The Effect of Literacy Learning via Mobile Augmented Reality for the Students with ADHD and Reading Disabilities

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Abstract. This study focuses on the effects of mobile augmented reality (MAR) on word recognition learning. The study developed an interactive effect and corresponding video on word learning in MAR. MAR uses the camera of the mobile phone. It is installed in to interpose virtual objects on the real life view through the camera. The study participants were two fifth-grade elementary school children with Attention Deficit Hyperactivity Disorder (ADHD) and reading disabilities. The study followed a single-case design using ABA' models in which A indicated the baseline, B indicated the intervention and A' indicated the maintenance phrase. The experiment period was almost 3 months. The independent variable was word recognition teaching with MAR on Chinese literacy ability of 'read the words' and 'select the correct the word to blank line'. The experimental results demonstrated that the scores for 2 children with ADHD and reading disabilities increased considerably during the intervention and maintenance phrases. The developmental applications of these results are also discussed.

Keywords: Performance of word recognition · ADHD · Reading disability · Mobile augmented reality

1 Introduction

Recently, multimedia in the interactive learning environment included words, pictures, animation and other innovative digital teaching aids in learning and instruction [1]. Teachers could transfer complete knowledge from multimedia teaching materials for vocabulary practice with struggling students [2]. The integration of real-time interactive multimedia as a support represents a significant improvement in traditional teaching strategies [3]. Augmented reality (AR), as an emerging interactive technology, has been applied to various fields [4]. AR technology enables the merging of virtual with real objects, resulting in AR environments [5] and can be used for a live direct or indirect view of a physical, real-world environment, the elements of which are augmented by computer-generated sensory inputs, such as animation [6]. The design of a mobile

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augmented reality (MAR) system that using recognized from a large database to track the corresponding content [7]. AR-guide for exhibitions supported between the virtual space and the physical scenes; that is, enhance the interaction between the additional, virtual information and the real exhibits [8].

MAR environments support virtual object overlay of real objects to change users' view of their environment [9]. The main advantages of MAR applications used across different fields have been widely discussed, such as exploring cities [10], education [11], language services [12], language learning [13], management system [14], awareness services [15], textiles, surgical interventions [16], games [17], home-training system, teaching [18] and learning disabilities [19]. MAR can enhance students' learning motivation.

ADHD can be considered a generalized impulsivity disorder and is one of the most prevalent mental health disorders in childhood [20]. Children with ADHD find it difficult to receive visual information and have an attention deficit; their learning abilities are hampered because in the process of receiving information, they are unable to grasp the correct information or receive too much information, which could disrupt their judgment. Studies of the academic achievements of children with ADHD imply that they are more likely to obtain lower grades in standard measures than control children of equivalent intelligence [21]. Students with ADHD experience problems with learning in an academic setting, often encountering difficulties with reading, spelling and writing [22]. Furthermore, they are rated below their peers on behaviours that enable academic success, such as motivation, engagement and study skills [23]. The development of children with attention and learning problems is discussed in both Bach and Pacton [24, 25]. Attention skills improved during action multimedia game training [26], using cognitive assistive technology in settings, indicate a higher frequency of participating in work for ADHD [27]. Assistive Technology is proving to be a critical in ensuring the success of students with learning [28].

Therefore, the MAR design could stimulate children's motivation for the learning process. It has advantages for teaching materials design, because through the free software and open source platform with contents that can be easily duplicated and combined, MAR could be a flexible interface for designing teaching materials for children with reading disabilities. As the platform is free, teachers and parents need not worry about the high price like assistive technology.

2 Materials and Methods

2.1 Participants

There were two participants in this study: twins with ADHD who were compared with regards to reading disabilities. Formal consent was obtained from their parents prior to the commencement of study. This study designed individual vocabulary learning for the special needs of the participants to enhance their learning motivation. We obtained formal consent from their parents for this study designed to enhance the learning motivation and effectiveness.

Participant A, an 11-year 1-month-old male. Wechsler Intelligence Scale for Children-Third Edition (WISC-III), full scale: 93; verbal scale: 99; performance scale: 88; verbal comprehension index (VCI): 101; perceptual organization index (POI): 85; freedom from distractibility index (FDI): 79; processing speed index (PSI): 106.

Participant B, an 11-year 1-month-old male. Wechsler Intelligence Scale for Children-Third Edition (WISC-III), full scale: 100; verbal scale: 102; performance scale: 98; verbal comprehension index (VCI): 105; perceptual organization index (POI): 104; freedom from distractibility index (FDI): 79; processing speed index (PSI): 103.

