

The Impact of Augmented Reality on Vocabulary Acquisition and Engagement Among College ESP Students

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Abstract—This quasi-experimental study investigated the effects of integrating augmented reality (AR) applications into vocabulary instruction for English for Specific Purposes (ESP) students. The study involved forty students from the College of Science at Majmaah University who participated in an eleven-week vocabulary course. Participants were assigned to either an experimental group, which utilized the JigSpace AR app, or a control group, which followed traditional teaching methods. Data analysis employed quantitative methods, focusing on pre- and post-tests to measure vocabulary acquisition (comprehension and production) and questionnaires to assess student engagement (participatory, agentic, cognitive, and emotional). The findings revealed a statistically significant improvement in vocabulary acquisition and engagement among students in the experimental group, providing compelling evidence for the efficacy of integrating AR into ESP vocabulary instruction.

Index Terms—augmented reality, vocabulary acquisition, student engagement, ESP students, language learning

I. INTRODUCTION

The integration of educational technologies, such as augmented reality (AR), is increasingly recognized as a valuable approach to enhancing language learning outcomes (Jalaluddin et al., 2020; Hung & Yeh, 2023). AR offers unique advantages by facilitating kinesthetic, collaborative, interactive, student-centered, and creative learning experiences (Alzahrani, 2020). The benefits of AR applications in language learning are becoming increasingly evident, particularly in addressing the limitations of traditional vocabulary acquisition methods.

Vocabulary acquisition is one aspect of language proficiency since it influences learners' ability to comprehend, express ideas, and communicate effectively (Cobb, 2007). Traditional vocabulary learning approaches often employ rote memorization and repetition but lack the contextual richness that aids in meaningful retention and application. Nation (2000) suggested that teachers use visual representations of the context of vocabulary to avoid difficulties learners may encounter when learning opposites, synonyms, and collocations. In addition, when learners take control of their vocabulary learning, they become more active in setting goals, planning their learning, and evaluating their progress (Gocić et al., 2024). Chiroboceam (2018) highlighted that ESP vocabulary and concepts should be presented in an interesting environment to motivate learners to learn and acquire them. Augmented reality technologies offer an immersive and interactive environment that has the potential to address these shortcomings by providing dynamic and contextualized language learning experiences (Belda-Medina & Marrahi-Gomez, 2023). AR moderately affects ESP students' achievements (Garzón & Acevedo, 2019). Additionally, implementing augmented reality in English for Specific Purpose (ESP) learning increases students' learning effectiveness and motivation and fosters independent thinkers and learners (Chen, 2019).

AR tools facilitate an interactive and visually engaging learning environment and thus foster students' creative communication and creative thinking (Majid et al., 2021). AR apps' unique features include bringing static images to life and creating dynamic 3D representations and therefore offer a new approach to vocabulary learning (Tsai, 2020). The JigSpace AR tool enabled the students in this study to explore complex concepts through interactive learning experiences powered by augmented reality. JigSpace has a platform that works with all operating systems (i.e., Android, iOS, macOS, and Windows). It allows students to create their jigs (3D interactive images), utilize science or chemistry templates and images on the app, insert their selected images, add texts and voice recordings, and share their final experience with their teachers and classmates.

A. Research Problem

This research study addresses the critical need to enhance vocabulary acquisition among ESP students in specialized fields such as science. Although existing ESP curricula typically include vocabulary instruction, the central challenge lies in identifying and implementing innovative strategies that effectively engage students in the learning process. One promising technique for achieving this engagement is training students to use cutting-edge technologies, such as AR tools,

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to enhance their learning of ESP. This method aims to make language learning more effective and engaging for college students, ultimately improving their proficiency. Therefore, this quasi-experimental study examines the impact of using JigSpace app on vocabulary acquisition and student engagement among College of Science students.

B. Research Objectives

This study pursued two primary objectives.

1. To determine the impact of using AR, specifically the JigSpace application, on ESP vocabulary acquisition, in terms of comprehension and production skills among college students.
2. To evaluate the effect of AR-enhanced vocabulary instruction on student engagement, including participatory, agentic, cognitive, and emotional aspects.

