# Dual-Coding Strategy for the Chinese Characters Learners: Chinese PCS Editor

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**Abstract.** This paper aims at developing a Chinese PCS Editing Processor with Picture Communication Symbols (PCS), Chinese Text-to-Speech Engine and recording engine to improve Chinese characters learners and learning environment for the children of elementary school. The design of Chinese PCS Editing Processor could reduce the complexity of making PCS teaching materials and time for the elementary school teachers and parents. This assistive technology design may have a range of convenient and efficient functions to support the children throughout learning process.

**Keywords:** Computer assisted language learning · Picture communication symbols · Chinese PCS editor · Dual coding theory

## 1 Introduction

Word identification is the essential skill to the process of reading [1]. The whole reading process involves two separate but highly interrelated areas - word identification and comprehension [2, 6, 8]. It requires readers familiar with letters of the alphabet and phonemic awareness. If a reader has difficulties in automatic word recognition significantly, that will affect the reader's ability to effectively comprehend what they are reading [7, 14]. Development of phonemic awareness is necessary to learn how to map speech to print. However written Chinese is a logographic orthography that differs greatly from alphabetic writing systems. The orthography–phonology relationship in alphabetic scripts is transparent. It is even harder for the text decoding difficulty readers to develop Chinese phonological ability.

The dual coding theory referred to the idea that visual and verbal information are processed differently and along distinct channels in the human mind, creating separate representations for information processed in each channel [11]. The mental codes corresponding to these representations are used to organize incoming information that can be acted upon, stored, and retrieved for subsequent use. Both visual and verbal codes can


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be used when recalling information [13]. Readers can facilitate two codes each due to the different sensory experiences from which they originated to read. Reading materials can also be presented in some other forms associated with texts to increase the efficiency of readers' recall and retention [3, 4, 10, 12]. Picture Communication Symbols (PCS) are a set of colour and black & white drawings which are easy to learn by children with little or no speech [5, 9].

With the development of digital technology, better texts in alternative picture and vocal environment can be created for children with the opportunities of multi-sensory interactions. In this paper, the Chinese PCS Editor was designed to provide children with Chinese picture-based sentence construction environment. The children's Chinese characters learning efficiency can be increased through the scaffolding process in the development of language abilities.

## 2 System Architecture

Based on Microsoft platform, the design of Chinese PCS Editor integrates PCS database developed by Unlimiter for use in augmentative and alternative communication (AAC) system [15], IBM ViaVoice Chinese Text-To-Speech Engine and Microsoft sound recorder (Fig. 1).

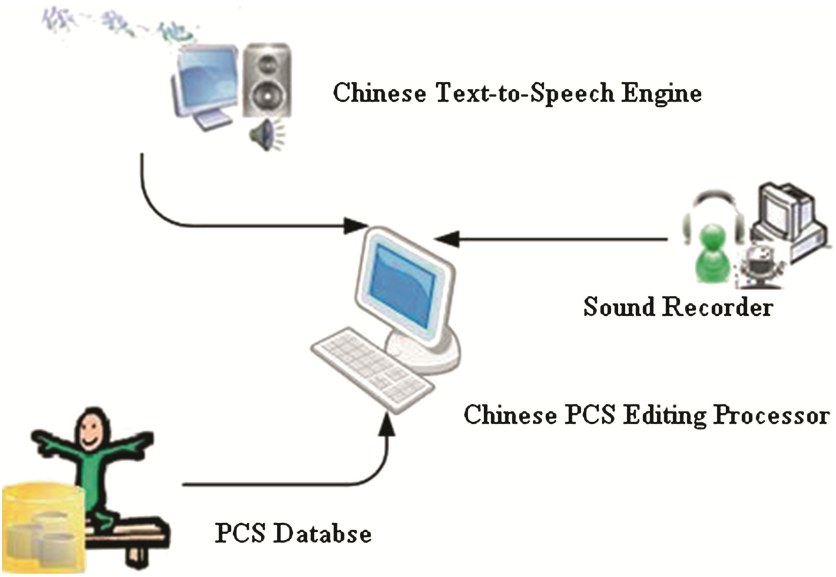


**Fig. 1.** System architecture

Usually children have developed their own picture and vocal vocabularies before they learn to identify word vocabularies. PCS database consisting of a core library of more than 3,000 symbols provides users for developing their own PCS starting from zero for certain needs to the Chinese characters with limited word identification

capabilities. Chinese Text-to-Speech Engine converting Mandarin text into speech allows users to use their computer to identify the Chinese characters verbally. Sound recorder can be helpful to users as a memory aid and as an alternative to writing.

## 3 User Interface

The Chinese PCS Editing Processor consists of PCS Producer and PCS Editing Board (Fig. 2).

