

Applying Augmented Reality to Chinese Radicals Learning: A Remedial Teaching Experiment in an Elementary School

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Abstract—In the regions of Chinese as the first language, children with backward Chinese characters ability are more likely to give up reading the subject content of long texts, which affects their learning in the long term. This study applies augmented reality (AR) to develop a remedial teaching model for Chinese radical recognition and assesses its effectiveness on underachieved students at an elementary school. Based on several Chinese characters that were easy for children to confuse radicals, an AR app for Android was developed and installed in tablet computers. The remedial teaching model involves students to use AR app to scan radical cards and trigger animations introducing the evolution of radicals. Students can practice Chinese character writing on the tablet computer's screen. With the multiple stimulus of AR, the teacher lead students collaboratively complete the worksheets. To assess students' learning outcomes, a quasi-experimental approach was administrated to 8 second grade students who had backward Chinese literacy, in which qualitative and quantitative data were collected. Results showed this remedial teaching model improved the disadvantaged students' recognition accuracy on Chinese characters and flips their motivation toward Chinese characters learning. During the remedial teaching program, use of AR was effective to get students more attentions and impressions on Chinese radicals. Finally, Implications for Chinese characters teaching practices are discussed.

Keywords—remedial teaching, augmented reality, Chinese radicals

1 Introduction

Chinese as a second language is increasingly popular but it is often difficult for beginners. A Chinese character has its grapheme, meanings, and pronunciations. The grapheme is composed of radical (Chinese: 部首) and part (Chinese: 部件). In Chinese, radicals are functioned as the classifications of graphemes. A radical can be incorporated

with different parts to form various characters. The complexity of Chinese characters caused students facing learning difficulty in mastering the Chinese characters recognition and writing skills [1].

When teaching Chinese characters, majority of teachers were used to introducing their writings, meanings, and pronunciations instead of radicals, even sometimes just asking students to memorize characters [2, 3]. Lack of recognition of radicals, students are often confused Chinese characters with similar radicals. For example, Chinese characters with radical 虫 (bug) are related to insects or animals. If students understand the meaning of radical 虫, they are able to differentiate the meanings of related characters such as 蛙 (frog) and 哇 (wow), despite these two have the same part 圭. Incorporating the radical 虫 with different parts can be extended to related characters such as 蚊 (mosquito), 蜂 (bee), and 蛇 (snake), by this way students are easily remembering Chinese characters derived from the same radical.

In Taiwan, students start to learn Chinese characters from elementary schools. In general, students learn Chinese radicals by rote in early grades. Early graders have only learned a small number of Chinese characters because it's not easy to remember the radical of each character they learned. As more Chinese characters have learned, students are likely confused by the same radical appeared in different characters [4]. Except for different level of Chinese literacy, the early graders have common behavioral problems in class such as self-distraction and interfering with teacher activities or classmates [5]. Students with difficulties in radical recognition or character writing gradually often reduce their motivation to learn Chinese. Lack of proficiency in Chinese, students may be frustrated with reading comprehension and have difficulties in learning other subjects. Therefore, how to improve students' proficiency in Chinese radicals is a key issue to elementary education in Taiwan.

In recent years, integrating multimedia, ranging from animation, virtual reality, to augmented reality, into Chinese learning has been widely discussed, not only for foreign novices [6] but also for native speakers [7]–[9]. Augmented reality (AR) refers to the computer-generated objects that help enhance the real-life environment in several creative ways. There are many mobile AR applications available for entertainment, navigation, education, medical, and other fields [10]. A review of past studies indicated that use of pedagogical mobile AR in school results in successful learning outcomes [11]. Applying AR technology to assist students to recognize Chinese radicals can be an innovative learning approach, in particular for slow learners. This study aims to incorporate AR into a remedial teaching model for assisting underachieved students to recognize Chinese radicals then testing this model in an elementary school.

2 Literature review

2.1 Theoretical perspectives for Chinese learning

Acquisition of Chinese characters is the fundamental to Chinese literacy development [12]. According to Piaget's (1952, as cited in [13]) learning theory, confrontation allows students to perform assimilation and accommodation. To help students learn Chinese efficiently, [14] suggests that teachers systematically guide students to

understand rules of radicals, parts, and derivatives. [15] suggests that simultaneously introduces pronunciation and character and is based on the key principles of constructivist learning theory had beneficial effects on the students in terms of motivation and quality of knowledge of Chinese vocabulary.

