# A STUDY OF TEXT-TO-SPEECH (TTS) IN CHILDREN'S ENGLISH LEARNING

by **Yi-Ching Huang** and **Lung-Chuan Liao**
Central Taiwan University of Science and Technology
No.666, Buzih Road, Beitun District, Taichung City 40601, Taiwan (R.O.C.)
getyiching @ yahoo.com, lawrencwliao @ yahoo.com.tw

**Abstract**

The purpose of this study was to explore the effects of the digital material incorporated into Text-to-Speech system for students' English spelling. The digital material was made on the basis of the Spelling Bee vocabulary list (approximately 300 words) issued by the selected school. 21 third graders from a private bilingual school in Taiwan were selected for this study. This study employed four data collection techniques, including questionnaire, pre-test and post-test, informal observation and interview, and semi-structured individual interviews. The research results showed that the use of digital material fostered the students' English spelling ability and their self-directed learning.

**Keywords:** Text-to-Speech; English spelling; self-directed learning

## 1. Introduction

Much attention has been paid to children's English learning in Taiwan. In addition, the Ministry of Education (2006) has notified elementary schools to start English courses from the third grade. The purpose is to hopefully improve Taiwanese children's competitiveness in English, so that they can be directly connected to the global world through this language. However, if English teachers do not have any innovative ideas and improved ways of teaching, but instead just thoughtlessly rescheduled English learning to the earlier age, children would not be able to benefit much. Appropriate English teaching strategies can only be developed while the children's differences in the cognitive development, individual needs, and characteristics are all taken into consideration. In such settings, the language learners' training resources for the four categories of skills, including listening, speaking, reading, and writing, are more limited, consequently affecting the efficiency of their English learning. In addition, the children are often not provided with proper guidance while doing self-study, outside of school or after school, resulting in the students ' frustration with English learning, and thereby reducing the willingness of independent learning.

With the rapid development of technology, the World Wide Web has become a vehicle for unlimited learning and teaching transmission media. Many language learning centers

nowadays use Computer-Assisted Language Learning (CALL) in training language skills. CALL cannot replace regular English education, but it can be used to make up for the shortcomings of traditional language teaching so as to enrich the content of the teaching material and increase students' interest in and effectiveness of learning. Many studies have confirmed the claim that correct and appropriate application of learning technology in teaching can effectively improve learning (Warschauer & Healey, 1998; Lee 2006). Text-to-speech (TTS) and Speech Recognition, for example, have been introduced into language teaching by scholars who advocate the computer-assisted approach to language learning (Handley, 2009).

Furthermore, The Act “Integrate Information Technology (IT) into curriculum development and pedagogical practices” issued by Ministry of Education in Taiwan in 2000 puts emphasis on combining technology with the curriculum, and then using it in practice to enhance the quality and effectiveness of the learning and teaching process. Mastering a language requires a large amount of input of corpora and practice, and integrating information technology into English teaching will no doubt strengthen students' English learning motivation.

Meanwhile, Cheng et al. (2003) also indicated that information technology integrated into English teaching not only increases the diversity of the course, but also creates a self-directed English learning environment in which students' differences are properly addressed. As for English teaching, with the help of information technology as rich database resources, interactive learning activities can be employed in the classroom as well. In the English learning environment teaching materials for learners play the most important part in interaction. Educators’ attention therefore should be focused on designing multimedia teaching materials to go with appropriate teaching methods and strategies because they will effectively promote English learning. However, children’s language learning cognition is different from that of adults. McGlothlin (1997) claims that while teaching a language to children their learning properties should be considered so as to construct appropriate learning environments and develop effective teaching strategies.

Multimedia educational materials are likely to meet the individual needs of students and increase the flexibility and interactivity integrated into subject teaching. Students will benefit the most from the basic language knowledge through tutoring or drilling combined with information technology; through simulating or playing games (Lu et al., 2014; Suh et al 2010).

In summary, information technology has a positive influence upon teaching English to children. English language teaching, if combined with computers and information technology, will provide another rich learning environment and channel for improved motivation and increased achievement. In this study, the researchers designed a set of English vocabulary learning materials as the teachers' diverse teaching resource and for the students' self-directed learning. To create these materials, synthetic engine components of text to speech, including American English pronunciation engine developed by the NeoSpeech and close-to-human voice technology, were used. The spelling list (about 300 words) for the Spelling Bee during the semester played as the main source. This research project aimed at exploring the influence of the English vocabulary learning multimedia materials upon the effectiveness in students' spelling improvement, attempting to answer the following research question: How do multimedia spelling programs affect student performance in spelling and student attitudes toward learning spelling?