The twin brothers, in addition to their diagnoses of ADHD and reading disabilities, lagged behind their peers in class in terms of academic performance; literacy words amount is poor; difficulty in recognizing and reading words; inability to write the words that were taught and using more or fewer strokes in words' structure. Overall, their short-term memory was good, but their long-term memory not as well as short-term memory.

2.2 Apparatus, Material and Setting

Teaching content included six units, a total of 60 target words via mobile phone with AR as the teaching process. According to the results of the evaluation assessment from the two participants, the level of basic literacy was 1300–1400, and this study used 60 target words from the sequence 1401–1500 of the 'Elementary School Children Common Words Report'. These 60 words could nor adopted in the textbooks, via the amount of the word's strokes, and Average distribution in different unit, also excluded the words appear in the textbook, the word stokes, as Table 1, and design the digital content via MAR.

The three subtests in the Mandarin Literacy Assessment included 'read the words', 'write the words' and 'fill the selected word in the sentence'. Each subtest selected three words from ten target words, randomly selected from six teaching units, for a total of 18 questions. In total, Mandarin Literacy Assessment includes 54 questions, establishing equivalence copies to avoid repeating the practice effect. Two special education teachers, with 12 and 15 years of experience, reviewed and revised each assessment.

The free Aurasma© application is available on both iOS and Android. Once installed, any user with a 3G or WiFi connection can use the app via a smart phone or tablet for free. Two teachers and two assistants conducted this study; they designed the word flash cards and arranged the corresponding Aurasma video, via the platform function, to combine flash card and corresponding film. The participant could then use a mobile phone to scan the image and create videos, animations or data.

The study contents include teaching literacy programs and teaching assistive technology. The participant used the Aurasma application on a mobile phone to scan the flash card, then will show the relative film, the screen show process as Fig. 1, in the teaching process, the teacher also offer paper work for real write the word to increase the memory the words. The concept of the study is shown in Fig. 1.

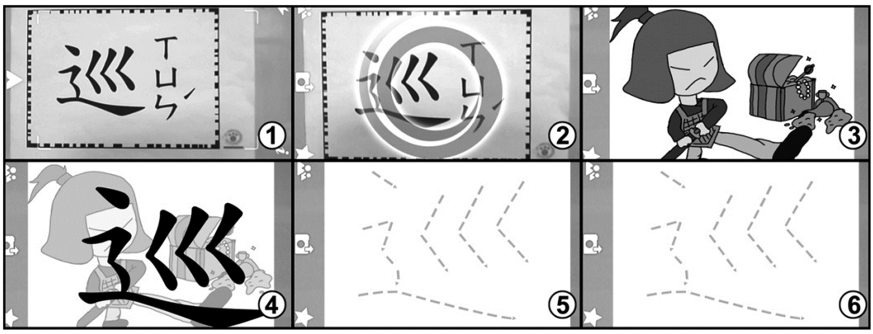

Fig. 1. The MAR concept of the study

2.3 General Procedure

The Aurasma© application is available on both iOS and Android. The user environment should provide 3G or WiFi connection via a smart phone, following the free channel with the content designed by the teachers' team. The study used Android and WiFi. Before the experiment, the teacher should explain how to participate in the process and demonstrate the same for the participants. Figure 2. shows the experimental setup.

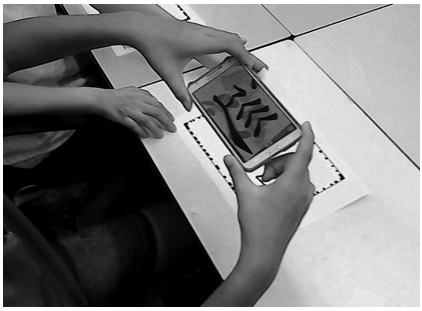

Fig. 2. The experimental device and setup

To control the participants' mood in different situations, this study selected a resource classroom used for normal activities. Teaching experimental period: baseline phrase during 6−24 October 2014; intervention phrase during 27 October−5 December 2014; maintenance phrase 15 December 2014−2 January 2015. To avoid potential interference from other students and ensure the study produces the appropriate effects, this study was separately handled. The teaching process was adopted in one-on-one session to control other factors.

The experimental design adopted an ABA for single-case research as the assessment method, in which A (baseline phase) was followed by B (intervention phase), and then followed the maintenance phase. The A represented baseline phases while the B represented intervention phases with the MAR system. Single-case design is a research

method involving deliberate assignment of different conditions to the same individual and measurement of one or more outcomes over time (Hedges). Cohen offered an effect size for predictive regression equations that could indicate the actual effect including a large (> 0.35), medium (0.15−0.35) or small effect size (0.02−0.15).