A review of researches on Chinese characters [16]–[18] teaching for elementary school students in Taiwan reveals the following trends:

- 1) When students had problems with learning Chinese characters, teachers used radical-derived learning strategies to assist students.
- 2) Limited by the number of samples, most studies adopted action studies or case studies, and a few used quasi-experimental design methods.
- 3) Most studies concluded that radical learning approach improved students' recognition of Chinese characters and reinforced their motivation to learn Chinese characters.

With unknown how such radical-derived learning approach can assist lower grade students with weak Chinese literacy

2.2 AR application for learning Chinese character

Augmented reality can be used as an alternative learning media especially for school children in their learning process. Past studies took AR advantages to develop Chinese learning applications for children who have special needs. In Taiwan, for examples, [19] developed a mobile AR software specifically for elementary school students who had attention deficit hyperactivity disorder (ADHD) or dyslexia to learn Chinese characters, it helped students to make progress in characters pronunciation, writing words, and choosing characters to fill in a sentence. [20] developed an AR film for demonstrating strokes and orders of Chinese characters, students were able to practice characters writing by watching the AR film. The above researches showed that teaching Chinese characters with AR can improve Chinese characters learning for elementary students with learning disabilities, also teachers can design learning materials with AR for students with different Chinese literacy levels. [21] developed a digital material of Chinese Mandarin Phonetic Symbols (also called Zhuyin) with AR for the teachers in lower grades of elementary school, a test by eight teachers suggested that user was satisfied with this digital material's content, multimedia, and interface.

Based on the above results, if teachers incorporate AR applications into remedial teaching strategies to assist backward students during the remedial teaching program, students use AR to understand radicals in Chinese characters instead of relying on memorization, it could flip their Chinese radicals learning.

2.3 Remedial teaching strategies for Chinese slow learners

Remedial teaching is identifying slow learners and providing them with the necessary help and guidance to help them overcome their problems, after identifying their areas of difficulty [22]. The remedial teaching involves series activities of diagnosis, reinforcement, and evaluation, to improve student's achievement. Ministry of Education in

Taiwan has promoted remedial teaching programs in elementary and secondary schools since 2011, using a standardized assessment system to screen out students who are encouraged to participate intensive support courses after school [23].

There are various remedial teaching modes for different subjects, such as resource program, learning station, learning lab, learning package, and computer-assisted instruction, the common strategies include direct teaching, mastery teaching, individualized instruction, and cooperative learning [18]. The contextual analysis enables teachers and students to achieve equilibration in teaching, and peer interaction emphasized by clinical teaching requires this as a theoretical basis to improve teaching effectiveness. Previous studies on effects of Chinese characters remedial teaching showed that animation was comparable to writing and more effective than reading in facilitating characters recognition [24], students achieved peer-level character recognition and dictation abilities with reading remediation materials [25]; and Chinese as a foreign language learners' ability to write Chinese characters was improved when they received Chinese character handwriting diagnosis and remedial instruction [26]. However, the effects of remedial teaching with AR on learners' motivation to learn Chinese characters is unknown.

3 Research method

The subjects were the second graders at an elementary school in Taipei City who did not pass the Chinese Language Literacy Test. There were eight students participated in the remedial teaching program for 5 weeks (initially for 10 weeks, due to COVID-19 breakout). Participants attended one after school class of remedial teaching weekly, after they received a diagnosis test. A remedial teaching model was developed specifically for Chinese radicals learning, including learning units, pedagogies, and assessment, based on the principles suggested by [27]. A set of Chinese characters with common confusing radicals to the second graders were selected. An AR app for recognition of Chinese radicals was developed with Vuforia engine in Unity, based on an AR framework suggested by [28]. Vuforia Engine is a software development kit for creating AR apps. When operating the AR app to scan a Chinese character card with the mobile device's camera, an animation corresponding to that character's radical is shown on the screen. After students watch animation, the teacher leaded students to fill in characters derived from a radical and extend each character to words on worksheet. All students received a test of Chinese radicals at the end of each class.