## 2. Literature review

### 2.1. Digitalized teaching materials

Asoodar et at. (2014), Ching (2009), & Yang et al. (2012) all suggest that instructors should make full use of information technology to aid the material designing process. Many teachers cannot attain perfection in teaching English because they graduated from non-English departments and are subject to the limitations of their professional abilities and cultural background. In this case digitalized teaching materials are definitely one of the most feasible resources. The characteristics of these particular materials are stated as follows:

1. Multiplicity

With the development of informational technology, digital textbooks shift the focus of learning towards the students' independent study. In order to foster learners' independence and motivation towards learning, diverse teaching contents that exhibit vivid and interesting features and allow students to learn in accordance with their individual interests are extremely important.

2. Hypertext

Teachers can systematically expand the teaching and learning database of materials and related supplementary information on teaching websites. By using network nodes, students can easily retrieve or download the course information. In addition, it will provide multiple

sources of information by way of hyperlink, breaking through the traditional linear reading style (Chen et. al., 2013, & Pacheco, 2013).

3. Authenticity

Jonassen, Peck, and Wilson (1999) pointed out that computer technology can bring the real world into the language learning environment and allow students to break through the restriction of having only a limited number of books in the classrooms. Furthermore, it increases students' opportunities to learn with real corpora.

4. Energy saving and environmental protection

Digital materials can be repetitively acquired, unlike printed ones, which can consequently help save paper and achieve environmental protection.

According to the unique features of digital materials as described above, it is obvious that digital materials can be incorporated as one of many ways of English teaching.

**2.2 The application of TTS in language learning**

In the recent years, computer assisted teaching and learning systems have been focusing on communication training, directly leading to an increase in the practice of people's communication skills as compared to previous years. This is made possible because computers are now capable of detecting, identifying, and processing spoken languages (Ehsani et al., 1998). This subsequently leads to TTS and Speech Recognition’s increasing popularity in language learning. TTS converts text information directly into a voice reading, and then uses natural semantic analysis techniques generated through artificial intelligence to make effective judgments on letters, words, the tone of numerals and special reading methods, and then employs speech synthesis patented technology to clearly read out the anthropomorphic sounds with adjusted speed and frequency. This allows each word to be pronounced correctly and naturally.

According to Dutoit (1997), the functioning of TTS (Figure 1) includes: (1) Natural Language Processing (NLP), a module that is able to produce voice recording of articles and combine the tone and rhyme and (2) Digital Signal Processing (DSP), a module which can convert the received symbol information into a voice. Zhu (2005) detailed the four major modules of TTS.

1. Textual Analysis: Analyzes the syntax and semantics of the text and converts it into language characteristic parameters. In other words, the computer can identify words, sentences, and pronunciations, and knows how to pronounce and when and how long to pause.

2. Rhythm Generator: Sends language characteristic parameters into the rhythm generator to produce the corresponding rhythm message of each syllable in the text, including the baseband track, volume, and duration, and converts the tone, voice, pause mode, and length of pronunciation into rhythmic parameters.
3. Synthesis Unit Generator: Outputs synthesis unit by following monosyllabic phonemes speech waveform samples in the speech database.
4. Text-to-Speech Synthesizer: Selects acoustic parameters from the sound database to match the sounds needed to be pronounced.

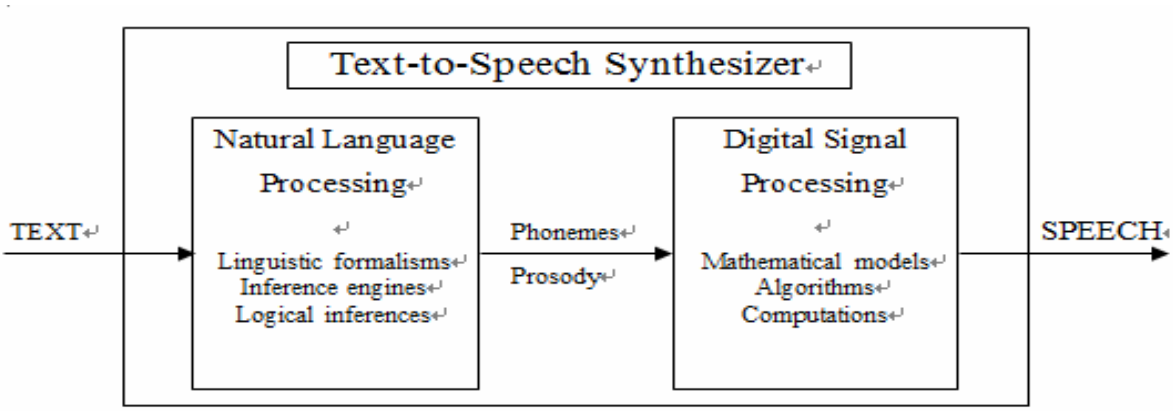


Figure 1: The Functioning of TTS (Dutoit, 1997)