The data was collected over 3 months. In the first phase, Baseline 1 (baseline phase) —Conduct 'Mandarin Literacy Assessment' Quiz—we collected three data points. The second phase, Intervention (B1), used a mobile phone, the augmented system and the relative teaching materials, for a six-week teaching intervention. There were a total of six teaching units, three lessons a week—a total of 120 min in each week. After the end of each unit, a Mandarin Literacy Assessment was conducted as an immediate assessment of the effectiveness of data collection, from which we collected six data points. We waited for one week and then, executed the maintenance phase, from which we collected three data points; this phrase used similar teaching materials, and a Mandarin Literacy Assessment was conducted.

3 Results

The results of this study included both a descriptive and qualitative analysis of the data. The data collected from all three phases were presented on graphs, in which the x-axis indicated the three phases of the study, and the y-axis showed the scores that the participant received for each task. This study investigated the effect of literacy learning via MAR for ADHD compare attention deficit, divided into three parts.

3.1 The Effectiveness of the Subtest of "Read the Words"

Figure 3 shows the effectiveness of the subtest of 'read the words'. Participant A is denoted with a square and participant B is denoted with a circle.

At baseline, participant A's mean score is 1.67, with a range of 1−2; participant B's mean score is 2.33, with a range of 2−3. The results of baseline indicated that participant A lacked the effectiveness of the subtest of 'read the words'. When the experiment proceeded to intervention stage, participant A's mean score was 10.67, with a range of 6–16; participant B's mean score was 8.83, with a range of 5−14—a completely different phrase. In maintenance stage, the intervention was withdrawn; participant A's mean score was 14.67, with a range of 14−15; participant B's mean score was 12.67, with a range of 12−13. From this single-subject research using an ABA structure, the effect analysis of participant A in baseline and intervention was xt's $p = .008 < .05$, with a slope *change* effect size of 3.5897. The effect analysis of participant B in baseline and intervention was xt's $p = .008 < .05$, with a slope *change* effect size of 2.6211. For baseline and maintenance phases of participant A, the xt's $p = .520 > .05$ and an intercept *change* effect size = 47.4923. For baseline and maintenance phases of participant B, the xt's $p = .520 > .05$ and an intercept *change* effect size = 38.8769. The maintenance phase showed a significantly increased effect compared with the baseline phase. A large effect can be seen between the maintenance and baseline phases. The maintenance phase showed a significantly increased effect compared with the baseline phase. From the data

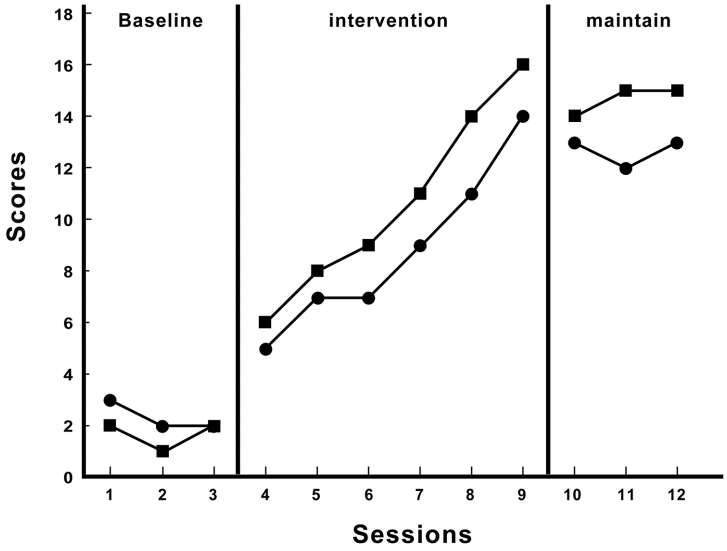

Fig. 3. The effectiveness of the subtest of 'read the words'

analysis, it was demonstrated that the intervention and maintenance phrases had a positive effect on participant A and participant B. We also used the Kolmogorov–Smirnov statistical test, the results of which also highlighted the significant improvement between the baseline and intervention phases ($p = .00 < .05$); the results indicated that the improvement between the baseline and intervention was significant.

3.2 The Effectiveness of the Subtest of 'Select the Correct the Word to Blank Line'

Figure 4 shows the effectiveness of the subtest of 'select the correct the word to blank line'. Participant A is depicted with a square and participant B is depicted with a circle.

