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Article

# An Empirical Study on the Effect of Contextualized Learning of English Vocabulary on Long-Term Memory Retention Supported by Augmented Reality Technology

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**Abstract:** With the development of augmented reality (AR) technology, the level of contextualization has been continuously improved. This paper utilizes ZAPPAR software to design and implement AR vocabulary teaching materials, aiming to enhance the realism of contextual learning in the classroom. A control experiment was conducted to verify the effectiveness of contextual learning under AR technology. Student learning data was collected through questionnaires and other methods, and Pearson correlation coefficients were further introduced to calculate the association between contextual learning ability under AR technology and students' long-term vocabulary acquisition. The experimental results show: The average scores for short-term and long-term vocabulary memory in the experimental group were 91.034 and 90.768, respectively, with a memory decay change of only -0.266 points, which outperformed the control class and the comparison method. The correlation coefficient between the AR-supported contextual learning method and long-term vocabulary acquisition was 0.35. Additionally, the regression coefficients for the three categories of vocabulary were 9.765, 32.821, and 0.503, respectively, indicating a positive effect on vocabulary memory.

**Keywords:** augmented reality technology; contextualized teaching; Pearson correlation coefficient; English vocabulary learning; long-term memory retention

## 1. Introduction

Augmented reality (AR) technology creates an enhanced reality experience by overlaying digital information onto the user's real-world environment [1-2]. In recent years, as the technology has matured and become more widespread, AR has been widely adopted in the field of education, particularly demonstrating significant potential in enhancing learning experiences and promoting student engagement [3-4]. In language learning within higher education, especially in English instruction, the application of AR technology has opened up new avenues, making learning more interactive and engaging [5-7]. In vocabulary learning, AR technology can visually associate words with their corresponding objects or scenes through 3D images, thereby improving memory retention [8-10].

In the field of education, AR technology demonstrates immense application potential. Study [11] found that applying AR technology to teaching provides students with a 360-degree real-world perspective, aiding their understanding of abstract concepts, thereby reducing the learning curve and improving brain efficiency. Study [12] proposed an AR-based school sports training program, using AR technology to analyze athletes' performance data and investigate the interactive effects of AR environments on athletes. The results demonstrated that AR sports training can enhance athletes' training



and learning capabilities. Literature [13] randomly assigned 100 middle school students to an experimental group and a control group, using AR-based teaching methods and traditional teaching methods, respectively, for science course learning. The study found that the experimental group's academic performance was significantly higher than the control group's, and their attitude toward the course was more positive. Literature [14] used Keller's textbook motivation assessment to evaluate students' motivation levels when using AR-based educational notes. The results indicated a strong correlation between the use of AR-based notes and improved academic performance, confirming that AR facilitates the learning process.

Research on the application of augmented reality technology in English teaching has provided some assistance in knowledge acquisition. Literature [15] indicates that the application of augmented reality technology has a significant impact on learners' language learning, with an estimated comprehensive effect of 0.93 for language learning and an estimated effect of approximately 0.42 for motivation. Additionally, as the application time increases, the effect on enhancing learners' motivation becomes more pronounced. Literature [16] compared and analyzed students' perceptions of English course content and teaching materials with and without the application of augmented reality technology. The results showed that students generally found augmented reality technology easy to operate and highly beneficial for their English learning. Literature [17] concluded through pre- and post-test results that augmented reality technology promotes learning outcomes in English subjects. Through questionnaire surveys and interviews, it was found that students experience greater learning enjoyment in augmented reality classrooms. Literature [18] developed an English learning system integrating game modes based on the high interactivity, immersion, and realism of augmented reality. Questionnaire survey results showed that the learning system combining augmented reality technology with game modes improved students' learning motivation and learning outcomes. Literature [19] designed and developed an augmented reality-based memory assistance application software. Through English teaching experiments, it demonstrated the effectiveness of augmented reality technology in enhancing learners' English speaking abilities and interest in English learning.