Many studies have pointed out that phonetics is the combination of phonemic awareness and phonological awareness (Drezek, 2007; Anthony & Lonigan, 2004). Drezek (2007) interpreted phonemic awareness as cognition of a smaller phonemic stage. By way of moving, deleting and combining phonemes, phonological awareness (PA) displays the ability to manipulate sound and distinguish the difference between writing and speaking (Kamii & Manning 2002). For instance, phonological awareness appears when the teacher asks students to read the word "pat" and then changes the letter p to c and re-reads the word "cat". Performing phonological awareness requires the identification of the difference between phonetics. For example, in the sentence, “I like to read,” “read” is pronounced /rid /, however, in “I read a book yesterday,” it is pronounced as /rɛd/. Phonetic awareness includes syllables, consonants and vowels (American Reading Association, 2008). Davidson and Strucker (2002) believe that both English native speakers and non-English native ones can improve their English fluency by learning phonetic symbols, syllable changes, and reading aloud. Phonological awareness scholars, Kirby et al. (2003), Anthony & Lonigan (2004), and Ivey &

Baker (2004), also emphasize the fact that phonological awareness at the kindergarten stage has great correlation with reading competitiveness. On the other hand, the lack of phonological awareness impacts dyslexia considerably. In other words, those who have good reading abilities read more extensively and people with dyslexia exclude reading, often times developing into the Matthew Effect (Stanovich, 1986). Accordingly, Drezek (2007) proposed that the bimodal input can help learners improve reading comprehension through phonological awareness. The first one is reading while listening (RwL). Learners read the article and listen to previously recorded audio CDs or cassettes, or listen to what the teacher is reading. The second is TTS, and TTS features convert text information into voice files, which makes the information in the computer more prominent. Bimodal input possesses three characteristics:

- RwL and TTS both trigger phonological awareness.
- Readers with severe dyslexia, including literacy difficulties and dyslexics, benefit more from RwL and TTS than learners with good reading skills.
- RwL and TTS reduce fatigue in reading and increase more interest as well as reading amount.

Elbro, Rasmussen & Spelling (1996), Dolan et al. (2005), and Garg (2011) all pointed out that TTS has a strong positive impact on learning languages. When conducting online reading tests, Olsen and Wise (1992) found that students employing TTS obtain higher literacy scores and acquire a larger vocabulary than those students who just use traditional computer programs. Davidson et al. (1991), Hebert & Murdock (1994), and Damper & Eastmond (1997) also indicated the fact that students' vocabulary significantly increases while using TTS to read articles. In addition, Davidson et al. (1991), Dawson et al. (2000), and Shany & Biemiller, (1995), van der Leij, (1981), and Yamagishi et al. (2009) all believe reading with the help of TTS greatly enhances students' accuracy and fluency of vocabulary. Furthermore, Elbro et al. (1996) argue that through syllables or letters coupled with TTS, language learners show significant improvement in vocabulary, comprehension, and fluency, compared with users following general curriculum.

The above-mentioned literature review addresses the effect of the TTS learning system on the students' reading achievement and vocabulary enhancement. Most of these studies, however, are quantitative-based and focus on the application of TTS with native English-speaking learners, not with students who are learning English as a foreign language. Since English plays an important role in the language education of Taiwan, the question of how to improve the four skills: listening, speaking, reading, and writing, becomes a crucial issue.

Many students often feel troubled while memorizing words because of not knowing how to pronounce them, but, at the same time, they are unable to keep up with the CD, due to failure to understand the content that the speaker is saying. Some students even become frustrated with learning English because they have no idea of how to speak with beautiful cadence. For this reason, research on developing teaching methods to improve these specific problems of learning English becomes a necessity. With substantial and rapid progress in TTS development, the most natural pronunciation and intonation generated through this technology has replaced the mechanized synthetic speech that was popular early before. This technology can provide learners not only with the best demonstration of the analog tone pronunciation, but also adds the flexibility and efficiency which cannot be achieved with pre-recorded files. Therefore, exploring the correlation between TTS and students' learning English proves to be necessary. In addition, related research on TTS has been not very common in Taiwan. This research will employ TTS to produce digital material to further study the students' learning English at an elementary school.

