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A Computer-Based Early Intervention for Thai Preschool Children at Risk of Dyslexia: A Pre- and Postintervention Study

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Abstract

Preschool children at risk of dyslexia show inadequate progress in their preliteracy skills; they often perform poorly in the domain of phonological awareness, letter knowledge, and rapid automatized naming. As a result, they tend to fall behind academically, specifically in reading, when they enter primary school. Because time is of the essence, early intervention becomes necessary to provide the best possible preliteracy outcome. To date, there has not been a study that investigates the effectiveness of early intervention in Thai, a language that is typologically and orthographically different from those in previous studies. In this preliminary study, training materials, created with phonological awareness and letter knowledge at the core, were presented via interactive Siriraj Pre-Literacy Enhancement software. In total, 73 typically developing preschoolers, aged 60 to 66 months, were enrolled. Preliteracy skills were measured by Rama Pre-Read (RPR). At-risk children received the 11-week computer-based early intervention training. After the intervention was completed, participants' preliteracy skills were evaluated by RPR (posttest). Sixteen children (21.9%) were at risk of dyslexia. Results after training indicated that preschool at-risk children of dyslexia in Thailand show a high magnitude of improvement in preliteracy skills, across all three domains. The computer-based early intervention to promote preliteracy skills is a feasible and effective form of remediation for Thai children at risk of dyslexia.

Keywords
- at-risk children
- dyslexia
- computer based
- early intervention
- preliteracy

Introduction

Specific learning disability (SLD) is a neurodevelopmental disorder that hinders one's learning skills in reading, writing, and mathematics. Developmental dyslexia, henceforth dyslexia, is a type of SLD that is characterized by an impairment in decoding, word reading accuracy and fluency, and spelling.[1] Clinical symptoms of dyslexia include reading slower than the expected rate, reading comprehension difficulties, and poor spelling.[2] These symptoms are visible regardless of whether one receives adequate education, possesses a normal-range IQ, and has sufficient socioeconomic opportunities.[3] In 2002, Peterson & Pennington[4] reported that 5 to 17.5% of the world's population was living with dyslexia, a prevalent neurodevelopmental disorder that should not be overlooked.

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Although the Diagnostic and Statistical Manual of Psychiatric Disease (DSM-5) recommends that dyslexia should be diagnosed at the beginning of primary education,[5] several diagnostic tests have been developed of an early evaluation, whereby preschool children who exhibit substandard preliteracy reading skills may be considered at risk of dyslexia. Examples of preliteracy tests include but are not limited to Early Grade Reading Assessment, which is used by practitioners in the United States,[6] and Rama Pre-Read (RPR), which is used by Thai practitioners.[7] It is important to highlight that children who score poorly on these tests are not clinically diagnosed as dyslexic; rather, they are classified as at risk of dyslexia, where they may undergo early intervention to help improve their preliteracy skills.

At-risk children with dyslexia show inadequate progress in their preliteracy reading skills compared to their peers. They perform poorly in the domains of phonological awareness, letter knowledge, and rapid automatized naming.[8] Researchers have investigated several intervention techniques such as using action video games[9] and music education[10]; unfortunately, many do not yield statistically significant results. Phonological awareness training, however, is an intervention technique that has received much attention and has been continually gaining traction in recent years.[11,12]

Generally, phonological awareness training is an intervention technique that aims to train at-risk children with dyslexia to develop metacognitive knowledge of sound segments within a word. They are trained to be self-aware that a word may consist of multiple distinct phonemic parts.[13] For example, the word *bat* can be decomposed into three phonemic segments: /b/+/æ/+/t/; together, they make up the word *bat*. With this knowledge, at-risk children with dyslexia can better identify, tease apart, and manipulate distinct phonemes, which ultimately contribute to improved preliteracy skills.

