International Journal of Evaluation and Research in Education (IJERE)
Vol. 15, No. 6, December 2026, pp. 5313~5327
ISSN: 2252-8822, DOI: 10.11591/ijere.v15i6.39843

Web 4.0 learning analytics in early vocabulary assessment

Sirikanya Maneenil[1], Suebwong Chuensombat[1], Pattaraporn Jamsai[2], Panita Wannapiroon[3]
[1]Office of Educational Technology, Sukhothai Thammathirat Open University, Nonthaburi, Thailand
[2]Kasetsart University Laboratory School, Faculty of Education, Kasetsart University, Bangkok, Thailand
[3]Department of Information Technology Management, Faculty of Information Technology and Digital Innovation, King Mongkut's University of Technology, Bangkok, Thailand

Article Info

Article history:

Received Apr 7, 2026
Revised Oct 23, 2026
Accepted Oct 31, 2026

Keywords:

Delayed language
Early literacy
Learning analytics
Learning platform
Primary education
Vocabulary assessment
Web 4.0

ABSTRACT

The objectives of this research were: i) to develop a Thai vocabulary literacy testing platform for grade 1 students; ii) to evaluate the quality of the platform; and iii) to assess user satisfaction. The study integrated the system development life cycle (SDLC) framework with Web 3.0 and 4.0 technologies to design a web-based testing system capable of smart learning analytics. The participants for this study consisted of five experts in educational technology, linguistics, and child development, along with 30 teachers who teach in first grade and 150 students. The research findings revealed that: i) the developed platform comprises four core systems, including a vocabulary bank management system, a user information management system, a vocabulary quiz system, and a data storage and report system, which effectively support the measurement and evaluation processes of students' vocabulary literacy; ii) the quality evaluation by experts indicated that the platform's overall quality was at the highest level (M=4.83, SD=0.38); and iii) the assessment of teacher satisfaction regarding the platform usage revealed the highest level of satisfaction (M=4.70, SD=0.49).

This is an open access article under the CC BY-SA license.

Corresponding Author:

Suebwong Chuensombat
Office of Educational Technology, Sukhothai Thammathirat Open University
Chaengwattana Road, Bang Phut, Pak Kret, Nonthaburi 11120, Thailand
Email: Suebwong.chu@stou.ac.th

1. INTRODUCTION

Delayed language development in children is a common issue both in Thailand and internationally. According to a survey by Ministry of Social Development and Human Security, in 2017, approximately 47.5% of Thai children experienced delays in language comprehension, and 43.2% in language expression, respectively. These figures represent a significant increase compared to 2010, when the rate was only 18.9% [1], [2]. This problem is not confined to Thailand, as it is prevalent in many countries. For instance, language delays in American children range from 5% to 12% [3]. Similarly, a study in Australia found that approximately 6.4% of school-aged children have developmental language disorder (DLD), reflecting that language issues are a population-level concern vital for education and public health policy [4]. Within Asia, research in China indicates that approximately 8.5% of preschool children suffer from DLD, significantly affecting their school readiness and social behavior [5]. These statistics indicate that delayed language development is a global issue. Such problems do not merely impact communication skills during childhood; they are directly correlated with cognitive levels, reading and writing disabilities, and extend to long-term social and behavioral challenges in adulthood [6].

Children with delayed language development often experience multifaceted impacts, including speech delays, unclear articulation, and ineffective communication. These challenges are frequently

accompanied by emotional issues, including anxiety and social withdrawal, and are correlated with lower cognitive levels compared to children with typical language development [7]. Furthermore, language development is closely linked to literacy skills; children with language delays are more likely to experience difficulties with spelling, sentence comprehension, and reading accuracy. A fundamental cornerstone of early childhood education is the 'vocabulary'. A limited understanding of word meanings leads to a 'word gap', which serves as a significant barrier to both academic learning and school adjustment [8].

To implement educational interventions that mitigate the impacts of delayed language development, teachers must prioritize vocabulary building starting at the preschool and first-grade levels. This is because vocabulary serves as a crucial foundation for language comprehension and overall learning [8]. However, current screening processes are often hindered by significant delays. Despite the high prevalence of language delays among young learners, many primary school teachers lack access to fast, practical, and culturally appropriate tools to assess vocabulary development, resulting in delayed identification and intervention. These delays typically result from a heavy reliance on specialists, overly complex procedures, and a lack of standardized vocabulary comprehension tests. Consequently, many children miss the opportunity to receive timely and effective intervention. Existing vocabulary assessment tools are often time-consuming, require specialist administration, and do not provide real-time feedback for classroom use, highlighting the need for an accessible, intelligent, and teacher-friendly assessment system.

The development of an educational platform leveraging Web 4.0 technology is a strategic approach to overcoming these limitations. By integrating standardized vocabulary literacy tests with Web 4.0, traditional assessments are transformed into web-based systems accessible via any browser, be it on a computer, tablet, or smartphone [9]. This advancement enables educators to conduct rapid initial screenings supported by accurate data recording and processing systems. Developing this platform is not merely about creating a modern educational innovation; it serves as a vital mechanism for proactive intervention, facilitating data referral to specialists and mitigating long-term impacts on the future child population. Recognizing these necessities, the researcher identified the importance of developing the Thai vocabulary literacy testing platform for grade 1 students. By utilizing Web 3.0 and 4.0 technologies, the platform ensures ease of access and speed through web browsers without the need for software installation. This enhances the efficiency of language development screening, allowing teachers and students to conduct assessments, plan interventions, and refer results to language experts in a timely manner, effectively addressing the practical needs within educational contexts. Ultimately, this study contributes by developing an intelligent Web 4.0 platform that integrates vocabulary assessment with learning analytics, enabling teachers to conduct rapid, data-driven screening and support early language development.

This study introduces a novel educational innovation by operationalizing Web 4.0 'intelligent web' concepts into a practical, localized early literacy screening infrastructure. The unique contribution of this paper is two-fold: technically, it bridges semantic data structures with formative learning analytics to track fine-grained student progress automatically; pedagogically, it addresses the early childhood 'word gap' through an age-appropriate, browser-based interface that requires no software installation. The integration of continuous automated logging with immediate multi-tier dashboard visualization establishes a new benchmark for smart assessment platforms, demonstrating how advanced digital environments can fluidly support cognitive and linguistic development theories in primary education.

2. LITERATURE REVIEW

2.1. Thai vocabulary

Core vocabulary refers to high-frequency words that are used regularly in both spoken and written communication. This concept can be defined through both narrow and broad perspectives. In a narrow sense, core vocabulary signifies the words essential for general daily communication. In a broad sense, it encompasses a limited set of high-frequency words, comprising both function words (pronouns, prepositions, and conjunctions) and content words (nouns, verbs, and adverbs) [10]. Furthermore, core vocabulary represents the specific range of words that learners at each grade level are expected to know, as they are fundamental to learning, daily life, and various subject-specific areas [11], [12]. Studies on the basic vocabulary of primary school students indicate that the foundational word list for grades 1–3 comprises a total of 1,001 core words. Specifically, grade 1 students are expected to have a command of approximately 993 basic words, which increases to 1,212 words in grade 2, and further expands to 1,332 words in grade 3. These figures reflect that a learner's vocabulary size grows progressively in accordance with their grade level and educational experience [10].

Regarding language development, children aged approximately six years, marking the beginning of primary education, are in the creative stage. During this period, children experience a rapid expansion in their vocabulary and idioms; they are expected to have a receptive vocabulary of approximately 13,500–15,000

words and an expressive vocabulary of over 2,500 words for communication. At this stage, they begin to use language to convey more abstract meanings, demonstrate a keen interest in storytelling, and start developing a serious engagement with reading and formal language learning [13], [14]. Furthermore, by the age of eight and beyond, a child's linguistic and speaking abilities increasingly resemble those of an adult [15].

