Development of Assistive Technology
When Learning Disability is no Barrier

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Keywords: Assistive Technology, Dysgraphia, Learning Disabilities, Soundex, Spell Checker, Text-to-Speech.

Abstract: Assistive technology does not cure a specific learning disability. These tools are allowing a student with learning disabilities to demonstrate their intelligence and knowledge. Assistive technology for the person with learning disabilities is a made-to-fit implementation. Trial and error may be required to find a set of appropriate tools and techniques for a specific individual. Therefore this paper is aimed to attest the use of assistive technology: Thai Spell Checker program which enhanced students with learning disabilities in their writing. This paper will also depict the details of the design and development of assistive technology tool, including information on the experiment with real users. The results from the study show that the assistive technology tool has a correct rate of 89% for detecting misspelling words. Additionally results indicate that the students have writing improvement in Thai language as 75%, 15%, 30%, 70%, and 35%.

1 INTRODUCTION

Assistive technology will be a tool for enhancing capacity or adjusting ability of a special child and will allow such child to learn better and more efficiently. In addition, Assistive technology is a technology that instructor can apply for facilitating the learning activity and increasing learning opportunity (Alper and Raharinirina, 2006). Learning methods of students with learning problems are different from other students. The techniques used are also different as well as the technologies. Although some students with learning disabilities will be able to study with normal students, they require special processes or methods of teaching to draw out their expertise and unique talents in order to replace or remove their weaknesses (Gersten et al., 2001). In Thailand most students with learning disabilities still have to learn the same way as normal students because the use of assistive technology in the country is still limited (Poobrasert et al., 2011). Though in the market, there are various types of assistive technology for students with learning disabilities, those tools are not suitable and not benefit Thai students. Most of this software is designed and developed for English speakers. The prices of those assistive technology tools are also expensive. Since Thai language is very unique and different from other languages, we then needed to integrate Thai text to speech (VAJA) and BEST corpus into the program. BEST corpus consists of Thai vocabularies from article, encyclopedia, news and novel. We also added Thai vocabularies from Thai textbooks. Hence, we have to design and develop our own assistive technology for students with learning disabilities in Thailand. As mentioned earlier, assistive technology will help increase the ability or adjusting proficiency of students with learning disabilities to learn effectively.

According to Shaywitz (2005) children with cognitive or learning difficulties need more general solutions which include providing a consistent design and using simplified language. They also gain benefit and comprehend the material better from viewing the text and hearing it read aloud. Therefore it is very important for the researcher to have a better understanding of disability issues. Moreover, the key to accessible user interface and the process of usability engineering are to ensure accessible user experience and their limitations. In this study, we also performed usability engineering to ensure that the Thai Spell Checker program is ready to use with the students with learning disabilities in Thailand.

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2 RELATED RESEARCH

2.1 The Thai Word Search Function

The Thai Word Search program is an assistive technology tool for students with learning disabilities in writing by providing help in searching for vocabulary either in the mode of Homophony or Soundex (a word that is pronounced the same but has different grapheme) or Word Approximation ; words with a similar depiction; probably be misspelled or wrong tone (Wren, 2004).

With respect to Thai Word Search program, when the student wants to write any vocabulary that he/she cannot spell it correctly, the student will just type part of word according to pronunciation or as guessed, the program will then check and demonstrate the words for selection that most likely matches the one desired by the student including their pronunciation.

2.2 Thai Text to Speech

In this paper, we applied the use of Thai text to speech (VAJA: Research and development of Speech and Audio Technology Lab [SPT], NECTEC) (SPT Lab, 2013) into our program.

Text to speech is a technology that can create any voice as desired and most of its use has to be associated with language processing technology. Text to speech can be integrated into Thai text in order to read and convert voice into it in Thai for every word as it has the function for word pronunciation, even for a word not appeared in a dictionary. In addition, the user can add a specific word such as an individual's name and freely customize pronunciation in order that software can convert text into voice as desired by the user.

Our program, Thai Spell Checker applies Thai text to speech as one of its components aimed to read text and convert it to voice for the user. Pronunciation of vocabulary by Thai Spell Checker can help students with learning disabilities to hear and select the desired vocabulary correctly.

