THE EFFECT OF ANIMATION-GAME ON THE STUDENTS WORKING MEMORY CAPACITY AMONG PRESCHOOLERS IN HEBEI PROVINCE, CHINA

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ABSTRACT

Memory is an integral part of intelligence. However, many studies have shown that working memory is a better predictor of academic success than intelligence. Although many parents are able to recognize the importance of memory for their children's development, they are still determining methods to improve their children's memory. This paper explores the improvement effect of animated games on children's memory, using empirical research to explore the types of games that improve children's problem-solving and to study new games that improve children's memory. The study experiment was conducted in rural and urban public kindergartens in Shijiazhuang, Hebei Province, China. 30 children were selected to participate in this experiment and divided into groups, each with 15 children. The first group will be trained with a picture book, while the second group will play an animated detective game. Each experiment was performed once a week and required a time frame of four weeks for completion. The main objective of this study is to explore the effectiveness of different games to attract children's attention and improve their memory. If the approach of using games for children's memory enhancement is successful, it will provide another type of game instruction for preschool education, resulting in improved teaching methods. Subsequently, children's memory levels and overall learning levels would improve as well.

Keywords: Working memory, preschool children, animation games, learning, children development.

INTRODUCTION

The working memory of children is uniquely different from each other. Some children have a good memory, while others can only remember the general content partially. There are even some who cannot remember any memory at all. This study aims to determine the factor of memory quality by using the games and animations approach toward children. As children are very interested in games and animations, such approaches will improve children's short-term memory as well. The children's study group involved in this study were in the age bracket of 5-6 years old.

This research article mainly focuses on memory development based on animated game platforms and is devoted to enhancing the memory of school-aged youngsters. It has become a ubiquitous symptom within children that they tend to forget specific words after they return home from school or learning nursery. This phenomenon indicates poor memory as a consequence. Ultimately, there needs to be more systematic training to improve thinking, nurture intellect, and establish a solid memory foundation. Games can help youngsters develop their ability to observe, pay attention, remember, and think creatively (Xu, 2013). Children are highly potent to be taught to explore, acquire, and master knowledge through animation games as a real-time realistic learning medium. This study emphasizes that strong memory creates the fundamental groundwork for children's cognitive development.

It is worth noting that preschoolers perform poorly on working memory tasks (Fitamen et al., 2019). While parents understand the value of memory, they also contribute a significant factor to this issue. Most of the time, they must be made aware of how to consciously grow children's memory due to their work commitment, thus limiting their time to accompany and exercise children's working memory. This would consequently result in parents' confusion and dilemma as well.

Memory is essential to intelligence, and having a good memory contributes to higher learning efficiency. Working memory is a brain system that allows humans to manipulate and recall a limited number of retained chunks of information over a short period of time. Many studies have shown that working memory is an even stronger predictor of academic success than intelligence (Alloway & Alloway, 2010). Intelligence query (IQ), short-term memory and study habits are significantly related to academic achievement (Alloway & Alloway, 2010). IQ, short-term memory and study habits are significantly related to academic achievement (Quilez-Robres et al., 2021). Therefore, working memory should be considered a significant predictor of academic success that can lead to unexpected over-achievement and failure at school (Maehler & Schuchardt, 2016). Generally, children with poor memory are cognitively considered to possess low intelligence levels, which will negatively impact their physical and mental development as they grow.

Animation and games are two of the most popular forms of entertainment for children, and both significantly impact children's development. Cultivation of aesthetic education

through animation characters, language, and story themes can develop aesthetic cognition, ideals, and taste for beauty in children (Jiang, 2020). The age interval between children of three years old and eight years old is fundamentally critical for developing children's brain function. Children's brains and their functionality are highly plastic during this stage. Deprivation of early brain development experience could result in central nervous system stagnation or even atrophy and irreversible harm. Children gain most of their early experiences through games requiring adult participation. Many studies have demonstrated the significant influence of games on cognitive processes (Dang, 2021). According to Rice et al. (2013), using animation has been found to enhance children's interest and attention levels and can enhance children's cognitive ability (Li et al., 2018). In Zipke's research (2017), interactive animation has been found to enhance children's memory, and animation has a more remarkable ability to capture children's attention than picture books. Children retain more memories when exposed to animation (Kocak & Goktas, 2021).