## 3. The study

### 3.1 Participants

A private elementary school was chosen and 21 third grade students and their English teacher participated in the study. Ten boys and eleven girls had been learning English as a foreign language for 3 years. This study lasted for a whole semester.

### 3.2 Design and procedure

This study focused on the digital materials for the spelling activity. Approximately 300 words for Spelling Bee contest in this semester were used and for each of the words vocabulary learning was combined with phonology by incorporating the TTS technique. The teaching material features word with pronunciation, click button features such as a bee, eraser, and help, and reading letter by letter. When students try to memorize a word, he/she can first click on "pronunciation" key, read the word out loud themselves, and then check the word on the computer. If the student is just getting started with a new word, he/she can click on "letter-by-letter" for help, such as the key—k--e – y. And if students want to re-test their spelling, they can click on the "eraser ", and then practice again. This set of digital speech teaching materials, when coupled with multimedia software such as PowerPoint, provides students

with separate syllables and allows them to distinguish individual syllables and memorize the words more easily (Figure 2).

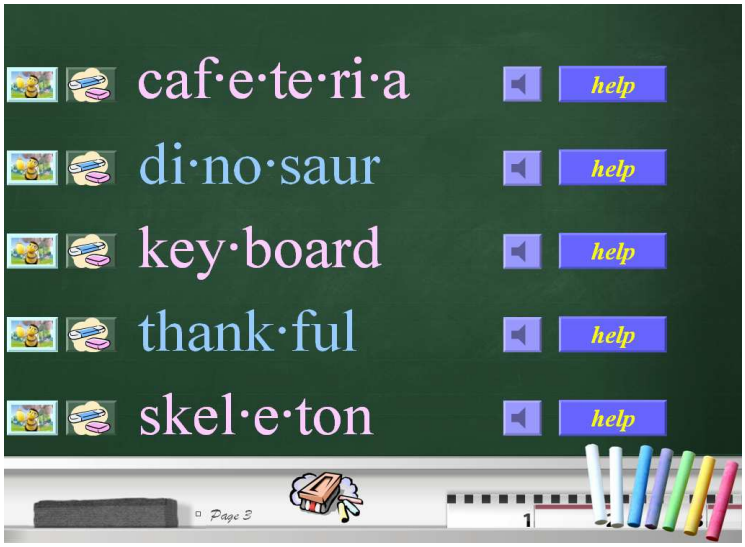


Figure 2: Digital learning material for Spelling Bee (sample)

A private elementary school in Taichung City was selected for this study. In order to reinforce the consistency of the research design, this study employed data triangulation. In other words, information from different sources was used in the study to increase reliability and validity of the research (Mills, 2000).

Before conducting this study, researchers had already communicated with the school's authorities and teachers and had obtained their consent. In the meanwhile, parents needed to sign the agreement after they had been informed upon the purpose and methods of this study. Right after the Spelling Bee vocabulary list (about 300 words) for the semester was announced, researchers used TTS to produce digital material. Each week, students were required to take a 30-word dictation test for side-by-side comparisons of test results before and after using this digital material. Students spent two hours per week using the digital material in the computer lab and each of them had his/her own CD for self-study at home. Researches performed 5-week observation in the classroom. When students have completed this 300-word examination, researchers conducted individual interviews with them and their teachers after school.

The contents of individual and group interviews have been labeled and the manuscripts were filed into separate archives for each participant. All of the data collected were read repeatedly and anonymously analyzed; each question was numbered and classified in parentheses. A single sentence, phrase or text was employed to identify its category. In

addition, each issue was analyzed based on the answer given by each of the participants. To screen the theme development, researchers analyzed the participants' answers to each question and then compared and contrasted or merged their categories when necessary.

### 3.3. Instrumentation

#### 3.3.1. Learning questionnaire

The questionnaire aims at eliciting attitudes after using the digital vocabulary spelling material. This questionnaire was designed by researchers with the purpose of finding out students' opinions and attitudes toward English learning. The questionnaire for digital vocabulary spelling material was distributed to students after the experiment in order to understand the effects of using the digital material.