Possessing phonological awareness per se is not sufficient. Reading is a skill that requires a thorough understanding of the alphabet; this is called letter knowledge.[14] It is essential for at-risk children with dyslexia to recognize that: a letter may appear in various forms (e.g., block vs. cursive), a letter is associated with a name (e.g., <w> is called a "double U" in English), and importantly, a letter is associated with a corresponding phoneme(s) (e.g., <c> in English can be realized as /k/ as in *cat* or /s/ as in *cinema* in English). In sum, the relationship between auditory information (sound) and visual representation (alphabet) must go hand-in-hand for at-risk children with dyslexia to improve their preliteracy skills.[15]

Several studies show that when phonological awareness training and letter knowledge training are executed in parallel as a unified intervention technique, it produces promising, long-lasting results. For instance, Elbro and Petersen[16] found that when phonemic awareness and letter knowledge training were used in a daily 30-minute session for 17 weeks, at-risk children with dyslexia demonstrated long-term improvement not only in reading but also in decoding both real words and pseudowords. Similarly, Hindson et al[17] reported that after 12 weeks of training, at-risk children with dyslexia scored higher on awareness of phoneme tests and could tackle irregular words more effectively. Combining phonological awareness and letter knowledge has proven effective and is currently a unified intervention technique that is widely used.

Early intervention is undoubtedly resource demanding. Scammacca et al[18] reported that the cost of training qualified teachers and assistants, combined with operation costs, could be as high as $ 2,700 per child; thus, this presents a problem of accessibility as the high cost limits the number of at-risk children with dyslexia who can undergo early intervention. Fortunately, with rapid technological advancement, computers have become more affordable, whereby they could be easily accessed and used in early intervention.

Affordability and accessibility alone do not justify implementation of computers in early intervention. In addition, research shows that children at-risk of dyslexia performed better in phonological awareness, word recognition, and letter naming when early intervention was implemented with software programs, compared to printed material.[19] Similarly, children at risk of dyslexia who underperform academically have been found to improve in the area of basic reading, phonological awareness, and classroom behavior once they have been trained with software programs, compared to other methods.[20] Considering the undeniable benefits that computers bring, which are lower cost, higher accessibility, and more positive preliteracy outcomes, it is not surprising that they are becoming the preferred choice.

It is important to emphasize that despite the successful implementation of computers, a teacher's presence remains crucial. Teachers now act to direct, encourage students to be interested in the computerized tasks, and minimize the children's frustration.[21] It remains an interactive process, where a teacher's goal is to seamlessly integrate the technology, positively encourage collaboration, and foster students' autonomy.[22] Although the role may have shifted, teachers are still critical to the success of early intervention.

There has not been any study that explores the effectiveness of computer-based early intervention in Thailand. To address this gap, we created a computer-software named the Siriraj Pre-Literacy Enhancement (SIPLE), which provides Thai at-risk children with dyslexia using phonological awareness and letter knowledge training; they are two combined techniques that have proven fruitful, as demonstrated in past literature. The objective of this preliminary study is to assess the effectiveness of SIPLE (computer based) as early intervention in Thai preschool at-risk children with dyslexia population.

Methods

Participants

This pre and postintervention study was carried out between January and August 2020 as part of a larger study to evaluate the effectiveness of SIPLE computer software in the Thai preschool at-risk children with dyslexia population. Eligible participants were monolingual Thai children aged 60 to

66 months who studied in a kindergarten in Bangkok. Candidates diagnosed with global developmental delay, delayed language development, attention deficit hyperactivity disorder, autism disorder, and mood disorder (e.g., depression and anxiety disorder) by a physician were not eligible for participation. A total of 73 participants met the inclusion criteria from six kindergartens in the Bangkok Noi school district.

Procedures

This study was approved by the Siriraj Institutional Review Board, Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand (Protocol number: 794/2562, IRB2). The first author explained the objective and study protocols to school officials; then, the study was publicly advertised at six kindergartens in Bangkok. Interested parents were encouraged to contact the first author directly for inquiries and the possibility of enrollment.

