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ORIGINAL ARTICLE

WeSign: A Software System to Support Vietnamese Sign Language Education for Deaf and Hard of Hearing Primary School Students

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ABSTRACT
Amid global efforts to enhance inclusive education, the gap between educational policy and the effective acquisition of sign language remains a significant challenge, particularly in developing contexts like Vietnam. This study explores the interplay between national standardization policies and the pedagogical implementation of technology for deaf and hard-of-hearing students. We introduce WeSign, an interactive software system designed to support Vietnamese Sign Language education by moving beyond traditional passive repositories. Through an AI-powered module, WeSign provides real-time feedback on fingerspelling and sign formation, fostering a self-directed learning environment. A mixed-methods approach was employed, comprising a needs assessment survey of 30 educators across three specialized institutions and a pilot evaluation involving 30 participants at a specialized school in Hanoi. Usability, measured via the System Usability Scale, yielded an overall mean score of 92.58 ("Best Imaginable"), indicating high acceptance among both teachers (94.00) and students (92.30). These results suggest that integrating AI-driven interactivity into the curriculum offers a promising framework for aligning with specific pedagogical requirements and Vietnam's Circular on National Standards for Vietnamese Sign Language. The study demonstrates that integrating AI-driven interactivity into the curriculum effectively meets specific pedagogical requirements and aligns with Vietnam's Circular on National Standards for Vietnamese Sign Language. Scholarly and policy implications highlight the system's potential to bridge educational gaps by providing a standardized, scalable platform for curriculum-aligned material development, thereby supporting the long-term autonomy and social integration of learners with hearing impairments.

1. INTRODUCTION

Enhancing communication abilities for children with deaf and hard of hearing, including those who are deaf or hard of hearing, offers significant benefits not only to the children but also to the wider Deaf and Hard of Hearing (DHH) community. In our increasingly technology-driven world, the development and application of technology in assisting teaching process has become crucial (Baglama et al., 2018; Lynch et al., 2022; Rehman et al., 2024). This

advancement enables disabled children to communicate with non-disabled people, facilitating better social integration, significantly boosts self-confidence and fosters critical language and cognitive development.

As of 2019, the World Health Organization (WHO) reported approximately 466 million people worldwide with hearing loss, accounting for 5% of the global population. Of these, 432 million (83%) were adults, while 34 million (17%) were children. By 2050, the number of individuals with hearing loss is expected to rise to 700 million (World Health Organization, 2024). In US, more than 90% of children with hearing and speech disabilities are born into families with hearing parents (Mitchell & Karchmer, 2004). Providing deaf children with access to sign language from an early age is crucial for their overall development, ensuring they acquire language during critical neurological periods.

Despite the introduction of national standards for Vietnamese Sign Language (VSL) education, a significant disconnect persists between policy directives and practical classroom implementation. Current digital resources for DHH students in Vietnam remain largely limited to static, passive repositories - such as digital dictionaries or pre-recorded video tutorials - which offer limited opportunities for active engagement or formative assessment. This absence of interactive, curriculum-aligned platforms creates a significant pedagogical gap, hindering students' ability to self-correct and practice sign formation in real-time. To address these critical limitations, we developed WeSign, an interactive software system designed to bridge this challenge. By integrating AI-powered feedback mechanisms with pedagogical materials aligned to national curriculum standards, WeSign transcends the role of a traditional resource repository, fostering an active, self-directed learning environment that empowers DHH students to master sign language with greater autonomy and precision.

To operationalize this objective, this paper examines the demand for sign language teaching software and details the development of the WeSign system. The demand for sign language teaching software based on survey results from three educational institutions is examined. Responses to design and develop WeSign, a web-based platform that employs Microservices Architecture and Artificial Intelligence (AI), are employed. It features a web application and a mobile application (for both Android and iOS), enabling educators to create curriculum-aligned materials, while allowing students to engage in structured or self-paced lessons. The system is utilized by teachers and students at a specialized school for deaf children in Hanoi. It features sign language learning materials for first-grade students, which are developed by teachers themselves in alignment with the standard school curriculum. These resources are intended for both in-class instruction and at-home review. Furthermore, the system serves as a supportive tool that enables parents and relatives to learn alongside the child, fostering an enhanced environment for the acquisition and use of sign language.

2. LITERATURE REVIEW

Studies by Xu (2013) and Chuan & Guardino (2016) have focused on developing sign language learning applications, namely SMARTSign and SmartSignPlay, for smartphones. These applications aim to support children and their parents in learning sign language together, thereby improving communication quality within the family. SmartSignPlay organizes commonly used American Sign Language (ASL) vocabulary and phrases into context-based lessons, where words are frequently used, illustrated through sample videos. Meanwhile, SMARTSign structures ASL vocabulary based on well-known children's stories. Experimental results indicate that parents who learned sign language vocabulary through storytelling consistently achieved higher sign recognition scores than those who learned vocabulary based on thematic categories. Additionally, parents enhanced their sign language proficiency by engaging with story-based applications, as explored in the study by (Weaver & Starner, 2011). Weaver further emphasized that the primary motivation for parents to learn sign language is to communicate more effectively with their children . Hall et al. (2019) emphasize that the primary need is for language itself, and relying solely on potentially inaccessible spoken language risks harmful language deprivation, negatively impacting cognitive and psychosocial outcomes. Complementing this, Humphries et al. (2017) frame early sign language exposure as a necessity for education and health, highlighting that natural sign languages are fully accessible visually and confer the same neurocognitive benefits as spoken languages. Therefore, teaching sign language early prevents the detrimental effects of language deprivation and supports deaf children in reaching their full linguistic, cognitive, and social-emotional potential.

In addition, technology-based applications designed to support students with hearing and speech disabilities in learning sign language within school settings have also garnered significant attention and development. The Sign

Instructor application (Chai et al., 2017) was developed with functionalities that teach sign language using standardized sign language materials in the form of videos, illustrations, and text. This application enables learners to practice sign language while simultaneously assessing the accuracy of their signed expressions. Adnyani et al. (2021) developed the Letsign application to facilitate the teaching and learning of ASL for students with hearing and speech disabilities in English language classrooms. The application incorporates thematic lessons covering topics such as family, animals, and clothing. The results demonstrated a significant improvement in students' sign language proficiency, as reflected in their performance scores after each learning session. Effectiveness of technology in sign language education is further reinforced by the study of Parvez et al. (2019), which examined the learning of mathematical concepts among children aged 5-10 with hearing and speech disabilities using Pakistani Sign Language. The study found that students who learned mathematical concepts through a sign language-based application achieved higher scores and completed tasks more quickly than those who learned through picture cards and traditional blackboard methods.

