



Optimized Design of Chinese Character Cards: An Empirical Study on the Effect of Memory Enhancement Strategies on Children's Working Memory

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Abstract

Designed Chinese character cards demonstrated substantial improvements in memory retention compared to traditional memorization methods, significantly enhancing the memory of Chinese characters for 10-12-year-old children and reducing the error rate in Chinese character writing. The study used a quasi-experimental design based on cognitive psychology, primarily focusing on the Ebbinghaus forgetting curve and spaced repetition techniques. A total of 24 children were involved and separated into two groups: an experimental group that used the optimized Chinese character cards and a control group that used traditional learning methods. The main objective was to evaluate the effectiveness of these optimized Chinese character card tools in reducing the memory error rate in Chinese character learning. Data were collected and analyzed using paired T-tests to compare the effectiveness of the optimized Chinese character cards with traditional methods. Significant findings were revealed, showing that children using the optimized cards exhibited substantial improvements in memory retention and decreased writing errors compared to traditional methods. These results highlighted the impact of integrating scientifically supported memory strategies into educational tools. The study made significant contributions to language education and cognitive development by providing evidence-based insights for educators and curriculum designers, underscoring the importance of adapting educational material designs to cognitive principles to enhance learning efficiency. However, certain limitations were acknowledged, including limited sample size and the controlled nature of the experimental environment. Future research directions were suggested, including expanding the sample size, examining long-term effects, and exploring the broader applicability of these strategies in more diverse and natural educational settings.

Keywords: Chinese character card design, Memory enhancement strategies, Spaced repetition, Chunked memory, Working memory

Introduction

Working memory was a critical cognitive function in children's learning process, especially in language acquisition (Holmes., 2009). Effective memory strategies are critical for improving young learners' cognitive development and academic performance. Due to their unique complexity and large number, Chinese characters are presented as significant challenges in the field of language learning (Chung & Nation, 2003). The complexity of these



characters necessitates innovative approaches for aiding their memory and retention. Traditional methods of teaching Chinese characters, which focus on rote memorization, often overlook effective memory strategies that cater to children's cognitive needs (Swanson & Alloway, 2012). There needs to be more integration but Researcher cognitive memory strategies and the design of teaching materials, especially Chinese character cards, a standard language learning tool. This study aims to bridge this gap by optimizing the design of Chinese character cards and integrating memory enhancement strategies to improve the working memory of children aged 10-12 years (Kuo & Anderson, 2006). This study introduces an approach combining cognitive psychology principles with educational design. The application of the Ebbinghaus forgetting curve model and spaced repetition in the context of Chinese character card was explored, providing a novel solution for enhancing memory retention (Perfetti & Stafura, 2014).

This approach uniquely involves empirical testing of these optimized cards in a controlled environment, assessing their impact on children's working memory. The research questions of this study are as follows: How do the memory enhancement strategies incorporated into the design of Chinese character cards affect children's memory retention? What specific design factors in Chinese character cards can enhance the effectiveness of memory strategies? How do these optimized cards improve memory retention compared to traditional methods? In response, a quasi-experimental design was used to answer Researcher these questions and compare the effectiveness of the optimized cards with traditional methods (Bowers & Bowers, 2017). The study combines empirical testing and analysis to evaluate the impact of design elements on memory retention. Contributions are made to educational psychology and language acquisition by demonstrating the effectiveness of integrating memory strategies into the design of educational materials. Insights are provided into the design of practical learning tools, offering evidence-based recommendations for educators and course designers (Roediger & Butler, 2011). This research enhances the understanding of memory strategies in language learning and sets new standards for designing educational materials that focus on children's cognitive development.

Literature Review

Experts and influential individuals have shown great interest in enhancing memory while learning languages, especially regarding Chinese characters. Current studies are exploring various technologies to improve the effectiveness of learning Chinese characters. Researchers explored various methodologies to examine their impact on short-term and long-term memory. Other significant research areas include how our brains remember and recall Chinese characters, what causes mistakes, and how sound memory works. A study found that spacing out the review of information improves memory retention more than other study methods (Barzagar., Nazari & Ebersbach, 2018). Studies indicate that forgetting curves play a role in aiding children's memory retention. Ebbinghaus was the pioneer in introducing the idea of the forgetting curve, which is a crucial aspect of memory studies. This curve illustrates how memories diminish with



time, emphasizing the importance of children revisiting and reinforcing their learning regularly.