2.3 Thai Query Correction

Another previous technology is called Thai Query Correction. Thai Q Corr is a service rendered in the pattern of web server with an ability to verify vocabulary wrongly written by the user, by presenting in, for instance, homophony or related written word due to wrong word writing or spelling (Haruechaiyasak et al., 2008). The Thai Spell Checker program also applied the use of "Linguistic Rule for LD" into the program.

3 DESIGN AND DEVELOPMENT OF ASSISTIVE TECHNOLOGY

3.1 Program Design

The main system architectural design of the Thai Spell Checker program is shown in Figure 1.

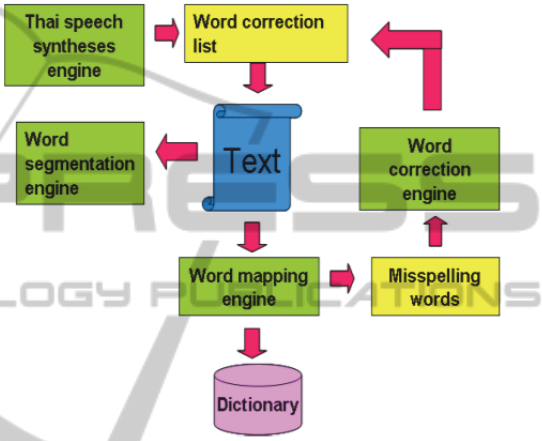

Figure 1: Main System architectural design of Thai Spell Checker Program.

Program design consists of searching function. The function can search for Homophony or Soundex and Word Approximation (see Figure 2).

3.1.1 Homophony or Soundex Search

Homophony or Soundex search will take searching word from the user and then apply W2P (Word-to-Phoneme; the phoneme is the basic building block for spoken words) tool to convert searching word into voice through the converting process which will discard ร, ล (two Thai letters having close pronunciation) before searching into a hash database of voice code, to gain the result in writing pattern and return it to the user. Homophony or Soundex search will pay attention to the only pronunciation of such word. When we have got a word in the writing pattern (Grapheme) we will then find its pronunciation and it is called Phoneme. Normal grapheme will be definite while Phoneme may be Phonetic or code or other kind of voice (Angkawattanawit et al., 2008).

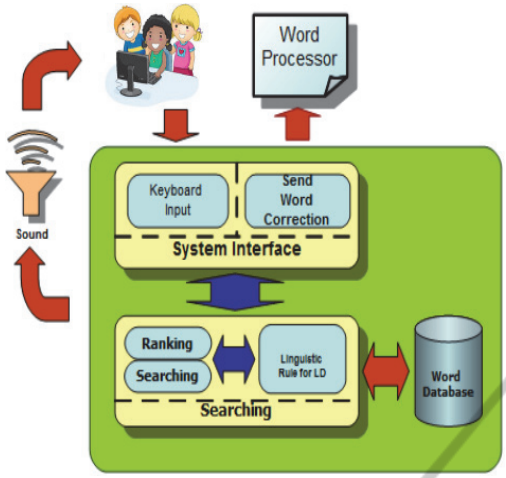

Figure 2: The system architectural design of Thai Word Search Function.

โรงเรียน = r-oo-ng^-0 | r-iia-n^-0

อากาศ = z-aa-z^-0 | k-aa-t^-1

Figure 3: G2P of โรงเรียน and อากาศ.

Procedures for Homophony or Soundex Search: It is able to convert Grapheme into Phoneme more easily. This will start from dividing words into syllables via the process of Lexeme Tokenizer (Su and Song, 2011) applying a mark **"|"** to define syllable. The intonation mark of such individual syllable will be then deleted by a Tone Remover process to avoid being confused by the system. Cancelled Letter Remover will be applied to delete the mark from syllable before the last process of converting Grapheme into Phoneme (G2P) (Kasuriya et al., 2003) (see Figure 3).