In summary, language and vocabulary development in early primary students progresses continuously. At the onset of their primary education, children should possess an extensive vocabulary and be capable of communicating effectively across all four language domains: speaking, listening, reading, and writing. These competencies serve as a crucial foundation for the development of higher-level learning skills in the future.

2.2. Vocabulary literacy test for primary school students

Vocabulary literacy tests for primary school students serve as essential tools for assessing and screening learners' language proficiency and vocabulary comprehension. These instruments vary in form according to their specific measurement objectives. A widely recognized example is the Wechsler intelligence scale for children-third edition (WISC-III), a standardized intelligence test composed of two primary sections: the verbal part and the non-verbal part. The verbal component specifically evaluates vocabulary comprehension, language usage, oral communication, as well as problem-solving and auditory learning abilities. While the WISC-III is applicable for children aged 6 to 16 years and 11 months, its administration and interpretation of results strictly require the expertise of a professional psychologist [16]. Furthermore, the Peabody picture vocabulary test-IV (PPVT-IV) is an assessment tool designed to measure vocabulary comprehension through word-picture association. During the test, the examiner speaks a stimulus word aloud, and the child is required to select the image that best matches the word's meaning from four pictorial options. The test items are arranged in order of increasing difficulty, and there is no time limit for completion. The PPVT-IV is applicable for individuals ranging from 2 years and 6 months of age through adulthood [7], [17]. The test for examining expressive morphology (TEEM) is another diagnostic tool that tests morphological skills across six main morpheme types. The assessment takes approximately seven minutes to complete and is suitable for children between the ages of 3 and 7 [18].

However, each type of assessment has a distinct scope and inherent limitations. For instance, the PPVT-IV and the receptive one-word picture vocabulary test-revised (ROWPVT) focus exclusively on measuring vocabulary comprehension. In contrast, the TEEM is strictly limited to evaluating morphological systems. Furthermore, these instruments face practical constraints regarding their application, linguistic translation, and overall suitability within the specific linguistic and cultural context of Thailand. The inherent constraints of these traditional instruments extend beyond mere cultural and linguistic mismatches; they present systemic operational bottlenecks in early primary education. Clinical and standardized tools like the WISC-III or PPVT-IV rely heavily on intensive, one-on-one administration by licensed specialists, rendering universal or school-wide screening logistically impractical within standard classroom contexts. Furthermore, because these conventional assessments are predominantly paper-based and summative, they fail to capture the dynamic, real-time progression of lexical acquisition. This creates a prolonged diagnostic latency, meaning that children experiencing delayed language development often go undetected during critical intervention windows. Consequently, this operational gap underscores an urgent need for an automated, scalable evaluation mechanism that transitions screening from resource-heavy clinical settings to accessible classroom environments.

2.3. Evolution of the web and learning platforms

The evolution of the web can be categorized into four significant eras, reflecting shifts in web architecture and the role of users within online information systems. Web 1.0 marked the inception of the world wide web, characterized by static websites focused on one-way information dissemination, where users acted primarily as passive consumers [19], [20]. Subsequently, Web 2.0 evolved into the social web, enabling users to create, share, and interact with online content through blogs, social networks, and media-sharing platforms, thereby fostering two-way communication and increased user engagement [21]. In the following stage, Web 3.0, or the semantic web, emphasized semantic data connectivity and decentralized technologies, such as blockchain and artificial intelligence (AI). This allowed systems to process data more intelligently and provide highly personalized services [21], [22]. Currently, the concept of Web 4.0 is envisioned as the intelligent web, which seamlessly integrates humans, machines, and smart devices through technologies like the internet of things (IoT), AI, and automation. This synergy facilitates intelligent data services that respond instantly to users across various contexts [19], [20]. Consequently, the progression from Web 1.0 to Web 4.0 illustrates a transition from a platform for information broadcast to one centered on active participation, intelligent data linking, and the integration of advanced digital technologies into daily life.

Learning platforms are integral components of Web 3.0 and 4.0 technologies, aiming toward the evolution of the 'intelligent web'. This paradigm integrates AI, the IoT, big data, and intelligent agent

systems, enabling the network to communicate, analyze, and respond to users intelligently in real-time [19], [23]. The core concept of Web 4.0 lies in establishing a network where humans and machines collaborate through meaningfully linked data that can be processed automatically. This ensures that the system can process information to provide smarter and more personalized services [24], [25]. Consequently, such technologies facilitate the development of sophisticated digital platforms capable of dynamically adapting content and learning processes to suit the specific needs of individual learners.

In educational contexts, online learning platforms are widely utilized as integrated service systems that consolidate data, tools, and digital resources to support instruction, communication, and access to knowledge for both learners and educators within an online environment [26]. These educational platforms play a pivotal role in advancing learning within the digital era and the 'new normal' societal context, emphasizing learner-centered instruction and fostering technology-enhanced interactions between students and teachers [27]. A key characteristic of these learning platforms is their function as a centralized space supporting personalized learning. They facilitate knowledge management tailored to individual learner needs, encompassing the storage and categorization of content, self-reflection, and progress tracking. Furthermore, they empower educators to transition into roles as mentors who provide essential guidance and feedback to enhance learning outcomes. These platforms also support the sharing of digital resources, cloud-based collaboration, and social networking integration to promote collective learning within online professional learning communities [28].

Consequently, the application of Web 4.0 technology in developing a vocabulary literacy testing platform for early primary students significantly enhances the efficiency of language assessment tools. The system is capable of dynamically adjusting the difficulty levels of test items and processing results to evaluate learners' proficiency against predefined criteria, thereby reflecting their actual ability. Furthermore, data connectivity through semantic structures and knowledge graphs enables the system to process vocabulary, word relationships, and linguistic contexts with greater precision. This results in assessments that are highly valid and effective in evaluating learning outcomes [25]. Therefore, integrating Web 4.0 concepts into the development of language assessment platforms represents a vital approach to elevating educational measurement tools into intelligent systems that effectively support learning in the Education 4.0 era. Integrating Web 4.0 technologies and learning analytics directly addresses these identified assessment bottlenecks by shifting the pedagogical paradigm from static measurement to intelligent, context-aware evaluation. While Web 3.0 advanced decentralized semantic data structures, Web 4.0 introduces smart automation capable of processing multimodal sensory interactions (audio-visual paired with pictorial choices) in real-time. Theoretically, this technological synergy mitigates cognitive load on young learners through adaptive item delivery, while simultaneously bypassing the necessity for specialized human administrators via automated scoring and risk-stratification dashboards. Learning analytics transforms raw interaction logs into immediate, actionable pedagogical insights. This effectively bridges the gap between early childhood linguistic development theories and daily instructional practice, empowering educators to execute data-driven, localized interventions before the 'word gap' permanently hinders a child's academic trajectory.

2.4. System development life cycle

The system development life cycle (SDLC) is a process-oriented conceptual framework used for the systematic development of information systems or software. It encompasses a series of stages, beginning with planning, analysis, design, development, and testing, and extending through system implementation and maintenance. The primary goal of the SDLC is to ensure that the developed system is of high quality, meets user requirements, and operates with maximum efficiency [29], [30]. The key stages of the SDLC can be summarized as:

- System planning is the initial stage of the system development process, focusing on defining the project's objectives, scope, and resources. This stage also involves conducting feasibility studies across technical, economic, and operational dimensions to determine whether the system development is appropriate and practically viable [31].
- Systems analysis is the stage focused on a detailed study of the problems and user requirements of the system. In this phase, systems analysts gather information from various stakeholders, including users, executives, or system developers, to define clear system requirements that align with the organization's objectives [30].
- Systems design is the stage where the system's structure and components are defined based on the requirements identified during the analysis phase. This process encompasses architectural design, database design, user interface (UI) design, and the specification of system workflows. The goal is to provide a comprehensive blueprint that ensures the subsequent development phase is executed effectively [29].
- Systems development and programming is the stage where system developers construct the system based on the specifications defined during the design phase. This involves using appropriate programming

languages, development tools, and technologies to build system functionalities, ensuring they meet the established requirements [32].
- System testing is the stage focused on verifying the accuracy and performance of the system. Testing is conducted across multiple levels, including unit testing, integration testing, and system testing. The primary objective is to ensure that the system operates correctly and remains free of errors that could adversely affect user experience (UX) and functionality [29].
- System implementation and maintenance is the stage involving the installation of the system within a live environment, user training, and post-installation support. This phase also encompasses system updates, bug fixes, and the development of additional functionalities to ensure the system can accommodate evolving requirements in the future [30], [31].