A recent study found a connection between students' capacity to grasp Chinese characters and their overall learning skills and cognitive abilities. Another study highlighted the significance of spaced memory learning techniques. These findings contribute to our understanding of memory processes and the effectiveness of different reinforcement strategies. Additionally, researchers successfully utilized cross-site learning approaches to help students manage their learning in conducive environments. The study demonstrates how helping students with complex subjects such as Chinese characters can be beneficial through effective character connections and techniques. The research concentrated on utilizing personalized software to enhance children's memory of learning Chinese characters and practically assessed memory retention. The aim was to integrate these ideas into learning materials, introduce innovative language teaching techniques, and offer a new point of view. Educators and curriculum developers can receive practical advice by taking an empirical approach. This method focuses on tangible outcomes and was strongly linked to earlier evaluations (Lestari & Pujiastuti., 2022).

Gaps in Argumentation Research

Recent academic studies on memory techniques for learning languages, especially when mastering Chinese characters, have focused on exploring cognitive approaches like spaced repetition, block memory, and the concepts found in Ebbinghaus' forgetting curve. The academic study provided valuable information on various methods to improve memory storage and recall (Cekic et al., 2018). However, a significant limitation in these studies was the need to effectively incorporate memory techniques into learning materials, as seen in the creation of character cards. Most research has mainly looked at theories and psychology, which has taken attention away from the practical implications of creating textbooks (Sarstedt et al., 2016).

The academic focus has mainly been on conceptual memory patterns, especially highlighted by spaced repetition and the ideas outlined in Ebbinghaus' forgetting curve. The study by Çekiç, A., & Bakla, A. (2019). sheds light on how memory was affected by different time intervals. Likewise, the study examines how well-distributed learning methods improve storage skills (Barzagar., Nazari., & Ebersbach., 2018). Furthermore, Franke and Sarstedt's (2019) study explores verbal memory acquisition abilities' psychological and theoretical foundations. Although this research has been significant, it was crucial to examine how these ideas can be used in educational materials, especially when creating word cards for writing. The principal objective of this inquiry was to fortify the theoretical scaffolding by integrating considerations of practical exigencies in educational design and the development of instructional materials. Seibert, Hanson, and Brown (2020) endeavor to dissect the cognitive processes in recognizing Chinese characters.

Nevertheless, their research necessitates further exploration into the pragmatic utilization



of these findings in creating educational resources (Hensel et al., 2015). Historically, numerous preliminary investigations advocated memorization techniques as pedagogical aids, yet this approach was later deemed inherently flawed by researchers. Consequently, the adoption of this novel strategy appears more judicious.

Methodology

Data Collection

Experimental Design

1. The study's objective was to ascertain whether enhancements made to the structure of Chinese characters can potentially augment children's working memory capacity.

2. Experimental Group: Participants were divided into two cohorts. The experimental group utilized enhanced Chinese character cards, whereas the control group employed conventional Chinese character cards.

3. The data collection process entails evaluating children's fundamental memory abilities to establish a baseline for future comparisons and recording pertinent details such as age, gender, and language preference. Each participant engaged in two research endeavors utilizing standard and enhanced role cards, with their performance duration and accuracy documented post-session. The reassessment of memory skills examines the impact of map layout on performance, with both cards offering learning opportunities and feedback for children.

4. Collecting and storing information: Researchers will use structured methods to gather and save data to reduce the chances of data loss, using audio and video recordings to ensure accurate data preservation.

5. The researcher anonymized the research subjects to ensure the confidentiality of all data and prevent unauthorized sharing or disclosure of personal information.

Experiment Execution

1. The researcher decided to take a primary school in Nanchang as the research object and ensure the accuracy of the data collection process.

2. The researchers checked the official identities of the interviewees to confirm their identities and assess their trustworthiness and expertise, as well as to ensure the accuracy and credibility of the study.