Data storage in Homophony or Soundex search system is done by the hash database (Main and Savitch, 2010). The advantage of hash database is the focus on swift searching and adding/deleting member until the static time O (1) but such data has to have no priority and duplicity (Viola, 2005). This first step is to take word aimed to search for into the searching system G2P by following the process mentioned above and voice code from these words will be converted where ร, ล will be discarded by the system (see Figure 4).

l-oo-ng^-0 | r-iia-n^-0

r-oo-ng^-0 | r-iia-n^-0

r-oo-ng^-0 | l-iia-n^-0

l-oo-ng^-0 | l-iia-n^-0

Figure 4: Sample of words where ร, ล were discarded by the system.

When these phonemes are identified, searching process will continue under the following steps:

- All correct words search,
- 1 wrong word searches *which will occur when the wrong word entered by the user has more than 2 syllables*, and
- All words in the vocabulary search pattern

These 3 processes will be followed respectively and if the result is gained at any step, it will be presented immediately.

3.1.2 Approximation Search

Search for approximation means searching for words having close Grapheme to designated word and may contain slightly different letter e.g. "กาลเทศะ" – "กาลเทศะ" or "วิจารณญาน" – "วิจารณญาณ" etc. These samples are set of homophony which can be searched by homophony or soundex search system. From the other perspective, these words contain only few different letters e.g. "วิจารณญาน" – "วิจารณญาณ" differ from each other by using "น" or "ณ". This approximation search will ignore pronunciation but close grapheme (Poobrasert, 2011). By the use of approximation search, the key attention is mistyping e.g. "ผจยภัย" – "ผจญภัย", "กรุงศรีอยุธบา" – "กรุงศรีอยุธยา" or "กลลวง – กลลงว" etc. It can be noticed that some word cannot be even spelled out or can be spelled without meaning. In case of "ผจยภัย" – "ผจญภัย", it may be the result of mistyping as the letter "ญ" and "ย" are on the same key but the shift key has not been pressed properly to change from "ย" to "ญ".

- Procedures for Approximation Search: Data storage in approximation search system is done by hash database. The advantage of which is the focus on swift searching and adding/deleting

member until the static time O (1) but such data has to have no priority and duplicity.

First step is to take designated word to be processed under the steps as follows:

- Search for all correct words, search by the Rule of LD (Pothibal, 2010) 1st round by the method shown below:
  - Deletion: refer to the step that word typed by the user will be deleted letter by letter, the result is n.
  - Transposition: refer to the step that word typed by the user will be switched letter by letter, the result is n-1.
  - Substitution: refer to the step that word typed by the user will changed letter by letter under *Rule of LD* e.g. letter "ก" can be changed to "ก" "ภ" "ถ" "ฤ" "ด" "บ" "ม" or "ย".
  - Insertion: refer to the step that the word typed by the user will be added letter by letter, the result is (n+1) x 66 results.
- Search again by Rule of LD, 2nd round.

The above processes will be followed step by step and if the result is gained at any step, it will be presented immediately. However, this method has some limitation, that is, it cannot correct the word containing fault for more than 2 letters and thus API Approxy, Edit distance has been introduced to increase the efficiency for search.

Figure 5 shows the procedures for approximation search.

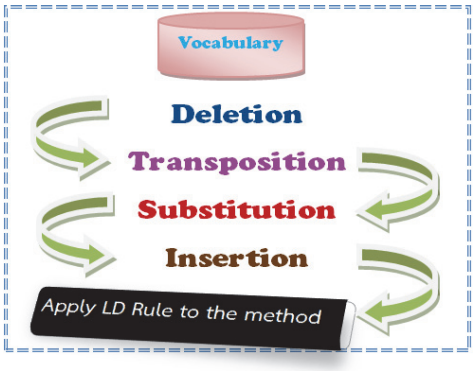

Figure 5: Procedures for approximation search.

- Interface Design of Thai Spell Checker Program: Figure 6 demonstrates the interface design of the Thai Spell Checker Program. The user uses the ribbon to issue the commands within the program. At the top of the ribbons are several tabs such as "File", "Format", "Insert" and "Setting". Spell Checker Button is located in the File tap.