Enacted in 2010, the Vietnam Law on Persons with Disabilities stipulates that individuals with hearing and speech impairments have the right to education in sign language (National Assembly of Vietnam, 2010). Vietnamese Government Decree No. 28, issued in 2012, defines hearing and speech disabilities as conditions involving a reduction or loss of hearing and/or speech functions, impairing the ability to produce clear sounds and sentences, thereby limiting verbal communication and information exchange (Government of Vietnam, 2012). Vietnam National Survey on Persons with Disabilities reported that 2.79% of children aged 2 to 17, equivalent to approximately 663,900 children, have at least one disability in (Vietnam General Statistics Office, 2016). This included rates of 2.74% for those aged 2-4 and 2.81% for those aged 5-17. Specifically, 0.84% of these children experience hearing and speech disabilities.

Accordingly, the Vietnamese government allocated funding to support educational access through the Vietnam National Assistance Program for Persons with Disabilities for the period 2012-2020, under Decision No. 1019/QĐ-TTg dated August 5, 2012 (Government of Vietnam, 2012). The Ministry of Education and Training initiated efforts by developing sign language learning materials and training educators in inclusive practices. Notable initiatives include the Inclusive Deaf Education for Pre-School Children (IDEO) Project (World Bank, 2015), implemented in multiple regions including Hanoi, Thai Nguyen, Quang Binh, and Ho Chi Minh City.

In 2020, the Ministry of Education and Training (MoET) took a significant step towards enhancing inclusivity for deaf and hard-of-hearing learners by issuing the Circular on National Standards for Vietnamese Sign Language (VSL) (Ministry of Education & Training, 2020). This official regulation represents a landmark development, as it provides formal recognition and establishes a national framework for the standardization VSL. The issuance of these standards by MoET is fundamental for the structured teaching and promotion of sign language within the education system. It lays the groundwork for developing consistent curricula, training qualified sign language teachers, creating standardized learning materials, and facilitating effective communication and integration for deaf students in schools across Vietnam. The Quality Improvement of Primary Education for Deaf Children (QIPEDC project, n.d.) executed in over 20 provinces across Vietnam. These initiatives prioritize the use of sign language as the primary language of instruction, creating a supportive learning environment for these children. Sign language classes in the community and on television are now increasingly vital to Vietnam's wider education enterprise and are gaining broader support from the government, INGOs, and DPOs/ OPDs.

Technological solutions supporting the learning of VSL have primarily been developed within universities through technology competitions and startup projects. One notable example is Sounds of Silent (SOS) - a smart device designed to convert sign language into spoken Vietnamese, developed under Project 1665 by Nguyen (2021). In 2022, a team of Vietnamese students from four universities successfully developed the Earlie application, which facilitates communication for individuals with hearing and speech disabilities via smartphones. The application converts sign language into speech with an accuracy of 91.25% for 20 common signs, making it a practical tool for real-life communication. Easy Comm is a platform designed to assist the deaf and hard-of-hearing community by providing real-time, two-way conversion between VSL and text or speech. The project utilizes Deep Learning technology to break down communication barriers, aiming to improve social integration and accessibility for its users (Han, 2024). This achievement was recognized within the framework of the Tech4Good global technology competition. Despite the existence of several web-based sign language learning softwares, many fall short by offering merely introductory content without the necessary interactive features. As a result, their effectiveness is notably limited.

Despite numerous efforts to apply technology in sign language education, significant limitations remain in current studies, particularly within the Vietnamese context. First, existing applications such as Sign Instructor or SMARTSign primarily focus on ASL and are not tailored to the linguistic characteristics of Vietnamese children. Second, domestic platforms like the QIPEDC project website or online dictionaries, while providing valuable resources, often lack interactive features. They function mainly as passive repositories where learners watch videos without receiving feedback on their performance accuracy. Third, the integration of AI to automatically evaluate and correct errors for DHH learners - a crucial element for self-directed learning - remains a largely unexplored area in educational technology research in Vietnam.

The primary objective of this study is to design and evaluate the effectiveness of the WeSign software system in supporting sign language teaching and learning for DHH primary school students. To achieve this, the study addresses the following three Research Questions (RQs):

- RQ1: What is the current demand and status of software usage in sign language education at specialized schools in Vietnam?
- RQ2: How can a cross-platform learning support system integrating AI be designed to meet the specific pedagogical requirements of DHH students?
- RQ3: What is the level of usability and acceptance of the WeSign system among teachers and students upon practical implementation?

While international sign language learning applications such as SMARTSign and SmartSignPlay have successfully enhanced sign acquisition in foreign contexts, their focus on ASL renders them linguistically unsuitable for the specific needs of Vietnamese learners. Within the domestic landscape, established platforms like the QIPEDC project website and various online dictionaries provide essential resources aligned with the national curriculum, yet they operate primarily as passive repositories. These tools lack the interactive engagement necessary for self-directed study, as they do not offer feedback on the accuracy of a learner's sign performance. Furthermore, while recent Vietnamese technological innovations like Earlie and Easy Comm have utilized Deep Learning for sign-to-speech conversion, they are designed primarily as communication assistants rather than pedagogical systems for structured classroom use. WeSign addresses these gaps by uniquely integrating an AI-powered module that provides instantaneous, real-time feedback on sign formation and fingerspelling. This interactivity, coupled with content strictly developed in accordance with the Ministry of Education and Training's Circular on National Standards for VSL, ensures that WeSign is not merely a digital library but a comprehensive educational tool tailored to the long-term autonomy of deaf and hard-of-hearing primary students in Vietnam.

