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Wiki Sign Dict: A Development of an Online Sharing Dictionary for Hearing Impaired

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Abstract: The aim of this research was to design and develop a website, technology and method for assisting Hearing Impaired (HI) people to learn Thai vocabulary. The website included a new word module, a translation and voting module to determine the most popular sign language interpretations. The most preferred will become the Thai sign language standard for teaching Thai vocabulary. The sample groups were selected by purposive sampling of 30 hearing impaired students in grades 5th who know Thai sign language and 9 expert reviewers who also understand Thai sign language. The experimental sample was divided into 2 groups: An expert group and a user group. The expert group completed two questionnaires: certification of the User Interface (UI) and preference of Thai sign language word interpretation standard. The user group also completed 2 questionnaires: user satisfaction with the UI and user test of the learning content to determine their learning outcome. This research was analyzed using descriptive statistics (Mean, SD, percentage and t-test). The results showed that the experts have accepted and certified the UI and also the content. The experts preferred the sign language standards which were most effective in explaining Thai vocabulary to HI learners. Those standards selected by the experts were 62.40% from the invented sign language words from the Setsatian School for the Deaf, 28.92% were sign language equivalents used by the Thailand Association of the Deaf Institute and 7.68% were sign language translations for Thai vocabulary from other schools. The users also accepted and certified the UI and content. The results also indicated that the HI student user's learning outcome was improved after using this system to learn Thai sign language vocabulary. The data were analyze utilizing statistical t-test at $p<0.01$ level.

Key words: Thai sign language, deaf, hearing impaired, online dictionary, Thai vocabulary, HI

INTRODUCTION

Hearing Impaired (HI) people for this research are defined as persons who are completely deaf, hard of hearing and those who have severe hearing loss. HI people compensate for their disability by using their eyes and other sensory components (Sri-On, 2003). HI learns by sight and other senses instead of hearing and they also have difficulty learning new and different material.

HI people learn by what they see and can create a level of understanding quickly. They can memorize using short term memory but they have difficulty with long term retention. Hearing loss affects language learning ability so HI have limited knowledge of Thai vocabulary word meanings have trouble ordering alphabet letters in words, recognizing the proper order of words in sentences, etc. (Gibson, 2003). The problem of lack of language learning abilities increases in proportion to the level of hearing disability. At present, the currently available learning media for HI is for the most part not effective for teaching them. For example, books for teaching HI students should have illustrative pictures along with vocabulary explanations (Sri-On, 2003).

In the classroom, teachers should provide supportive learning media teaching aids to teach new vocabulary such vocabulary cards or illustration cards. But many of their teachers provide instruction to them using only a blackboard without any other supporting document or media teaching aids. This temporary supporting visual material is normally then deleted after the classes and is unuseable for the students. A survey of families with HI learners by Iam-Khong and Suksakulchai (2011) and revealed a social aspect to HI language learning difficulties. The survey found that 41.82% of HI students

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do not live with both parents because of divorce and so, the HI learners rely on the single parent for learning support. In only 41.82% of subjects is the mother or remaining parent able to explain the meaning of Thai vocabulary in Thai Sign Language (TSL). Significantly, 36.37% of parents of HI learners are not able to explain the meaning of Thai vocabulary in TSL. Moreover, only a small number of students might use a dictionary or sign language dictionary to find a meaning for new words and most HI ask their parents to be a walking, talking dictionary and help explain the meaning of new vocabulary to them. This is a difficult situation for HI and their parents who often cannot clearly explain the meanings of the new words in a way that the HI learner can understand.

When HI students do learn the meanings of new vocabulary, their comprehension may not always be accurate. According to Iam-Khong and Suksakulchai (2010) when most students encounter vocabulary, they do not understand they will ask someone who is knowledgeable (42%), some do not care and skip the word (29%) and some try to find the meaning of the word by themselves (29%). But most often, the students cannot find an accurate explanation for new vocabulary words. These problems affecting HI learners in acquiring vocabulary affect HI learning achievement score. This is especially, so in Thai language subject class levels 2-4 where they perform at a lower level than do normal students (Iam-Khong *et al*., 2011). Iam-Khong and Suksakulchai (2011) suggested that TSL have been developed over time without overall direction and consistent, unified standards. TSL instruction and standards has also had limited development because learning and interaction takes place in small isolated groups of HI learner who cannot develop their own knowledge and who are not a part of a larger social network so, there is not an opportunity to share ideas and knowledge with other groups of TSL learners.

As a result, each group in a particular area or region may have their own distinct dialect and vocabulary that other groups may share or understand. This lack of connected social infrastructure and other factors mentioned above affects the development of a grammar and sentence structure in TSL and severely affect HI language expression and vocabulary development and comprehension. In addition, the lack of understanding of normal spoken and written Thai language vocabulary words is another reason for not comprehending Thai vocabulary in sentences (Pittman *et al*., 2005). These language limitations of HI have a profound impact on their knowledge test scores.