3. Researchers consider it essential to obtain feedback on experiments to evaluate their reliability and data accuracy. Researchers use various techniques to increase participant engagement, such as offering incentives or streamlining the process.

Sample Characteristics

This study explored the impact of the configuration of Chinese character cards on the cognitive capacities of children aged 10 to 12. To ensure comprehensive representation, a meticulously chosen participant pool encompassed various ages and genders. The researcher



used this sampling approach to guarantee that the data collected accurately represented the target group and enhanced the study's ability to be applied to a larger population. The study's experimental sample comprised a total of 24 youngsters. The youngsters attending Nanchang Foreign Languages Higher Technical School have their Chinese scores rigorously assessed to ensure their results remain below 85 points. These students had shown a Researcher learning foundation during the learning process, especially in writing Chinese characters. Their error rate was significantly higher than the class average. In addition, they often needed clarification and mistakes in recognizing, writing, and using Chinese characters.

Data verification preprocessing

All necessary data researcher collected and verified, including test results before and after the experiment and basic information about the children. A careful comparison confirms the correctness of the experimental records. The experimental data are consistent with the planned experimental process without any deviation. Outliers, such as unreasonable memory test scores, have been identified and processed. The data cleaning process was completed, and invalid or incomplete records researcher removed, such as data on children who did not complete the test. The data was normalized and standardized to ensure consistency but Researcher data of different magnitudes. In addition, the data of the experimental and control groups researcher unified in format and time points to form a complete data set. Finally, all data had been backed up to prevent data loss, and privacy protection standards researcher strictly adhered to throughout the data handling process.

Data analysis

Analysis method selection

In this study, experimental verification was a critical link, aiming to empirically test the impact of Chinese character cards on working memory. To ensure the accuracy and reliability of the analysis, the T-test was chosen as the primary data analysis method. The T-test was a statistical method used to compare whether there was a significant difference in the means of two data sets. Considering that this experiment aimed to compare the effects of optimized Chinese character cards and traditional cards, the T-test was the best choice. It effectively determined whether there was a statistical difference but Researcher the two groups. This study's data structure and research questions researcher highly consistent with the T-test. The researcher's data researcher continuously independent and came from two different conditions, which met the application conditions of the T-test. The T-test was considered the most suitable due to its simplicity and wide application. Many classic documents have confirmed the reliability and validity of the T-test. For example, Student (1908) first proposed this method. Since then, the T-test has been widely used in various fields and has become a standard method for comparing the means of two sets of data.

Data analysis process



In this experiment, 12 children aged 10-12 researcher selected, comprising six boys and six girls, with Chinese scores all researchers than 85 points. After obtaining consent from their parents or legal guardians, a preliminary assessment of baseline Chinese character memory levels was conducted. The scoring template included a pretest score of 1 point for each correctly memorized or recognized Chinese character and a posttest score, with memory improvement assessed by comparing the two.

During the three-month experiment, the experimental group was taught using specially designed Chinese character cards in a systematic and targeted manner to improve memory efficiency and learning motivation. Meanwhile, the control group continued regular Chinese character learning. After the experiment, the t-test and R software researcher used for the statistical analysis of data to compare the performance of the experimental and control groups in Chinese character memory.

The effectiveness of memory enhancement strategies in improving low-achieving children's Chinese character memory was evaluated by comparing the data from the two groups. It provided essential insights into understanding the application of memory enhancement strategies in Chinese character learning.

Research Result

1 Pre-test and post-test experimental results of the control group

Analyzed Researchers the pre-and post-test scores of the control group.

The control group had a pre-test mean of 48.583 and a standard deviation 15.054. On the post-test, they had a mean of 48.417 and a standard deviation 13.996. Most pupils in the control group did not exhibit a substantial disparity but Researcher their post-test and pre-test results. More precisely, it was noted that the post-test scores of five student's researcher more significant than their pre-test scores, the post-test scores of six student's researcher than their pre-test scores, and one student had identical pre and post-test scores.

The findings researcher analyzed using paired t-tests.