3. MATERIALS AND METHODS

This study employs a mixed-methods approach, combining technical system development with empirical quantitative evaluation. The research procedure is divided into two main phases:

Phase 1 - Needs Assessment: To address RQ1, a survey was conducted with 30 teachers across three specialized educational institutions. The instrument used was a questionnaire utilizing a 5-point Likert scale (1 = Not necessary/Never, 5 = Extremely necessary/Always) to assess the necessity and frequency of technology use. The collected data were analyzed using descriptive statistics (Mean, standard deviations).

Phase 2 - System Design and Pilot Evaluation: Based on the needs assessment results, the WeSign system was developed and subsequently piloted to answer RQ3.

- Participants: The pilot study involved 5 teachers and 25 first-grade students at Nhan Chinh School for the Deaf (Hanoi).
- Procedure: Participants were guided to use the key functions of WeSign, including the AI-powered self-practice module, over a period of two weeks.
- Instrument: Following the hands-on experience, the System Usability Scale (SUS) by (Bangor et al., 2008) was employed to measure software usability. The SUS questionnaire consists of 10 items (5 positive and 5 negative) rated on a 5-point scale. The composite SUS score (0-100) indicates the level of user acceptance of the system.

Regarding student demographics, it is important to note that although the participants were enrolled in Grade 1, their ages ranged from 9 to 15. This age-grade discrepancy is common in specialized deaf education in Vietnam, where

language deprivation often leads to delayed school entry or slower academic progression. To ensure the reliability and validity of the usability evaluation for this specific cohort, the 10-item SUS instrument was administered under the close guidance of experienced educators. Teachers assisted the students by translating the standard scale items into simplified VSL and utilizing visual aids - such as facial expression icons - to explain the 5-point Likert scale. This moderated approach was designed to bridge linguistic gaps and ensure that students fully comprehended each item before providing their subjective feedback, thereby maintaining the integrity of the usability data.

3.1. Sign Language in Teaching and Communication for Children with Deaf and hard of hearing

The use of sign language (SL) is essential for children with Deaf and hard of hearing and can be applied in two primary ways: Sign Language as a First Language and Sign-Supported Speech (Woodward & Nguyen, 2012; Pham et al., 2023).

3.1.1. Sign Language as a First Language

This approach uses sign language as the primary method of communication for deaf and hard-of-hearing students, while spoken language is learned as a second language. Under this approach, students develop bilingual proficiency in sign language and reading and writing skills in spoken Vietnamese.

Although this method is considered ideal for engaging with deaf and hard-of-hearing students, several challenges exist in its practical implementation:

- A shortage of deaf and hard-of-hearing teachers, which results in an insufficient pool of professionals who are capable of effectively teaching sign language as a first language.
- Most teachers in inclusive classrooms are hearing individuals, resulting in the predominant use of spoken language rather than sign language among instructors.

3.1.2. Sign-Supported Speech

Sign-supported speech is characterized by the concurrent use of spoken language and sign language by educators during teaching. This approach allows teachers to deliver lessons through verbal communication and sign language simultaneously.

There are several approaches to using sign-supported speech in teaching deaf and hard-of-hearing students:

- Simultaneously speaking and fingerspelling difficult words or words that do not have corresponding sign language representations.
- Speaking while incorporating sign language gestures either in the grammatical order of spoken language or by using signs to underscore key words within a sentence, without strictly adhering to the grammatical structure of sign language (Bui, 2015).

3.2. Demand and Current Use of Software in Sign Language Teaching and Learning

Survey Organization

We conducted a targeted survey among key stakeholders, primarily teachers, to gather insights into the demand and current use of software in sign language education at three specialized educational institutions in Vietnam: Nhan Chinh School for the Deaf (Hanoi); Xa Dan Primary and Secondary School (Hanoi); DakLak Center for Inclusive Education Development (Daklak).

Survey Methodology

Our system analysis began with a needs assessment focused on software use at Nhan Chinh School for the Deaf, Xa Dan Primary and Secondary School, and Dak Lak Center for Inclusive Education Development. We distributed Google Forms questionnaires to teachers and relevant stakeholders to collect data. Based on the survey responses, we conducted an in-depth analysis and developed functional diagrams and use-case diagrams to outline the system design.

To enhance the software development process, we conducted pilot testing of the software and gathered feedback through interviews with teachers, students, and parents of school students. We also consulted experts in deaf education from the National Center for Special Education, Vietnam Institute of Educational Sciences, to refine the software.

3.3. Proposal for Educational Software in Sign Language Teaching for Deaf and Hard-of-Hearing Children

In an effort to further facilitate the teaching and learning of sign language for deaf and hard-of-hearing students, educators have expressed the need for improved educational software with enhanced features and content. The software system targets three main user groups:

• Teachers: Manage educational content and classes for grades 1-5.

• Students: Learn sign language through structured lessons and exercises as guided by teachers.

• Other Users: Individuals interested in learning sign language who can access certain content without requiring system login.

Functional Requirements of the System:

User Management

• User Authentication and Account Management: Provides essential features for user registration, login, password reset, and email verification, ensuring secure and protected access to personal information.

• Teacher Account Approval: Manages and approves teacher account requests before granting access to teaching functionalities.

Teaching Management

• Class Management: Allows teachers to organize and manage classes, including relevant information such as topics, vocabulary, and assessments for each class.

• Learning Topic Management: Enables addition, modification, updating, and deletion of learning topics. Each topic may be further divided into subcategories, such as vocabulary, sentences, and passages.

• Vocabulary, Sentence, and Passage Management: Allows teachers to add, edit, update, and delete vocabulary, sentences, and passages used in sign language instruction.

• Question and Assessment Management: Facilitates the creation and administration of quizzes and assessments to evaluate learners' knowledge and progress.

Learning Management

• Class-Based and Topic-Based Learning: Enables users to participate in structured learning programs by class or topic, following teacher guidance or engaging in self-directed learning.

• Assessments and Evaluations: Provides users with the ability to take assessments assigned by teachers or conduct self-assessments to gauge their progress.

4. RESULTS AND DISCUSSIONS

4.1. Survey Results

4.1.1. User Demographics

We classified the survey participants into 8 distinct categories as shown in Figure 1, with parents of deaf children representing the largest group at 35.4%. This was followed by teachers of deaf children at 14.6% and relatives of deaf children at 12.5%. Other notable groups included individuals interested in learning sign language (10.4%) and professionals supporting deaf individuals (7.3%). DHH individuals and education professionals each accounted for 6.2%, indicating a varied stakeholder interest in sign language education.