Thus, HI people have overall lower academic achievement than normal people. In this age of information technology, computer based tools and learning materials can be used to improve HI learning and ICT teaching aids can also support teaching methods for HI students (Hameed, 2007) and internet usage has improved learning support and learning achievement for HI people. Learning information technology is now popular among HI because HI students are attracted to Computer Assisted Instruction (CAI) in general and also specific technology to assist HI learners (Bishop *et al*., 2000). For example, the research of Phophong and Meanrach (2001) developed the TSL computer software index which is a program for HI learners to present them with animation and short text descriptions. Program pages can navigate through content using next or previous commands for learning representations until the HI user understands. The HI users can select vocabularies that they are interested in and sort content by category to (accessing sort). This database has 650 vocabulary categories contained in the application. But this program does not work for people whom have no ability to read and write. Viradraikul and Thongpitak (2001) developed The Online Computer Assistance to TSL for sign language teaching for normal and HI people. But HI people need more time to learn enough normal text commands to communicate with the application.

Also, the program is limited in its capability to insert and update its content to add or modify vocabulary in the system. Only admin can update the content (Puengpongse, 2006) (Jai-Ngam). CAI is too difficult to add, update or edit new vocabulary in its content databases and there are only few of sign language CAI applications.

Therefore, the current designs for human computer interaction and CAI/ICT applications are not easy to use are not convenient and do not address all specific requirements needed to be effective and beneficial for HI people (Mandel, 1997). The problems discussed above as well as past and current research findings indicate that the language learning problems for HI learners exist in primary and elementary school and extend through higher education environments. Therefore, rsearchers have developed the online dictionary system for the hearing-ipaired; contributed by volunteers (Online TSL Dictionary system-TSLD), to assist in solving these language learning problems. The system started with grade 5th students but can be applied to all subjects and grade levels for HI students to learn new vocabulary words. This system was developed to increase the HI student's ability to recognize and understand the meaning of individual Thai vocabulary words as well as Thai vocabulary words used in sentences.

MATERIALS AND METHODS

Research question: This research addresses the question: How can HI students be assisted to improve their

understanding and long-term memory retention of Thai vocabulary words, as well as comprehends phrase and sentences using Thai vocabulary words.

TSLD system design: Based on the literature review include: vocabulary cards can help HI people to remember and spell the vocabularies with regularly practice. Components for HI students learning Thai vocabulary are vocabulary cards, illustration cards, SL and finger spelling and giving explanations of word meaning using story telling is a very special method for teaching HI people that helps them remember better. The teacher should use examples of the vocabulary words in a short story that they can understand.

Teachers should explain the meanings using SL and also example sentences because it can help HI remember and comprehend the meanings of words in context and help them, retain the knowledge in long term memory (Hermans *et al*., 2008). From literature review, they concluded to the questionnaires and interview form with SL assistant for teachers and students. They found that all of the students wanted the 4 components; visual written language vocabulary presentation, pictures that illustrate the vocabulary meaning, SL equivalents of the vocabulary words and finger spelling of the vocabulary words to help explain the meaning of TSL vocabulary (Iam-Khong and Suksakulchai, 2010). The components of a method for teaching HI learners who also have difficulty retaining Thai vocabulary in long term memory is shown in Fig. 1.

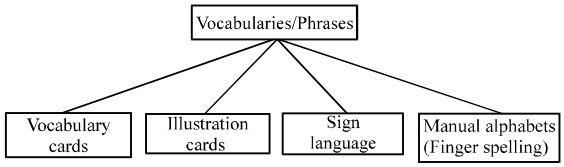


Fig. 1: A component of learning Thai vocabulary of HI learner

System approach: Based on a component of learning Thai vocabulary of HI learner, the researchers developed the TSLD system to support HI learners using PHP, AJAX, CSS, J Query and Java Script technologies base on web application system. This system presents the meaning of Thai vocabulary content using Adobe Flash and a My SQL database. The system is separated into three main parts; adding new words, voting system and iranslation as showed in Fig. 2. The architecture shows Fig. 2 has 3 modules including; a new word module translation module and a voting module. This system was designed and developed based on McConnell's Waterfall Model (McConnell, 2006) and the Knowledge