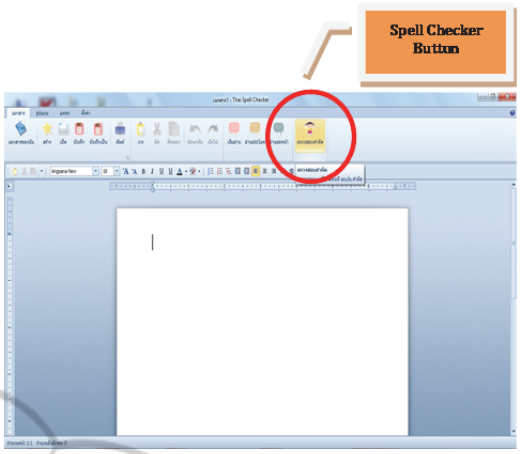

Figure 6: Interface design of Thai Spell Checker Program.

When click the Spell Checker button, the new dialog box will appear. This box details the spell checker working area (Figure 7), including misspelled words which are indicated by pink highlight and suggested word lists.

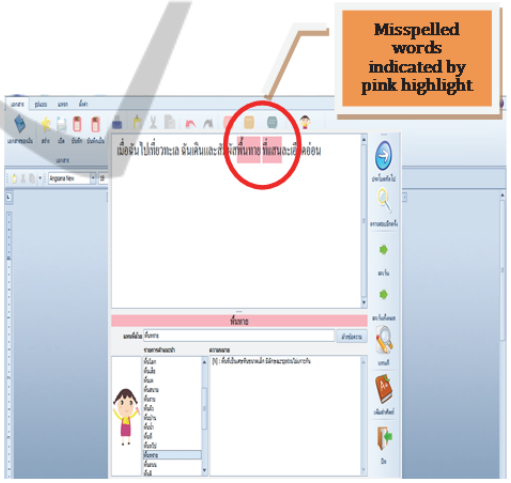

Figure 7: The Thai spell checker working area.

4 METHODOLOGY

The usability testing was performed before conducting the experiment with real users. Usability testing measures the usability of the system (Cockton, 2013). In this study we use heuristic evaluation (Hvannberg and Lárusdóttir, 2007) which is the most popular of the usability inspection methods (Nielsen, 1994). Nielsen and Landauer suggested that the best results come from testing no more than five evaluators and running as many small tests as we can afford (Rosson and Carroll, 2010).

We are trying to fix all bugs and errors found during the usability testing. At present the system evaluation shows the correction's scores of 89%. We therefore expect that our assistive technology tool will assist students with learning disabilities who struggle with writing become better writers. Thus the program was suitable to use in an actual experiment.

In this study *single subject research design* (a single-case experimental design) (Gay and Airasian, 2003) was also applied into our experiment. We use this method when the sample size is one or when a number of individuals are considered as one group. These designs are typically used to study the behavioral change an individual exhibits as a result of some treatment. In single-subject design, each participant serves as his or her own control. The Thai Spell Checker program was experimentally applied to five students with learning disabilities who struggle with writing in grade 5th at the school in Bangkok.

- Method for Selecting Students:
  - Students with learning difficulties who struggle with writing in grade 5th were selected to conduct Pretest.
  - Students' writing ability was tested on the specific vocabulary where each of which was allocated about 12 minutes to finish the test (25 words).
  - The researcher collected writing results from the student and then selected five out of them (under the assistance from the Thai instructor).

5 EXPERIMENT

5.1 The Experiment – Practicing Method

All of the five students are assigned to write 20 vocabularies on their workbook without using the assistive technology program. When finished they are allowed to type the same set of vocabulary on the computer and use the program "Thai Spell Checker" to assist them. Figure 8 shows an example of one LD student handwriting and Figure 9 demonstrates the Thai Spell Checker program. Figure 8 shows an example of one LD student handwriting and Figure 9 demonstrates the Thai Spell Checker program. Figure 8 shows an example of one LD student handwriting and Figure 9 demonstrates the Thai Spell Checker program.