In the questionnaire, items 1 to 12, grouped under the cognitive component, are mainly used to evaluate the effectiveness of the material; the purpose of items 13 to 18, the action component, is to survey students' true behavior in learning English. Finally, the affective component, items 19 and 20, is supposed to exhibit students' interest in learning English (see Table 1).

Table 1: Attitude questionnaire

| **Cognitive Component** |
|---|
| 1. Do you normally have difficulties trying to memorize words? |
| 2. Do you know the English pronunciation of the words you're trying to memorize? |
| 3. Do you think the Spelling Bee is like a kind of software for a game? |
| 4. Do you like using the Spelling Bee software to memorize words? |
| 5. Do you think the Spelling Bee software is helpful in memorizing words? |
| 6. Do you think the Spelling Bee software is like a teaching assistant helping you memorize the words? |
| 7. Do you think the Spelling Bee software helps you with pronunciation? |
| 8. Do you think the Spelling Bee software helps to deepen the impression of words on you? |
| 9. Do you understand the pronunciation given by the Spelling Bee software? |
| 10. Do you have difficulties using the Spelling Bee software? |
| 11. Does your family think the Spelling Bee software helps you memorize words? |
| 12. Do you think memorizing words is not so difficult after using Spelling Bee software? |
| **Action Component** |
| 13. Do you need anyone to help you memorize words? |
| 14. Can you test yourself while using the Spelling Bee software instead of having someone else test |

| |
|---|
| you? |
| 15. Do you use the "eraser" function key to correct misspellings while using the Spelling Bee? |
| 16. Can you spell the words when you hear the pronunciation of the word from Spelling Bee software? |
| 17. Do your family members use the Spelling Bee software with you? |
| 18. How many times a week do you use the Spelling Bee software? |
| **Affective Component** |
| 19. Do you enjoy using the Spelling Bee software? |
| 20. Which part of the Spelling Bee software do you like most? |

### 3.3.2 Pretest and posttest

Prior to the implementation of this digital learning material, researchers used the word table to give a spelling pretest to the surveyed class, and then a spelling post-test afterwards in order to learn whether digitalized teaching material affect students' spelling ability.

### 3.3.3 Informal observation and interviews

With the consent of teachers, researchers made non-participating observation on the students' dialogue and interactions on campus and the students' computer classes during five occasions. Informal interviews with these students and teachers were also carried out during their leisure time. In these informal observation and interviews, researchers also took notes of issues or details which might be missing in the semi-structured individual interviews.

Teachers and students all volunteered for individual semi-structured interviews; each interview took about 90 minutes. The questions in the booklet were designed and created by researchers; individual interviews were tape-recorded and then typed out in Chinese. Students were still very young; their answers were inevitably too short or general. Accordingly, each student was individually interviewed twice in order to be more objective.

### 3.5 Results and discussion

This study found that the digital vocabulary spelling material can (a) strengthen the students' spelling ability, and (b) promote students' self-learning motivation, according to interviews with the students and teachers, observation, questionnaire and documented records.

In the individual interviews, the teachers all agreed that this set of vocabulary materials helped the students' spelling. Teachers explained:

> In the very beginning, they (students) thought the Spelling Bee was very strange and interesting. When they clicked the mouse, the computer talked. And when they keyed in a

word, the computer would produce a stimulus sound. So to them, it was fun. I think it's of great help to them. They can obtain training both in spelling and pronouncing the word "key", so when they do review, they will have a much clearer understanding.

The teachers also believe that this material improves students' phonological awareness. They said that students can listen, and then spell the word out immediately. In the interview with students, 18 students believe that vocabulary teaching material helped them in learning English words. For example, Kevin said memorizing words becomes much easier. Sun believed that after using the software, memorizing words turns out to be relatively simpler and it was far easier to correctly spell. Johnny mentioned that this material makes him comprehend the pronunciation, and thus accelerate the speed of spelling. In language learning, phonological identification is the basis for successful pronunciation. Children are trained to pronounce through spelling. That is why children need to learn pronunciation as to know the spelling of each word (Fox & Mitchell, 2001). In this study, the data collected from interviews prove that the Spelling Bee software allows students to learn the pronunciation before learning the spellings.