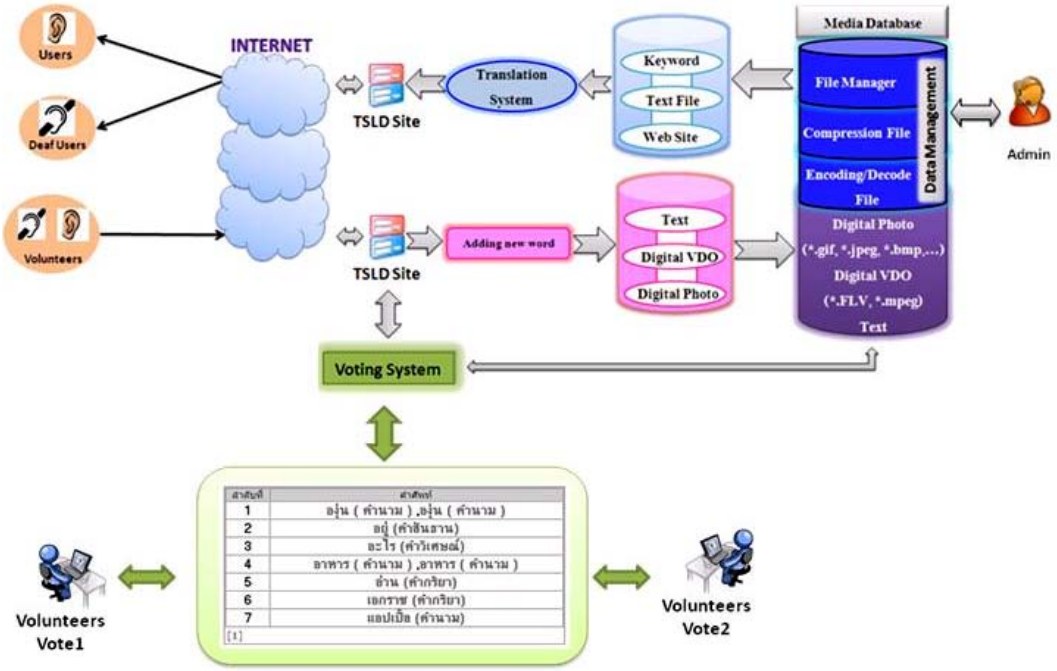


Fig. 2: The architecture of the TSLD system

Management model of Nonaka and Takeuchi (Awad and Ghaziri, 2010). The research describes the structure of the 3 modules as follows:

New word module: The module for the volunteers adds vocabularies and definitions in the form of digital new video content and digital photos into the Digital media database. The system will provide data management, system finger spelling pictures for the screen display shown in Fig. 3-4. From Fig. 4 when the volunteers adding new word to the system pass web application form, the script of the system is automatic management for generate picture of finger spelling location of character and vowel according to Thai grammar.

Translation module: The module obtains the meaning of a vocabulary inputting The Universal Resource Locator