After enrollment, participants' parents were interviewed for the demographic characteristics of the participants and their families. The recorded data include (1) participant's information (gender, age, daily duration of screen media use and reading hours, and the number of storybooks in the house); and (2) family information (family history of specific learning disability, parental educational level, and household income). Enrolled participants also took the Denver II and Mullen Scales of Early Learning (MSEL) to ensure that they do not present signs of developmental delay or delayed language skills. Participants with normal development were assessed for their preliteracy reading skills with RPR.

Parents of participants who are classified as at risk of dyslexia based on the outcome of RPR as a pretest are provided with details of an 11-week interactive SIPLE software early intervention training. After their consent, participants were trained with SIPLE at school under a teacher's supervision.

One week after the end of the intervention, participants take the RPR posttest. The RPR pretest and RPR posttest were identical and administered on-site at the school by the first author and a child psychologist.

Additionally, in a follow-up, teachers who supervised participants in the computer-based early intervention group were interviewed on the satisfaction of results, as well as any obstacles or difficulties in interacting with the participants during the training.

Measurements

Rama Pre-Read

The RPR is a paper-based, preliteracy reading test often used as an initial assessment for children at risk of dyslexia in Thailand that consists of three subtests: (1) letter knowledge; (2) rapid letter automatized naming test; and (3) initial sound matching test.[7] Participants who score lower than the 10th percentile in *any* subtest are categorized as at-risk of dyslexia, following a study by Yampratoom et al[23] (2017), where the 10th percentile cut-off was established based on normalized data from 412 Thai children aged 60 to 71 months. Yampratoom et al explained that the RPR uses conservative cut-off criteria for early detection, which could potentially lead to prompt early intervention training.

Denver II

The Denver II is a child developmental screening tool from birth to 72 months of age. We partially used this test to assess participants in the domains of motor and personal–social development, where results were classified as either normal development or suspected delayed development. The Denver II has a sensitivity of 0.56–0.83 and a specificity of 0.43–0.80.[24]

Mullen Scales of Early Learning

We used the MSEL to assess receptive and expressive language. Participants were assessed for their verbal abilities, which are factors known to correlate with children's reading skills.[25] Participants with a T-score in receptive or expressive language domains below 30 were diagnosed as having language developmental delays. Internal consistency ranges from 0.45 to 0.77, and interrater reliability ranges from 0.91 to 0.99.[26]

Early Intervention Training

The training program is summarized in ►**Table 1**. Designed to be systematic, structured, cumulative, and sequential,[27] content of the training material promotes preliteracy skills, emphasizing the training of phonological awareness and letter knowledge. It consists of 11 lessons, one per week, and each lesson takes approximately 10 to 15 minutes. Computer-based early intervention training took place at school and was monitored by teachers who are familiar with

Table 1 A summary of the early intervention training

Lesson/input	Phonology (Sound)	Orthography (Written letters)	Semantics (Picture)	Task
Lesson 1	Yes	Yes	Yes	Input
Lessons 2–3	Yes	No	Yes	Match sounds and pictures to letters
Lessons 4–5	Yes	Yes	No	Match sounds and letters
Lessons 6–8	Yes	Yes	Yes	Phonological awareness
Lessons 9–10	Yes	No	Yes	Phonological awareness
Lessons 11	Yes	Yes	Yes	Writing letters

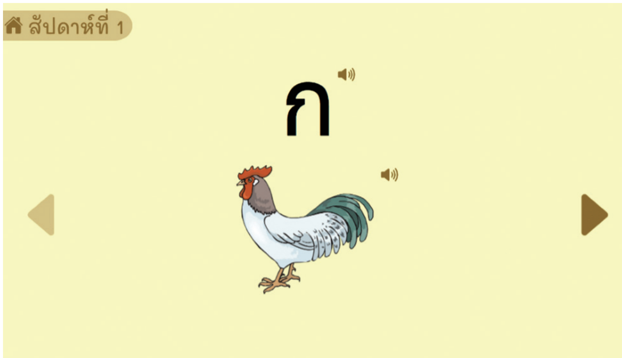

Fig. 1 An example of the training material

SIPLE. All auditory input and feedback are computerized and automatic. When auditory input is required, participants could click on the speaker icon for auditory input. When participants provide a correct answer, SIPLE provides a clapping sound as feedback. When participants provide an incorrect answer, SIPLE provides encouraging verbal feedback saying, “try again, it’s almost correct!”. The description of lessons in the computer-based early intervention group is as follows.