Children's games possess both hedonic functions and developmental functions. People's research on the function of children's game development must involve the role of games in children's memory development. For example, the preschool education expert, Mr Chen Heqin, believes that game-playing activity has the value of "developing the body, cultivating understanding and memory, and sharpening the brain in children's physical and mental development. Currently, concerning most of the monographs related to a game, some scholars believe that the game benefits children's physiology, cognition, and personality development (Yannakakis & Hallam, 2008).

The research questions are as follows:

1. What are the types of games that improve children’s working memory?
2. What are the effects of different methods on children's interest in improving working memory?
3. How are the effects of introducing new games to improve children's working memory in rural and urban areas?

RESEARCH DESIGN

This study was conducted in two public kindergarten schools in rural and urban areas. Each school had 30 students divided into two groups, with 15 students each. The first group participated in the intervention plan, while the second group was the control group. These two groups of students are being supervised by their corresponding teachers, and both groups undergo game training once per week with the same training content that lasts for a day. All the interventions were carried out after they went to school usually. The intervention group is exposed to the detective game training method, while the control group is given the picture

book training. The textbooks used in the first and second groups have the same content but different formats, with the intervention group using an iPad for video games while the control group using a paper-based picture book.

PARTICIPANTS

This study is conducted within the public kindergartens in both rural and urban areas of Shijiazhuang City, Hebei Province. The population of this study involved children aged 5-6 who are middle-ranked among the classes of No. 2 Kindergarten and Chunyu Kindergarten. This study will utilize purposive sampling techniques. The condition of purpose sampling is that children aged 5-6 can access children who have experienced picture books and games.

INSTRUMENT

Question 1 requires a questionnaire to be distributed to 10 experts in the corresponding professional field according to Delphi's theory (Rahimianzarif & Moradi, 2018) and (Ahmad Zamzuri et al., 2022). The questionnaire used the Likert scale. Questions 2 and 3 use the true-experimental to collect the student's response performance, and the teacher keeps records.

DATA COLLECTION AND ANALYSIS PROCESS

Question 1 contains the feedback result of the questionnaires from 10 experts collected using Delphi's method, and the results are analyzed with smart PLS according to Delphi's theory. Questions 2 and 3 are analyzed using an SPSS-based approach to the answers provided by the children.

RESULTS

Research Question 1

To investigate the types of games that improve children’s memory. Fuzzy logic (Ahmad Zamzuri et al., 2022) is based on the observation that people make decisions relying on imprecise and non-numerical information. Figure 1 shows the result of the questionnaire collected from 10 industry experts.

Expert	Expert Answers			
	Number games	Detective game	Mind games	Role playing
1	4	4	4	2
2	3	5	3	1
3	4	5	4	3
4	4	5	4	2
5	2	5	4	1
6	4	5	4	5
7	4	5	2	2
8	4	5	3	3
9	3	5	4	2
10	3	4	3	1

Figure1. Summary of expert's feedback

According to the fuzzy theory, the results of expert feedback are being converted according to the corresponding fuzzy figures in Figure2. Figure 3 implies the converted results of Figure 2.