The paired t-test assessed the average disparity but Researcher two measurements from an identical set of observations. Here, it was utilized to compare the pre-and post-test scores of the control group.

The calculated paired difference was 0.167. The t-value was 0.09, and the p-value was 0.93. Statistically significant findings are typically defined as having a p-value less than 0.05 or 0.01. In this study, a p-value greater than 0.05 indicated no statistically significant difference but Researcher the pre and post-test scores of the control group.

It was concluded from the data that for the control group, optimizing the design of Chinese character cards using memory enhancement strategies had not produced significant results in improving children's working memory.



Figure 1. The control group was pre-test and post-test the test site.

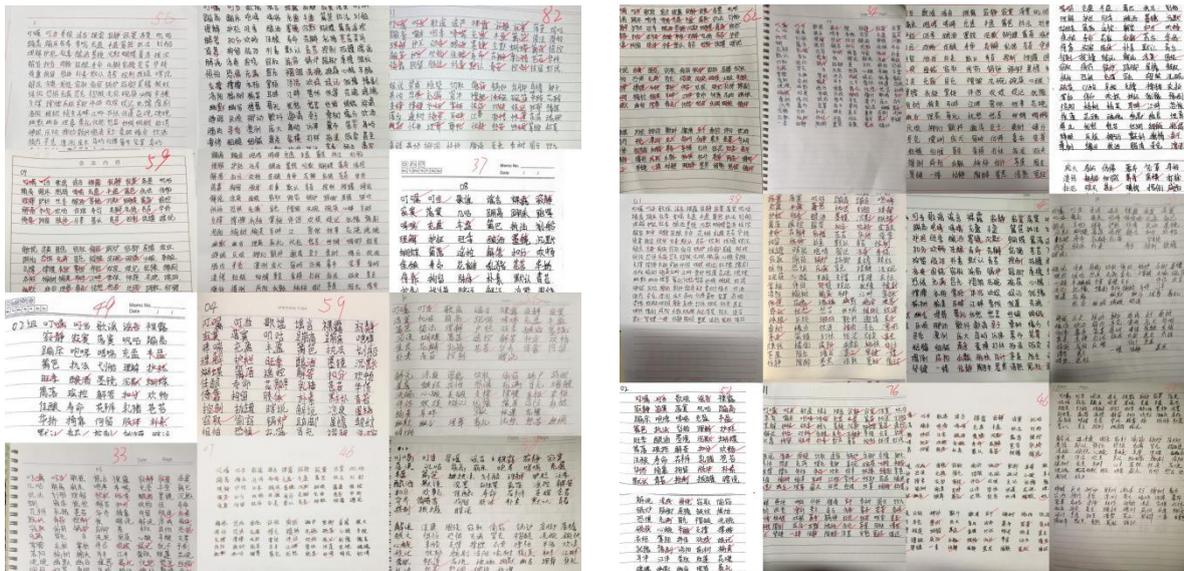


Figure 2. The writing results of pre-test and post-test in control group

Table 1. Pre- and post-test scores of the control group

student number	01	02	03	04	05	06	07	08	09	10	11	12	divide equally
pre-test score	56	49	33	59	26	42	46	37	59	56	82	38	48.583
post-test score	38	52	34	63	32	45	46	35	62	59	76	39	48.417
difference (the result of subtraction)	-18	3	1	4	6	3	0	-2	3	3	-6	1	-0.17

Table 2. Results of paired t-test analysis

groups	name (of a thing)	Paired (mean ± standard deviation)		Difference (pair 1 - pair 2)	t	p
		Pairing 1	Pairing 2			
control subjects	Pre-test Score	48.583±15.054	48.417±13.996	0.167	0.09	0.93
	Post-test Score					