Lesson 1: *The letter recognition activity* is an input-focused activity consistent with the orthography-semantic-phonology Triangle Model.[28] Stimuli in this lesson contain a letter, a semantically related picture (picture of a common word in Thai that contains the letter in the initial word position), and auditory input of the letter. For example, as shown in ►**Fig. 1**, participants are presented with the letter “ก” (letter), a picture *gai* “chicken” (semantic), and the word-initial letter sound /g/ (phonology).

Video 1

Letter knowledge and phonological awareness training.

Online content including video sequences viewable at: https://www.thieme-connect.com/products/ejournals/html/10.1055/s-0043-1767809.

Video 2

Phonological awareness (cont.) and initial sound matching training.

Online content including video sequences viewable at: https://www.thieme-connect.com/products/ejournals/html/10.1055/s-0043-1767809.

Lessons 2 and 3: *Picture-letter matching* is an activity that focuses on matching a picture with the letter that represents the word-initial sound. There is no auditory input in these lessons. For example, when a picture of *gai* “chicken” is shown, participants are presented with a choice of letters: “ภ,” “ก,” and “ถ”. Notice that these letters are visually similar; however, they differ phonetically. These lessons aim to increase participants’ awareness of letters that are similar in shape.

Lessons 4 and 5: *Phoneme-letter matching* is a more complex training activity that focuses on realizations of the same phoneme. In the Thai orthographic system, a phoneme can be represented by multiple letters, depending on the syllable’s suprasegmental feature.[29] In other words, although Thai has 21 consonant phonemes, there are as many as 44 letters that are used based on the consonant class. In lessons 4 and 5, participants are presented with an auditory input, with multiple realizations as options to choose from. For instance, if the auditory input is /kh/ (rising), then the participants are presented with the letter choices of: “ข” (/kh/ rising), “ฆ” and “ฆ” (/kh/ mid).

Lessons 6 to 8: *Phonological awareness activity* requires participants to draw a connection between all three elements: phonology, orthography, and semantics. For example, when the picture of a tree branch “ging” (semantic input) is presented, the correct answer is the letter <ก>, which represents the /g/ phoneme, which is the initial consonant of the word.

Lessons 9 and 10: *Initial sound matching* is a picture-matching activity that requires participants to match two pictures that have the same initial consonant sound. For example, a picture of *goong* “shrimp” should be matched with a picture of *gob* “frog” since these two pictures have the same initial consonant phoneme /g/.

Lesson 11: Multisensory integration is the last lesson in the training. Participants are asked to practice writing the letter that represents the auditory input. For example, the picture *goong* “shrimp” is presented with corresponding auditory input; then, participants should write “ก,” which represents the /g/ phoneme.

Statistical Analyses

Demographic data were analyzed and described using descriptive statistics. A comparison of the mean of the RPR pretest and RPR posttest score was performed by a paired *t*-test for normally distributed data and Wilcoxon signed-rank test for nonnormally distributed data. A chi-square test was performed to assess the difference in the number of participants for nominal data. Normally distributed data were presented as mean ± standard deviation; nonnormally distributed data were presented as median (min–max). Data were analyzed using SPSS (version 18.0).

Results

Seventy-three participants were enrolled in this study. None of the participants met the exclusion criteria, and all participants had normal developmental levels as assessed by Denver II and MSEL. Results from the RPR pretest indicate that 16 participants (21.9%) scored in the 10th percentile in any subtest; hence, they were categorized as at risk.