Adhering to the systematic stages of the SDLC ensures that information system development meets established standards, mitigates development risks, and enhances the efficiency of the system in practical application. This is particularly crucial within the context of educational platform development, which demands high levels of accuracy, reliability, and effective user responsiveness [32].

3. METHOD

3.1. Participants

The participants in this study consisted of two main groups: experts and first-grade teachers.
- The experts in educational technology, linguistics, and child development were selected through purposive sampling. The inclusion criteria required that each expert possess three to five years of professional experience in their respective fields.
- The first-grade teachers were selected through purposive sampling. The inclusion criteria required that each participant possess three to five years of professional teaching experience in the relevant field.

3.2. Research instruments

The quality assessment form for the Thai vocabulary literacy testing platform for grade 1 students is designed as a 5-point Likert scale. The assessment form is divided into three sections: i) section 1 collects the general information of the evaluators; ii) section 2 assesses the quality levels of the vocabulary literacy testing platform using a five-point rating scale as: very high (5 points), high (4 points), moderate (3 points), low (2 points), and very low (1 point); and iii) section 3 provides space for additional suggestions regarding the platform's usage.

The satisfaction evaluation form for the grade 1 Thai vocabulary literacy testing platform is designed as a 5-point Likert scale. The instrument is structured into three sections: i) section 1 gathers the general information of the evaluators; ii) section 2 assesses the levels of user satisfaction with the vocabulary literacy testing platform based on a five-point rating scale, defined as: most satisfied (5 points), highly satisfied (4 points), moderately satisfied (3 points), slightly satisfied (2 points), and least satisfied (1 point); and iii) section 3 provides a space for additional suggestions regarding the platform's usage.

3.3. Data analysis

Data collected from the evaluation instruments were systematically analyzed using descriptive statistics, specifically focusing on the mean (M) and standard deviation (SD). The calculation of means allowed the researchers to interpret the overall level of platform quality and user satisfaction according to the predetermined criteria. Furthermore, the SD was computed for each dimension to examine the variability and distribution of the scores provided by the participants. These statistical values collectively provided a robust foundation for interpreting the research outcomes.

3.4. Research procedures

The research procedures in this study are divided into two primary phases:
- Phase 1: the development of the Thai vocabulary literacy testing platform for grade 1 students.
- Phase 2: the study of results following the implementation of the Thai vocabulary literacy testing platform for grade 1 students.

3.4.1. Phase 1: the development of the Thai vocabulary literacy testing platform for grade 1 students

The development of the Thai vocabulary literacy testing platform for grade 1 students utilizes the SDLC framework as a systematic guideline for system engineering. This approach ensures that the platform's design and development are efficient, that every function effectively meets user requirements, and that the system robustly supports the assessment of students' vocabulary literacy. The development process consists of six key stages as:

a. System planning

The researcher defined the development objectives with the primary goal of creating and developing a Thai vocabulary literacy testing platform for grade 1 students. The scope of the assessment focuses on the foundational vocabulary list required for grade 1 students as mandated by the Office of the Basic Education Commission (OBEC), Ministry of Education. Currently, there is a lack of standardized testing tools for school-wide use in Thailand. Therefore, the development of this platform will provide a standardized instrument to assist teachers in measuring and evaluating students' linguistic development. The results obtained can be utilized to plan further student improvement, offering significant benefits to students, teachers, and parents alike. The conceptual framework for the platform design is presented in Figure 1.

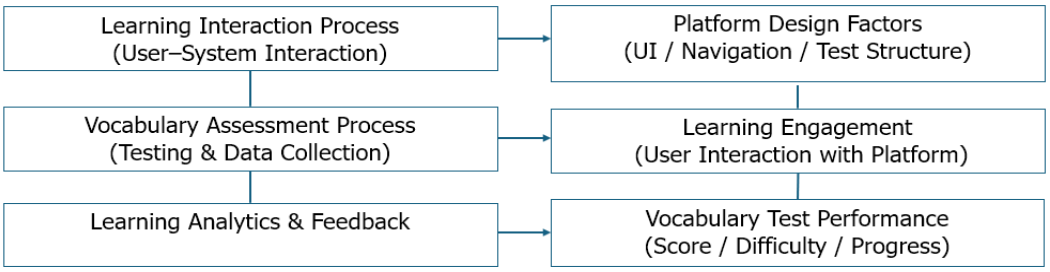


Figure 1. Vocabulary recognition test platform design

The vocabulary recognition test platform design serves as the structural blueprint for the platform's core components. This framework is established to design the following processes:

- The learning interaction process encompasses the interactions between students and the system, such as user login, test selection, and assessment responses. These interactions are integrated into the design of the platform's core components, which include UI design, system navigation, and the vocabulary bank system.
- The vocabulary assessment process involves testing and collecting student data through learning engagement metrics. These metrics include test duration, the number of items completed, and the consistency of platform usage.
- Learning analytics and feedback is a system designed to analyze learning data to generate actionable feedback for both students and teachers. This process is facilitated through test scores, vocabulary difficulty levels, and student progress tracking based on predefined benchmarks.

b. System analysis

Involves studying user requirements and defining the functional specifications of the system. The primary users of the platform consist of test administrators (teachers) and examinees (students). This stage includes analyzing core system processes, such as user registration, student data management, and vocabulary bank management. The vocabulary is categorized into specific word classes, including verbs, adverbs, and nouns, with a randomization feature based on category and difficulty levels to generate test items. Furthermore, the analysis defines the testing procedures, scoring mechanisms, and data storage protocols to systematically track students' vocabulary development

c. System design

Involves defining the platform's operational structure and system components in detail. This phase covers the database design, as depicted in the system architecture diagram in Figure 2, for storing user data, student information, and assessment results. The core structural components of the system are defined as:

- The vocabulary bank management system is responsible for storing, categorizing, and maintaining the quality control of the assessment items used within the platform.
- The user information management system is designed to display content, features, and navigation menus customized according to the "user roles" within the platform.
- The vocabulary quiz system is designed to assess students' vocabulary literacy through an audio-visual assessment format, featuring audio-based questions paired with pictorial multiple-choice options. The system automatically records test results, including the date and time of the assessment, while performing data analysis to evaluate each student's vocabulary proficiency level according to predefined criteria.
- The data storage and report system is designed to systematically store student assessment results and perform in-depth data analytics. The system generates reports in a user-friendly format for teachers and administrators, ensuring that the insights are easy to interpret and actionable for further educational planning. This infrastructure robustly supports both testing operations and the effective analysis of student learning outcomes. Furthermore, the UI design encompasses essential components, including user

registration, student profile management, test instructions, and real-time score displays. Specifically, the test format is tailored for Grade 1 students by integrating text, audio pronunciation, and pictorial options. This approach facilitates multimodal learning, allowing students to select the correct image corresponding to the vocabulary heard, thereby enhancing lexical recognition through multiple sensory channels.

