with substantial improvements in literacy performance among participating learners.

Discussion

This study examined the effectiveness of a Brain-Based Learning (BBL) innovation designed to enhance Thai reading and writing skills among Grade 3 students in a non-formal education setting. The learning model achieved efficiency levels of $E1=84.64$ and $E2=83.13$, surpassing the 80/80 benchmark, and students' posttest scores were significantly higher than pretest scores, $t(40)=21.57$, $p<.001$, $d=3.36$. These results indicate that the BBL-based instructional approach promoted measurable gains in literacy performance within a short, 15-hour intervention period.

The findings support core BBL principles, which posit that effective learning occurs when instruction aligns with natural brain processes—engaging emotion, pattern recognition, multisensory input, and reflection (Bunsoem & Satham, 2024). The six-step learning sequence employed in this study—stimulation, reading, control, imaginative thinking, knowledge sequencing, and content summary—appears to have facilitated neural connections through imagery, affective engagement, and distributed practice. These mechanisms likely enhanced working memory integration and semantic encoding, leading to improved reading comprehension and written expression. Similar outcomes have been reported in prior Thai literacy research emphasizing visual scaffolds, multisensory activities, and collaborative discussion as mediators of comprehension and creative writing (Caine & Caine, 1994). Thus, this study extends evidence that structured BBL approaches can effectively support literacy development in non-formal educational contexts where learner diversity and motivation are critical.

The positive outcomes highlight the value of BBL-informed lesson design for alternative education programs. Teachers can adapt the six-stage model to encourage student participation, creativity, and peer interaction—key aspects of engagement among learners with heterogeneous backgrounds (Chayboonkrong & Worapongpat, 2024). Incorporating visualization, storytelling, and reflective journaling into Thai language lessons may enhance literacy while maintaining enjoyment and intrinsic motivation. Furthermore, the 15-hour modular format demonstrated in this study provides a practical framework that can be integrated into flexible learning schedules common in non-formal centers. Teacher training on BBL pedagogy, observation-based feedback, and activity adaptation is essential for sustaining fidelity of implementation.

Several limitations should be acknowledged. First, the one-group pretest–posttest design precludes causal inference; improvements may partly reflect test familiarity or teacher expectancy effects. Second, the sample size ($n=41$), although adequate for detecting large effects, limits generalizability to other grade levels and settings. Third, there was no external benchmark for comparing posttest scores (Dongling & Worapongpat, 2023), so claims regarding comparative performance should be interpreted cautiously. Fourth, fidelity monitoring was limited to teacher observation rather than independent rating, and potential variability in instructional delivery could have influenced outcomes. Finally, the short intervention duration did not allow evaluation of long-term retention or transfer of literacy gains.





Future studies should employ quasi-experimental or randomized designs with control or comparison groups to strengthen causal claims. Including follow-up assessments would help determine the durability of literacy improvements. Further investigation into neurocognitive correlates (Jariyathitinant & Adipattaranan, 2018) could clarify how BBL activities activate specific learning pathways. Expanding the model to other grade levels and integrating digital media or gamified components may enhance engagement in non-formal contexts. Additionally, mixed-methods designs involving student interviews or classroom observations could enrich understanding of how BBL practices influence motivation and self-efficacy in literacy learning.

New Knowledge from Research

The BBL-Literacy Pathway Model for Non-Formal Education
This study contributes new theoretical and practical insights into how Brain-Based Learning (BBL) principles can be adapted to strengthen Thai literacy within non-formal education contexts. The resulting BBL-Literacy Pathway Model integrates cognitive, affective, and experiential mechanisms that foster reading and writing development among diverse learners.

Table 4 Core Constructs and Relationships

Table with 3 columns: Construct, Description, and Relationship. Rows include Context-Adapted BBL Sequence, Cognitive-Affective Engagement, Integrated Literacy Processing, and Sustained Literacy Growth.

Context-Adapted BBL Sequence (BBL Sequence) is the independent variable or instructional input. It is defined as an adaptable six-phase Brain-Based Learning (BBL) instructional sequence, which is adapted according to the contextual needs of learners from a non-formal education background. The BBL Sequence consists of learner motivating strategies, multisensory activating procedures and reflective writing processes, which aim at triggering cognitive and affective learning mechanisms.

Cognitive-Affective Engagement (Cognitive-Affective Engagement) is learners' internal reaction to instruction. It is measured as learners' curiosity, affective involvement, mental imagery and peer-related activity during literacy instruction. Cognitive-Affective Engagement was conceptualized as a mediating variable and its primary purpose was to explain the nature of the relationship between instructional input (BBL Sequence) and learning (proximal or distal outcome). The construct operationalized the process of how the BBL Sequence was transformed by the learners into effective engagement and learning.

Integrated Literacy Processing (ILP) is the overall construct, which assessed learners' integrated performance of both reading and writing. In other words, learners' ability to relate reading comprehension with writing using processes such as visualizing, interpreting and organizing ideas was used to measure ILP. In the current model, the proximal learning outcome was expected to operationalize the immediate cognitive gain from effective and engaged learning.





Sustained Literacy Growth (SLG) is the overall construct used to assess the distal learning outcome, which included gains in accuracy of reading performance, reading fluency and quality of creative writing after a specific amount of time, which in this study was one week.

Recommendations

1. Implications for Practice

Structured yet Flexible BBL Sessions: Implement the six-stage BBL cycle across approximately 10 activity modules (15 hours total), adjusting pacing to learner readiness and literacy levels.

Teacher Preparation and Fidelity: Teachers should receive training on BBL principles—particularly how to build motivation, guide imagery-based reading, and facilitate reflection—to ensure consistent implementation fidelity.

Learner-Centered Differentiation: Adapt reading materials and writing prompts to suit varying literacy proficiencies and experiential backgrounds typical of non-formal learners.

Active and Reflective Learning Materials: Employ visual stimuli (e.g., story illustrations, poems, rhymes) and structured reflection sheets to encourage comprehension, vocabulary retention, and creative expression.

Continuous Monitoring: Use formative assessments and observation checklists at each BBL stage to provide feedback and adjust instruction dynamically.

2. Recommendations for Future Research

Experimental Validation: Conduct controlled or quasi-experimental studies comparing BBL-based and traditional literacy instruction to strengthen causal claims.

Multi-Site and Longitudinal Designs: Implement multi-center trials across different provinces and follow-up assessments to evaluate the durability and transfer of literacy gains.

Moderator Analyses: Examine how baseline proficiency, age, or socio-emotional variables moderate the effects of BBL-based interventions.

Cross-Skill Expansion: Extend the BBL framework to other Thai language domains (listening, speaking, reasoning) or STEM literacy for broader pedagogical utility.

Cost-Benefit and Feasibility Studies: Assess implementation costs, teacher workload, and learner satisfaction to determine sustainability in resource-limited non-formal settings.

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