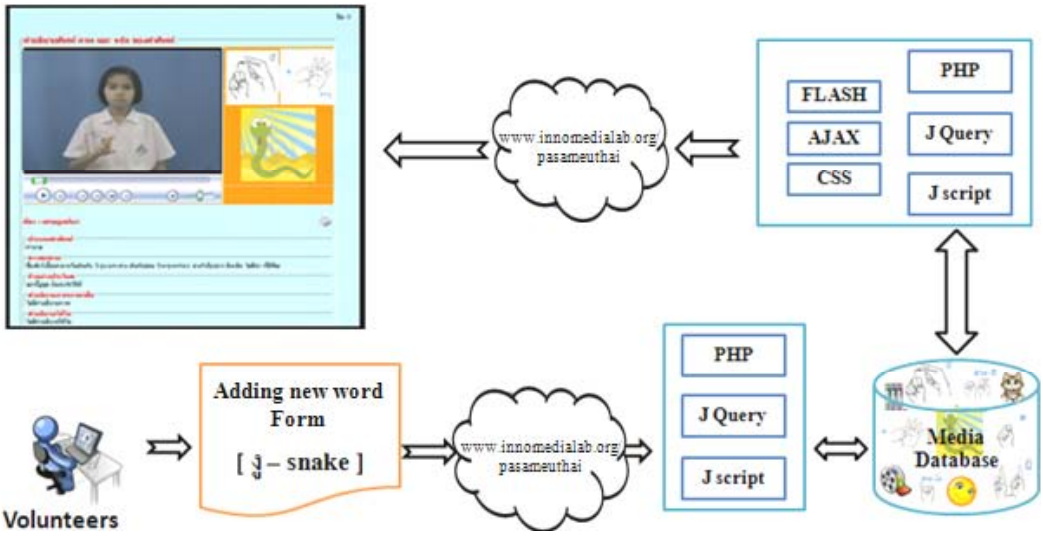


Fig. 3: The work flow shows the processing of the New word module in TSLD system

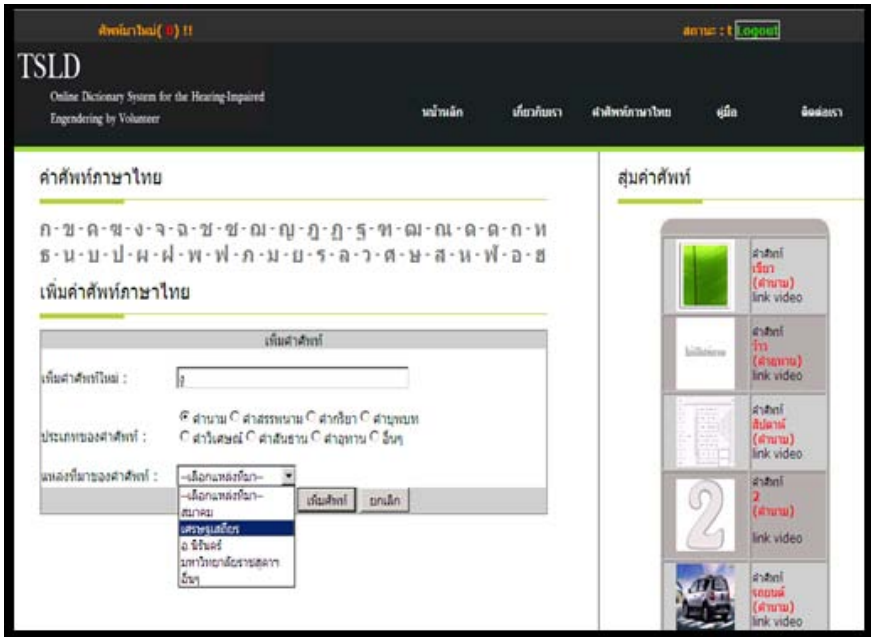


Fig. 4: Continued

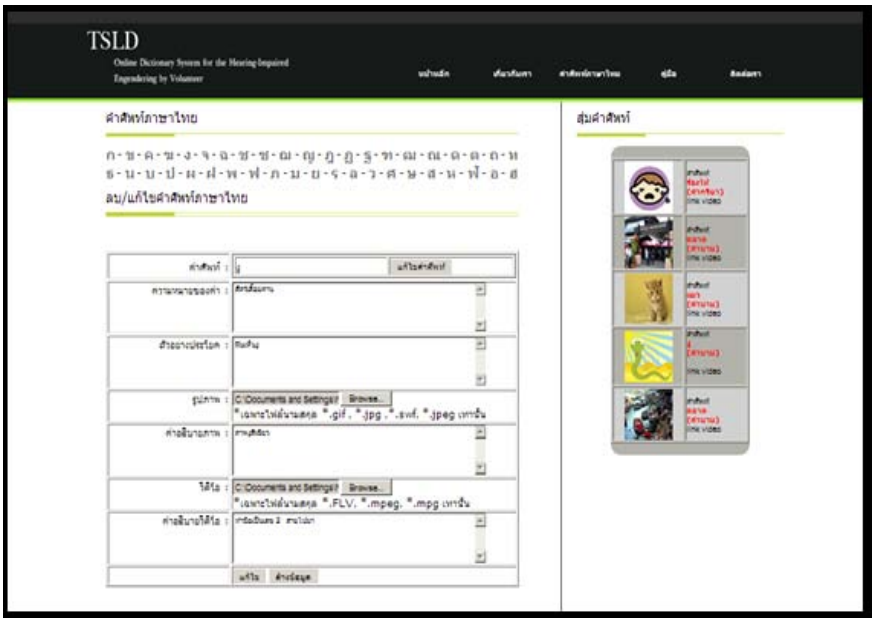


Fig. 4: Adding new word process from in TSLD system

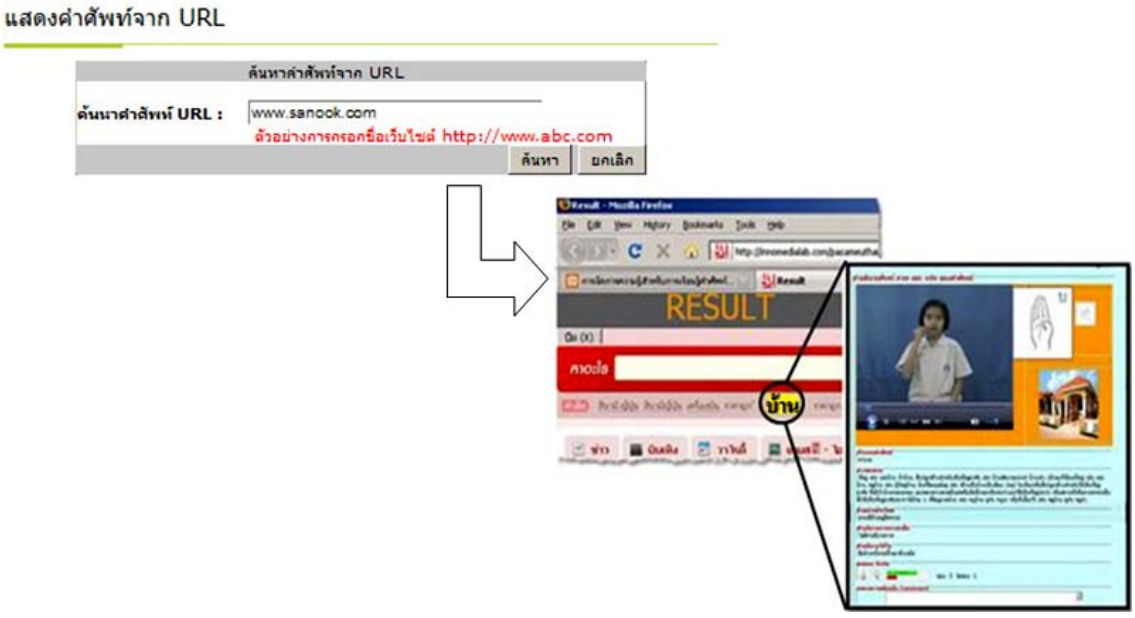


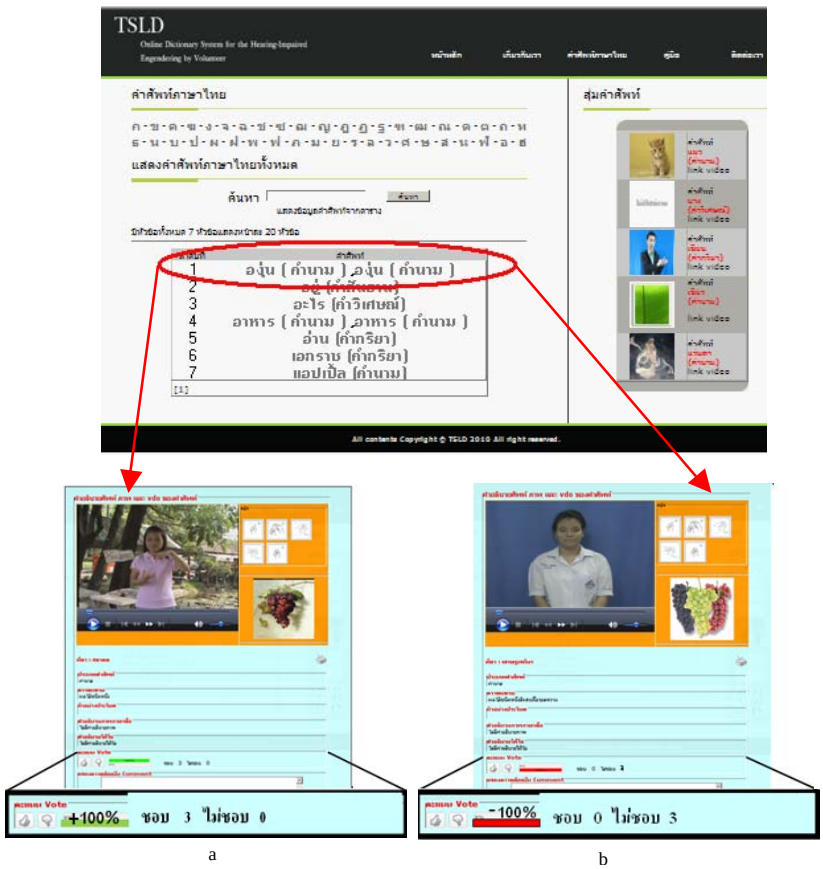
Fig. 5: TSLD searching result from browsing on the website for the Thai word for (°éÒ[1]-house)

(URL) and text file. The system will look up vocabularies in its database system. If the word matches a vocabulary word in the database, the system will display the word with a yellow highlight.

When users click on the highlight vocabulary word, a window will appear on the screen to explain the meaning of the word shown in Fig. 5 and 6.

Voting module: The module focus on voting system for the meaning of the word by volunteers. The explanation of the words selected can helped HI to remember and understand the words. TSLD system will present the definition of vocabularies that has been rated as acceptable by volunteers using a scoring method that includes the Voting module shown in Fig. 6. All

Fig. 6: TSLD searching result display for the Thai word for (°éÒ¹-house) from a text file



a b

Fig. 7: The result's from Voting module to promote a standard for a TSL show like or dislik: Fig. 7 b is better than Fig. 7a

vocabularies that were added to the system were filed into the Digital media database. The score will be re-calculated and re-ranked by weighted majority algorithm and FIFO algorithm. When volunteers vote for a vocabulary entry, the system will retain and sort the entries for the same word. It will display multiple for the word entries in the same record for the convenience shown in Fig. 7. Figure 7 shows the word grape was produce by 2 volunteers. The description to explain of the word has a different SL. Then member of TSLD system vote to grape from understanding and the system requires that the volunteers can vote with the word one by only once. The result shows voted by volunteers Figure 7b (Like 3/Dislike 0) is a better than Fig. 7a (Like 0/Dislike 3), so that Fig. 7b has been selected to the meaning of this word in TSLD system.

RESULTS