* p<0.05 p<0.01

2 Pre-test and post-test experimental results of the experimental group

2.1 Experimental group pretest scores

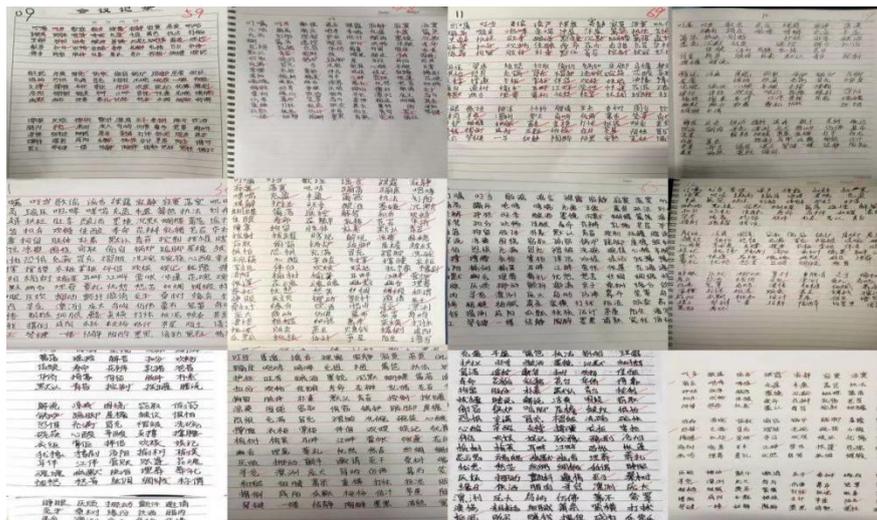


Figure 3. The writing results of pre-test in Experimental group

Table 3. Pre-test scores of the experimental group

student number	01	02	03	04	05	06	07	08	09	010	011	012	divide equally
pre-test score	36	33	48	57	32	65	62	34	59	19	69	75	49.083

Intervention using optimized Chinese character cards

By using these carefully designed Chinese character card tools, researchers enabled students to not only enhance their memory of Chinese characters but also master how to use these cards to optimize their learning paths. After the intervention, student’s researcher tested on their knowledge of Chinese characters to gain insight into the actual effectiveness of these

strategies. Through these tests, the specific impact of memory strategy intervention on students' Chinese character mastery was carefully evaluated by researchers, thus providing data support for the further application and optimization of memory enhancement strategies.

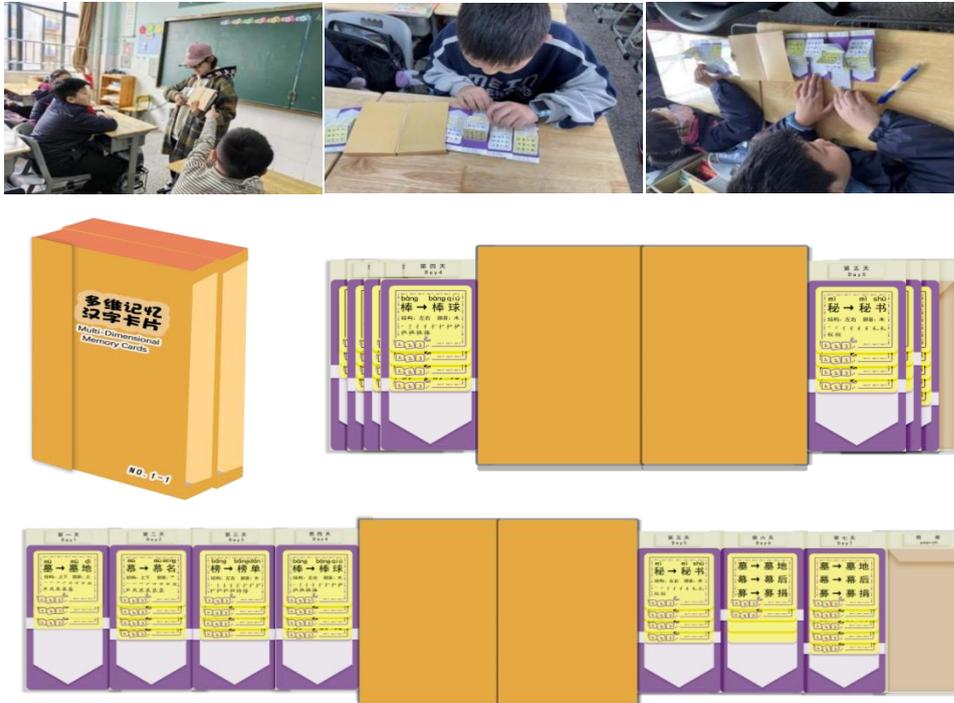


Figure 4. Intervention experiment using Chinese character cards

Analysis of pre and post-test scores of the experimental group after the intervention