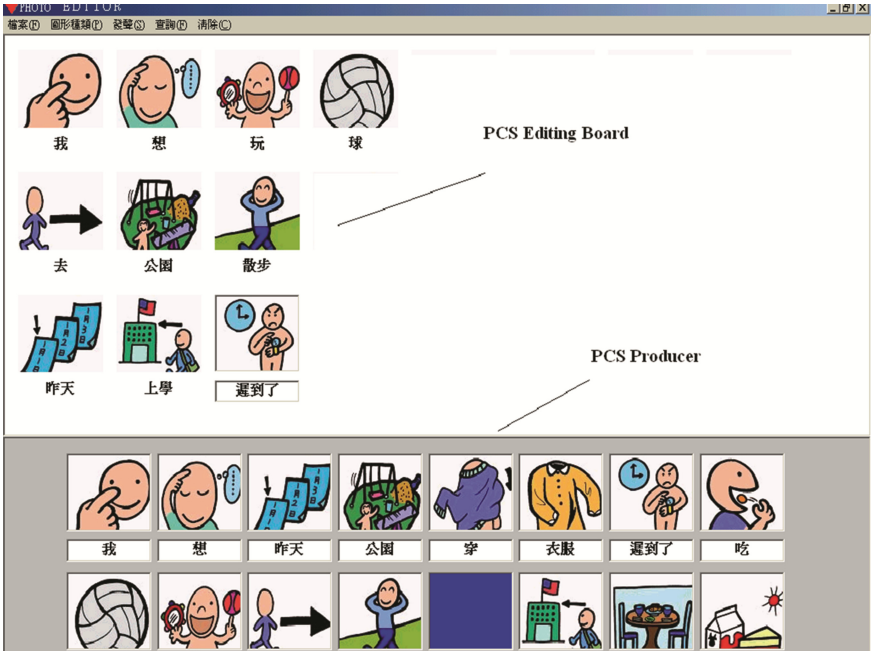


**Fig. 2.** Chinese PCS editor

The setting of PCS Producer includes the number of input PCS plates and the specified PCS setup. The choices of input PCS plates are divided into 2, 4, 6, 8 or 16. Users could manipulate the "Query" function provided on the function bar of Chinese PCS Editor to setup the specified PCS into one PCS plate (Fig. 3). For the unavailable PCS in the PCS database, users could either input the text directly or add picture/photograph by themselves for the PCS Editing Board further use.

PCS Editing Board is where the users write the sentences by dragging the target PCS from the PCS Producer. The Chinese PCS Editor could save and open the PCS sentences for users for later use and practice (Fig. 4).