Augmented reality-assisted vocabulary learning can achieve the effect of transforming abstract concepts into concrete ones, thereby enhancing students' memory performance. Literature [20] established a user-friendly augmented reality application and applied it to vocabulary learning. The study found that augmented reality technology can improve students' attention and satisfaction, enabling them to better remember words. Literature [21] used augmented reality technology for vocabulary learning, memory level, and English language learning effectiveness testing. The results showed that under augmented reality intervention, the experimental group's vocabulary learning scores improved by 72 points, and their memory test scores only decreased by 17 points, indicating that augmented reality can enhance the experimental group's vocabulary memory. Literature [22] employed two tools—pre- and post-delayed tests and interviews—to determine the practicality of augmented reality technology in English vocabulary learning. Results showed significant differences in average scores between the experimental and control groups. Interview results indicated that augmented reality technology helps students better understand word meanings and enhances learning motivation. Literature [23] Based on a flipped hybrid classroom, this study investigated the effects of augmented reality on students' vocabulary learning, self-efficacy, and personality traits. The results showed that the experimental group performed better than the control group in all research variables, indicating that the implementation of augmented reality has a beneficial impact on these variables. Literature [24] explored the impact of augmented reality technology on vocabulary development and attitudes toward AR in preschool English education using a pretest-posttest control group experimental design. The results showed that there were significant differences between the experimental group and the control group in terms of vocabulary learning and attitudes, with the experimental group performing better. Literature [25] indicates that learners can improve their vocabulary mastery through augmented reality technology. Observation data show that learners exhibit more positive attitudes during the learning process under augmented reality intervention, feeling enjoyment and enthusiasm toward vocabulary learning.

Augmented reality technology has achieved significant results in the field of education. However, through the above literature review, it was found that in current augmented reality education application research, the application of multimodal learning analysis tends to be simple, which is not conducive to the full utilization of its “decoding” function. Future research should strive to achieve online data sources, higher-order evaluation indicators, and integrated method associations.

To enhance the contextualization level of English teaching in higher education institutions, this paper introduces augmented reality (AR) technology to assist college students in vocabulary memorization. The ZAPPAR software is selected as the technical platform, and an AR vocabulary teaching courseware system is designed, including the creation and instructional use of AR vocabulary scan images. Through comparative experiments and questionnaire surveys, the level of contextualized teaching in higher

education institutions supported by AR technology is quantified. The Pearson correlation coefficient in statistics is used to process the obtained student learning data. The study analyzes the actual relationship between AR-supported English contextualized teaching and long-term English vocabulary memory, and examines its importance for students' long-term English learning.

## **2. Contextualized English Vocabulary Learning Design Supported by Augmented Reality Technology**

### *2.1. Study Design*

#### 2.1.1. Research Subjects

The subjects of this study were students from two classes (Class 1 and Class 2) majoring in Business English at a university in Province S. Class 1 was the experimental group and Class 2 was the control group, with 30 students in each group. The vocabulary levels of the two groups were comparable before the experiment: an independent samples t-test ( $P>0.5$ ) of the pre-test scores of the two groups showed no significant difference between them.

#### 2.1.2. Research Tools

This study is an experimental study. In terms of data collection methods, this study used questionnaire surveys and testing methods.

#### 2.1.3. AR Vocabulary Teaching Courseware Design

This study uses ZAPPAR software to design AR vocabulary teaching courseware. The software is an application developed by AR company ZAPPAR that enables users to customize AR experiences through smartphones. After registration, one ID can be used free of charge for 30 days. The software is easy to operate and simple to learn. The specific steps for designing AR courseware using ZAPPAR software are as follows.

Step 1: Register and log in via the website. After successful login, click to add a new project to design the AR lesson plan.

Step 2: Select the project type. Choose the project type as “Designer (Legacy)”, name the project, open it, and begin designing.

Step 3: Design the background image for the lesson plan. To make the lesson plan more engaging, you can upload an image. Click “IMAGE” to upload the background image (image formats can be .JPEG or .PNG).

Step 4: Design the 2D buttons for the courseware. If the courseware has more than one page, buttons need to be added. Click “BUTTON” to design the buttons (if you have pre-designed button images, click ‘IMAGE’). After successfully creating the buttons, add the page-turning function by clicking “Actions-OnTap-GoToScene(scene2)” one by one.

Step 5: Add music. This study is designed for English vocabulary teaching courseware, so the music section can include the pronunciation of vocabulary words. Click SOUND-UPLOAD SOUND-.MP3 one by one (the sound source is video resources already downloaded or created on the computer, with the sound format being .MP3-Properties-Play on start/Pause other media).

Step 6: Insert other related materials. For example, for teaching the spelling of certain English vocabulary words, you can insert videos introducing the evolution of English vocabulary or dynamic stroke writing of English vocabulary. If inserting a video, click VIDEO to upload; the video source can be a video resource already downloaded or created on the computer, or an online video.

Step 7: Complete and publish. After finishing the courseware design, click Publish to send the AR scan image of the courseware to students.

#### 2.1.4. Use of AR Vocabulary Teaching Materials

First, teachers distribute AR scan images to students. Before class, students download the ZAPPAR app and are introduced to its usage.

Second, vocabulary is taught using AR-based materials, covering the form, pronunciation, meaning, and usage of words. In online classes, students use their phones to scan AR lesson materials, while teachers share the effects of scanning AR images via Google Meet. Students who are unable to scan can also learn vocabulary by viewing the shared screen.