II. LITERATURE REVIEW

A. Vocabulary Acquisition and Augmented Reality

Effective vocabulary acquisition is a fundamental component of overall language proficiency and is essential for successful communication across various contexts (Nation, 2001; Lyu, 2024). Within specialized professional contexts, mastery of technical terminology is paramount for ESP students, especially in fields such as science, medicine, engineering, and business, where precise comprehension and production are essential (Bekteshi & Khaferi, 2020; Chiroboceam, 2018). When studying ESP, students face difficulties due to its complex lexical and grammatical structures (Tyson, 2021). Therefore, teachers must adopt effective engagement learning activities and contextualized experiences to help students improve their ESP vocabulary acquisition (Cobb, 2007).

Integrating technology, such as AR, in learning is one example of these activities that can help students overcome difficulties with ESP vocabulary, concepts, and terms. In language classes, AR applications can significantly enhance teaching methodologies and provide richly contextualized learning experiences (Cheng & Tsai, 2013; Solak & Cakir, 2015). AR tools create interactive, dynamic learning experiences that blend the physical and digital worlds and thus enhance students' comprehension and vocabulary retention (Chittaro & Ranon, 2009; Dunleavy et al., 2009). Hence, the inherent visual, interactive, and contextualized nature of AR learning experiences closely aligns with the principles of effective vocabulary acquisition (Belda-Medina & Marrahi-Gomez, 2023).

Previous studies have extensively examined the effectiveness of augmented reality (AR) in vocabulary acquisition. For example, Guamán et al. (2023) found that EFL students held positive attitudes toward AR, as it facilitated their vocabulary acquisition. Similarly, Majid and Salam (2021) highlighted that AR supports the development of lower cognitive language skills, such as word identification, understanding meanings, and spelling. Yangin Ersanli (2023) demonstrated that AR-enhanced storytelling significantly improved students' vocabulary retention and motivation. Likewise, Chen et al. (2018) and Tsai (2020) emphasized the role of AR-based learning in enhancing vocabulary knowledge and student engagement. Hung and Yeh (2023) further revealed that students' acquisition and creative abilities outperformed their counterparts in the control group due to studying vocabulary in AR game-based activities. Moreover, AR applications offer interactive and meaningful engagement with academic vocabulary using dynamic 3D representations, enhancing learning.

B. AR and Students' Engagement

Beyond cognitive benefits, AR has been associated with increased student engagement in learning activities. AR engagement in learning provides an interactive experience within the real world. The immersive nature of AR experiences captures students' attention and motivates active participation (Dunleavy et al., 2009). For Billingham and Duenser (2012), AR can create creative learning settings that meet the needs of students accustomed to using digital devices. Studies by Sadikin and Martyani (2020) and Rozi et al. (2021) concluded that AR flip cards enhanced students' interest and experience in learning vocabulary inside and outside the classroom. Tyson (2021) reported that students were satisfied with using augmented reality (AR) for acquiring and retaining academic vocabulary, as well as for improving class engagement. According to Cabero-Almenara et al. (2019), using AR strongly correlates with students' enhanced motivation, engagement, and better academic achievements in ESP subjects.

Accordingly, previous research suggests that AR enhances vocabulary acquisition by promoting engagement and providing a multimodal learning environment. The interactive nature of AR enables learners to explore and manipulate virtual elements through a multisensory learning experience. Therefore, the features of AR not only accommodate various learning styles but also facilitate a deeper understanding of vocabulary in its contextualized use. Thus, using AR provides interactive and engaging language learning experiences that enhance both the acquisition and retention of vocabulary.

Despite the significant use of AR in pedagogical settings, challenges in its integration still exist. Cheng and Tsai (2013) identified barriers such as technical constraints, limited access to AR devices, and the need for teacher training. In the context of higher education, Osuna et al. (2019) identified teacher professional development as the biggest obstacle to implementing AR in universities. Later, Alzahrani (2020) added other challenges, such as information overload, cognitive strain, limited familiarity with the technology, educator hesitancy, complex usage, high costs, and technical problems. Recognizing and addressing these challenges is essential for effectively implementing AR tools in language classrooms.