This study used a quasi-experimental design approach to compare students' recognition rate and learning motivation of Chinese radical before and after the remedial teaching program and triangulated with qualitative data. The assessment tools include radical tests and the Chinese Character Learning Motivation Scale, plus qualitative data including interviews with students, classroom observation feedbacks from peers, and teaching reflection notes.

4 Results

Eight students and their parents consented to participate in the remedial teaching program. According to the diagnosis test, participants' learning weaknesses included distraction in class, low learning motivation, low self-confidence, impatience, slow writing speed, insufficient practices, and one had attention deficit hyperactivity disorder (ADHD).

4.1 Remedial teaching strategies for Chinese slow learners

A remedial teaching model was implemented to eight second grade students with weak Chinese radical recognition. This model consists of the following steps:

- 1) Preparation: Chinese character cards, tablet PCs, and worksheets.
- 2) Activities: Students operate tablet PC to scan a Chinese character card, watch the radical animation displayed on the AR App, and practice writing the radical on the tablet PC (as shown in Figure 1). The teacher asks the students the meaning of the radical and assists students to complete the derivatives from that radical on worksheet, as an example shown in Figure 2.
- 3) Integration: The teacher summarizes the content of unit then students receive a test of Chinese radicals.

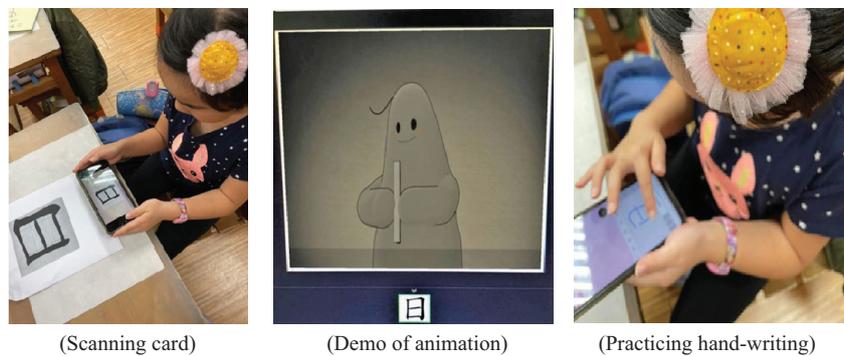


Fig. 1. Learning a Chinese radical '日(sun)' with AR app

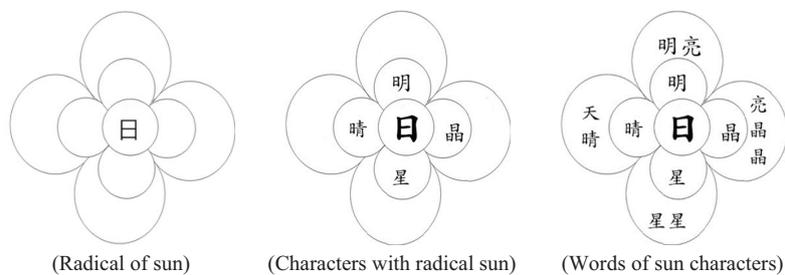


Fig. 2. An example of derivatives and words from a radical on a worksheet

4.2 The remedial teaching model

A paired sample t-test approach was used to compare the difference on pre-test and post-test of Learning Motivation Scale. Result showed $t(7) = 20.344$ ($p < .001$) at a significant level. It indicated that students' learning motivation with Chinese radicals has been improved after they received the remediations.

Using a paired sample t-test to compare the scores of Chinese radical tests, results showed that the average score of pretests was 43.7 (standard deviation = 0.23), the average score of post-tests was 85 (standard deviation = 0.93), $t(7) = 7.51$ ($p < .001$) at a significant level, and the average score of post-tests was nearly double pre-tests. It indicated that students' recognition of Chinese radicals was improved after the remedial teaching program.

4.3 Analysis of qualitative data

Interviews with students. Most students had a high degree of acceptance of using the AR app for Chinese radicals learning and had a positive attitude towards this remedial teaching model. It is plausible that students can control their own learning pace with the AR app on tablet PC and complete worksheets. Therefore, this remedial teaching is easier to attract students in class and to motivate their learning on Chinese radicals.