In this research, the experiments were divided into 2 experimental groups; an expert, Deaf instructor and SL interpreter) and 30 HI students in grades 5th from 3 schools of education, HI school under the special education elementary education department, ministry of education in Bangkok and Nonthaburi province including: Setsatian School for the Deaf under the Royal Patronage of his royal highness cown Prince Maha Vajiralongkorn, thungmahamek and nakhon pathom school for the deaf.

An expert review: In this study, the research was divided into two questionnaires and interview form certification of the User Interface (UI) with TSLD system and preference of Thai SL word interpretation standard by 9 Experts, who were selected by purposive sampling for their knowledge and understanding of Thai SL.

Certification of the UI: The experimental divide into 2 time, in the 1st time, an expert test for 1 week the result shown to the edit font size and shape for the hearing impair would be use font size 14 px. Upper and picture of finger spelling would be fit in a screen to comfortable for HI learner. SL video can display repeat that the condition learning and transfer knowledge emphasize the drill and practice of HI learner.

And the 2nd time, researchers test for 1 month using questionnaire and interviews form. The questionnaire is divided into 5 main objectives with 23 questions. Each scoring was given in 5 levels such as excellent, good, average, fair and improvement needed. The researchers analyzed data collected using descriptive statistics (Mean and SD) (Table 1). Data were collected and analyzed by standard deviation and satisfaction levels according to five main objectives:

- Size, shape, appropriateness and correctness of alphabets or the distribution of data
- Colors, clarity being simple and appropriateness of pictures
- Colors, clarity, simple and appropriateness of videos, easy to edit, update, add or delete vocabularies and notify error
- Compatibility of the multimedia and the opinion button on the display system to comment SL vocabularies

The results found that expect had good level of satisfaction mean of 4.89 (SD = 0.33), 4.89 (SD = 0.33), 4.89 (SD = 0.33), 4.89 (SD = 0.33) and 5.00 (SD = 0.00), respectively.