Third, conduct AR vocabulary exercises. After students have completed their studies, the teacher has them do AR exercises to assess their learning outcomes and observe their use of the technology. Based on the results, the teacher provides targeted supplementary explanations and clarifications.

Fourth, classroom observation records. The teacher records the effectiveness of students' use of the technology, issues encountered during use, student feedback, the teacher's teaching experiences, insights, and reflections, and finally summarizes and provides recommendations.

## 2.2. Pearson Correlation Coefficient

The Pearson correlation coefficient is a statistical measure used to assess the linear relationship between two variables, typically denoted by  $r$  or  $\rho$ , with values ranging from  $[-1.0, 1.0]$ . The larger the absolute value, the stronger the linear dependence.

In statistics, the Pearson correlation coefficient is defined as the ratio of the product of the covariance and standard deviation of the variables. When applying the Pearson correlation coefficient to the population variables  $x$  and  $y$ , it is often denoted by  $\rho$ :

$$\rho_{x,y} = \frac{\text{COV}(x, y)}{\sigma_x \sigma_y} \quad (1)$$

where  $\text{COV}(x, y)$  is the covariance of the population variables  $x$  and  $y$ , and  $\sigma_x$  and  $\sigma_y$  are the corresponding standard deviations. Using the mean and expected value of the population variables,  $\rho_{x,y}$  can also be expressed as follows:

$$\rho_{x,y} = \frac{E[(x - \mu_x)(y - \mu_y)]}{\sigma_x \sigma_y} \quad (2)$$

where  $E[(x - \mu_x)(y - \mu_y)] = \text{COV}(x, y)$ ,  $\mu_x$  and  $\mu_y$  are the mean values of  $x$  and  $y$  respectively, and  $E[\cdot]$  represents the expectation. Since  $\mu_x = E[x]$  and  $\mu_y = E[y]$ ,  $\sigma_x^2 = E[(x - E[x])^2] = E[x^2] - [E[x]]^2$ ,  $\sigma_y^2 = E[(y - E[y])^2] = E[y^2] - [E[y]]^2$ ,  $E[(x - \mu_x)(y - \mu_y)] = E[(x - E[x])(y - E[y])] = E[xy] - E[x]E[y]$ , therefore  $\rho_{x,y}$  can be fully expressed in the form of expectation:

$$\rho_{x,y} = \frac{E[xy] - E[x]E[y]}{\sqrt{E[x^2] - [E[x]]^2} \sqrt{E[y^2] - [E[y]]^2}} \quad (3)$$

When applying Pearson's correlation coefficient to an observed sample dataset  $(x_i, y_i), i = 1, 2, \dots, n$ , it is usually denoted by  $r$ . Based on the observed sample, the covariance and variance of the sample can be estimated. Substituting these into formula (1) yields the formal expression for  $r$ :

$$r_{xy} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2} \sqrt{\sum_{i=1}^n (y_i - \bar{y})^2}} \quad (4)$$

where  $\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$  and  $\bar{y} = \frac{1}{n} \sum_{i=1}^n y_i$  are the means of the observed samples. After equivalent transformation,  $r_{xy}$  can also be expressed in the following form:

$$r_{xy} = \frac{n \sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n \sum x_i^2 - (\sum x_i)^2} \sqrt{n \sum y_i^2 - (\sum y_i)^2}} \quad (5)$$

From the above equation, we can see that  $r_{xy}$  can be calculated after one pass through the observation data, but because it depends on  $n$  (the size of the sample data set) during the calculation process, numerical instability sometimes occurs. In fact, an equivalent representation of  $r$  can also be obtained using the product of the standard deviations and the mean of the observation samples:

$$r_{xy} = \frac{\sum x_i y_i - n\bar{x}\bar{y}}{(n-1)s_x s_y} \quad (6)$$

where  $s_x = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2}$  and  $s_y = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (y_i - \bar{y})^2}$  are the standard deviations of the observed sample.

The expected value of the Pearson correlation coefficient  $r_{xy}$  for an observation sample dataset that follows a normal distribution is  $E(r_{xy}) = \rho_{x,y} - \frac{\rho_{x,y}(1-\rho_{x,y}^2)}{2n} + \dots$ , confirming that  $r_{xy}$  is a biased estimate of  $\rho_{x,y}$ . The unique unbiased estimator of  $\rho_{x,y}$  with minimum variance is given by  $r_{adj}$ :  $r_{adj} = r_{xy} {}_2F_1\left(\frac{1}{2}, \frac{1}{2}; \frac{n-1}{2}; 1-r_{xy}^2\right)$ , where  ${}_2F_1(a, b; c; z)$  is the Gaussian hypergeometric function.