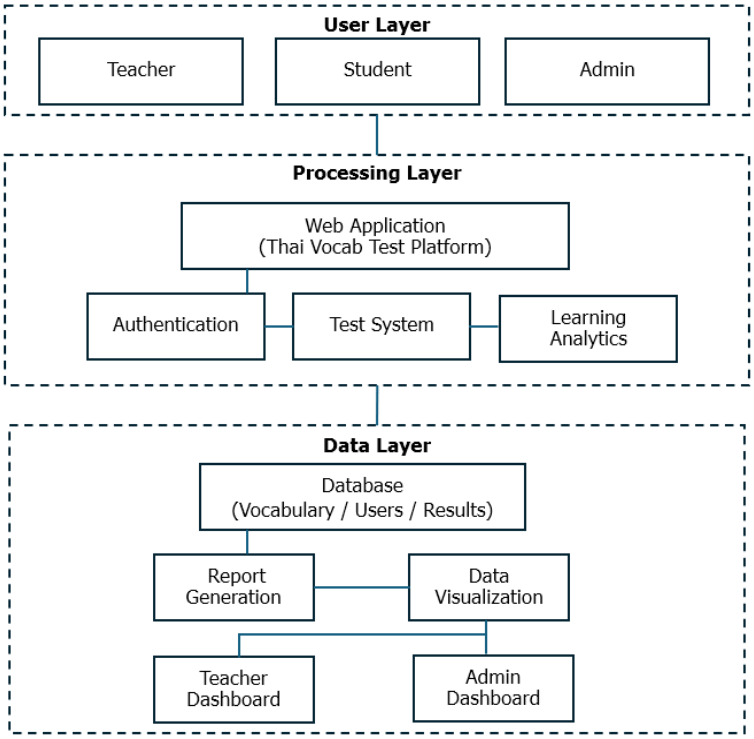


Figure 2. System architecture diagram

d. System development

This phase involves transforming the structural models and designs into a fully functional platform. The process focuses on developing the four core system modules and implementing critical functions. These include an algorithmic randomization feature for selecting vocabulary across all word classes and difficulty levels, test duration tracking, automated scoring, and student assessment history logging. These features are integrated to ensure that teachers can systematically and continuously monitor students' vocabulary literacy development.

e. System testing and validation

Following the development phase, rigorous system testing was conducted to evaluate the functional accuracy and overall performance of the platform. Pilot testing involved both teachers and students to ensure the seamless display of vocabulary text, audio pronunciation, and pictorial options. This stage also included verifying the integrity of user and student data registration, as well as the precision of automated scoring and result logging. Furthermore, the system's resilience was tested under various conditions, such as network requirements, specialist instability, or power interruptions, to ensure that the platform could robustly save current progress and prevent data loss. To guarantee the platform's readiness for implementation, five experts-specializing in educational technology, linguistics, and child development-were invited to evaluate the platform's quality. The evaluation criteria were pre-established, with the target quality set at the 'highest' (excellent) level.

f. System implementation and maintenance

This final stage involves the actual deployment of the testing platform within the educational context. Test administrators (teachers) can utilize the system to register student data, conduct assessments, and monitor vocabulary literacy progress. The platform is capable of displaying test scores and student development through data visualizations, such as tables, graphs, and percentages. Additionally, the system allows for historical data retrieval and data exportation for further analysis and reporting. Teachers are also able to record individual qualitative feedback on each student's performance. This recorded information serves as a critical resource for instructional planning and targeted linguistic support, ensuring that each student receives appropriate language intervention in the future.

3.4.2. Phase 2: the study of results and effectiveness of the Thai vocabulary literacy testing platform for grade 1 students

In the second phase, a comprehensive training workshop was conducted for 30 participating teachers to ensure their readiness before the official deployment of the platform. The session began with an introduction to the platform's development background and a high-level overview of the four core system modules. This provided the teachers with a holistic understanding of the workflow, followed by an in-depth exploration of the testing and reporting systems. After completing the registration process, these teachers implemented the platform with a sample group of 150 grade 1 students over a one-month data collection period. Upon the conclusion of the testing period, the teachers' satisfaction was evaluated using a 5-point Likert scale questionnaire, which also included a section for qualitative suggestions to inform future system enhancements. The interpretation of the mean scores was defined as:

- A mean score of 4.55 to 5.00 represents the highest level of satisfaction.
- A score between 3.55 and 4.54 indicates a high level of satisfaction.
- A score of 2.55 to 3.54 signifies a moderate level of satisfaction.
- A range of 1.55 to 2.54 reflects a low level of satisfaction.
- A score from 1.00 to 1.54 indicates the lowest level of satisfaction.

The data obtained from this evaluation, along with the teachers' feedback, serves as a vital resource for refining the platform and ensuring its pedagogical effectiveness for grade 1 students.

4. RESULTS AND DISCUSSION

4.1. Development of a Thai vocabulary literacy testing platform for grade 1 students

Based on the strategic planning and the system development process guided by the SDLC framework, the Thai vocabulary literacy testing platform for grade 1 students was successfully developed with the following features and components (accessible at www.thaivocabtest.com), as visually demonstrated in Figures 3-8.