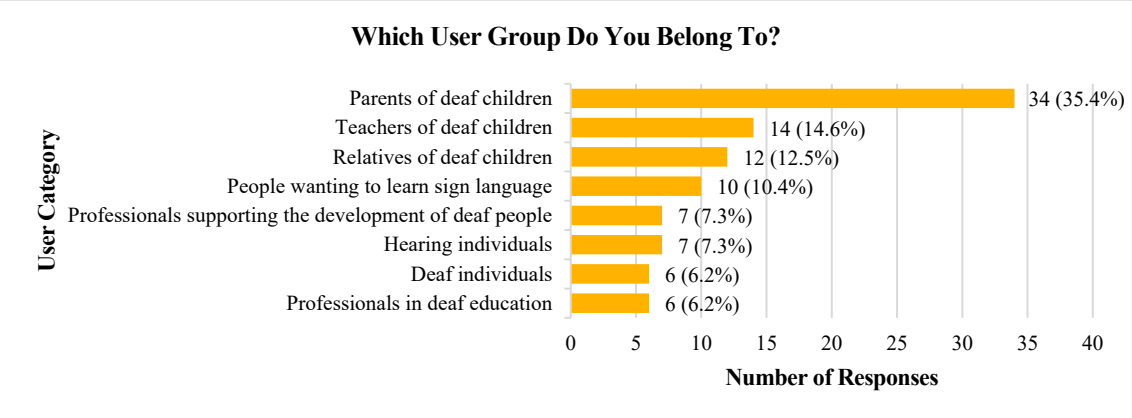


Figure 1. User Demographics

Subsequently, Figure 2 reveals the current sign language proficiency levels of children. A significant 36.8% fall into the lowest proficiency level (Level 1), demonstrating an urgent need for basic educational resources. Meanwhile, 17.6% reached Level 5 proficiency, showing a smaller yet capable group. There was a wide range of intermediate levels, with 8.8% of respondents having no prior knowledge of sign language. This emphasizes the necessity for an educational software that caters to diverse learning needs, providing continuous learning pathways from beginner to advanced levels.

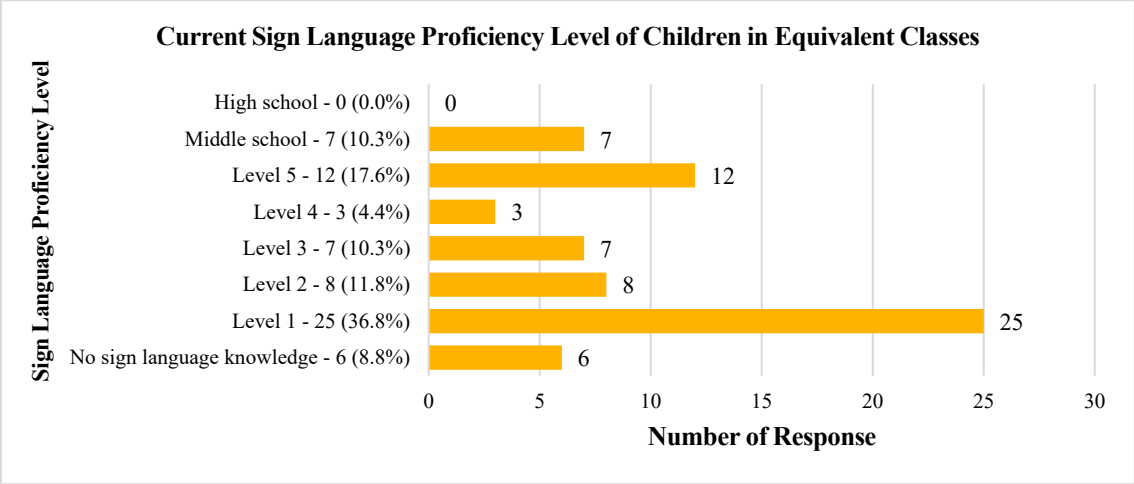


Figure 2. Sign language Proficiency of Children

4.1.2. Demand for Educational Software in Sign Language Teaching

To evaluate the necessity of sign language educational software, we employed a five-point Likert scale, where 5 = Extremely necessary and 1 = Not necessary. Among 30 teachers surveyed, 69.2% deemed such software to be extremely necessary, while 23.1% found it very necessary. Additionally, 3.8% of respondents indicated that the software was moderately necessary, and another 3.8% considered it slightly necessary. No respondents (0%) regarded the software as unnecessary.

A similar five-point scale was used to assess the frequency of software usage in sign language education in Figure 3. The results indicated that the highest proportion of respondents (46.2%) reported using the software frequently (Level 4), followed by 34.6% who reported always using it (Level 5). Meanwhile, 15.4% of teachers used the software occasionally (Level 3), and 3.8% reported using it rarely (Level 2). No respondents (0%) reported never using the software (Level 1). Additionally, participants showed strong interest in the software, with 96.7% expressing enthusiasm, and 100% indicated a willingness to try it., as shown in Figure 4.