The absolute values of  $\rho_{x,y}$  and  $r_{xy}$  are both less than or equal to 1.0, where  $|\rho_{x,y}| = 1.0$  indicates that the distribution of the population variables  $x$  and  $y$  is linear,  $|r_{xy}| = 1.0$  indicates that all sample points in the observed dataset lie on the same straight line. Specifically,  $\rho_{x,y} = 1.0$  and  $r_{xy} = 1.0$  mean that the distribution between the variables can be perfectly represented by an equivalent linear equation, i.e., all observed sample points lie on the same straight line, and the  $y$  values increase as the  $x$  values increase on this line;  $\rho_{x,y} = -1.0$  and  $r_{xy} = -1.0$  mean that the distribution between the variables can also be perfectly represented by an equivalent linear equation, but on this line, the  $y$  value decreases as the  $x$  value increases;  $\rho_{x,y} = 0.0$  and  $r_{xy} = 0.0$  mean that there is no linear dependency between the variables. More generally, the value of  $(x_i - \bar{x})(y_i - \bar{y})$  is positive if and only if both  $x_i$  and  $y_i$  fall on the same side of the corresponding mean, so that  $r_{xy} > 0.0$  is only possible if both  $x_i$  and  $y_i$  tend to be greater or less than their mean, and  $x_i$  and  $y_i$  tend to either side of their mean, then  $r_{xy} < 0.0$ , and no matter which trend it is, the more pronounced the trend is,  $|r_{xy}|$ , the stronger the linear dependency.

$\rho_{x,y}$  and  $r_{xy}$  both exhibit symmetry, i.e.,  $\rho_{x,y} = \rho_{y,x}$  and  $r_{xy} = r_{yx}$ , and simple changes in variable positions or scales do not affect the values of  $\rho_{x,y}$  and  $r_{xy}$ . For example, if we perform simple linear transformations on  $x$  and  $y$ :  $x' = a + bx$  and  $y' = c + dy$ , where  $a$ ,  $b$ ,  $c$ , and  $d$  are constants, and  $b, d \neq 0$ , then  $\rho_{x,y} = \rho_{x',y'}$ .

In actual data analysis, the correlation between variables can be any linear or nonlinear functional relationship, as well as more complex statistical dependencies. However, the Pearson correlation coefficient is only sensitive to linear dependencies between variables and is not universally applicable.

### 3. Practical Application of Contextualized English Vocabulary Learning Supported by Augmented Reality Technology

#### 3.1. Comparisons between the Experimental Group and the Control Group within Each Vocabulary Group

After completing a three-semester controlled experiment, data related to vocabulary size were collected from students in the two classes through a questionnaire survey. Table 1 presents the results of intra-group comparisons of vocabulary size for the two classes. Both the experimental and control groups showed a gradual increase in vocabulary size across the three assessments, with each subsequent assessment yielding higher scores than the previous one. These differences were statistically significant at the 0.001 level. This indicates that there was a noticeable change in vocabulary size before and after the experiment, confirming the effectiveness of the intervention.

**Table 1.** Results of each comparison within the vocabulary group.

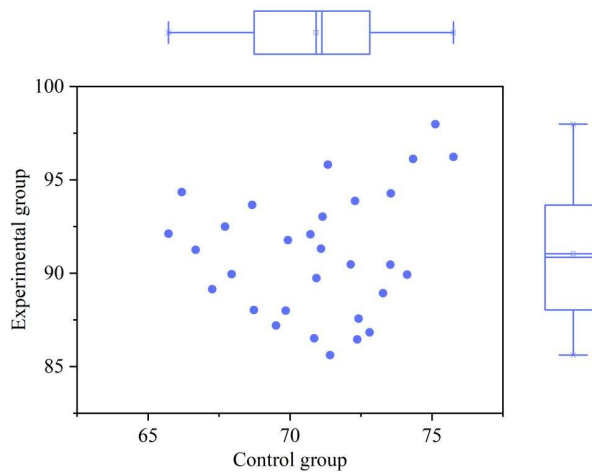
Group	(I) Time	(J) Time	Average value difference (I-J)	Standard error	Sig.	95% confidence interval of the difference	
						Lower limit	Upper limit
Control group	1	2	-817.3775*	17.015	0.001	-847.446	-787.309
		3	-990.557*	39.333	0.001	-1064.702	-916.412
	2	1	788.9045*	17.015	0.001	758.836	818.973
		3	-187.416*	36.322	0.001	-255.616	-119.216
	3	1	962.084*	39.333	0.001	887.939	1036.229
		2	158.943*	36.322	0.001	90.743	227.143
Experimental group	1	2	-859.4535*	16.523	0.001	-888.549	-830.358
		3	-1276.116*	38.157	0.001	-1347.94	-1204.292
	2	1	830.9805*	16.523	0.001	801.885	860.076
		3	-430.8995*	35.206	0.001	-496.96	-364.839
	3	1	1247.643*	38.157	0.001	1175.819	1319.467
		2	402.4265*	35.186	0.001	336.366	468.487

\* Indicates that the significance level of the mean difference is 0.05.