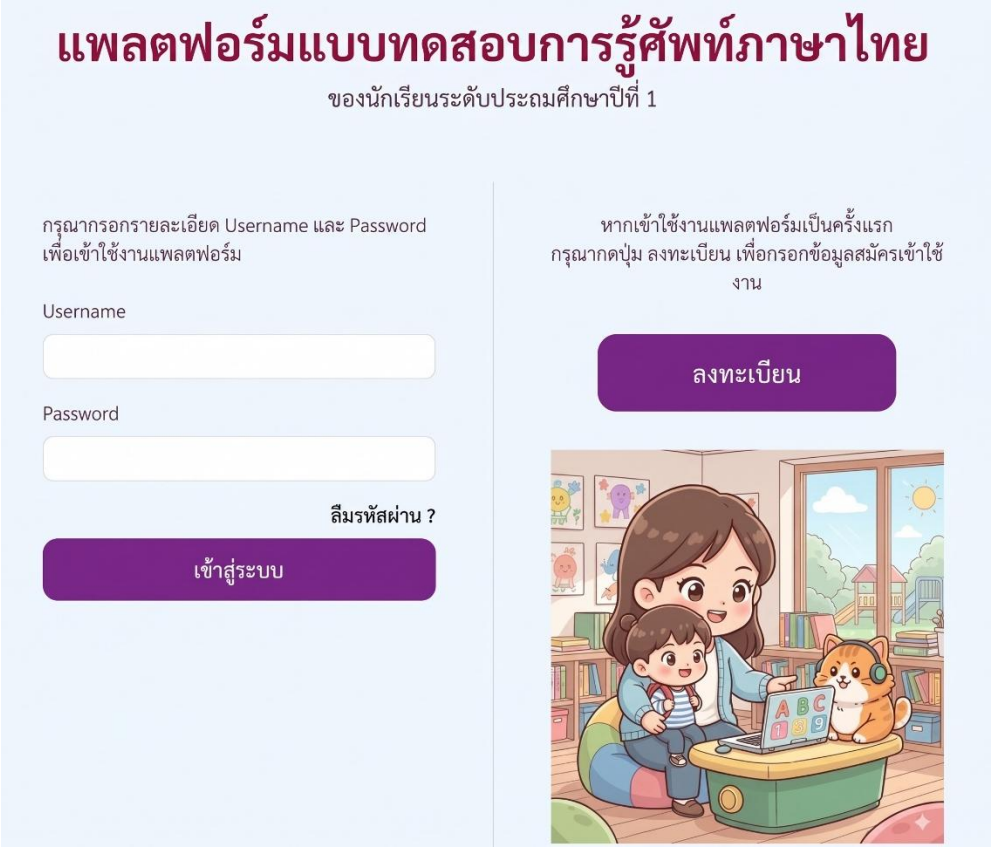


Figure 3. Thai vocabulary recognition test platform



Figure 4. Admin dashboard

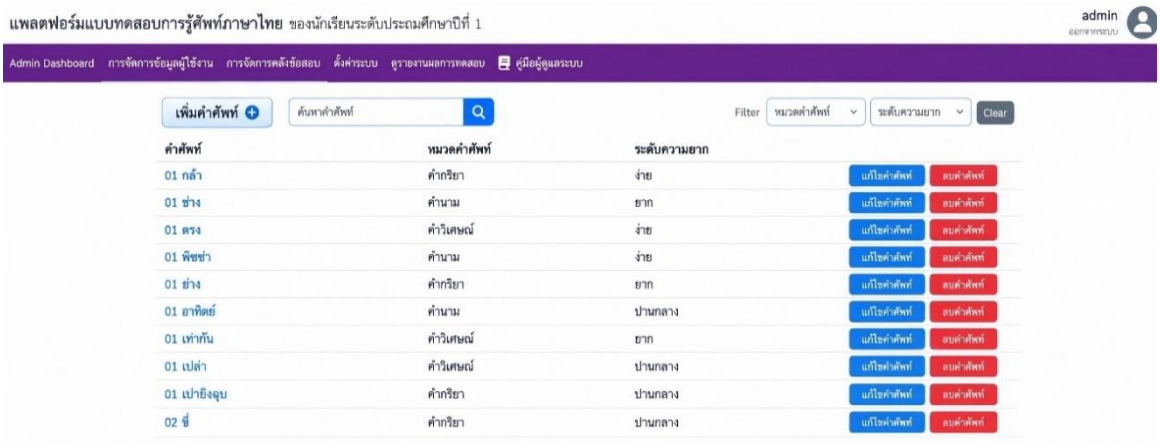


Figure 5. Vocabulary bank management system

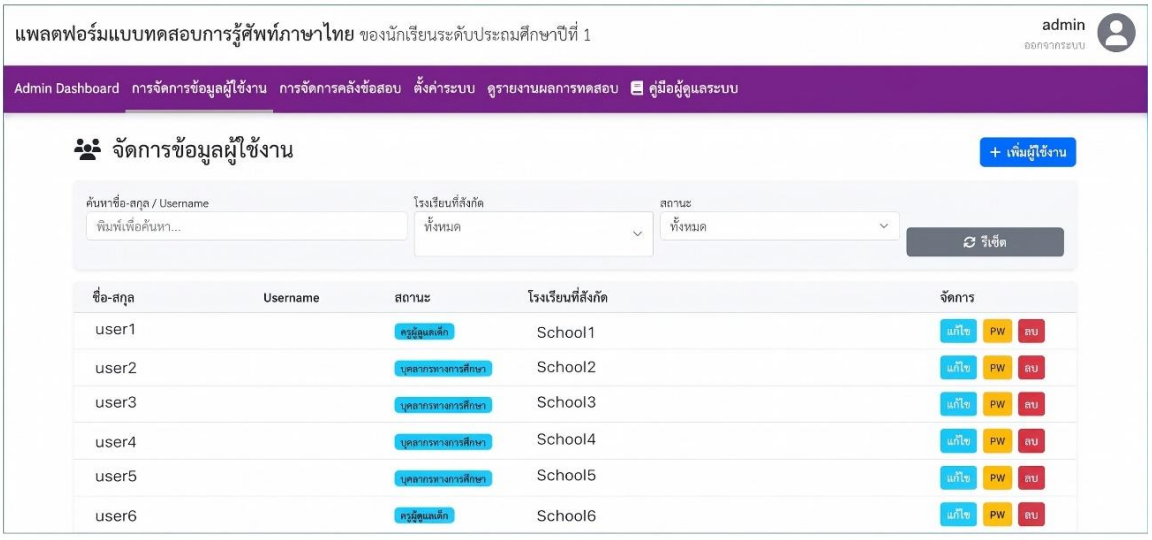


Figure 6. User info management system

4.2. Quality evaluation of the Thai vocabulary literacy testing platform for grade 1 students

The results of the quality evaluation by experts are presented in Table 1. According to the findings presented in Table 1, it can be concluded that the overall quality of the Thai vocabulary literacy testing platform was evaluated at the highest level (M=4.83, SD=0.38). When analyzing individual dimensions,

the three highest-rated areas were teacher functionality (user), which achieved a perfect score (M=5.00, SD=0.00), followed by the design aspect (M=4.92, SD=0.28), and administrator functionality (admin) (M=4.90, SD=0.31). In addition to the quantitative data, qualitative feedback and suggestions from the expert panel were categorized into various dimensions. Regarding the usability efficiency of the platform, experts noted that the system is highly convenient and user-friendly. The comprehensive presentation of information ensures that all functions are accessible and can be utilized with maximum efficiency. However, certain limitations were identified within the registration process, particularly for users affiliated with organizations under the Ministry of Higher Education, Science, Research and Innovation (MHESI). Currently, the system does not support the entry of workplace types other than schools. Therefore, it is recommended to expand the selection of organization types or workplaces to include a more diverse range of affiliations.