To sum up, previous studies have indicated positive effects on vocabulary acquisition and student engagement. However, a comprehensive identification of the specific AR effectiveness in vocabulary acquisition and engagement among college students is still needed, motivating the current study.

C. Research Questions

1. How does AR affect ESP college students' acquisition of vocabulary in terms of comprehension and production?
2. What is the engagement level with AR in vocabulary classes, considering participation, initiative, cognitive involvement, and emotional aspects?

III. METHODOLOGY

A. Participants

The participants were female first-year students enrolled in the ESP course at the College of Science, Majmaah University. The target group consisted of 40 students with an average age of 19 years old, drawn from the industrial chemistry and physics programs during the second term of the 2023–2024 academic year. Despite being from different departments, both groups followed the same ESP textbook and General Chemistry course, which provided the wordlist used for the experimental group's Augmented Reality (AR) project and the pre- and post-vocabulary acquisition tests. The experimental group was from the chemistry department, while the control group was from the physics department. Focusing exclusively on female students ensured homogeneity within the participant group, addressing potential gender-related differences in learning preferences (Kim, 2016).

B. Study Design

This study employs a quasi-experimental design. The study groups were formed based on the existing course structure, with the experimental group (EG) receiving augmented reality-enhanced vocabulary instruction, whereas the control group (CG) did not use AR tools throughout the semester.

C. Instruments

(a). The Engagement Questionnaire

The present study's researcher designed the engagement questionnaire following the framework by Giang and Lan (2022). The aim is to determine the potential effect of AR on fostering diverse forms of engagement within the educational setting. The questionnaire is a five-point Likert scale with 28 statements divided equally into four dimensions: participatory, agentic, cognitive, and emotional engagements. Two versions of the engagement questionnaire were developed. The items in Appendix A, the EG questionnaire, focus on integrating AR apps into vocabulary classes. Conversely, Appendix B represents the CG questionnaire, which emphasizes traditional teaching methods using text and workbooks.

(b). Wordlists

Two lists from the students' textbook and the General Chemistry course were utilized for vocabulary instruction and the design of the acquisition test.

(c). The Vocabulary Acquisition Test

The test can be found in Appendix C. Designed by the researcher, it evaluates students' acquisition of ESP vocabulary in chemistry through four questions. These questions target both comprehension and production aspects of vocabulary. Question 1 assesses comprehension through morphological knowledge. Question 2 focuses on semantic knowledge via word recognition. In Question 3, students demonstrate their ability to produce vocabulary. Question 4 examines comprehension of lexical meanings. The questions include matching exercises, fill-in-the-gaps, multiple-choice questions, and a writing task. The test is scored out of 20 marks, with each question contributing 5 marks.

(d). Validity and Reliability of the Tools

The validity was confirmed by a panel of experts in TEFL and applied linguistics. The researcher employed the test-retest method to verify the reliability. The correlation coefficients between the two administrations were 0.75 for the first questionnaire, 0.83 for the second questionnaire, and 0.68 for the vocabulary test. These positive correlation coefficients show consistent and reliable measurements across the two administrations.

D. Pre- and Post-Assessments

Both groups were pre-tested to measure their vocabulary knowledge and skills. After the teaching sessions, post-tests evaluated vocabulary acquisition across comprehension and production. Appendix B was used for pre-assessment engagement measurement in both groups. For the post-assessment, the control group completed the same questionnaire, while the augmented reality (AR) group filled out Appendix A.

E. Augmented Reality Tool

Students in the experimental group engaged with various AR apps and platforms to enhance their understanding of chemistry vocabulary, concepts, and terminology.