In students' vocabulary tests, the first spelling test scores earned during the semester were regarded as the pre-test results; the test was carried out by dictation. The same questions, after being rearranged, were used for the posttest. In Table 2 the average t-test goes up from 73.2 to 85.1. As Table 2 showed, there was a statistically significant increase in spelling test scores from the pre-test ($M = 73.2$, $SD = 16.77$) to the post-test ($M = 85.1$, $SD = 19.1$), $t(20) = 5.98$, $p < .0001$. The students increased their spelling test scores from a pre-test score mean of 73.2 to a post-test score mean of 85.1. This indicated the digital spelling software had a positive effect on students' English spelling abilities.

Table 2. T-test of students' pretest and posttest scores

| | | Pre-test | | Post-test | | | | |
|---|---|---|---|---|---|---|---|---|
| Student | N | Mean | SD | Mean | SD | d.f. | T. | P |
| | 21 | 73.2 | 16.77 | 85.1 | 19.1 | 20 | 5.98 | <0.001 |

According to the questionnaire, 57% of the students had difficulty memorizing the words in the Spelling Bee vocabulary list before being introduced to the software. After learning to use the Spelling Bee computer software, 67% of the students expressed the view

that memorizing words is not as difficult as they used to think. 81% of the students believe that the Spelling Bee computer software help deepen the impression of words. The family of 71% of students thought that the Spelling Bee computer software helps students memorize words. In conclusion, these data indicated that the Spelling Bee computer software for students to learn words obtained high appreciation.

The data mentioned above pointed out that the students derived great benefits from employing the TTS integrated with vocabulary learning. The digital learning material for the Spelling Bee features an eraser that allows students to immediately know and correct their own errors and practice again, improving the students' spelling ability. Barbetta, Heron, and Heward (1993) explained that the instant whole-word phonological correction and feedback has a positive effect on literacy skills. Due to the variability of each word in the table, such as verb form and past tense, students must be able to distinguish the part of speech and pronunciation in order to memorize words. The results of this study showed that the students significantly improve in spelling. Wise et al. (2000) explained the phonological synchronous display strengthens the decoding procedures between letters and phonemes of spelling culture.

The results of the interviews and questionnaires showed that TTS improved the students' intrinsic motivation to learn. In the personal interviews, the teacher pointed out that the TTS for the Spelling Bee vocabulary reinforces the students' self-study passion, saying that with this approach parents do not have to worry about cassettes or CDs or the correctness of students' pronunciation. Furthermore, the software is so attractive that young students are able to pay attention to it and benefit from contents. In terms of self-study, the teacher believed that the TTS is truly helpful. The TTS therefore provides the students with a helpful way for self-study, if correctly applied to English teaching. In individual interviews with students, 18 of them agreed that they will review and prepare for the exam through this digital material. Jimmy said: "With this software, I can try to memorize words at my own speed." Kevin thought that with this software he no longer needs any assistance from parents to memorize words.

Wang (1995) pointed out that self-directed learning emphasizes learners' self-control and motivation, autonomy and voluntary throughout the learning process. In this study, survey data shows that 71% of the students think the Spelling Bee software functions like an assistant teacher helping them memorize words. 86% of the students thought that they can use the Spelling Bee computer software to memorize words and test themselves at the same time. 81% of students feel that they know how to erase the misspelled word and re-do it. The questionnaire data prove that students regard this software as an after-school assistant teacher

or a self-study tool. By using this software, students can practice repeatedly, which enhances positive attitudes towards learning and increases learning efficiency. Xu (2004) mentioned that e-materials applied to elementary English teaching can enhance students' attitude in the fifth and sixth grade.

According to the personal interviews and questionnaire, students articulated great interest in the vocabulary teaching material generated by TTS. 52% of them approved of the Spelling Bee TTS learning system; they liked the “eraser” and “Help” very much because the “eraser” helped them learn and “Help” reminds of letters and spelling, thus adding some interaction to the learning process. The software for vocabulary teaching based on the TTS features interactive learning, and thus enables the students to memorize words without any fear, provides them with a self-directed learning environment, and enhances their self-study motivation.

### 3.6 Limitations of the study

In this study, the curriculum design for Spelling Bee at the school is based on the semester, and thus the production, implementation and research of TTS digital vocabulary spelling material must be completed within one semester. The result of English word learning was expected to explore the effects of digital learning materials upon students' English learning. During the experimental stage, each student would need a computer for practicing TTS material. Researchers spent a considerable amount of time downloading TTS to every computer because of equipment limitations at this school. Meanwhile, the conditions for executing the program on each computer were not the same - some were fast, others were slower, and still others even crashed. Technical problems on computers brought frustration and difficulties for students using the digital material.