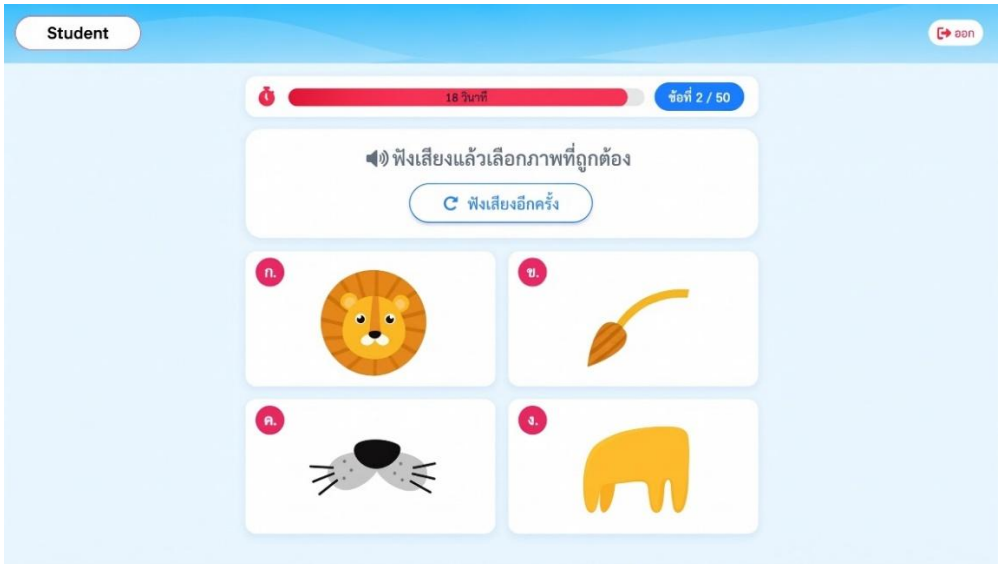


Figure 7. Vocabulary quiz system

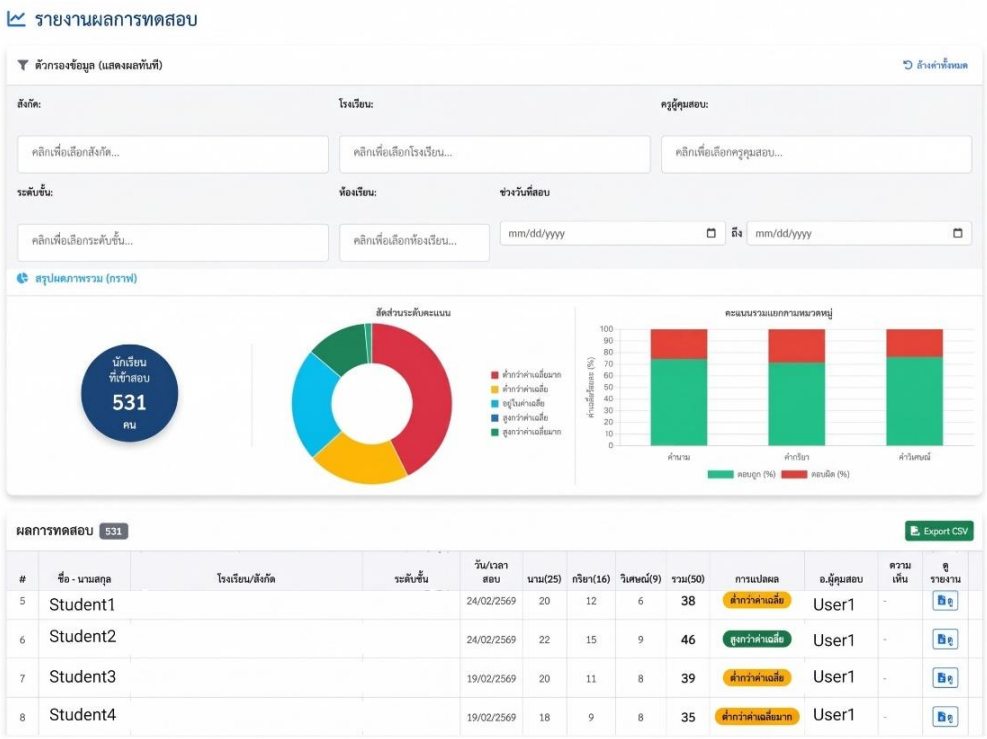


Figure 8. Data storage and report system

Table 1. Results of the quality evaluation of the Thai vocabulary literacy testing platform for grade 1 students by experts

Items	M	SD	Interpretation
Design aspect	4.92	0.28	Highest
Usability efficiency	4.60	0.50	Highest
Utility and Benefits	4.68	0.48	Highest
Teacher functionality (user)	5.00	0.00	Highest
Administrator functionality (admin)	4.90	0.31	Highest
Overall evaluation	4.83	0.38	Highest

Regarding the utility and benefits, teacher functionality (user), and administrator functionality (admin), the findings indicate that the platform effectively facilitates the management of individual student data and robustly supports post-assessment data processing. However, it was noted that when instructors need to conduct assessments for a large number of students, the process of adding student profiles individually can be time-consuming. Consequently, it is recommended that the system develop a bulk data entry feature, such as a batch import function for entire classrooms. This would allow instructors to copy or upload existing student data directly from external documents, thereby significantly reducing preparation time and enhancing the overall operational efficiency of the platform.

4.3. Satisfaction evaluation of the Thai vocabulary literacy testing platform for grade 1 students

Based on the results in Table 2, it can be concluded that the overall user satisfaction toward the Thai vocabulary literacy testing platform was at the highest level (M=4.70, SD=0.49). Every evaluated dimension within the survey consistently achieved a mean score above 4.60, which falls squarely into the highest satisfaction tier. Furthermore, the relatively low SD across all items indicate a high degree of consensus and agreement among the 30 participating teachers regarding the platform's efficacy.

Table 2. Results of user satisfaction evaluation toward the Thai vocabulary literacy testing platform by participating teachers

Items	M	SD	Interpretation
1. Platform usability and interface design	4.70	0.11	Highest
2. Assessment process and data management	4.67	0.08	Highest
3. Outcome and perceived value	4.76	0.04	Highest
Overall evaluation	4.70	0.49	Highest

When considering the specific dimensions in descending order, the outcome and perceived value received the highest rating (M=4.76, SD=0.04), followed by platform usability and interface design (M=4.70, SD=0.11), and assessment process and data management (M=4.67, SD=0.08). Regarding the qualitative feedback and suggestions, the findings can be categorized into various dimensions. Firstly, in terms of the utility of platform functionality, it was found that the testing features are particularly distinctive due to the integration of audio-visual elements and clear instructional video clips. These components effectively enhance students' vocabulary comprehension and cognitive processes. Furthermore, the reporting system provides high clarity, with the ability to analyze results by word category and perform comparative assessments, which is highly beneficial for student development. Overall, the platform is user-friendly, supports a wide range of devices, and features a convenient data management system. These attributes significantly reduce the instructors' workload while simultaneously enhancing overall operational efficiency.

Secondly, regarding the platform functionalities for improvement, the feedback indicated that the clarity and appropriateness of the visual elements should be refined. Additionally, the volume levels and pronunciation clarity of the vocabulary audio must be optimized to prevent student confusion. It is also recommended that the assessment format be further tailored to the developmental stages of young learners; for instance, by reducing the number of multiple-choice options and the overall number of test items. Furthermore, the design of supplementary skill-building activities for out-of-classroom learning should be considered. In terms of technical usability, the platform should account for varying internet speeds and enhance the granularity of student data-such as recording age in both years and months-to ensure higher precision in the assessment results.

Lastly, additional recommendations for implementation: it was found that the platform holds high potential for practical application, effectively facilitating both teachers and students while providing rapid assessment results. However, it is recommended that the instructional media and vocabulary be further tailored to align with the specific contexts and proficiency levels of learners, particularly for students with special needs. Furthermore, the platform should incorporate features that support learning beyond the classroom, such as a home-based practice system and parental involvement modules, alongside a continuous

longitudinal tracking system for student development. The system should also support bulk data entry for student profiles. Ultimately, the platform's scope should be expanded to cover diverse grade levels, with adjustments to the testing duration and content to better reflect the students' daily life contexts, thereby enhancing the overall effectiveness of the evaluation process.

4.4. Discussion

The research findings demonstrate that developing a platform within the SDLC framework is not merely a technical procedure, but rather a 'systemic mechanism' that tangibly elevates language assessment tools into an intelligent digital format. The four core systems developed effectively integrate the entire assessment process, from test creation to comprehensive learning analytics. This reflects a clear transition from traditional 'statistical testing' toward a 'data-driven assessment system'. Theoretically, this study bridges the gap between educational technology and assessment theory by positioning Web 4.0 and learning analytics not merely as administrative tools, but as mechanisms for continuous, formative assessment. By integrating real-time data analytics with early literacy screening, the platform operationalizes the concept of adaptive learning within the Education 4.0 framework. It demonstrates how intelligent digital environments can systematically support cognitive and linguistic development theories in early childhood, moving beyond traditional summative evaluations. Such progress aligns with the frameworks of Pressman [29] and Sommerville [30], who assert that a hierarchical and structured development process enhances the reliability and efficiency of information systems. Furthermore, the integration of Web 4.0 technologies and learning analytics empowers the platform to 'learn from learner data' and provide instantaneous feedback, which is the cornerstone of Education 4.0 [19], [23]. This holds significant policy implications as it assists in closing the 'word gap' through timely linguistic developmental screening. Additionally, the multimedia-based test design corresponds with early childhood learning theories that emphasize multisensory perception, thereby increasing the efficiency of vocabulary acquisition. Consequently, this research does not merely result in a tool but establishes a 'systemic innovation' capable of evolving into a fully intelligent assessment platform in the future.