"It's good! It's much more fun than normal classes." (Student Interview-01)

"I like to use this method to teach classes, because I can do it myself, so I don't feel bored." (Student Interview-02)

"After watching the animation, you can write radicals on the tablet, which is very interesting." (Student Interview-04)

"My memory is not good. I have forgotten a lot of the characters I learned before... Now the teacher teaches like this way, I am easy to get it." (Student Interview-05)

"I want to join this program again! Only our class is the most special." (Student Interview-08)

Teaching reflection. Teachers faced new problems in every class, such as students did not operate the tablet PC smoothly, the volume of animation was too loud, should students wear headphones, and students wanted more time to operate the AR app. However, these problems as learning enhancements were useful to motivate students. To complete the worksheets, students actively provide derivatives from a radical, while timely oral encouragement from the teacher was critical to students.

"The common weakness of 8 students are: easy to be distracted in class, long-term low achievements cause low self-confidence...attracting students to focus could be a big challenge. The first time to use AR, I was in a hurry. Fortunately, with the help of teachers who observed in the classroom, this situation should be better next time." (Teacher reflection-02)

“The progress of the worksheet was a bit rushed, and it was too late to make a summary before the test. ...the students answered very seriously, which was quite rewarding!” (Teacher reflection-04)

“Student A suddenly spaced out when he was writing a test paper today. I walked over and asked him the reason. He said he had forgotten what’s the answer, but he didn’t answer other questions. ...After my verbal encouragement, he continued to go through it...” (Teacher reflection-07)

“Today, 6 students completed the test early and there were no blanks in the questions. After handing in the papers, they took the cards and tablet back to their seats and play AR... It seems that the early graders need reinforcements to improve their learning motivation.” (Teacher reflection-12)

Classroom observation. Concentration is a problem to early graders. When everyone got a tablet computer, how to keep students’ focus on the class became a challenge to remedial teaching. To solve this problem, the teacher often asked students for attentions, such as ‘open eyes’ or ‘look at me’. The classes only proceeded for 5 units, halfway of teaching experiment, because of COVID-19 outbreak. The rest units would schedule students to practice sentences according to the Chinese characters they learned.

“On the first day of class today, it was obvious that the children were very excited. Although they answered loudly to the teacher, their eyes always fixed on the tablet computers. I wonder students really listened to teacher. After they got tablet computers, there were a lot of problems, and the teacher was a little too busy.” (Classroom observation feedback-01)

“The classes went smoothly, Unfortunately, the following ones are suspended due to the epidemic. However, if sentences can be extended from the Chinese characters in worksheets, it will be more complete.” (Classroom observation feedback-05)

Triangulation and limitation. To confirm the effectiveness of remedial teaching, this study collected multiple data sources about the students’ learning during the teaching experiment, including motivation scale, student interviews, classroom observation feedback, and reflection notes. Analysis of quantitative and qualitative data showed students’ evident improvements in recognition of Chinese radicals and characters. However, a limitation is that findings are only applicable to early graders in this elementary school. Subjects in this study were underachieved in Chinese tests at that time but they voluntarily attended the remedial program.

5 Conclusion

Remedial teaching is assigned to assist students in order to improve their academic competencies such as literacy. This study develops a remedial teaching model for Chinese radicals that incorporates an AR app into mastery learning and direct teaching

strategies. As suggested by [29], apps designed to promote active, engaged, meaningful, and socially interactive learning within the context of a supported learning goal are considered educational. The AR app developed in this project was compiled with the above four pillars of learning and successfully integrated into the proposed remedial teaching model for linguistically underachieved children.

Eight second-grade students with backward Chinese levels at an elementary school received the remedial teaching experiment, in which quantitative and qualitative data were collected. According to the results of the semi-experiment, this study concludes that: (1) the AR app flips children to active learners and enables improved Chinese radicals learning.; (2) participants have more concentration and deeper impression on class when using the AR app; (3) the proposed remedial teaching model improves participants' recognition of Chinese radicals; (4) the proposed remedial teaching model enhances participants' learning motivation toward Chinese radicals.

For future directions, as the rapid growth of artificial intelligence, adaptive instructional systems that dynamically adjust to course content and learning paces based on individual needs will play an innovative role in remedial teaching.

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