### 3.7 Conclusions and suggestions

This study employed text-to speech technology, including the American English pronunciation engine developed by NeoSpeech. This set of English vocabulary learning material was designed and produced by using close-to human voice reading technology with about 300 words in the word table for the Spelling Bee contest at the school, providing diverse teaching resources for teachers and self-learning environments for students. The purpose of this research was exploring the influence of the digital learning material upon students' English learning. The findings indicate that the digital material enhances students 'spelling ability and self-study motivation, according to the interviews with students and

teachers, observation, questionnaires and documentation. Researchers would like to offer some suggestions, based on the results and the procedure:

1. Text-to speech technology gives English educators a tool for integrating informational teaching and English teaching materials. In addition, teachers can determine what computer-aided teaching content to apply without being limited by textbooks, which increases the richness of the teaching.
2. Before memorizing words, students need to have correct information regarding the words' pronunciation in order to effectively learn English.
3. Developing interesting and interactive teaching and learning activities should be promoted to help students with learning spelling.

**References**

Anthony, J. L. & Lonigan, C. J. (2004). The nature of phonological awareness: converging evidence from four studies of preschool and early grade school children. *Educational Psychology*, 96(1), 43-55.

Barbetta, P. M., Heron, T. E., & Heward, W. L. (1993). Effects of active student response during error correction on the acquisition, maintenance, and generalization of sight words by students with developmental disabilities. *Applied Behavior Analysis*, 26, 111-119.

Ching G. S. (2009). Implications of an experimental information technology curriculum for elementary students. *Computers and Education*, 53 (2), 419–428.

Cheng, J., Gruninger, M., Sriram, R. D., and Law, K. H. (2003). Process specification language for project scheduling information exchange. *International Journal of IT in Architecture, Engineering and Construction*, 1(4), 307-328.

Chena, I. J., & Yen, J. C. (2013). Hypertext annotation: Effects of presentation formats and learner proficiency on reading comprehension and vocabulary learning in foreign languages. *Computers & Education*, 63, 416–423.

Damper, R. I., & Eastmond, J. F. G. (1997). Pronunciation by analogy: impact of implementational choices on performance, language and speech. *Language and Speech* 40(1), 1-23.

Davidson, J., Coles, D., Noyes, P., & Terrell, C. (1991). Using computer-delivered natural speech to assist in the teaching of reading. *British Journal of Educational Technology*, 22(2), 110-118.

Davidson. R. K., & Strucker, J. (2002). Patterns of word-recognition errors among adult basic education native and nonnative speakers of English. *Scientific Studies of Reading*, 6(3), 293-316.

Dawson, L., Venn, M., & Gunter, P. L. (2000). The effects of teacher versus computer reading models. *Behavioral Disorders*, 25(2), 105-113.

Dolan, R., Hall, T. E., Banerjee, M., Chun, E., & Strangman, N. (2005). Applying principles of universal design to test delivery: the effect of computer-based read-aloud on test performance of high school students with learning disabilities. *Journal of Technology, Learning, and Assessment*, 3(7), 1-33.

Drezek, J. (2007). Adult ESOL reading comprehension and text-to-speech software. Unpublished Master thesis. The University of Texas at Arlington.

Dutoit, T. (1997). *An Introduction to Text-to-speech Synthesis*. Dordrecht: Kluwer Academic.

Ehsani, F., & Knodt. E. (1998). Speech technology in computer-aided language learning: Strengths and limitations of a new call paradigm. *Language Learning & Technology*, 2(1), 45-60.

Elbro, C., Rasmussen, I., & Spelling, B. (1996). Teaching reading to disabled readers with language disorders: A controlled evaluation of synthetic speech feedback. *Scandinavian Journal of Psychology*, 37(2), 140-155.

Fox, B. J., & Mitchell, M. J. (2001).Using technology to support word recognition, spelling, and vocabulary acquisition. In R. Thurlow, W. J. Valmont & S. B. Wepner (Eds.), *Linking Literacy and Technology: A Guide for K-8 classrooms* (pp.42-75). Newark, DL: International Reading Association.

Garg, M. K. (2011). Role of technology in English Language Teaching. *International Journal of Education & Allied Sciences*, 3(1). 105-110.

Hebert, B. M., & Murdock, J. Y. (1994). Comparing three computer-aided instruction output modes to teach vocabulary words to students with learning disabilities. *Learning Disabilities Research & Practice*, 9(3), 136-141.