### 3.2. The Impact of Augmented Reality Technology Teaching on Short-term and Long-term Vocabulary Memory

#### 3.2.1. Short-Term Memory

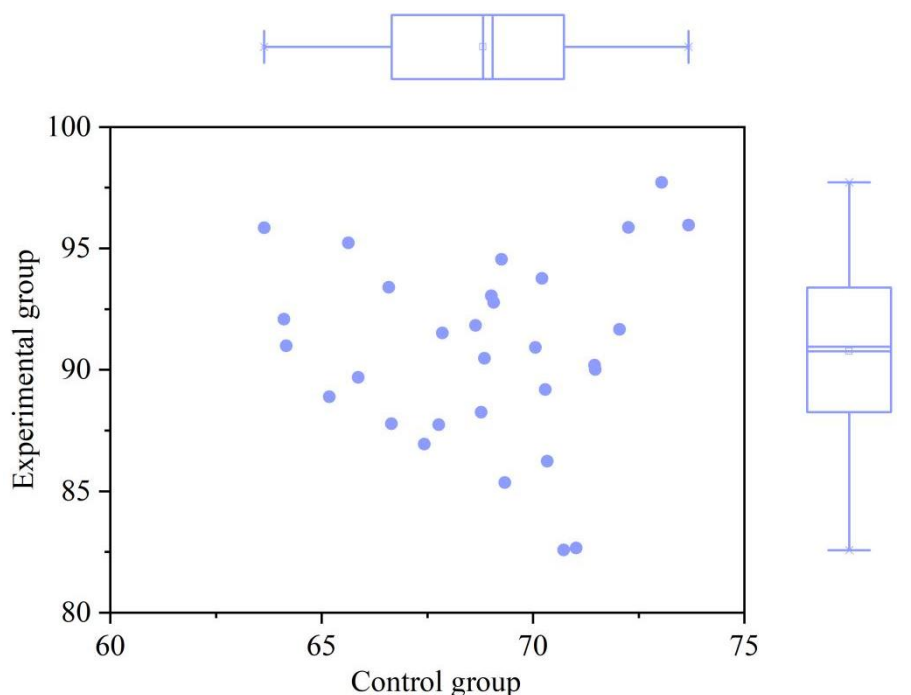
Figure 1 shows the post-test data for the experimental class and the control class, demonstrating the impact of AR vocabulary contextualization instruction on short-term memory for vocabulary learning. The post-test scores of the control group students had an average of 70.914, with a standard deviation of 2.679, and the highest and lowest scores were 75.76 and 65.72, respectively. The post-test scores of the experimental group students had an average of 91.034, with a standard deviation of 3.299, and the highest and lowest scores were 97.980 and 85.610, respectively. There was a significant difference in post-test scores ( $p < 0.05$ ), indicating that the application of AR-based contextualized vocabulary instruction in university English vocabulary teaching has a more positive effect on students' short-term memory for vocabulary learning.



**Figure 1.** (Post-test) Independent sample  $t$ -test analysis.

### 3.2.2. Long-Term Memory

Figure 2 shows the delayed test data for the experimental class and the control class, demonstrating the impact of AR vocabulary contextualization instruction on long-term memory for vocabulary learning. The control group had an average score of 68.813, with a standard deviation of 2.700, and the highest and lowest scores were 73.680 and 63.640, respectively. The experimental group had an average score of 90.768, with a standard deviation of 3.810, and the highest and lowest scores were 97.720 and 82.570, respectively. There were significant differences in the delayed test scores ( $P < 0.05$ ), indicating that the application of AR vocabulary contextualization teaching in university English vocabulary teaching also has a promotional effect on students' long-term memory of vocabulary learning. Due to the natural decline in human memory, the long-term memory scores of the experimental class students showed a slight decrease compared to their short-term memory scores, which falls within the normal range.