At baseline, participant A's mean score is 1.67, with a range of 1−2; participant B's mean score is 2.33, with a range of 2−3. The results of baseline indicated that participant A lacked the effectiveness of the subtest of 'select the correct the word to blank line'. When the experiment proceeded to intervention stage, participant A's mean score was 7.83, with a range of 4−10; participant B's mean score was 8.17, with a range of 4−11—a completely different phrase. In maintenance stage, the intervention was withdrawn; participant A's mean score was 7.67, with a range of 7−8; participant B's mean score was 8, with a range of 8−8. From this single-subject research using an ABA structure, the effect analysis of participant A in baseline and intervention was xt's $p = .045 < 0.05$, with a slope change effect size of 1.4058. The effect analysis of participant B in baseline and intervention was xt's $p = .018 < 0.05$, with a slope change effect size of 2.3998. For baseline and maintenance phases of participant A, the xt's $p = .520 > 0.05$ and an intercept effect size = 14.4198. For baseline and maintenance phases of participant B, the xt's $p = .225 > .05$ and an intercept effect size = 33.8800. The maintenance phase showed a significantly increased effect compared with the baseline phase. A large effect

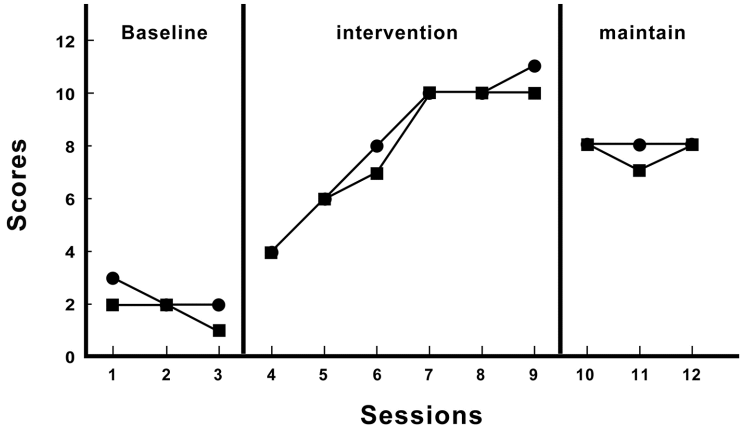

Fig. 4. The effectiveness of the subtest of 'select the correct the word to blank line'

can be seen between the maintenance and baseline phases. The maintenance phase showed a significantly increased effect compared with the baseline phase. From the data analysis, it was demonstrated that the intervention and maintenance phrases had a positive effect on participant A and participant B. We also used the Kolmogorov–Smirnov statistical test, the results of which also highlighted the significant improvement between the baseline and intervention phases ($p = 0.00 < 0.05$); the results indicated that the improvement between the baseline and intervention was significant.

4 Discussion

The two study participants had ADHD compare with reading disabilities. In the study, via MAR teaching materials and mobile phone, there are significant effects observed in the intervention and maintenance phases.

The study by MAR builds a multi-sensory learning environment, via an interactive man–machine, increases the opportunities for participants to operate MAR; attracts their interest and attention and, through visual and auditory feedback, enables participants via different sensory stimulation activities to enhance students' effective absorption of knowledge.

Via MAR and the free applications, this study amounts to an assistive tool that saves time, money, effort and is suitable to promote learning motivation. The target words used in this study are often used in real-life situations; the instructional videos captured daily life combined with the actual situation; it is possible to match the participants' learning level and life experiences; the tool improves understanding of abstract words and then guides participants to apply these words in real environments to maximize the effectiveness of how to teach Chinese words.

In interviews with the participants' tutors, tutor A had 11 years of teaching experience (participant A's tutor), and tutor B had 11 years of teaching experience (participant

B's tutor). Their enthusiasm for teaching indicated that they could clearly grasp the learning situation of the participants.

Tutors A and B, though the MAR teaching materials and teaching process, enhanced the rate of correct responses in read and write words and improved the progress in selecting words in sentences. Tutor A represented participants A's very skilled operation of a mobile phone, and the MAR teaching materials were easy to use, and it enhanced the learning motivation for participant A. Tutor B found participant B lively and happy to participate in a dynamic curriculum. MAR may allow students to have direct operation and thus, increase their motivation of learning process.

Overall, participants who can take visual and auditory cues from colour pictures and dynamic videos, with easy to comprehend literacy content, not only acquire learning outcomes but also enhance their confidence and in particular, use these target words in real-life circumstance. ADHD compare reading disabilities could use multimedia for this learning process, and abundant digital teaching materials could enhance their attention and thereby promote their learning efficiency.

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