All 31 participants with a risk of dyslexia joined the training using computer-based early intervention under

Table 2 Demographic characteristics of at-risk participants

Demographic characteristics	Descriptive results ($n = 16$)
Male[a]	6 (37.5%)
Age (months)	64.74 ± 1.84
Daily screen time (hours)[b]	1.75 (0–4.5)
Daily reading time (hours)[b]	0.5 (0–2)
Number of storybooks in the house (books)[b]	10 (0–100)
Family history of learning problem[a]	4 (25%)
Parental education (below the bachelor's degree)[a]	
Paternal education	7 (43.75%)
Maternal education	8 (50%)
Monthly household income[a]	
< 1,000 U.S. Dollars	6 (37.5%)
≥ 1,000 U.S. Dollars	10 (62.5%)
MSEL (T-scores)	
Receptive language	39.03 ± 6.50
Expressive language	36.90 ± 6.98

Abbreviation: MSEL, Mullen Scales of Early Learning.
Note: Data were presented as mean ± SD
[a]Data were presented as number of participants (percentage)
[b]Data were presented as median (min–max).

parents' consent. Demographic data of at-risk participants with dyslexia were demonstrated in ►**Table 2**.

►**Table 3** demonstrates a comparison between the RPR pretest and the RPR posttest. Participants show an improvement in RPR post-test score compared to the RPR pretest score in all domains of preliteracy reading skills.

In a follow-up, there was no report of computer-related side effects in the computer-based early intervention group. Teachers who supervised the implementation of SIPLE neither did report difficulties using the software nor did they report that SIPLE interfered with routine activities in the classroom.

Discussion

Firstly, the literature that examines the effectiveness of phonological awareness and letter knowledge in the early intervention was conducted in languages using the Latin alphabet such as English,[30] Spanish,[31] and Dutch.[32] Our study is the first to demonstrate its effectiveness in Thai, a language that is typologically and orthographically different from those in previous studies. As such, we speculate that phonological awareness training, combined with letter knowledge training, could be a versatile early intervention technique that applies to a wide variety of languages, regardless of language family and/or orthography type. Indeed, further exploration in this area is necessary to confirm versatility across language types.

In addition, this study shows that computer-based early intervention resulted in improved preliteracy skills. It is consistent with previous studies stating that dynamic, computer-based materials have been reported to improve children's language production in general.[33] Based on the findings in this study, we believe that computer-based early intervention offers several technical features which might have partially contributed to a great magnitude of improvement in preliteracy skills. We suspect that this could have been influenced by SIPLE's dynamic and game-like nature, which potentially created an enjoyable learning experience that fosters and encourages prolonged engagement with the training material.

Table 3 Comparison between RPR pre- and posttest of at-risk participants with dyslexia participating in computer-based early intervention

RPR subtests	Pretest	Posttest	*p*-Value
Letter knowledge (points)	47.25 ± 17.19	68.25 ± 15.54	<0.001
Rapid letter naming (seconds)[a]	143 (92–238)	100 (64–184)	<0.001
Initial sound matching (points)[a]	1 (0–1)	8 (5–9)	<0.001

Abbreviation: RPR, Rama Pre-Read.
Note: Data were presented as mean ± SD.
[a]Data were presented as median (min–max).

In addition, literature shows that when a sound is repeated, it provides better sound-to-letter mapping.[34] With SIPLE, at-risk children with dyslexia had the option to click the speaker icon multiple times to hear a sound (of a phoneme or a word) before making a decision. Moreover, SIPLE is guaranteed to provide readily available and standardized auditory input that can be repeated on demand.

Although SIPLE may offer advantageous technical features, we believe that the environment of training may have played a critical role. Studies have shown that in an educational context, teachers are more effective in interacting and engaging with preschool children.[35] They are trained professionals who have an understanding of various stages in the learning process, as well as extensive experience in classroom management where they employ appropriate strategies to monitor, support, and encourage children's learning journey in an educational context. Furthermore, the school environment is physically set up to accommodate learning; it is designed to minimize distraction from external surroundings for focused learning. Combining professionally trained teachers with a hospitable environment, the school appears to be an ideal venue for uninterrupted learning.[36]

The study suffers from some limitations such as the environmental settings in this study; therefore, we cannot confidently conclude that the great magnitude of improvement in preliteracy skills was solely driven by the use of SIPLE software. We suspect that when early intervention software is executed and monitored in an appropriate learning environment, it is deemed to produce an optimal outcome. We strongly encourage that future studies on early intervention take environmental settings into account in the study design since it has the potential to influence the outcome.