		FUZZY likert		
Strongly disagree	1	0	0	0.2
Disagree	2	0	0.2	0.4
Not sure	3	0.2	0.4	0.6
Agree	4	0.4	0.6	0.8
Strongly agree	5	0.6	0.8	1

Figure 2. Associated fuzzy scale

Expert	Digital game			video games			puzzle game			role playing		
	A	B	C	A	B	C	A	B	C	A	B	C
1	0.4	0.6	0.8	0.4	0.6	0.8	0.4	0.6	0.8	0	0.2	0.4
2	0.2	0.4	0.6	0.6	0.8	1	0.2	0.4	0.6	0	0	0.2
3	0.4	0.6	0.8	0.6	0.8	1	0.4	0.6	0.8	0.2	0.4	0.6
4	0.4	0.6	0.8	0.6	0.8	1	0.4	0.6	0.8	0	0.2	0.4
5	0	0.2	0.4	0.6	0.8	1	0.4	0.6	0.8	0	0	0.2
6	0.4	0.6	0.8	0.6	0.8	1	0.4	0.6	0.8	0.6	0.8	1
7	0.4	0.6	0.8	0.6	0.8	1	0	0.2	0.4	0	0.2	0.4
8	0.4	0.6	0.8	0.6	0.8	1	0.2	0.4	0.6	0.2	0.4	0.6
9	0.2	0.4	0.6	0.6	0.8	1	0.4	0.6	0.8	0	0.2	0.4
10	0.2	0.4	0.6	0.4	0.6	0.8	0.2	0.4	0.6	0	0	0.2
Average	0.3	0.5	0.7	0.56	0.76	0.96	0.3	0.5	0.7	0.1	0.24	0.44
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3

Figure 3. Fuzzy numbers generated from the conversion of expert's feedback.

The square function for each group of ABC numbers in Figure 3 is being implemented to merge the three columns into a single column. Therefore, a single corresponding consolidated figure value is obtained. After the value is obtained, the average and total average values are calculated by dividing the total value by the number of answer inputs. The consensus was reached if the mean distance and expert's assessment were equal to or less than the 0.2 threshold. The percentage of d<=0.2 for each group is calculated afterwards, and the total percentage is determined using the averaging approach.

Expert	Number games	Detective game	Mind games	Role playing game
1	0.153	0.244	0.153	0.081
2	0.153	0.061	0.153	0.344
3	0.153	0.061	0.153	0.234
4	0.153	0.061	0.153	0.081
5	0.458	0.061	0.153	0.344
6	0.153	0.061	0.153	0.843
7	0.153	0.061	0.458	0.081
8	0.153	0.061	0.153	0.234
9	0.153	0.061	0.153	0.081
10	0.153	0.244	0.153	0.344
Average	0.183	0.098	0.183	0.267
Average	0.183			
Accept each item has d <=0.2	Accepted	Accepted	Accepted	Rejected
Percentage of Each Item d ≤ 0.2	90%	80%	90%	40%
Total percentage	75%			

Figure 4. Summary of Processed Square Function Fuzzy Value

Based on Figure 4, any results with threshold percentage of equal or higher than 75% are deemed acceptable, while any result lower than this threshold value are considered rejected.