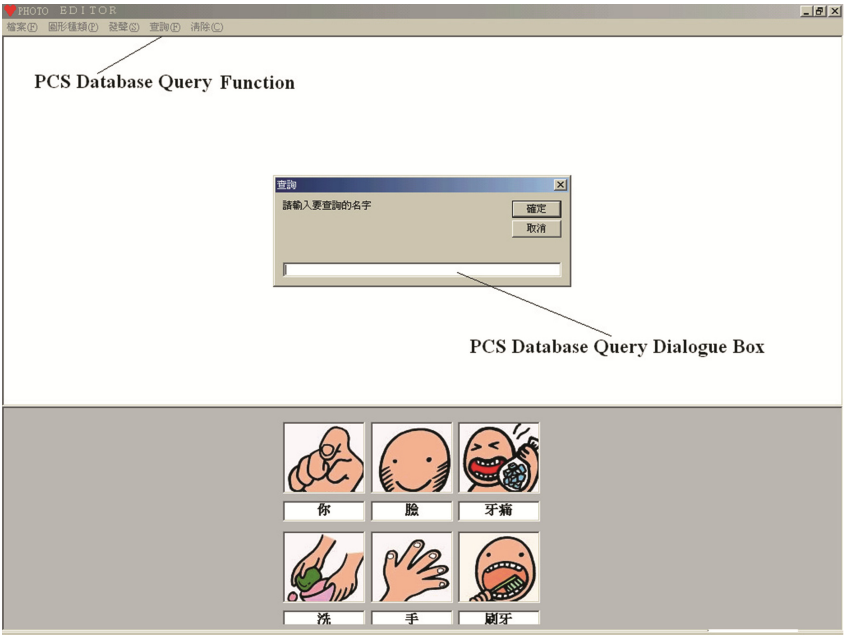


**Fig. 3.** PCS database query

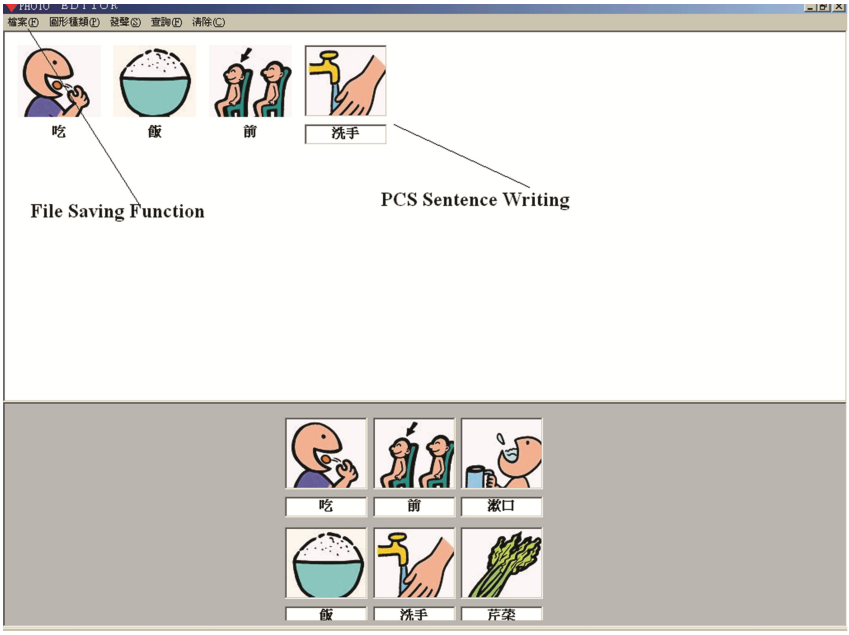


**Fig. 4.** Teaching materials making

As the output of speech is automatically produced by the Chinese Text-to-Speech Engine, users could repeatedly select a PCS word or PCS sentences to listen. At the same time, users could also express themselves through the PCS writings with the spoken out from the Chinese Text-to-Speech Engine. Any PCS dragged to the PCS Editing Board would be read out immediately to impress the users for learning purpose.

For any PCS in the PCS plate of PCS Producer, users could alter relative PCS words from the PCS database by clicking the right button of mouse, such as replacing "ball" with "basketball" (Fig. 5).

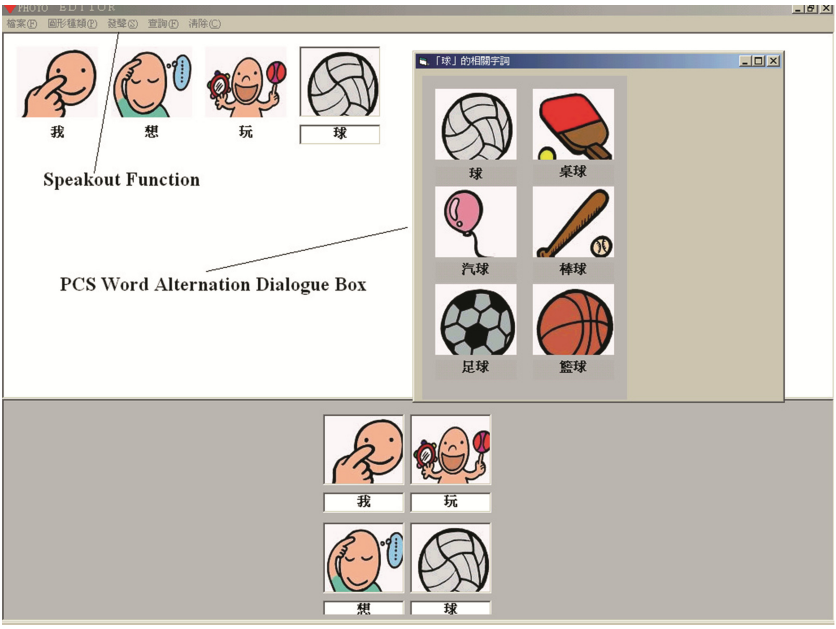


**Fig. 5.** PCS word alternations

In brief, Chinese PCS Editor works as a Word Processor with PCSs instead of words. And it is totally a software solution for the assisted Chinese character learning. Users could manipulate it easily in short time and make learning efficiently.

## 4 Benefits Evaluation

This Chinese PCS Editor was designed as a support for children in the learning process of Chinese characters at one elementary school in Taipei. The posttest scores ($M = .56$, $SD = .19$) were significantly greater than pretest scores ($M = .39$, $SD = .20$), $F(1, 93) = 87.73$, $p < .001$. Although there was no overall significant effect of tutoring conditions on posttest scores, learning with Chinese PCS Editor produced significant word identification and reading comprehension.

## 5 Conclusion

There are three anticipated effects from the completion of Chinese PCS Editor for children in the learning process of Chinese characters as the follows:

1. Encouraging the special education professionals and speech language pathologists developing digitalized PCS training materials. The operational interfaces of Chinese PCS Editing Processor are simplified to reduce the learning curve for the expertise users.
2. Providing easier use of learning environment. As using Chinese PCS Editor, the additional connected hardware is no more needed in comparison with traditional PCS drawing board.
3. Developing the potential of children with communication disorders for writing with symbols. The PCS editing function of Chinese PCS Editing Processor would facilitate children in the cognitive process of words, phrases, sentences and paragraph.

The Chinese PCS Editor for children with Chinese character identification difficulty tries to scaffold the unfamiliar texts from their pre-established picture and vocal vocabularies. While decoding the actual Chinese words, children could focus their attention on what the text actually means. With the eased burden of decoding, children are free to think about and gain. Children can thus derive more benefit from reading activities. Children will have greater opportunities for independence than ever before with such design. The design of Chinese PCS Editor could reduce the complexity of making PCS teaching materials and time for the special education educators, rehabilitation specialist/therapist and parents of communication disorders.

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