This is a preliminary study with a limited number of participants from the Bangkok metropolitan area. In addition to factoring in environmental settings, we recommend increasing the sample size and recruiting a more diverse pool of participants for generalizability. In addition, the current study has no control group and lacks long-term tracking of reading skills. Further studies using larger randomized controlled trials with longitudinal monitoring would further elucidate the effectiveness of this intervention.

Conclusion

At-risk children with dyslexia have a high tendency to fall behind in school because of their substandard preliteracy skills. Early intervention offers an opportunity for these children to improve such skills promptly. This preliminary study demonstrates that computer-based early intervention, using SIPLE, could bring additional benefits to Thai children at-risk of dyslexia. We hope that insights from the present study lay a foundation for future studies in the area of early intervention in the children at-risk of dyslexia population.

Conflict of Interest
None declared.

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References

1 Cutting LE, Clements-Stephens A, Pugh KR, et al. Not all reading disabilities are dyslexia: distinct neurobiology of specific comprehension deficits. Brain Connect 2013;3(02):199–211
2 Fletcher JM, Lyon GR, Fuchs LS, Barnes MA. Learning Disabilities: From Identification to Intervention. 2nd ed. New York: Guilford Press; 2018
3 Démonet JF, Taylor MJ, Chaix Y. Developmental dyslexia. Lancet 2004;363(9419):1451–1460
4 Peterson RL, Pennington BF. Developmental dyslexia. Lancet 2012;379(9830):1997–2007
5 American Psychiatric Association, DSM-5 Task Force. Diagnostic and Statistical Manual of Mental Disorders: DSM-5TM, 5th ed. Washington, DC: American Psychiatric Publishing; 2013
6 Dubeck MM, Grove A. The early grade reading assessment (EGRA): Its theoretical foundation, purpose, and limitations. Int J Educ Dev 2015;40:315–322
7 Munthli A, Anansiripinyo T, Silakorn W, et al. Assessment of phonological awareness in Thai children at risk for learning disabilities. Paper presented at: In Proc. 19th International Congress of Phonetic Sciences; 2019; 3036–3040.
8 Bishop DV, Snowling MJ. Developmental dyslexia and specific language impairment: same or different? Psychol Bull 2004;130(06):858–886
9 Łuniewska M, Chyl K, Dębska A, et al. Neither action nor phonological video games make dyslexic children read better. Sci Rep 2018;8(01):549
10 Cogo-Moreira H, Andriolo RB, Yazigi L, Ploubidis GB, Brandão de Ávila CR, Mari JJ. Music education for improving reading skills in children and adolescents with dyslexia. Cochrane Database Syst Rev 2012;8(08):CD009133
11 Cardoso RKDOA, Capellini SA. Efficacy of phonological awareness intervention in students at risk for dyslexia. Revista Psicopedagogia 2009;26:396–407
12 Lees L. Effects of Phonological Intervention on At-Risk Kindergarten Students with Reading Difficulties. Theses, Dissertations and Capstones. Marshall University; 2016
13 Stanovich KE. Progress in Understanding Reading: Scientific Foundations and New Frontiers. New York: Guilford Press; 2000
14 Adams MJ. Beginning to Read: Thinking and Learning About Print (A Bradford Book). Bradford Books; 1994
15 Fraga González G, Žarić G, Tijms J, Bonte M, van der Molen MW. Contribution of letter-speech sound learning and visual print tuning to reading improvement: evidence from brain potential and dyslexia training studies. Brain Sci 2017;7(01):10
16 Elbro C, Petersen DK. Long-term effects of phoneme awareness and letter sound training: an intervention study with children at risk for dyslexia. J Educ Psychol 2004;96(04):660–670
17 Hindson B, Byrne B, Fielding-Barnsley R, Newman C, Hine DW, Shankweiler D. Assessment and early instruction of preschool children at risk for reading disability. J Educ Psychol 2005;97(04):687–704
18 Scammacca N, Robers G, Vaughn S, et al. Interventions for Adolescent Struggling Readers: A Meta-Analysis with Implications for Practice. 2007. Accessed November 10, 2022 at: https://files.eric.ed.gov/fulltext/ED521837.pdf
19 Mioduser D, Tur-Kaspa H, Leitner I. The learning value of compter-based instruction of early reading skills. J Comput Assist Learn 2000;16(01):54–63
20 Troia G, Whitney S. A close look at the efficacy of Fast ForWord Language for children with academic weakness. Contemp Educ Psychol 2003;28:465–494
21 Voogt J, McKenney S. Using ICT to foster (pre) reading and writing skills in young children. Computers in the Schools 2007;24(04):83–94
22 Segers E, Verhoeven L. Multimedia support of early literacy learning. Comput Educ 2002;39(03):207–221
23 Yampratoom R, Aroonyadech N, Ruangdaraganon N, Roongpraiwan R, Kositprapa J. Emergent literacy in Thai preschoolers: a preliminary study. J Dev Behav Pediatr 2017;38(06):395–400
24 Frankenburg WK, Dodds J, Archer P, Shapiro H, Bresnick B. The Denver II: a major revision and restandardization of the Denver Developmental Screening Test. Pediatrics 1992;89(01):91–97
25 Catts HW, Adlof SM, Hogan TP, Weismer SE. Are specific language impairment and dyslexia distinct disorders? J Speech Lang Hear Res 2005;48(06):1378–1396
26 Mullen EM. Mullen Scales of Early Learning: AGS Edition. Circle Pines, MN: American Guidance Service; 1995
27 Singleton C. Intervention for Dyslexia. 2009. Accessed November 10, 2022 at: http://www.bdadyslexia.org.uk/files/Singleton-Report.pdf
28 Seidenberg MS, McClelland JL. A distributed, developmental model of word recognition and naming. Psychol Rev 1989;96(04):523–568
29 Iwasaki S, Ingkaphirom P. A Reference Grammar of Thai. Cambridge, UK: Cambridge University Press; 2005
30 Richardson U, Lyytinen H. The GraphoGame Method: the theoretical and methodological background of the technology-