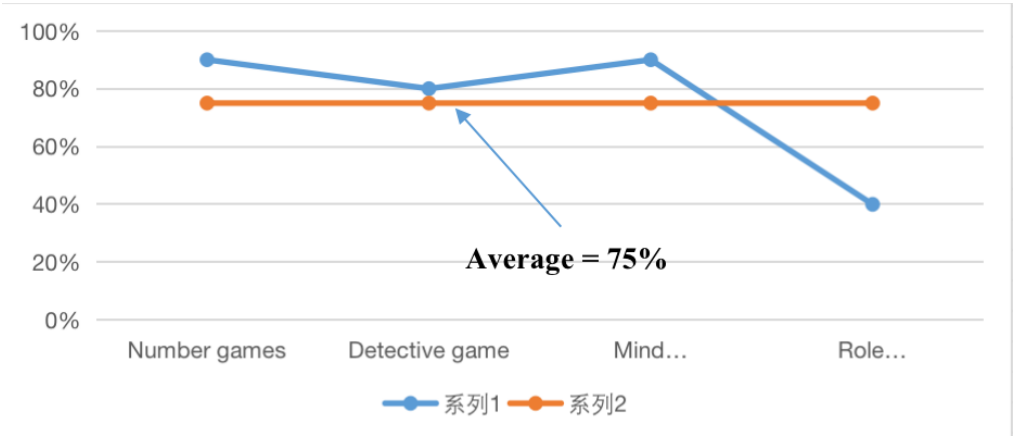

Figure 5. Plot graph of resulting percentage and average threshold percentage

Figure 5 shows the corresponding percentage across four study categories compared to the average acceptable threshold percentage. The average percentage obtained from the study is 75%, which is higher than the 70% threshold in Fuzzy Theory. This result verified the validity of the data collected. The threshold value, d, which is equal to the distance between the average blurred view and the expert view, is calculated, and a decision is made based on the d value. This parameter will be accepted if the value of d is less than threshold 0.2 and rejected if the d threshold is greater than 0.2.

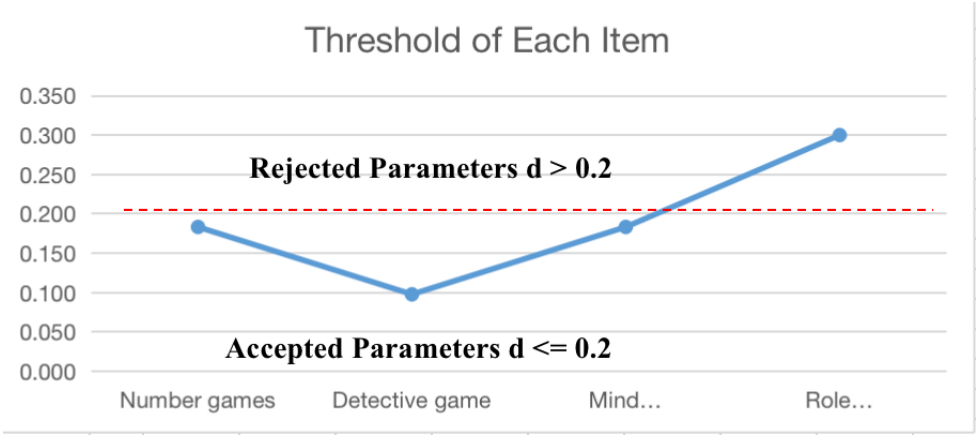

Figure 6. Threshold value d of each category

Figure 6 demonstrates the threshold value d for all 4 study categories. Based on the figure, the role-playing game approach is rejected because its d value surpasses the acceptable threshold d value of >0.2. Next, smart PLS are being used to measure the model evaluation. In the convergent validity, the individual item reliability is greater than 0.70, the composite reliability is greater than 0.70, and the average variance extraction is greater than 0.50. As shown in Figure 7, the values of loading factors are greater than 0.70, the values of composite reliability are greater than 0.70, and the values of average variance extracted (AVE) are greater than 0.50, so the model is established and verified.

Variables	Items	Loading factors	Composite reliability	Average variance extracted (AVE)
number game	1	0.807	0.893	0.737
	2	0.885		
	3	0.881		
detective game	4	0.816	0.920	0.698
	5	0.846		
	6	0.873		
	7	0.865		
	8	0.774		
mind game	9	0.872	0.921	0.745
	10	0.876		
	11	0.83		
	12	0.875		
memory	13	0.857	0.908	0.768
	14	0.900		
	15	0.871		

Figure 7. Convergent validity

Based on the results obtained from convergent validity in Figure 7, the cross-loading method is applied to show the discriminate validation in Figure 8. The highest value is each corresponding column, highlighted in yellow for identification purposes.