Preference of TSL word interpretation standard: In this part, using questionnaires and interview form to the preferences for SL for each standard were analyzed by using scores from the voting system. The researcher selected 5th grade vocabularies in total 13 words. Each vocabulary had 4 styles of SL from each of the different TSL standards sources (Table 2). Then, the sample groups completed the questionnaires. The collected data were analyzed using descriptive statistics and the results are shown in Table 2. From Table 2, the results of the voting data showed that 62.30% of words were selected from Setsatian School of the Deaf which is the 1st school in Thailand. The participants said finger spelling helped students to remember and understand the words. The reason is that the SL for teaching students should be finger spelling of vocabulary words using the TSL alphabet as well as unique and mixed TSL descriptive gestures,

Table 1: The expert's questionnaire results

	Expert		
Objectives	n	Mean	SD
Size, shape, appropriateness and accuracy of font for the distribution of data	9	4.89	0.33
Colors, clarity, simple and appropriateness of pictures	9	4.89	0.33
Colors, clarity, simple and appropriateness of videos	9	4.89	0.33
Easy to edit, update, add or delete vocabularies and notify error	9	4.89	0.33
Compatibility of the multimedia and the opinion button on the display system to comment SL vocabularies	9	5.00	0.00
Average	9	4.91	0.26

Table 2: Shown percentage of using TSL from different of institutes

TSL standards	Percentage
Setsatian school of the deaf	62.400
Thailand association of the deaf institute of deaf	29.920
Nirun TSL book	2.056
Office of the non-formal and informal education	5.012
Total	100.000

Table 3: The HI students questionnaire results

	HI students		
Objectives	n	Mean	SD
Size, shape, appropriateness and accuracy of font for the distribution of data	30	2.90	0.31
Colors, clarity, simple and appropriateness of pictures	30	2.93	0.25
Colors, clarity, simple and appropriateness of videos	30	2.93	0.25
Compatibility of the multimedia and the opinion button on the display system to comment SL vocabularies	30	3.00	0.00
Average	30	2.94	0.20

29.92% expert selected TSL from Thailand Association of the Deaf Institute of Deaf because this type of SL is easy to remember and understand also is used by the deaf in Thailand to communicate. From the interviews, experts said that the TSLD system is very good for both normal and HI people who want to learn TSL.

A user review: In this study, the researchers were divided into two questionnaires and translate by SL interpreter which are user satisfaction with the UI and a student user test of the learning content to determine their learning outcome. The researchers tested TSLD system with 30 HI learners who were studying in the 5th grade. The samples were selected by purposive sampling.

User satisfaction with the UI: They do 3 times for try out; using one sample group method for test a system by 1 HI student, using small group method for test a system by 5 HI students and using large group method for test system by 18 HI students then to improve a system by HI student advice every time (Iam-Khong and Suksakulchai, 2011). And next time, the result show a good level of UI, they take TSLD system to use with 30 HI students.

The questionnaire was divided into four main objectives with 4 questions using scales (satisfy, average and improve). For 3 scales of measurement because it easy to understanding of HI student. Data were analyzed using descriptive statistics (Mean and SD; Table 3). Data were collected and analyzed to find the mean, standard deviation and satisfaction levels according to four main objectives:

- Size, shape, appropriateness and correctness of alphabets or the distribution of dat
- Colors, clarity, being simple and appropriateness of pictures
- Colors, clarity being simple and appropriateness of videos
- Compatibility of the multimedia and the opinion on the display system to comment SL vocabularies

The results found that HI students had a high level of satisfaction with the system UI and content at 2.90 (SD = 0.31), 2.93 (SD = 0.25), 2.93 (SD = 0.25) and 3.00 (SD = 0.00), respectively.

User test of the learning content to determine their learning outcome: This phase is divided into 2 phases: the understanding and remembering of the meaning and understanding in sentences/phases.

The test of learning remembering and understanding of vocabularies: Researchers test ability test of learning remembering and understanding of vocabularies from 3 schools by pre- and post-test questionnaires that pass to checked by expert. The questionnaires have 20 questions and all time, the pre- and post-test is divided into 2 set and switch the question and answer. We divided teaching period into 3 times (Vocabularies per week) including:

One week: HI students make a pre-test questionaires.

Two to four week: They divide a vocabulary in 3 set (7, 7 and 6 (Vocabularies per week)) then teach with TSLD system in a class. And after that students can review their lesson online.

Five week: HI student take a post-test questionnaires. Then pre- and post-test was used to analyze the result using descriptive statistics, mean, SD and one sample t-test to analyze as shown in Table 4. Results indicate a significant preference for post-test ($M = 17.433$, $SD = 3.256$) over pre -test ($M = 8.533$, $SD = 4.431$), $t(29) = 2.756$, $p = 0.01$. HI student can earn better scores after using this program.