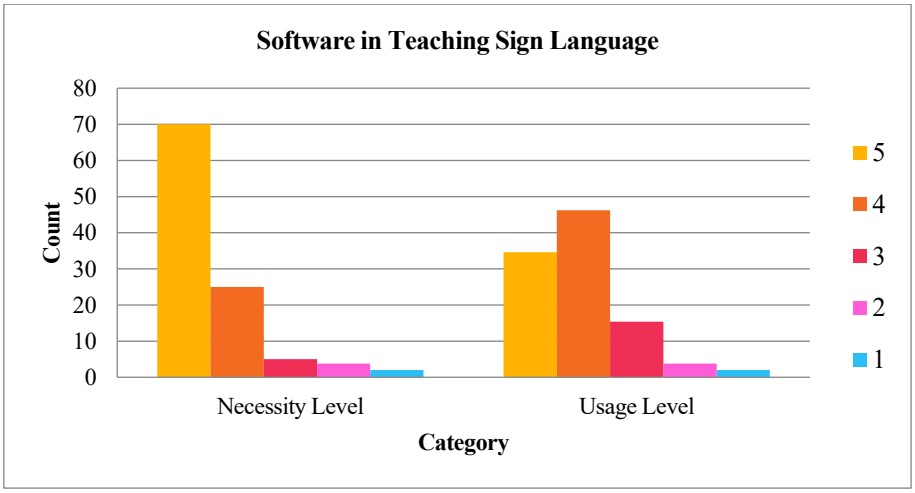


Figure 3. Demand for Educational Software in Sign Language Teaching

Figure 4. Interest in Using Sign Language Learning Software

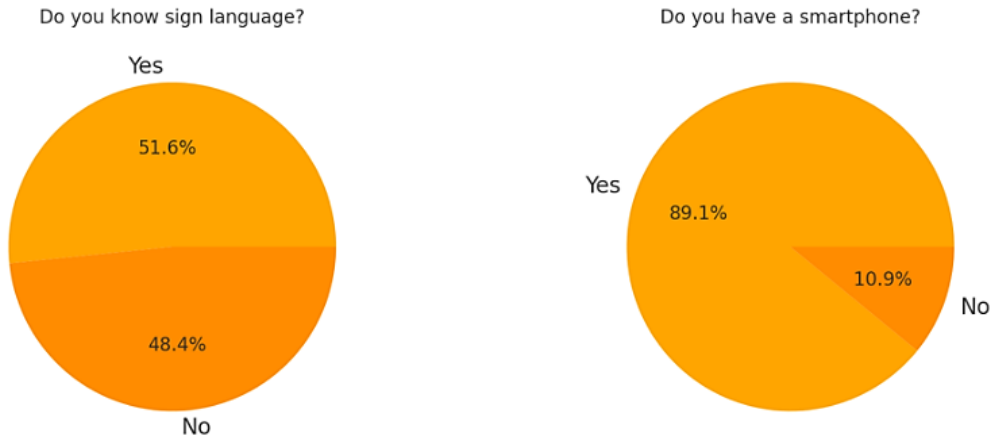
Table 1 summarizes the survey results on the demand for educational software in sign language teaching. The mean score for necessity was 4.68 on a 5-point scale, while the mean frequency of usage was 4.31 on the same scale, both with a standard deviation (SD) of 0.6.

Table 1. Demand for Educational Software in Sign Language Teaching

Level	Necessity Level (%)	Frequency of Use (%)
5	69.2	34.6
4	23.1	46.2
3	3.8	15.4
2	3.8	3.8
1	0	0

4.1.3. Current Use of Educational Software in Sign Language Teaching

A survey was conducted among 30 teachers from Nhan Chinh School for the Deaf, Xa Dan Primary and Secondary School, and Dak Lak Center for Inclusive Education Development to evaluate the current state of educational software usage in sign language teaching. The results indicate that 95.8% of teachers were aware of at least one or more educational software tools for teaching deaf and hard-of-hearing students using sign language.



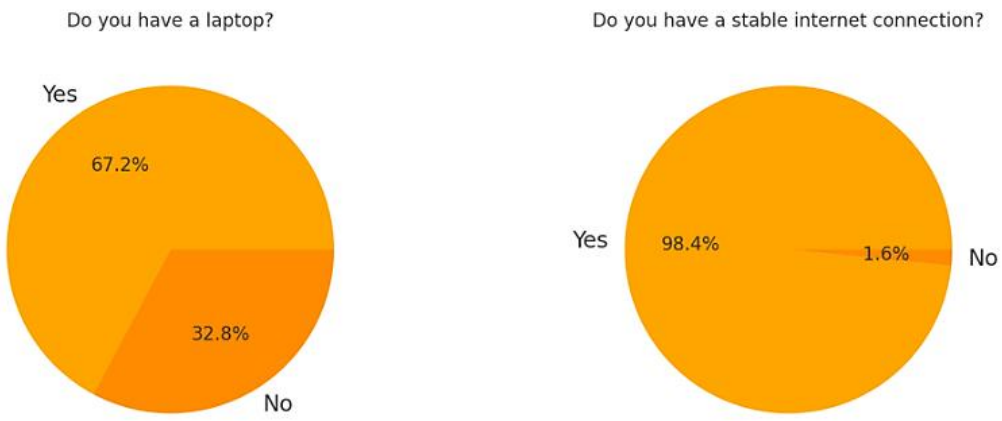


Figure 5. Access to Digital Devices and Internet

The most widely recognized platform was the QIPEDC website (qipedc.moet.gov.vn), which is part of the Quality Improvement of Primary Education for Deaf Children (QIPEDC) Project. This project was funded by the Global Partnership on Results-Based Approaches (GPRBA) through the World Bank. In addition to QIPEDC project, teachers reported using other online Vietnamese resources such as: (*Online Vietnamese Sign Language Dictionary*, n.d.); YouTube.com for educational materials; Foreign sign language learning applications. Regarding how teachers became familiar with these resources, survey responses indicated that: 32% of teachers were introduced to these platforms by educational institutions or organizations; 24% discovered them independently; 24% were informed by colleagues; 12% learned about them through expert recommendations; 8% received information from other sources.

In terms of accessibility and usability, factors such as access devices (computers, smartphones), internet connection, software accessibility, and functionality were generally rated as favorable, with 68% to 76% of teachers indicating that these conditions were reasonably sufficient for software utilization as seen in Figure 5.

4.2. Overall Architecture of the Software System

In the system shown in Figure 6, users can access the application's functionalities either through a web browser on a computer or a mobile application. The server processes user requests by retrieving data from the database and the file storage system (e.g., learning materials).