Items	number game	detective game	mind game	memory
1	0.807	0.575	0.53	0.515
2	0.885	0.714	0.631	0.602
3	0.881	0.761	0.653	0.669
4	0.737	0.816	0.629	0.689
5	0.745	0.846	0.635	0.628
6	0.695	0.873	0.716	0.626
7	0.619	0.865	0.743	0.641
8	0.551	0.774	0.765	0.651
9	0.656	0.766	0.875	0.723
10	0.573	0.74	0.872	0.681
11	0.566	0.697	0.876	0.681
12	0.648	0.681	0.83	0.716
13	0.609	0.666	0.708	0.857
14	0.612	0.695	0.735	0.9
15	0.618	0.681	0.692	0.871

Figure 8. Discriminate validation via cross loading method

Figure 9 shows the assessment result of the structural model, which proved that these three game approaches are effective in children's memory improvement. Therefore, the evaluation of digital, video, and puzzle games (detective games) are well supported, and efficacy proven.

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	
detective game -> memory	0.214	0.215	0.05	4.317	0.000	supported
mind game -> memory	0.521	0.521	0.041	12.647	0.000	supported
number game -> memory	0.158	0.157	0.047	3.356	0.000	supported

Figure 9. The discriminate validity

Research Question 2

To determine the impact of different methods on children's interest in improving children's working memory. In order to address the second problem, a mixed model analysis of variance (ANOVA) with one within-subject factor and one between-subject factor was used to determine whether there were significant differences among the levels of PreCityDrawing and PreCityGame among the groups.

Assumptions

Normality. The assumption of normality was assessed by plotting the quantiles of the model residuals against the quantiles of a Chi-square distribution, also called a Q-Q scatterplot (DeCarlo, 1997). For the assumption of normality to be met, the quantiles of the residuals must not deviate far from the theoretical quantiles. A major deviation could indicate that the parameter estimates are unreliable. Figure 10 presents a Q-Q scatterplot of model residuals.

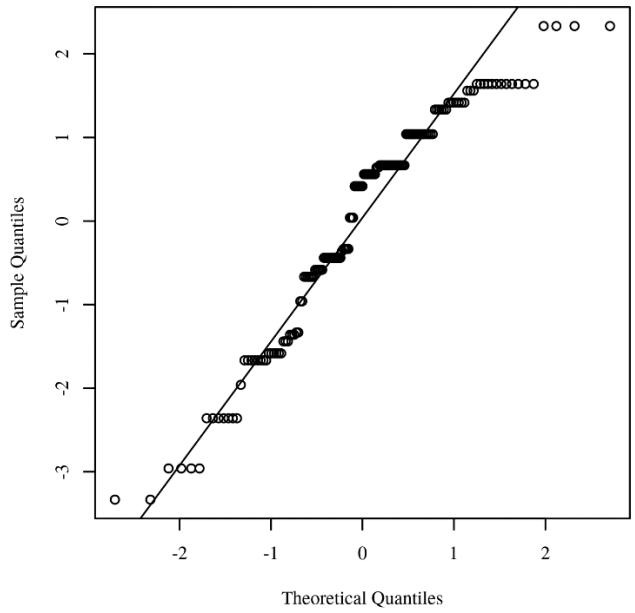

Figure 10. Q-Q scatterplot for normality of the residuals for the regression model

Sphericity: Mauchly's test was used to assess the assumption of sphericity (Field, 2013) and (Mauchly, 1940). The results showed that the variances of difference scores between repeated measurements were all similar based on an alpha of .05, p = .648. This result indicates that the sphericity assumption was met.

Between Effects: For the category of Group, PreRuralDrawing was significantly less than PreRuralCartoon, t (47) = -4.49, p < .001. No other significant differences were observed within the Group. Marginal means contrasts for the Mixed Model ANOVA are presented subsequently. The definition of drawing in this section refers to a picture book, while the definition of the game refers to a detective game.

Table 1. Marginal means contrasts for each combination of within-subject variables for the Mixed Model ANOVA（pre）

Contrast	Difference	*SE*	*df*	*t*	*p*
Group|1					
PreCityDrawing - PreCityGame	-0.60	0.36	47	-1.65	.235
Group|2					
PreRuralDrawing - PreRuralGame	-1.67	0.37	47	-4.49	< .001

Note. Tukey Comparisons were used to test the differences in estimated marginal means.