Analysis of pre and post-test scores in the experimental group was conducted:

The mean of the pre-test scores of the experimental group was analyzed and found to be 49.083 with a standard deviation of 17.850, and the mean of the post-test scores was 96.417 with a standard deviation of 26.158. All the students in the experimental group improved in their post-test scores, where the improvement ranged from 3 to 92 points.

The average improved score was calculated to be 47.33.

Paired t-tests researcher used to analyze the results:

The paired difference was calculated as -47.333, $t = -6.324$, corresponding to $p = 0.000$. Usually, $p < 0.05$ or 0.01 was considered statistically significant. In this study, $p < 0.01$ was observed, which meant that the difference but Researcher the pre and post-test scores of the experimental group was statistically significant.

The above data shows that using memory enhancement strategies to optimize the design of Chinese character cards produced a significant positive effect on children's working memory in the experimental group. The students' post-test scores greatly exceeded their pre-test scores, with an average improvement of 47.33 points. T-test results further confirmed this, yielding a $p = 0.000$, which was a statistically highly significant result, indicating that this improvement

was statistically significant and not just a random fluctuation. The improvement of the experimental group and control group was significant. The results show that using a memory enhancement strategy in Chinese character card design can significantly improve children's working memory.

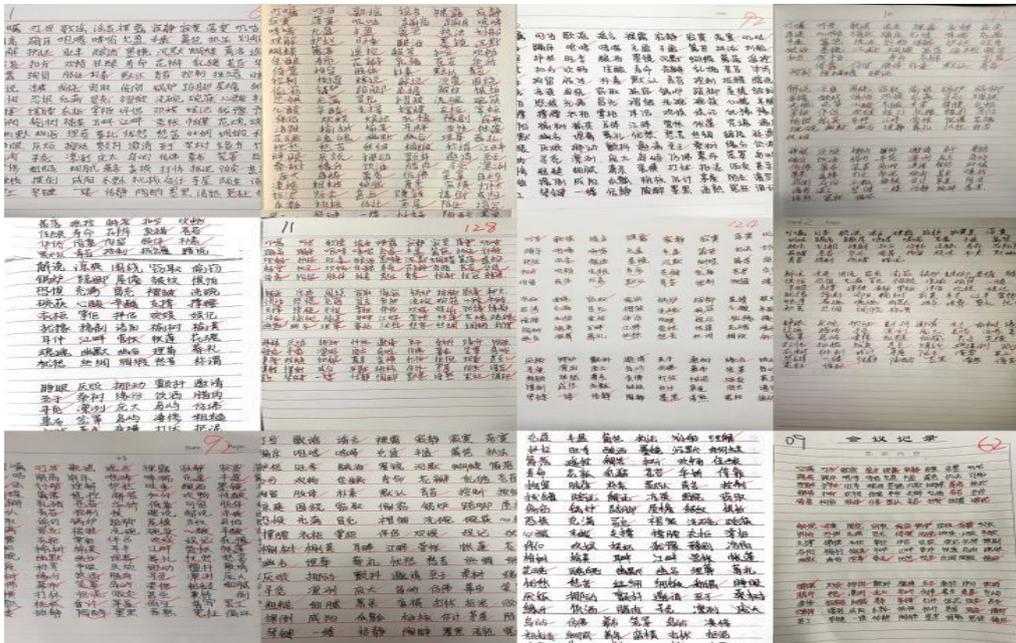


Figure 5. The writing results of post-test in Experimental group

Table 4 Pre- and post-test scores of the experimental group

student number	01	02	03	04	05	06	07	08	09	010	011	012	divide equally
pre-test score	36	33	48	57	32	65	62	34	59	19	69	75	49.083
post-test score	65	55	92	127	124	92	124	88	62	95	128	105	96.417
difference (the result of subtraction)	+29	+22	+44	+70	+92	+27	+62	+54	+3	+76	+59	+30	47.33