Handley, Z. (2009). Is text-to-speech synthesis ready for use in computer-assisted language learning? *Speech Communication*, 51(10), 906–919.

Higgins, E., & Raskind, M. (1997). The compensatory effectiveness of optical character recognition/speech synthesis on reading comprehension of post-secondary students with learning disabilities. *Learning Disabilities: A Multidisciplinary Journal*, 8, 75-87.

Ivey, G., & Baker, M. (2004). Phonics instruction for older students? Just say no. *Educational Leadership*. 3, 35-39.

Jonassen, D. H., Peck K. L. & Wilson S. G. (1999). *Learning with Technology*. Englewood Cliffs, NJ.: Merrill/Prentice Hall.

Kamii, C. & Manninga, M. (2002). Phonemic awareness and beginning reading and writing. *Research in Childhood Education*, 17(1), 38-46.

Kirby, J. R., Parrila, R. K., & Pfeiffer, S. L. (2003). Naming speed and phonological awareness as predictors of reading development. *Educational Psychology*, 95(3), 453-464.

Lee, R. (2006). Effective learning outcomes of ESL elementary and secondary school students utilizing educational technology infused with constructivist pedagogy. *International Journal of Instructional Media*, 33(1), 87-93.

Lu, C., Chang M., Kinshuk, Huang E., & Chen C. W. (2014). Context-aware mobile Role Playing Game for learning--a case of Canada and Taiwan. *Educational Technology & Society*, 17(2), 101-114.

McGlothlin, J. D. (1997). A child's first steps in language learning. *The Internet TESL Journal*, 3(10). Available from http://www.aitech.ac.jp/~iteslj/Articles/McGlothlin-ChildLearn.html.

Mills. G. E. (2000). *Action Research: A Guide for the Teacher Researcher*. N.J.: Upper Saddle River.

Olson, R. K., & Wise, B. W. (1992). Reading on the computer with orthographic and speech feedback. *Reading and Writing: An Interdisciplinary Journal*, 4, 107-144.

Pacheco, M. B. (2013). Putting two and two together: middle school students' morphological problem-solving strategies for unknown words. *Adolescent & Adult Literacy*, 56(7), 541-553.

Shany, M. T., & Biemiller, A. (1995). Assisted reading practice: Effects on performance for poor readers in Grade 3 and 4. *Reading Research Quarterly*, 30(3), 382-395.

Stanovich, K. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly*, 21, 360-406.

Suh, S., Kim, S.W. & Kim, N.J. (2010). Effectiveness of MMORPG-based instruction in elementary English education in Korea. *Educational Technology & Society*, 13(3), 224-232.

Van der Leij, A. (1981). Remediation of reading-disabled children by presenting text simultaneously to eye and ear. *Bulletin of the Orton Society*, 31. 229-243.

Warschauer, M. & Healey. D. (1998). Computers and language learning: An overview. *Language Teaching*, 31, 55-71.

Wise, B.W., Ring, J. & Olson, R.K. (2000). Individual differences in gains from computer assisted remedial reading. *Journal of Experimental Child Psychology*, 77, 197-235.

Yamagishi, J., Nose, T., Zen, H., Ling, Z. H., Toda, T., Tokuda, K., King, S., & Renals, S., (2009). Robust Speaker-Adaptive HMM-Based Text-to-Speech Synthesis, Audio, Speech, and Language Processing, IEEE Transactions on, 17(6), 1208-1230.

Yang, Y. T. C. & Wu, W. C. I. (2012). Digital storytelling for enhancing student academic achievement, critical thinking, and learning motivation: A year-long experimental study. *Computers and Education*, 59(2), 339–352.

Zhu, S-G. (2005). Speech synthesize note. Available from http://irw.ncut.edu.tw/peterju/speech.html#categories.

**Appendix 1. Word Table**

| | | | |
|---|---|---|---|
| Wednesday | Saturday | Thursday | sentence |
| problem | character | beginning | commotion |
| data | classroom | sandwich | estimate |
| resource | subtract | range | boil |
| tally mark | temperature | arrive | calendar |
| difference | environment | across | tortoise |
| sunlight | culture | bakery | early |
| oven | ingredient | dough | customer |
| instead | recipe | hair | |

**Appendix 2. Interview Questions:**

1. What do you think about the Spelling Bee software?
2. Does the Spelling Bee software help your pronunciation?
3. How do you memorize English vocabulary?
4. What would you do if you have some problem with vocabularies?
5. Is the spelling bee test easier with the help of the Spelling Bee software?