The test evaluation the student's understanding of the meaning of the sentences or phrase: They use pre- and post-test questionnaire that passed to checked by expert (Lark-Horovits and Mark, 1973).

The questionnaires were including to find the meaning of the word and to draw the image-related vocabulary or sentence/phrase. All time, the pre- and post-test is divided into 2 set and switch the question and answer. The scores using descriptive statistics one sample test the result shown in Table 5. In a test was divide in 3 weeks including:

Table 4: The result for recognition and understanding of the meanings of the Thai vocabulary words utilizing t-test for one sample

Test	N	M	SD	df	t	p-value
Pre-test	30	8.533	4.431	29	10.535	Significant
Post-test	30	17.433	3.256	29	29.313	p<0.01

Table 5: The result test for recognition and understanding of sentence and phrase by t-test for one sampleresults indicate a significant preference for post-test (M = 8.733, SD = 1.484) over pre-test (M = 2.200, SD = 2.041), t (29) = 2.756, p = 0.01. HI student can earn better scores after using this program

Test	N	M	SD	df	t	p-value
Pre-test	30	2.200	2.041	29	5.877	Significant
Post-test	30	8.733	1.484	29	32.196	p<0.01

One week: They give content for HI student and open to use TSLD system with a find the meaning of the word and understanding in content. Total 1 h for pre-test (Close computer test).

Two weeks: They explain the content including TSLD system for understanding and find the meaning of the word to show HI student about 40 and 20 minus for themselves to find and understand word or sentence/phrase.

Three weeks: They give a content for HI student and next to do post-test (Close computer test).

DISCUSSION

The online dictionary system for the HI contributed by volunteers was developed using components for teaching Thai vocabulary to HI learner. These components and their associated method used in this research assisted HI students learn the vocabulary meaning via website with effective explanations designed for HI people. Researchers were developed TSLD system to improve ability of HI people to memorize and understand individual Thai vocabulary words and also their meaning in the context of phrase. This new TSLD system is different from other web-based applications in that it has three effective features for teaching HI learners. One feature is a module for adding and modifying new vocabulary content. Another feature is its method for explaining the vocabulary word meanings. The last feature is a method for selecting the best translations for Thai vocabulary words from different types of SL from various recognized TSL standards institutions.

It gives opportunity for both HI and normal people to understand HI SL communication which is a channel for community sharing discussions and knowledge transfer. It can decrease the TSL communication gap. This system also supports text file and web searching which is an advantage lacking in previous systems. The system additionally permits other systems to retrieve vocabulary and word meanings (Foundation) (Rajabhat Institute Pibulsongkram). Family members can communicate ideas to HI people using features such as the video capture or illustration searching to explain the meaning of words (Jackson *et al*., 1997). Both of these activities are similar to the learning by doing method where as part of family or community activities, HI people can absorb automatically by an osmosis-like process vocabulary and meaning naturally and easily as they participate (Lang *et al*., 1999), etc. This system is suitable for preparing for preparing for classes and after school study and also useable for classroom instruction by teachers. They also applied the teaching style described above for assisting HI students to remember and understand vocabulary by using a spelling series of TSL alphabetic finger letters to spell out of words not just individual letters that make up the word (Hermans *et al*., 2008).

Al-Bayati and Hussein (2009) found that the finger spelling not appropriate for HI people but that conclusion differs from the conclusion of this research. This research used different assumptions and practice regarding the use of finger spelling of Thai vocabulary words. We used finger spelling in series of sequential signs not frame by frame of individual finger signs (like showing separate single letters vs. putting the letter of a word together). They also, connected the vocabulary words to pictures because visual images are very important to HI learners and a teaching method using them enables HI students learn best (Campbell *et al*., 2008). Because a learning process using pictures with SL is very important to them (Ju, 2009). Abstract pictures support them to get long term memory (Piaget and Inhelder, 1970). HI student need different learning methods and support than normal students. The ratio of teacher to HI students in classroom of HI student is 1/8 in normal classroom, the ratio is 1/(20-30) (Al-Bayati and Hussein, 2009). An explanation of vocabulary which mixes between SL and alphabet (finger spelling) can help them to remember the vocabulary. Teaching methods for HI people should start with illustrations such as look in SL which shows 3 fingers (index, middle and ring fingers) for 3 alphabets, sport show finger spelling (that same (a) in English), etc. (Communicative Skills Program, 1976). They argue that the difference in the pre- and post-test's scores for long term memory ability and comprehension of vocabulary that researchers found in this research is significant and validates our method and assumptions. HI teacher would like to change learning process with lead learning assistant technology support and urgent for change transfer knowledge process method; teach Thai language by Thai grammar sentence/phase not teach Thai language follow TSL because that method have and an effect to learning achievement of Thai Language of HI student.