The highest level of quality evaluation for the Thai vocabulary literacy testing platform for grade 1 students significantly reflects the alignment between 'system engineering design' and 'practical user requirements'. Specifically, the highest rating in teacher functionality demonstrates that the platform effectively reduces the burden of measurement and evaluation, shifting the teacher's role from a traditional assessor to a 'data-informed instructor'. This transformation aligns with Laudon and Laudon [32], who emphasize the importance of user-centered system design. Practically, these insights enable teachers to implement differentiated instruction, using specific data to tailor vocabulary interventions for individual students rather than relying on a one-size-fits-all approach. At the institutional level, schools can utilize this platform to implement systematic early screening programs at the beginning of the academic year, ensuring that students with language delays are rapidly identified and supported. By providing real-time data analytics, the platform effectively eliminates the diagnostic bottleneck that has historically delayed early-literacy interventions. Instead of waiting weeks for specialist evaluations, teachers receive immediate feedback, enabling them to implement targeted interventions precisely when grade 1 students need them. Upon deeper analysis, the research findings also indicate that the platform functions as an 'educational infrastructure' that supports efficient individual student data management, consistent with the work [8], who found that web platforms enhance data management efficiency and the implementation of learning activities. However, suggestions regarding bulk data support and system flexibility highlight critical issues of scalability, which Valacich and George [31] identify as a vital factor for modern information systems, particularly when scaling to the institutional or policy levels. Consequently, while the platform exhibits high quality, future development should aim toward becoming a 'large-scale system ready for national-level implementation'.

The highest level of satisfaction reported for the Thai vocabulary literacy testing platform for grade 1 students, particularly in the dimensions of outcome and perceived value, reflects the platform's ability to generate 'perceived learning value' for its users. This is a critical factor for the long-term adoption of educational technology. Furthermore, the teachers' ability to utilize real-time data for student analysis highlights the role of learning analytics in shifting assessment from being merely the 'end of learning' to becoming a 'continuous learning support tool' [23]. From another perspective, the high satisfaction regarding usability underscores the success of the UX design, which is a primary determinant for the success of digital platforms [19]. Nevertheless, suggestions concerning the refinement of media, age-appropriate test length, and the extension of learning beyond the classroom indicate that 'instructional design' remains a core element requiring continuous development. Specifically, strengthening the connection between school, home, and parents aligns with the concepts of Kleij *et al*. [8], who emphasize that vocabulary development relies on diverse and consistent learning contexts. Consequently, these research findings are significant not only in validating the platform's efficiency but also in outlining a trajectory toward a 'digital learning ecosystem' that systematically integrates data, learners, teachers, and parents.

4.5. Limitations of the study

Despite the significant pedagogical and technological advancements demonstrated by the developed platform, several limitations must be acknowledged. First, the generalizability of the quantitative outcomes is constrained by the sample size and geographical scope, as the study evaluated the platform using purposive sampling with 150 grade 1 students and 30 teachers within a localized educational context in Thailand. Consequently, the findings may not fully reflect the diverse institutional dynamics or infrastructural capacities of schools nationwide. Second, from a technical perspective, the platform currently lacks scalability features, such as a bulk data entry system or batch profile import function. This imposes a higher administrative workload on teachers when managing large classrooms. Furthermore, the system architecture's rigidity in user registration restricts its utilization by educators outside the traditional school system, such as those under the Ministry of Higher Education. Lastly, the platform's execution is dependent on varying local internet speeds, and the audio-visual elements. Specifically, volume consistency and the density of test items require finer calibration to match the evolving attention spans and sensory needs of young learners with potential delayed language development.

5. CONCLUSION

In conclusion, this study transcends the mere technical development of a digital application, establishing an intelligent, scalable infrastructure that operationalizes data-driven precision teaching within early primary education. The alarming prevalence of the early 'word gap' and delayed language development among grade 1 students can no longer be adequately mitigated through traditional, reactive pedagogical approaches or delayed specialist referrals. Therefore, this diagnostic platform acts as a mandatory evolution for modern primary classrooms, fundamentally transforming the educator's role from a passive observer into a precision instructor equipped with real-time learning analytics. By integrating automated vocabulary bank management with immediate multi-tier dashboard visualizations, the system effectively eliminates the diagnostic latency that historically obstructed early childhood literacy interventions. The empirical evidence, validated by an outstanding expert quality rating (M=4.83, SD=0.38) and a perfect teacher functionality score (M=5.00, SD=0.00), demonstrates that shifting toward this data-driven educational paradigm is an absolute necessity to ensure timely, targeted, and equitable linguistic support for young learners during their most critical developmental windows.

Looking toward the future, the prospects for developing these research results are extensive and multifaceted. From a technical standpoint, the study suggests enhancing the platform's efficiency by implementing batch data import functions to streamline classroom management and expanding its application to a wider range of educational institutions, including those under the Ministry of Higher Education. Furthermore, the discussion points toward the integration of more advanced Web 4.0 "intelligent web" capabilities, such as using AI to create adaptive testing environments that can tailor vocabulary difficulty to a child's performance in real-time. By refining audio-visual media to eliminate student confusion and leveraging the platform's learning analytics for longitudinal tracking of student progress, this research provides a scalable foundation for revolutionizing early childhood literacy assessment through digital transformation.

FUNDING INFORMATION

This project is funded by National Research Council of Thailand (NRCT): Contract number N42A670870.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Sirikanya Maneenil	✓					✓	✓		✓		✓		✓	
Suebwong Chuensombat		✓						✓		✓	✓			
Pattaraporn Jamsai				✓	✓	✓	✓			✓				✓
Panita Wannapiroon	✓					✓				✓		✓		

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to human use has been complied with all the relevant national regulations and institutional policies in accordance with the tenets of the Helsinki Declaration and has been approved by the authors' institutional review board or equivalent committee.

DATA AVAILABILITY

The authors confirm that the data supporting the findings of this study are available within the article.

REFERENCES

[1] Ministry of Social Development and Human Security, "*Child and youth development report, year 2017*," (in Thai), 2017. Accessed: Jan. 20, 2026. [Online]. Available: http://km.dcy.go.th/km/pdf-file/Development_Report_2560.pdf

[2] W. Aekplakorn, "*The Fourth National Health Examination Survey (NHES IV)*," 2010. Accessed: Jan. 21, 2026. [Online]. Available: https://kb.hsri.or.th/dspace/handle/11228/2976

[3] A. Othman, "Child developmental delays and disorders: Speech and language delay," *FP Essentials*, vol. 510, pp. 17–21, 2021.

[4] S. D. Calder, C. G. Brennan-Jones, M. Robinson, A. Whitehouse, and E. Hill, "The prevalence of and potential risk factors for developmental language disorder at 10 years in the Raine Study," *Journal of Paediatrics and Child Health*, vol. 58, no. 11, pp. 2044–2050, Nov. 2022, doi: 10.1111/jpc.16149.

[5] S. Wu *et al.*, "Prevalence, co-occurring difficulties, and risk factors of developmental language disorder: first evidence for Mandarin-speaking children in a population-based study," *The Lancet Regional Health - Western Pacific*, vol. 34, pp. 1–13, May 2023, doi: 10.1016/j.lanwpc.2023.100713.

[6] T. Sunderajan and S. Kanhere, "Speech and language delay in children: prevalence and risk factors," *Journal of Family Medicine and Primary Care*, vol. 8, no. 5, pp. 1642–1646, 2019, doi: 10.4103/jfmpc.jfmpc_162_19.

[7] S. Sawangjit, C. Kongsaktragul, and N. Ruangdaraganon, "Evaluation of read to live program on language development during early childhood period and caregiver reading–related behaviors," *Nursing Research and Innovation Journal*, vol. 21, no. 2, pp. 229–243, 2015.

[8] S. W. van der Kleij, A. P. Burgess, J. Ricketts, and L. R. Shapiro, "Tracking vocabulary and reading growth in children from lower and higher socioeconomic backgrounds during the transition from primary to secondary education," *Child Development*, vol. 94, no. 1, pp. 57–66, Jan. 2023, doi: 10.1111/cdev.13862.