Table 5 Results of paired t-test analysis

groups	name (of a thing)	Paired (mean ± standard deviation)		Differenc e (pair 1 - pair 2)	t	p
		Pairing 1	Pairing 2			
experimental group	Pre-test Score Pairing Post-test Score	49.083±17.85	96.417±26.15	-47.333	-6.324	0.000

* $p < 0.05$ $p < 0.01$



Analysis of Pre- and Post-test Results of Control and Experimental Groups

(1) Analysis of Pretest Scores: The experimental group's average pretest score was 49.083, with a standard deviation of 17.850. In comparison, the control group had an average pretest score of 48.583, with a standard deviation 15.054. The calculated t-value was 0.074, which corresponds to a p-value of 0.942. This p-value was significantly more significant than the threshold of 0.05, indicating no significant difference but Researcher the two groups regarding their pretest results. It was noted that the working memory capacities of the two groups of student’s researchers comparable before the commencement of the trial, ensuring an equitable baseline for subsequent studies.

(2) Analysis of post-test scores: The mean post-test score for the post-experiment test was 96.417, with a standard deviation of 26.158. Conversely, the mean post-test score of articles in the control group was 417, with a standard deviation 13.996. The t-value was 5.605, and the p-value was 0.000, significantly below 0.01. There was a notable disparity in the post-test scores but Researcher the two groups. The post-test assessment test experiment demonstrated that the experimental group, which utilized a combination of optimized design of Chinese character cards and memory enhancement procedures, considerably improved their working memory performance compared to the control group.

(3) Synopsis and inquiry: The preliminary examination of the test phase before the experiment revealed no notable disparity in the working memory capacity but Researcher the two groups of children. This discovery confirmed the impartiality of the experiment and the fact that the initial circumstances researcher precisely the same for both groups. At the commencement of the investigation, both the experimental and control cohorts exhibited comparable levels of memory acuity, thereby ensuring the dependability of the experimental outcomes.

In the concluding phase of the examination, conventional mnemonic strategies researcher employed by the research team, yielding outcomes comparable to those observed during the initial assessment. It indicates that extant methodologies may possess limited efficacy in immediate memory enhancement. Conversely, the integration of enhanced Chinese character cards elicited a favorable influence on participants' memory performance within the experimental cohort, a departure from the effects attributable to other variables. Subsequent examination revealed a notable enhancement in memory retention among participants within the experimental cohort, a statistically significant discrepancy when contrasted with the control group.

Discussion

This study examined the efficacy of integrating memory-enhancing techniques into flashcard-based learning approaches aimed at enhancing memory retention and educational outcomes among children aged 10 to 12 years within the context of Chinese character acquisition. The primary research objective was integrating this strategy into card design, with a specific emphasis on evaluating its efficacy compared to current approaches. This study employed a quasi-experimental approach to assess the impact of improved and existing word



cards on children's working memory. T-tests researcher used to analyze the results. The results show that researchers using chunked storage will significantly improve memory efficiency. The researchers applied these strategies to Chinese character cards and examined their practical impact on children's education and the development of Chinese character memory tools. In future studies, researchers should prioritize the expansion of sample sizes, conduct experiments in real-world environments, and consider the long-term impacts and individual variations.

Studies have discovered that using techniques to strengthen memory can significantly enhance the ability of youngsters between the ages of 10 and 12 to remember Chinese characters. Researchers conducted a study on techniques for enhancing children's working memory by using Chinese character card fusion. The main goal is to use Chinese character cards to change traditional teaching methods and improve children's ability to memorize Chinese characters more effectively. To evaluate this concept, the researchers used T-tests to analyze differences in children's memory test scores before and throughout the intervention. The children were divided into two groups: one group used ordinary Chinese character cards, and the other used improved Chinese character cards. Research shows that children who use Chinese character cards that incorporate memory-enhancing strategies experience significant improvements in their long-term memory. The selection of the T-test is contingent upon the experiment's capacity to detect alterations in the data and its conformity to the experimental protocol. Research comparing groups that received memory-enhancing tactics on Chinese character cards with those that did not has demonstrated that such strategies can enhance children's memory abilities. These results offer a fresh perspective on applying theoretical knowledge to practical educational practice through design innovation. This work enhances the information processing theory of Chinese character learning, particularly in the context of children's education, and the utilization of Bing house's forgetting curve theory. The empirical study demonstrates that these ideas are utilized in developing targeted instructional resources and have a synergistic impact that encompasses both theoretical and practical aspects. This study offers empirical evidence to support the cognitive psychology theory and inform the development of instructional aids. It provides novel approaches and demonstrates the practical usefulness of theory in addressing educational was issues.