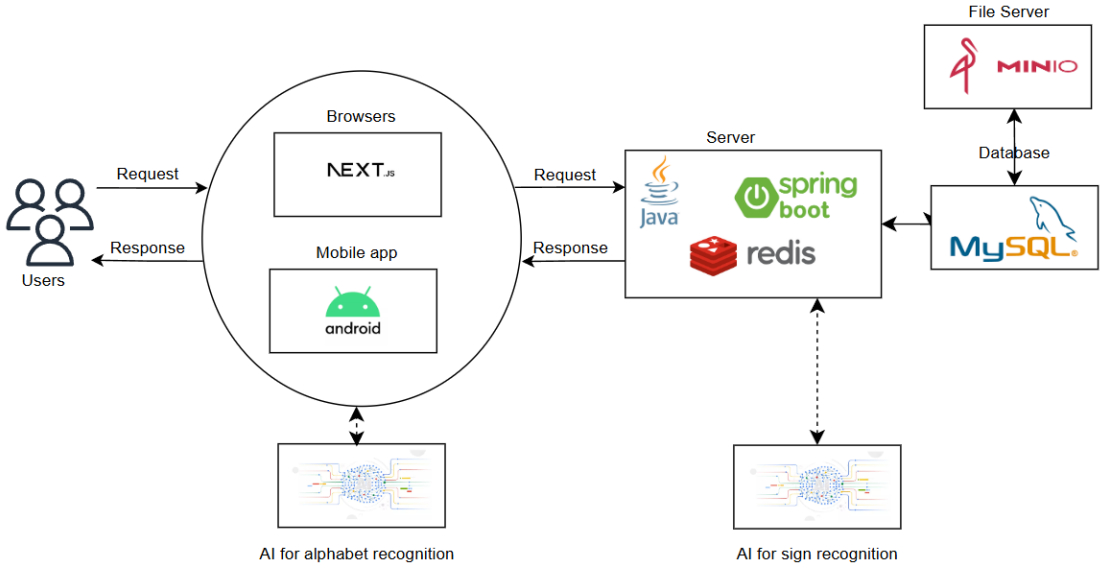


Figure 6. Overview of the System Architecture

Within the WeSign system, specific AI powered features have been implemented to enhance the interactive learning experience, particularly for independent practice. These functionalities are integrated into modules for alphabet and individual sign (word-level) recognition. For instance, the alphabet recognition module enables students to practice Vietnamese fingerspelling; users sign a specific letter towards their device's webcam, and the system processes this visual input to provide feedback on whether the letter was recognized. Similarly, the sign recognition feature allows students to practice producing individual vocabulary signs, receiving system feedback on their execution.

4.2.1. Web-based app

We have developed a web-based platform for maximum user accessibility, requiring only a computer and an internet connection. The user interface (UI) is designed for intuitive and seamless interactions, following a Continuous Integration/Continuous Deployment (CI/CD) approach for rapid feature updates based on user requirements. Users without login credentials can access foundational learning options, including the alphabet, numbers, vocabulary, sentences, and passages categorized by grade levels from Grade 1 to Grade 5. Upon registration and login, students are provided with access to additional features such as assessments and practice exercises. Teachers, on the other hand, gain access to comprehensive learning management functions, including class management, topic management, vocabulary management, and assessment management. Learners can select a grade level (1 to 5) corresponding to their current level (Figure 7) and search for any sign language term available in the learning material dictionary provided by teachers (Figure 8).

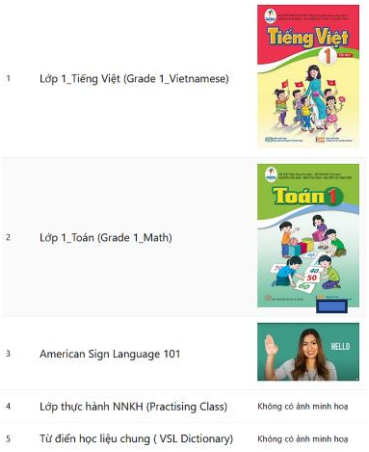


Figure 7. Class-Based Learning Interface

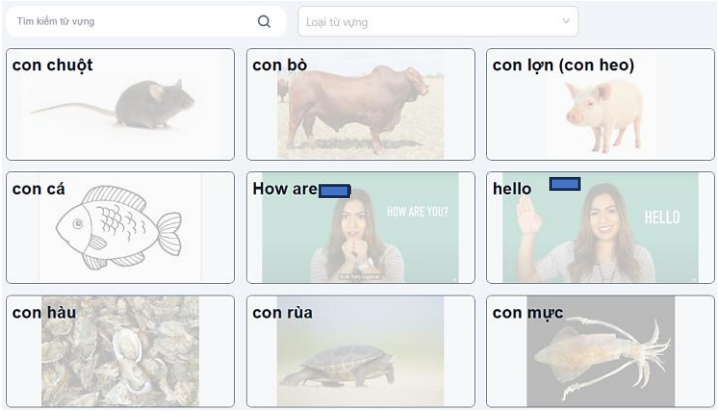


Figure 8. Dictionary-Based Learning Interface (Sign Language)

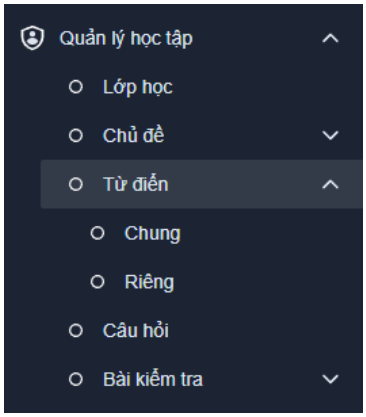


Figure 9. Teacher Interface for Learning Material Management

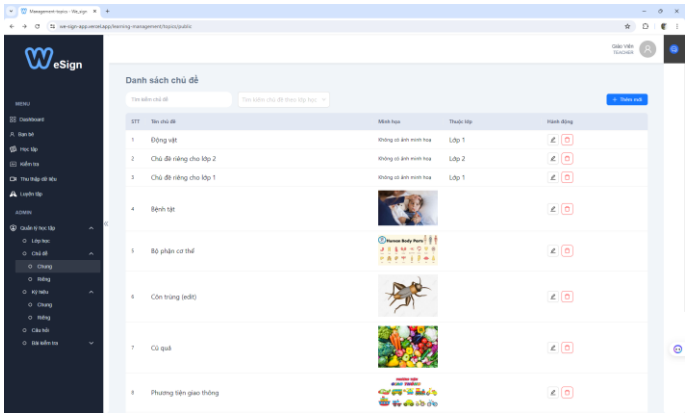


Figure 10. Topic Management Interface for Different Grade Levels

A key feature of the system is that it allows teachers to create customized own learning materials tailored to their specific class and the topics they cover. At a more detailed level, teachers can develop content for individual words,

sentences, and passages. These learning materials can be shared among multiple teachers or used individually by each teacher, as illustrated in Figures 9, 10. Teachers can manage classes and learning materials across different topic levels, categorized by grade. The learning material dictionary consists of words, sentences, and passages organized into general topics that can be shared across multiple classes or class-specific topics. Teachers have the flexibility to create both shared and private learning materials:

- Shared materials are standardized and agreed upon among teachers.
- Private materials are added to enhance or supplement learning content based on each teacher's specific approach.