[9] E. Bamrungsi, S. Pungpracha, P. Huawanich, and N. Budhong, "The development of Web application for creating and sharing joint events," (in Thai), *Science Journal, Chandrakasem Rajabhat University*, vol. 33, no. 2, pp. 93–104, 2023.

[10] Institute of Thai Language, "Report on the study of basic vocabulary for Grade 1-3 students, academic year 2011," 2011. Accessed: Jan. 20, 2026. [Online]. Available: http://academic.obec.go.th/web/document/view/158

[11] The Ministry of Education, "The basic education core curriculum B.E. 2551 (A.D. 2008)," 2008. Accessed: Feb. 2, 2026. [Online]. Available: https://academic.obec.go.th/images/document/1525235513_d_1.pdf

[12] English Language Institute, "Basic English vocabulary for primary level," (in Thai), 2016. Accessed: Feb. 20, 2026. [Online]. Available: https://www.lertchaimaster.com/doc/Glossary-english.pdf

[13] P. Luangsuwan, *Early childhood education: activities and instructional media for development and learning skills*. Bangkok: Chulalongkorn University Press, 1994.

[14] Y. Dejakup, *Early childhood education*. Bangkok: MAC, 1999.

[15] B. Panyayong, *Handbook of mental health and psychiatric care for physicians*. Nonthaburi: Department of Mental Health, 2001.

[16] C. Wechwirun, "Intelligence testing tools," (in Thai), *Warasan Rajanukul*, vol. 22, no. 3, pp. 167–198, 2007. [Online]. Available: https://library.dmh.go.th/raja/dublin.php?ID=24&serialmode=box

[17] L. M. Dunn and D. M. Dunn, *Peabody picture vocabulary test*, 4th ed. Minneapolis, MN: Pearson Assessments, 2007.

[18] K. G. Shipley, T. A. Stone, and M. B. Sue, *Test for examining expressive morphology (TEEM)*. Tucson, AZ: Communication Skill Builders, 1983.

[19] A. K. Ibrahim, "Evolution of the Web: from Web 1.0 to 4.0," *Qubahan Academic Journal*, vol. 1, no. 3, pp. 20–28, Jun. 2021, doi: 10.48161/qaj.v1n3a75.

[20] U. Mester and A. Toth, "The evolution of web development: the role of AI in shaping future web technologies," *Discover Artificial Intelligence*, vol. 5, no. 1, p. 391, Dec. 2025, doi: 10.1007/s44163-025-00567-4.

[21] W. Gan, Z. Ye, S. Wan, and P. S. Yu, "Web 3.0: the future of internet," in *ACM Web Conference 2023 - Companion of the World Wide Web Conference, WWW 2023*, Apr. 2023, pp. 1266–1275, doi: 10.1145/3543873.3587583.

[22] Y. Lin *et al.*, "A unified blockchain-semantic framework for wireless edge intelligence enabled web 3.0," *IEEE Wireless Communications*, vol. 31, no. 2, pp. 126–133, Apr. 2024, doi: 10.1109/MWC.018.2200568.

[23] Z. Zhou, Z. Li, X. Zhang, Y. Sun, and H. Xu, "A review of gaps between web 4.0 and web 3.0 intelligent network infrastructure," in *2023 IEEE World Forum on Internet of Things: The Blue Planet: A Marriage of Sea and Space, WF-IoT 2023*, Oct. 2023, pp. 1–6, doi: 10.1109/WF-IoT58464.2023.10539509.

[24] F. L. Almeida, "Concept and dimensions of Web 4.0," *International Journal of Computers & Technology*, vol. 16, no. 7, pp. 7040–7046, Nov. 2017, doi: 10.24297/ijct.v16i7.6446.

[25] M. Yahya, J. G. Breslin, and M. I. Ali, "Semantic web and knowledge graphs for industry 4.0," *Applied Sciences*, vol. 11, no. 11, p. 5110, May 2021, doi: 10.3390/app11115110.
[26] A. Porges, "Online platforms: a new landscape of learning," (in Thai), The Kommon, 2021. Accessed: Feb. 11, 2026. [Online]. Available: https://www.thekommon.co/online-learning-platform-lifelonglearningfocus/
[27] B. Chaitontuek and P. Phosing, "The use of platform innovation for Thai society," *Journal of local Governance and Innovation*, vol. 5, no. 3, pp. 117–130, 2021.
[28] J. N. Songkhla, *Digital learning design*. Bangkok: Chulalongkorn University Press (in Thai), 2018. [Online]. Available: https://library.catc.or.th/book-detail/9407
[29] R. S. Pressman, *Software engineering: a practitioner's approach*, 7th ed. New York, NY: McGraw-Hill Education, 2010.
[30] I. Sommerville, *Software engineering*, 10th ed. Harlow, U.K.: Pearson Education Limited, 2016.
[31] J. S. Valacich and J. F. George, *Modern systems analysis and design*, 9th ed. Harlow, U.K.: Pearson Education Limited, 2021.
[32] K. C. Laudon and J. P. Laudon, *Management information systems: managing the digital firm*, 15th ed. Harlow, U.K.: Pearson Education Limited, 2018.

BIOGRAPHIES OF AUTHORS



Sirikanya Maneenil is an assistant professor at the Office of Educational Technology, Sukhothai Thammathirat Open University (STOU), Thailand. She earned a doctoral degree in Educational Technology and Communications from Kasetsart University, Thailand. She previously served as an academic specialist in audiovisual education and has 10 years of experience in the production of instructional media. She has worked as an instructional designer and instructor for courses offered on the Thai MOOC platform (ThaiMOOC). Her research interests and areas of expertise include the design and management of open online learning systems (MOOCs), online learning environments, multimedia instructional design, and the production of educational television and radio broadcasting programs. She can be contacted at email: sirikanya.man@stou.ac.th.



Suebwong Chuensombat is an assistant professor at the Office of Educational Technology, Sukhothai Thammathirat Open University. He earned his Ph.D. in Educational Technology and Communications from Kasetsart University. His professional expertise spans instructional system design for distance learning, user interface (UI) and user experience (UX) design, and interactive media development. Dr. Chuensombat's research interests focus on brain-based learning (BBL), augmented reality (AR) in education, and mobile learning environments. He has made significant contributions to the field through his extensive work on interaction simulation videos designed to enhance digital intelligence and ethical technology use among undergraduate students. He can be contacted at email: suebwong.chu@stou.ac.th.



Pattaraporn Jamsai is an assistant professor at the Department of Educational Psychology and Guidance, Faculty of Education, Kasetsart University. She earned her Ph.D. in School Psychology from the University of Northern Colorado, USA, and holds degrees in Developmental Psychology and Secondary Education from Chulalongkorn University. Her research expertise focuses on special education, inclusive education, and child development, particularly for students with learning disabilities and ADHD. Dr. Jamsai has authored numerous publications in international and national journals, including studies on digital empathy skills and inclusive education systems. Beyond her academic role, she has extensive clinical experience as a school psychologist. She can be contacted at email: pattaraporn.ja@ku.th.



Panita Wannapiroon is a distinguished professor in the Department of Information Technology Management, Faculty of Information Technology and Digital Innovation, King Mongkut's University of Technology North Bangkok (KMUTNB), Thailand. She earned her Ph.D. in Educational Communications and Technology from Chulalongkorn University. Currently, she serves as the Director of the Innovation and Technology Management Research Center. Her primary research interests encompass digital learning ecosystems, artificial intelligence in education (AIEd), and instructional innovation. Dr. Wannapiroon has made significant contributions to the field through her extensive work on experiential design learning models and intelligent platforms. Her recent research focuses on integrating AI and immersive technologies to enhance digital competencies and ethical decision-making in higher education, establishing her as a leading expert in educational digital transformation. She can be contacted at email: panita.w@itd.kmutnb.ac.th.