According to the data comparison, the marginal means contrast of the games category is higher than the picture books category, but detective story games are higher than ordinary games. With both the value of (PreCityDrawing – PreCityGame) and (PreRuralDrawing – PreRuralGame) recorded at -1.65 & -4.49, the negative values indicated that the picture book is not as attractive as the game. Among them, the value of t is less than 0.001, indicating that the exposure to games in rural areas is higher than that of picture books. Based on the feedback of particular teachers, parents in rural areas are less motivated to read picture books to their children than children in urban areas.

Table 2. The marginal means contrasts for each combination of within-subject variables for the Mixed Model ANOVA（post）

Contrast	Difference	*SE*	*df*	*t*	*p*
Group|1					
PostCityDrawing - PostCityGame	1.08	0.16	48	6.63	< .001
Group|2					
PostRuralDrawing - PostRuralGame	1.00	0.16	48	6.14	< .001

Note. Tukey Comparisons were used to test the differences in estimated marginal means.

As observed after a certain period of game training, children still prefer games rather than reading picture books. The accuracy rate and answering time of the game group are better than those of the picture book group. After getting the teachers their regular feedback, the evidence has shown that the children are more focused and react faster when playing games. Thus, gaming has been proven to affect children's memory positively.

In the post-test, an independent sample t-test is applied and tested, which clearly shows that the game's positive impact is higher than that of the picture book.

Table 3. The independent sample T-test to conduct a comparative study on the picture book group and the game group.

	picture			animation-game					
Variable	*M*	*SD*	*n*	*M*	*SD*	*n*	*t*	*p*	*d*
Posttest	2.54	1.48	148	3.59	0.70	145	-7.76	< .001	0.90

Independent t-test result shows a much more prominent result, with higher statistical power than student's t-test, when the two samples have unequal variances and sample sizes (Ruxton,

2006). The result of the independent samples *t*-test was significant based on an alpha value of .05, t (211.30) = -7.76, $p < .001$, indicating that the null hypothesis can be rejected. Using the independent sample T-test to conduct a comparative study on the picture book group and the game group, the result is P equal to 0.001, which is less than 0.05. Therefore, there is a significant difference between the picture book and game groups. In conclusion, the game approach is more effective than the picture book group for children's memory.

During the data collection stage, it is evident that children are more interested in the game. Children show consistent interest in having games and are always absent in the picture books session.

Research Question 3

To analyze the effect of introducing new games on improving children's working memory in rural and urban areas.

The solution to problem 3 requires the application of an independent-sample t-test to check whether the means for rural areas and cities are significantly different. Using the independent-samples t-test on an alpha value of 0.05, t (211.30) = -7.76, p < .001, the results of the independent-samples t-test are significant, indicating that the null hypothesis can be rejected. This finding proved that there is a significant difference between the rural and urban means between categories 1 and 2 in Figure 4.4.

Table 4. The independent sample T-test to conduct a comparative study on the city group and the rural group.

	City			Rural					
Variable	*M*	*SD*	*n*	*M*	*SD*	*n*	*t*	*p*	*d*
City And Rural	2.57	1.48	75	2.53	1.50	70	0.18	.857	0.03

Using the independent sample t-test to conduct a comparative study between urban and rural areas yields the value of P=0.857, greater than 0.05. Therefore, the conclusion can be deduced where there is no significant difference between urban and rural and thus not statistically significant.

DISCUSSION AND CONCLUSION

The study showed that the puzzle game (detective) improved children's memory significantly better than other games. Compared with picture books and games, games are more effective

in attracting children's interest and improving children's memory. The study has shown no difference in children's use of games to improve memory in urban and rural areas. Currently, games of the detective game type are the better option for improving children's memory. This could be due to the high concentration of attention required to focus on the game's storyline. Another contributing factor is that the children must remember the critical information due to the gaming process to solve the puzzle.

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