An unexpected finding of this study was that applying memory enhancement strategies in designing Chinese character recognition cards had limited effectiveness for some children. This study's findings indicate that most children experienced notable enhancements in memory after utilizing optimized Chinese character cards. Researcher, it was worth noting that a small number of children did not exhibit substantial improvements in memory, which contradicts the initial idea. The experimental circumstances may have yet to comprehensively encompass all the learning situations and backgrounds of the children. The research highlights the diverse cognitive profiles, learning styles, and foundational knowledge exhibited by young individuals, distinguishing them from their peers. It was imperative to customize educational strategies to individual needs, as memory enhancement techniques do not uniformly benefit all youth. Researchers must consider unique differences between individuals and across learning environments within a theoretical framework. Validate this by examining initial concepts and



unique distinctions and implementing flexible teaching techniques. This study provides new perspectives on teaching methods and cognitive processes. Smith et al. (2017) found significant differences in how children of different ages and cognitive abilities use memory skills. The findings support the results and demonstrate different responses and outcomes when employing memory strategies.

This study shows how memory strategies can help individuals retain information over the long term. This study aims to improve children's working memory for recognizing Chinese characters. Researchers need more research to understand the impact of memory capacity on memory duration and the factors that make it difficult for some people to remember information effectively. Researchers use theories from cognitive psychology to study how children learn and retain information. Barzagar., etc. (2018) The results of the study are consistent with previous studies' result. Research shows that some people can retain information for long periods, while others have difficulty retaining information for long periods. Children can take advantage of memory-enhancing techniques by using Chinese character cards to improve their memory of Chinese characters and reduce their writing errors. It provided a new perspective for the personalized application of memory strategies. Additionally, extended findings explored the role of memory strategies in long-term memory retention through long-term observation, thus providing a more comprehensive perspective for educational practice. These mutually complementary findings researcher jointly enriched by the original theory, provided valuable guidance for designing educational tools for children's Chinese character learning, and demonstrated the close integration of theory and practice.

Conclusions

This study was dedicated to applying memory enhancement strategies to optimize children's Chinese character learning. Comparative experiments confirmed that the optimized Chinese character cards significantly improve memory compared with traditional methods. The main contribution of the research was to successfully apply cognitive psychology theory to the design of educational tools and form a new multidimensional memory theory. Highlights include the innovative integration of memory strategies such as attention guidance, encoding processes, chunking, and storage, significantly improving learning efficiency. The findings of this study have important implications at the theoretical, practical, and policy levels. First, this study verifies the applicability of information processing theory in Chinese character learning and provides an empirical basis for the theory. More importantly, by integrating memory enhancement strategies into the design of Chinese character cards, the application field of Ebbinghaus' forgetting curve theory was extended. In addition, integrating cognitive load theory improves learning efficiency and enriches related theories. At a practical level, the findings of this study provide a new perspective on the design of Chinese character cards. The optimized card design enables children to memorize and learn Chinese characters more effectively, improves learning motivation and effectiveness, and provides educators with a new teaching tool. Despite the remarkable results, this study has limitations in sample selection and experimental environment control, which may affect the broad applicability of the findings.



Future research could consider expanding the sample range, exploring long-term effects, and conducting research in a more natural educational setting. Specific research questions include: How do customize memory strategies and Chinese character card designs according to the needs of learners of different ages? What are the long-term effects of memory strategies and Chinese character card designs?

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