**Figure 2.** (Time-delay test) Independent sample t-test analysis.

### 3.2.3. Comparative Analysis of Memory Decline Trends in Different Vocabulary Teaching Models

Table 2 shows the rate of memory decay for English vocabulary learning under three different modes during the week between the immediate test (post-test) and the delayed test. Under the AR vocabulary contextualized teaching mode, students' immediate memory and long-term memory scores for vocabulary were 91.034 and 90.768, respectively, with a score change of -0.266 points. In contrast, the scores for the multimedia mode and vocabulary list mode were 86.745 and 70.256, and 88.902 and 72.431, respectively, with score changes of -16.489 points and -16.471 points. The AR-based contextualized teaching model for vocabulary learning results in more robust vocabulary memory, demonstrating greater pedagogical advantages in both short-term and long-term memory.

**Table 2.** Comparison of memory decline trends.

	Immediate memory	Long-term memory	Change in grades
Article method	91.034	90.768	-0.266
Multimedia mode	86.745	70.256	-16.489
Vocabulary list pattern	88.902	72.431	-16.471

### 3.3. Correlation Coefficient between Vocabulary Learning Methods and Vocabulary Test Scores

To investigate the strategies employed by college students in English vocabulary learning and their impact on memory effectiveness, this study sets vocabulary learning methods and students' cognitive attitudes as independent variables, while using vocabulary test scores as the dependent variable for analysis. Pearson correlation analysis was employed to calculate the strength of association between each factor and the final vocabulary test scores. Table 3 presents the correlation coefficients between vocabulary learning methods and vocabulary test scores. Among the 11 vocabulary learning methods, the vocabulary contextualization learning method based on augmented reality technology had the highest correlation coefficient of 0.35 and was the only method significantly correlated at the 0.01 level ( $p = 0.009 < 0.01$ ). This method had the greatest impact on students' long-term vocabulary memory.

**Table 3** Correlation coefficient between learning methods and vocabulary scores

Classification	Method	Correlation coefficient	Significance level
Concept	Rote learning	-0.32	0.04
	Context association	0.19	0.05
Cognitive strategy	Language background speculation	0.24	0.05
	Semantic check	0.26	0.08
	Look up in the dictionary	0.23	0.05
	Lenovo	0.21	0.04
	Morphological analysis	0.25	0.05
Social/emotional strategy	Extensive reading	0.31	0.02
	Application	0.33	0.02
	Cooperation	0.32	0.03
	Self-encouragement	0.31	0.02
	Contextualized learning	0.35	0.009

### 3.4. Regression Analysis of Contextual Learning Ability and Long-Term Memory Vocabulary Size

#### 3.4.1. Regression Analysis of Contextualized Learning Ability and Comprehension Vocabulary Size

Long-term vocabulary size was set as the dependent variable, with other variables as control variables, and contextual learning ability based on augmented reality technology as the independent variable. A regression analysis was conducted using the entry form. Table 4 presents the results of the regression analysis of contextual learning ability on receptive vocabulary size. Among these, English vocabulary learning contextual understanding ability and CET level were included in the regression model, indicating that these two variables have a significant predictive effect on the receptive vocabulary size of English second language learners. The multiple regression coefficient for English vocabulary learning contextual understanding ability is 9.765, indicating that for every 1-point increase in English learners' contextual understanding ability in vocabulary learning, their English receptive vocabulary size increases by 9.765 words.

**Table 4.** Contextualized regression analysis of comprehension vocabulary.

Dependent variable: Comprehension vocabulary in English					
Model 1 (including all control variables)			Model 2 (including only key significant variables)		
Independent variable	$\beta$	Significance	Independent variable	$\beta$	Significance
(Constant)	1876.004	0.000	(Constant)	1976.471	0.000
Friend	99.228	0.326	Situational understanding ability	9.765	0.001
Extracurricular	-109.281	0.329	CET level	406.368	0.001
Contact	-3.613	0.863			
Frequency	156.349	0.137			
Language	134.496	0.169			
Situational understanding ability	8.618	0.003			
Gender	-59.773	0.687			
Grade	51.789	0.337			
Chinese American	64.389	0.456			
Time limit	122.358	0.297			
CET level	399.209	0.004			
R <sup>2</sup> =0.529, the overall level of the equation is significant at 0.05			R <sup>2</sup> = 0.431, the overall level of the equation is significant at 0.01		

### 3.4.2. Regression Analysis of Contextualized Learning Ability and Productive Vocabulary Size

Table 5 presents the results of the regression analysis examining the relationship between contextualized learning ability and productive vocabulary size. Among these, the contextual understanding ability of English vocabulary learning and CET level were included in the regression model, indicating that these two variables have a significant predictive effect on the productive vocabulary size of English second language learners. The multiple regression coefficient for the contextual understanding ability of English vocabulary learning is 32.821, indicating that for every 1-point increase in the contextual understanding ability of English vocabulary learning, the English comprehension vocabulary size increases by 32.821 words.