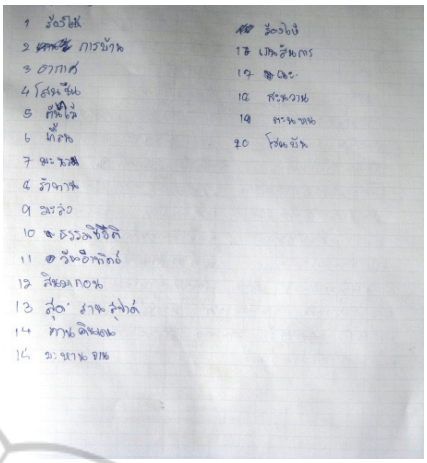

Figure 8: Example of one LD student handwriting.

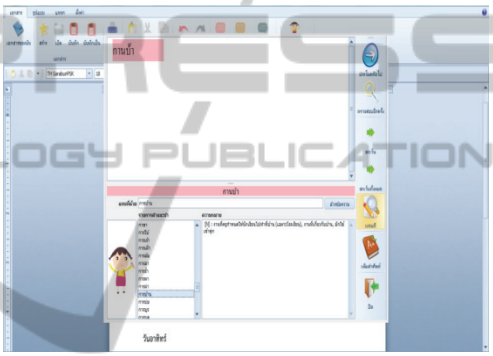

Figure 9: The Thai Spell Checker Program.

6 RESULTS

The results in Table 1 showed that students with learning disabilities in this study improved their ability of writing when use assistive technology.

The student#1 received the lowest score on his pretest. With his endurance and trying to use assistive technology to complete the tasks, he received full score on his post test. Therefore his improvement of writing was 75% which was the highest score.

The student#2 received 13 scores on his pretest and 16 scores on his post test. His writing improvement was 15%.

The student#3 received 14 scores on her pretest and 20 scores on her posttest. Consequently, the improvement in learning of the students#3 was 30%.

The student#4 received seven scores on her pretest and 20 scores on her post test. It is indicated that her improvement in learning was 70%.

The student#5 received 13 scores on the pretest and 20 scores on the post test. Hence, the assistive

technology helped him to improve his writing for 35%.

Table 1: Comparison of test scores.

Students	Without AT	With AT
1	5	20
2	13	16
3	14	20
4	7	20
5	13	20

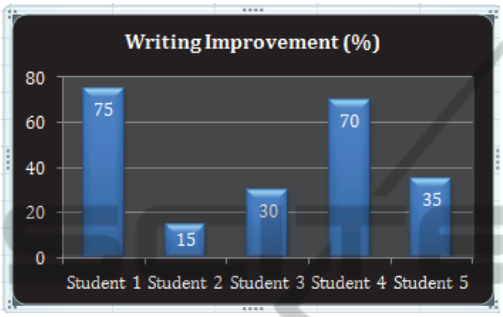

Figure 10: The Writing Improvement of all five students.

7 CONCLUDING REMARKS

This paper presents an assistive technology tool to help students with learning disabilities in Thailand to learn to write. The method addresses the combination number of different word search techniques to spell check a document and provide interactive feedback to the users. Five students with learning disabilities who participated in the study were in agreement with the advantages of the assistive technology; Thai Spell Checker which could help Thai spelling and search Thai words well and fast. The students mentioned that the program assisted them to be able to choose vocabulary and print the work correctly. The program also allowed them to learn the meaning of new vocabularies. They agreed that Thai Spell Checker was user friendly, and not complicated.

In addition, the program also helps the students to know how each word is spelled as it provides pronunciation for each word. Although the pronunciation by the program for some word was deviated from the computer-generated simulation of human speech (VAJA-TTS), most students in this study admitted that the program could help them to be able to pronounce vocabulary better than without using the program. Not only the pronunciation, but we also expect that assistive technology tool such as Thai Spell Checker will help enhancing the writing skill of students with learning disabilities in Thailand.

Finally, in this study, we have not conducted the experiment using other Spell Checker programs with these students for the purpose of the study is to assist the students who struggle with writing become better writers in Thai language. The study is the first of its kind to be carried out in Thailand, however the approach and method adopted for this problem can also be transferred to other languages.

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