enhanced learning environment for learning to read. Hum Technol 2014;10(01):39–60
31 Romeo A, Garay U, Tejada E, de la Serna AL. Efficacy of Berni: a software for preschoolers at risk of dyslexia. Int J Child Comput Interact 2021 (e-pub ahead of print). Doi: 10.1016/j.ijcci.2021.100411
32 Regtvoot AG, van der Leij A. Early intervention with children of dyslexic parents: Effects of computer-based reading instruction at home on literacy acquisition. Learn Individ Differ 2007;17(01):35–53
33 Khaleghi A, Aghaei Z, Behnamghader M. Developing two game-based interventions for dyslexia therapeutic interventions using gamification and serious games approaches entertainment computing journal. Entertain Comput 2022 (e-pub ahead of print). Doi: 10.1016/j.entcom.2022.100482
34 Wolf M, Ullman-Shade C, Gottwald S. Lessons from the reading brain for reading development and dyslexia. Aust J Learn Difficulties 2016;21(02):143–156
35 Pedler M, Hudson S, Yeigh T. The teachers' role in student engagement: a review. Aust J Teach Educ 2020;45(03):48–62
36 Ravelli L. Towards a social-semiotic topography of learning spaces: tools to connect use, users, and meanings. In Ellis RA, Goodyear P, eds. Spaces of Teaching And Learning: Integrating Perspectives on Teaching and Research. Singapore: Springer; 2018:63–80