CONCLUSION

The aim of this research was to design and development a TSLD system based on the Waterfall model of McConnell and the Knowledge Management model of Nonaka and Takeuchi. This system was divided into 3 modules: new word module, translation module and voting module. The experimental sample was divided into 2 groups: an expert group and a user group. The expert group completed two questionnaires: certification of the User Interface (UI) and preference of TSL word interpretation standard. The user group also completed questionnaires: user satisfaction with the UI and User test of the learning content to determine their learning outcome. This research was analyzed using descriptive statistics (Mean, SD, percentage and t-test). The results showed that the experts have accepted and certified the UI and also the content. The experts preferred the SL standards which were most effective in explaining Thai vocabulary to HI learners. Those standards selected by the experts were 62.40% from the invented SL words from the Setsatian School for the Deaf, 28.92% were SL equivalents used by the Thailand Association of the Deaf institute and 7.68% were SL translations for Thai vocabulary from other schools. The users also accepted and certified the UI and content. The results also indicated that the HI student user's learning outcome was improved after using this system to learn TSL vocabulary. The data were analyze utilizing statistical t-test at $p<0.01$ level.

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REFERENCES

Al-Bayati, M.A. and K.Q. Hussein, 2009. Effects of tutorial e-lessons for hearing impaired persons on motivation towards learning (general science topic as case study). Eur. J. Sci. Res., 38: 189-198.

Awad, E.M. and H. Ghaziri, 2010. Knowledge Management. Updated 2nd Edn., International Technology Group Ltd., North Garden, VA.

Bishop, J.M., L. Taylor and F. Froy, 2000. Computer-mediated communication use by the deaf and hard-of-hearing. Kybernetes, 29: 1078-1086.

Campbell, R., M. MacSweeney and D. Waters, 2008. Sign language and the brain: A review. J. Deaf Stud. Deaf Educ., 13: 3-20.

Communicative Skills Program, 1976. A Basic Course in Manual Communication. 2nd Edn., Sesatian School of the Deaf, Bangkok, Pages: 161.

Gibson, I., 2003. Teaching strategies used to develop short-term memory in deaf children. http://www.batod.org.uk/content/articles/mgwts/teachingstrategiesmgwts.pdf.

Hameed, A., 2007. Information and communication technologies as a new learning tool for the deaf. Proceedings of the World Congress on Egnineering and Computer Science, Oct. 24-26, San Francisco,USA., pp: 1-5.

Hermans, D., H. Knoors, E. Ormel and L. Verhoeven, 2008. The relationship between the reading and signing skills of deaf children in bilingual education programs. J. Deaf Stud. Deaf Educ., 13: 518-530.

Iam-Khong, N. and S. Suksakulchai, 2010. The current state and expectation in computer and internet usability for the data revelation of primary school for the hearing impaired students. ACE, Osaka, Japan.

Iam-Khong, N. and S. Suksakulchai, 2011. Online Sign Language Dictionary for Hearing Impaired People. Chengdu, China.

Iam-Khong, N., S. Suksakulchai, W. poolek and J. Plubsawat, 2011. The comparative study of learning achievement in Thai language between hearing impaired and normal students: Case study of thugmahamek school of the deaf. Proceedings of International E-Learning Conference, Jan. 13-14, Bangkok, pp: 189-194.

Jackson, D., P. Paul and J. Smith, 1997. Prior knowledge and reading comprehension ability of deaf adolescents. J. Deaf Stud. Deaf Educ., 2: 172-184.

Ju, J.M., 2009. The effects of multimedia stories of deaf or hard-of-hearing celebrities on the reading comprehension and english words learning of taiwanese students with hearing impairment. Asia J. Manage. Humanity Sci., 4: 91-105.

Lang, H., M. Stinson, F. Kavanagh, Y. Liu and M. Basile, 1999. Learning styles of deaf college students and instructor's teaching emphases. J. Deaf Stud. Deaf Educ., 4: 16-26.

Lark-Horovits, B.l. and L. Mark, 1973. Understanding Children's Art for Better Teaching. Charles E. Merrill, Ohio.

Mandel, T., 1997. The Elements of User Interface Design. Wiley, USA., ISBN: 9780471162674, Pages: 440.

McConnell, S., 2006. Software Estimation: Demystifying the Black Art. Microsoft Press, Grove City.

Phophong, A. and W. Meanrach, 2001. A Text to Speech Converter for Thai Language. Department Electrical Engineering, Institution King Mongkut's Institute of Technology North Bangkok, Bangkok.

Piaget, J. and B. Inhelder, 1970. The Psychology of the Child. Basic Book, New York, Pages: 192.

Pittman, A.L., D.E. Lewis, B.M. Hoover and P.G. Stelmachowicz, 2005. Rapid word-learning in normal-hearing and hearing-impaired children: Effect of age, receptive vocabulary, and high frequency amplification. Ear. Hear., 26: 619-629.

Puengpongse, W., 2006. Computer assisted instruction for Thai Sign Language on Internet. Master Thesis, Information Technology, Institution King Mongkut's Institute of Technology North Bangkok.

Sri-On, J., 2003. Lesson Learn of Thai Sign Language for Hearing Impaired People. Ratchasuda College of Mahidol University, Bangkok..

Viradraikul, C. and O. Thongpitak, 2001. Computer Assisted Instruction for Thai Sign Language on Internet. Thai University, Bangkok.