**Table 5.** Contextualized regression analysis of productive vocabulary.

Dependent variable: English productive vocabulary					
Model 1 (including all control variables)			Model 2 (including only key significant variables)		
Independent variable	$\beta$	Significance	Independent variable	$\beta$	Significance
(Constant)	-2253.561	0.000	(Constant)	-2120.192	0.001
Friend	112.044	0.414	Situational understanding ability	38.163	0.000
Extracurricular	-158.916	0.241	CET level	426.715	0.000
Contact	-63.231	0.734			
Frequency	14.302	0.962			
Language	11.985	0.986			
Situational understanding ability	32.821	0.001			
Gender	418.117	0.092			
Grade	-14.897	0.915			
Chinese American	221.812	0.121			
Time limit	214.634	0.224			
CET level	414.527	0.002			
R <sup>2</sup> = 0.627, the overall level of the equation is significant at 0.05			R <sup>2</sup> =0.518, the overall level of the equation is significant at 0.01		

### 3.4.3. Regression Analysis of Contextual Learning Ability and Vocabulary Depth Knowledge

Table 6 presents the results of the regression analysis examining the relationship between contextualized learning ability and vocabulary depth knowledge. Among these, the contextual understanding ability of English vocabulary learning and CET level were included in the regression model, indicating that these two variables have a significant predictive effect on the vocabulary depth knowledge of English second language learners. The multiple regression coefficient for the contextual understanding ability of English vocabulary learning is 0.503, indicating that for every 1-point increase in the contextual understanding ability of English vocabulary learning, the English comprehension vocabulary size increases by 0.503.

**Table 6.** Contextualized regression analysis of lexical depth knowledge.

Dependent variable: In-depth knowledge of English vocabulary					
Model 1 (including all control variables)			Model 2 (including only key significant variables)		
Independent variable	$\beta$	Significance	Independent variable	$\beta$	Significance
(Constant)	51.429	0.000	(Constant)	56.417	0.001
Friend	3.502	0.477	Situational understanding ability	0.503	0.000
Extracurricular	-1.371	0.343	CET level	6.755	0.001
Contact	-0.796	0.572			
Frequency	839.275	0.841			
Language	3.089	0.125			
Situational understanding ability	0.275	0.001			
Gender	4.186	0.471			
Grade	1.539	0.924			
Chinese American	3.756	0.316			
Time limit	4.248	0.365			
CET level	6.156	0.001			
R <sup>2</sup> = 0.701, the overall level of the equation is significant at 0.05			R <sup>2</sup> = 0.682, the overall level of the equation is significant at 0.01		

#### 4. Conclusion

This paper introduces augmented reality technology to enhance the contextualization level of English vocabulary teaching in higher education institutions and uses Pearson's correlation coefficient to explore the association between this teaching method and long-term vocabulary memory. The experimental class using this teaching method achieved an average long-term memory score of 90.768, significantly higher than the control class's average score of 68.813. The difference in students' short-term and long-term vocabulary memory scores was only -0.266, lower than the -16.489 and -16.471 observed in the two comparison methods. This method showed a significant correlation with vocabulary test scores at the 0.01 level, with a correlation coefficient greater than 0.35. In terms of long-term memory for receptive vocabulary, productive vocabulary, and vocabulary depth knowledge, for every 1-point increase in students' contextual understanding ability, the corresponding vocabulary memory levels increased by 9.765, 32.821, and 0.503, respectively. Future research can further explore the relationship between specific influencing factors in contextualized teaching and long-term vocabulary memory, and continuously optimize the level of English vocabulary contextualized teaching under augmented reality technology.