Teachers can create topics linked to various learning materials, including signs (words), sentences, or passages related to that topic. For example, the sign for "fish" can connect to images and demonstration videos recorded by teachers and uploaded to the system. Each uploaded video represents a sign, sentence, or passage and can be reused across different topics and assessment without requiring to be re-uploaded. Teachers can also create assessments to evaluate students based on class level or topic (Figure 11 and 12). These assessments aim to measure students' proficiency in sign language and support the development of more effective communication strategies for deaf and hard-of-hearing learners.

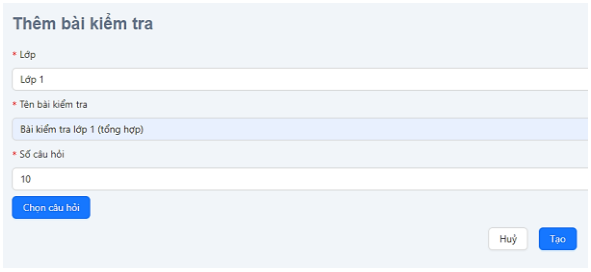


Figure 11. Teacher Interface for Creating Class Assessments

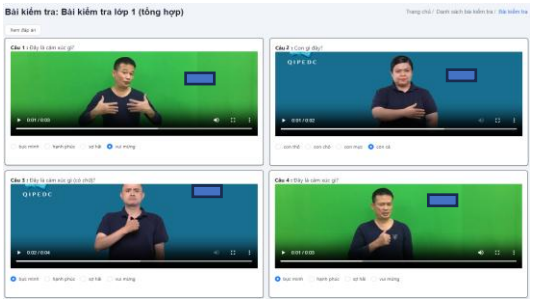


Figure 12. Learner Interface for Taking Assessments

4.2.2. Mobile app

The mobile application's interfaces, as shown in Figure 13, are similar to the web platform, providing access to learning materials and enabling learning anytime, anywhere. As depicted in Figure 13:

- Figure 13a is the main menu, which allows access to the various functions.
- Figure 13b shows the class selection interface.
- Figures 13c and 13d are the interfaces for learning by word (sign) and by sentence, respectively.

Figure 13a) Main menu

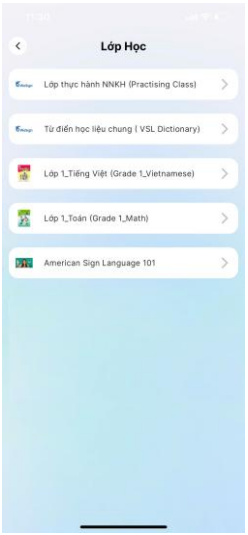


Figure 13b) Class Selection

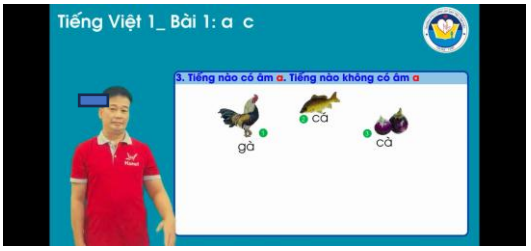


Figure 13c) Word-based learning

Figure 13d) Sentence-based learning

4.2.3. AI-Powered Feature for Self-Practice Support

A key interactive feature of WeSign is its AI-powered practice module, specifically designed to help users, particularly students, self-assess and improve their practical sign language skills. The feature follows a distinct workflow to provide learners with immediate feedback on their sign execution.

The workflow for this feature operates as follows:

• *Sign Selection for Practice:* First, users browse the catalog of alphabet or vocabulary lessons and select a specific sign they wish to practice.

• *Practice and Video Recording*: Upon selection, the system allows the user to record a live video using their computer or smartphone camera while performing the chosen sign. Alternatively, users can upload a pre-recorded video for analysis.

• *Analysis and Result Feedback:* The input video is then processed by a custom-trained AI model for recognizing Vietnamese sign language alphabet and vocabulary. The model analyzes the hand movements and shapes, returning the character or sign (word) it identifies as a correct result.

This process provides learners with objective and real-time feedback, enabling them to compare their performance against a model video, identify errors, and make adjustments to improve accuracy. This fosters effective self-study, boosts confidence, and can accelerate the learning process without the need for constant teacher supervision.

Figure 14 displays the user interface for the AI-powered sign language practice module within the WeSign software. The interface is designed to help a student practice signs by comparing their performance to a reference video and receiving feedback from an AI model.

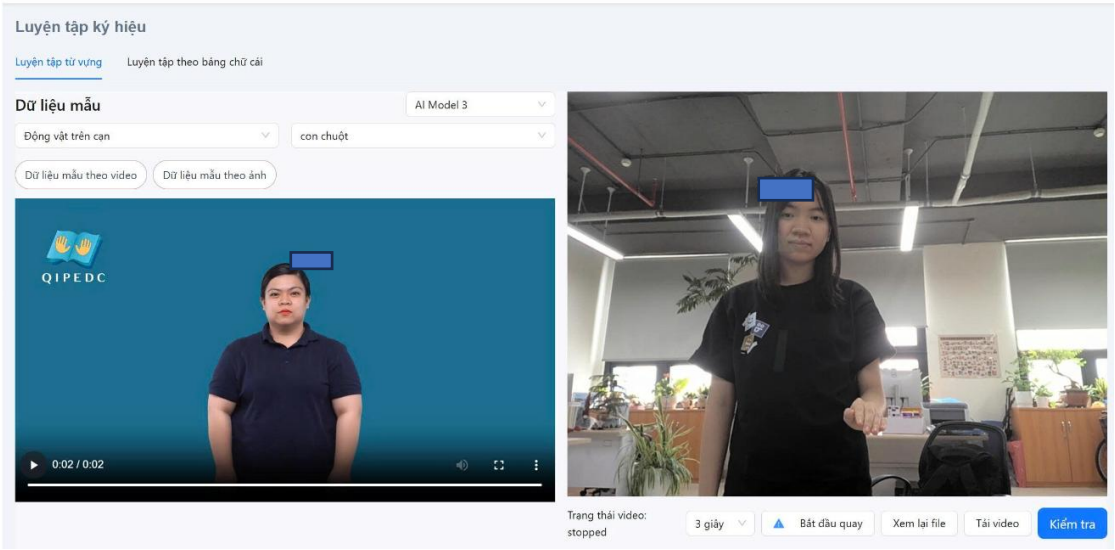


Figure 14. Practising a sign with AI-based recogniton module

The screen is divided into two main parts:

(1) On the left is the "Dữ liệu mẫu" (Sample Data) section: This area provides the learning reference material. In this example, it shows a video of an expert signer performing the sign for "con chuột" (mouse) under the topic "Động vật trên cạn" (Terrestrial animals).

(2) On the right is the user's practice area: This section displays a live video feed from the student's webcam as they practice the sign. Below the video are controls to record ("Bắt đầu quay"), upload ("Tải video"), and submit their performance for evaluation ("Kiểm tra"). The selection of an "AI Model" suggests that the system uses artificial intelligence to analyze the student's video and provide feedback on their sign formation, a key feature for autonomous practice.

The AI models were built by the authors in Nguyen et al. 92025) using a large-scale VSL dataset published in the paper (Dinh et al., 2025). The MultiVSL200 dataset is Vietnam's first multi view, isolated sign language recognition dataset, corresponding to 200 common signs. MultiVSL200 includes a total of 18,981 videos performed by 30 individual signers.

4.3. Usability Evaluation

Table 2 presents the detailed descriptive statistics for each item of the SUS. The data reports the Mean and Standard Deviation (SD) for the 10 survey items, aggregated from the responses of all 30 participants (N=30), comprising 5 teachers and 25 students. Items are categorized into positive and negative groups to elucidate user consensus regarding various aspects of the system's usability.

Table 2. Descriptive statistics of the SUS items (N=30)

Item	Statement	Type	Mean	SD
Q1	I think that I would like to use this system frequently.	Positive	4.60	0.62
Q2	I found the system unnecessarily complex.	Negative	1.40	0.72
Q3	I thought the system was easy to use.	Positive	4.63	0.49
Q4	I think that I would need the support of a technical person to be able to use this system.	Negative	1.27	0.45
Q5	I found the various functions in this system were well integrated.	Positive	4.73	0.58
Q6	I thought there was too much inconsistency in this system.	Negative	1.20	0.41
Q7	I would imagine that most people would learn to use this system very quickly.	Positive	4.70	0.53
Q8	I found the system very cumbersome to use.	Negative	1.27	0.52
Q9	I felt very confident using the system.	Positive	4.77	0.50
Q10	I needed to learn a lot of things before I could get going with this system.	Negative	1.27	0.58

The usability evaluation of the WeSign system using the SUS yielded highly positive feedback from end-users. Data from 30 participants were analyzed and summarized in Table 3 as follows:

Table 3. Aggregate SUS scores by participant group

Participant Group	N	Mean Score	SD	Adjective Rating*
Teachers	5	94.00	3.35	Best Imaginable
Students	25	92.30	5.30	Best Imaginable
Overall	30	92.58	5,08	Best Imaginable

**Adjective ratings are based on the interpretative ranges proposed by Bangor et al. (2008), where a score above 80.3 is considered "Excellent" to "Best Imaginable".*

The overall mean SUS score reached 92.58 (SD = 5.08). According to the rating scale by Bangor et al. (2008), this result classifies the system as "Best Imaginable," significantly exceeding the standard average score of 68. Teacher Group: Achieved a mean score of 94.00 (SD = 3.35). Teachers highly rated the integration of classroom management and material creation features, indicating that the system is not unnecessarily complex and does not require frequent technical support. Student Group: Achieved a mean score of 92.30 (SD = 5.30). Students responded particularly positively to items regarding confidence in using the system and the ability to learn its functions quickly.

The minimal discrepancy between the two user groups suggests that the User Interface (UI) and User Experience (UX) of WeSign are well-designed and user-friendly, suitable for both adults (teachers) and young children (primary students). These results confirm the feasibility of widely deploying WeSign in specialized educational environments.

It is important to clarify that the high scores obtained from the SUS primarily reflect the participants' level of satisfaction and the perceived ease of use of the WeSign system. These findings demonstrate user acceptance rather than serving as direct evidence of improvements in the students' sign language proficiency or academic learning outcomes. Future studies should incorporate longitudinal assessments and standardized performance tests to comprehensively evaluate the pedagogical impact and the long-term effectiveness of the system on student learning.

5. CONCLUSION

In response to the need for enhanced teaching quality for DHH students in Vietnam, this study developed and evaluated WeSign, a web-based platform designed to support sign language education. Implementation during the 2024-2025 academic year at the Nhan Chinh School for the Deaf demonstrated the system's practical utility in facilitating both in-class instruction and self-directed learning. The findings indicate high user acceptance, with an overall mean SUS score of 92.58 ("Best Imaginable"), reflecting a strong positive reception from teachers and students. However, it is essential to interpret these results with caution. These scores primarily reflect user satisfaction and interface accessibility rather than direct evidence of improvements in student sign language proficiency or academic learning outcomes. Furthermore, this study has several limitations. The evaluation was conducted as a pilot with a small sample size (N=30), which restricts the generalizability of the findings. Additionally, the short deployment period and the focus on a single specialized school limit our ability to account for the diverse socio-economic and pedagogical conditions present across Vietnam.

Future research should address these constraints by incorporating larger, more diverse cohorts and implementing longitudinal assessments to rigorously measure the system's impact on actual student learning gains. Moving forward, future development of WeSign will focus on continuously updating system features, improving AI-powered self-learning modules with automated evaluation, and maximizing the system's practical impact through ongoing user feedback. This project serves as a foundational step, and these findings may encourage further integration of AI-driven technologies to create more inclusive and effective learning opportunities for DHH children.

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