## References

1. Carmigniani, J., & Furht, B. (2011). Augmented reality: an overview. *Handbook of augmented reality*, 3-46.
2. Billinghurst, M., Clark, A., & Lee, G. (2015). A survey of augmented reality. *Foundations and Trends® in Human-Computer Interaction*, 8(2-3), 73-272.
3. Billinghurst, M. (2002). Augmented reality in education. *New horizons for learning*, 12(5), 1-5.
4. Martin, J., Bohuslava, J., & Igor, H. (2018, September). Augmented reality in education 4.0. In *2018 IEEE 13th International Scientific and Technical Conference on Computer Sciences and Information Technologies (CSIT)* (Vol. 1, pp. 231-236). IEEE.
5. Tulgar, A. T., Yılmaz, R. M., & Topu, F. B. (2022). Research trends on the use of augmented reality technology in teaching English as a foreign language. *Participatory Educational Research*, 9(5), 76-104.
6. Azimova, D., & Solidjonov, D. (2023). Learning English language as a second language with augmented reality. *Qo 'Qon Universiteti Xabarnomasi*, 1, 112-115.
7. Jamrus, M. H. M., & Razali, A. B. (2019). Augmented reality in teaching and learning English reading: realities, possibilities, and limitations. *International Journal of Academic Research in Progressive Education and Development*, 8(4), 724-737.
8. Solak, E., & Cakir, R. (2015). Exploring the Effect of Materials Designed with Augmented Reality on Language Learners' Vocabulary Learning. *Journal of Educators Online*, 12(2), 50-72.
9. Lai, J. Y., & Chang, L. T. (2021). Impacts of augmented reality apps on first graders' motivation and performance in English vocabulary learning. *Sage Open*, 11(4), 21582440211047549.
10. Zhang, M. M., Hashim, H., & Yunus, M. M. (2025). Analyzing and comparing augmented reality and virtual reality assisted vocabulary learning: a systematic review. *Frontiers in Virtual Reality*, 6, 1522380.
11. Roopa, D., Prabha, R., & Senthil, G. A. (2021). Revolutionizing education system with interactive augmented reality for quality education. *Materials Today: Proceedings*, 46, 3860-3863.
12. Liu, Y., Sathishkumar, V. E., & Manickam, A. (2022). Augmented reality technology based on school physical education training. *Computers and Electrical Engineering*, 99, 107807.
13. Sahin, D., & Yilmaz, R. M. (2020). The effect of Augmented Reality Technology on middle school students' achievements and attitudes towards science education. *Computers & Education*, 144, 103710.
14. Cabero-Almenara, J., Barroso-Osuna, J., Llorente-Cejudo, C., & Fernández Martínez, M. D. M. (2019). Educational uses of augmented reality (AR): Experiences in educational science. *Sustainability*, 11(18), 4990.
15. Cai, Y., Pan, Z., & Liu, M. (2022). Augmented reality technology in language learning: A meta-analysis. *Journal of Computer Assisted Learning*, 38(4), 929-945.
16. Su, Y. S., Lai, C. C., Wu, T. K., & Lai, C. F. (2022). The effects of applying an augmented reality English teaching system on students' STEAM learning perceptions and technology acceptance. *Frontiers in Psychology*, 13, 996162.
17. [17]Shaumiwaty, S., Fatmawati, E., Sari, H. N., Vanda, Y., & Herman, H. (2022). Implementation of augmented reality (AR) as a teaching media in English language learning in elementary school. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini*, 6(6), 6332-6339.
18. Chen, S. Y., Hung, C. Y., Chang, Y. C., Lin, Y. S., & Lai, Y. H. (2018, August). A study on integrating augmented reality technology and game-based learning model to improve motivation and effectiveness of learning English vocabulary. In *2018 1st international cognitive cities conference (IC3)* (pp. 24-27). IEEE.
19. Wu, D., & Lo, J. H. (2017). Application of English Teaching Materials with Augmented Reality to Language Learners' Vocabulary Learning. In *2017 Academic Conference on Education, Teaching and E-learning (AC-ETeL 2017)* (pp. 529-539).
20. Santos, M. E. C., Lübke, A. I. W., Taketomi, T., Yamamoto, G., Rodrigo, M. M. T., Sandor, C., & Kato, H. (2016). Augmented reality as multimedia: the case for situated vocabulary learning. *Research and Practice in Technology Enhanced Learning*, 11, 1-23.
21. Yilmaz, R. M., Topu, F. B., & Takkaç Tulgar, A. (2022). An examination of vocabulary learning and retention levels of pre-school children using augmented reality technology in English language learning. *Education and Information Technologies*, 27(5), 6989-7017.
22. Binhomran, K., & Altalhab, S. (2021). The impact of implementing augmented reality to enhance the vocabulary of young EFL learners. *The JALT CALL Journal*, 17(1), 23-44.
23. Khodabandeh, F., & Mombini, A. (2024). Exploring the effect of augmented reality technology on high school students' vocabulary learning, personality traits, and self-efficacy in flipped and blended classes. *Education and Information Technologies*, 29(12), 16027-16050.
24. Topu, F. B., Yilmaz, R. M., & Tulgar, A. T. (2024). The effects of using augmented reality on vocabulary learning and attitude of pre-school children in English education. *Education and Information Technologies*, 29(10), 11733-11764.
25. Hudaya, A., & Sadikin, I. S. (2019). The effect of Aurasma augmented reality (AR) to enhance young learners' vocabulary mastery. *PROJECT (Professional Journal of English Education)*, 2(6), 783-790.