The explored tools included Chemistry AR+, McGraw Hill AR, MolecuAR, LeARnCHEM, and JigSpace. Finally, JigSpace emerged as the preferred choice among students due to its interactive platform and because this app supports various operating systems such as Android, iOS, MOS, and Windows. JigSpace enables users to interact with 3D representations to create an interactive and dynamic vocabulary learning environment. Below are the steps that were taken in the implementation of JigSpace:

1. Students were instructed to download the JigSpace app and create accounts using their Gmail or Apple ID.
2. With the guidance of the researcher, students independently explored the app's features.
3. Students could choose from a collection of templates of free chemistry images and incorporate them into their Jigs.
4. Students could click on their preferred template to experience it in augmented reality (AR).
5. Students used the available chemistry tools and images as their featured template, empowering them to craft AR Jigs (3D images) based on selected concepts through a user-friendly platform.
6. While creating their Jigs, students could upload images, add text, rotate them, and even record a voice.
7. Students saved their 3D concept recordings to photos and easily shared them with their teacher and classmates. They shared videos, the link, or the QR code, allowing their teacher and colleagues to view their Jigs in AR. For examples of students' Jigs (see Figure 1).

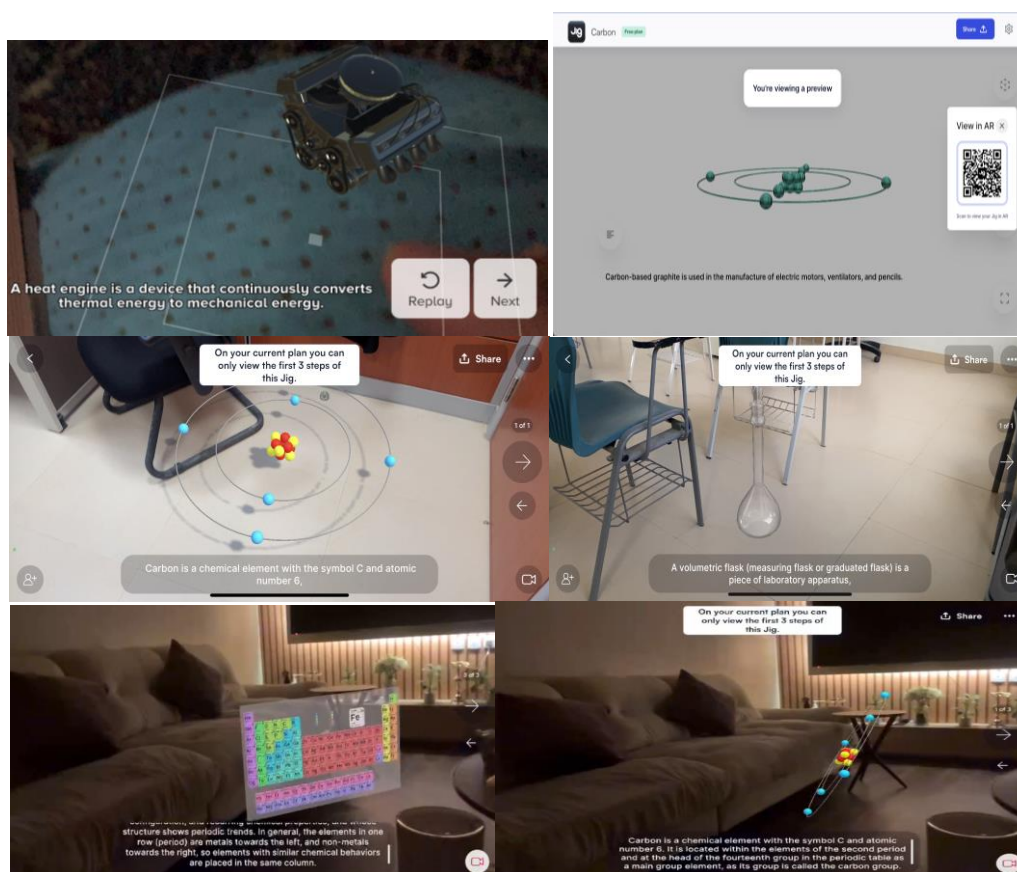


Figure 1. Examples of the Jigs Made by the Students

Note. These Jigs were created by students using the JigSpace app to visualize chemistry concepts in 3D

F. The Framework of the Study

TABLE 1
DISTRIBUTION OF THE SESSIONS

1 st Week	2 nd Week	3 rd Week	4 th Week	5 th - 10 th Weeks	11 th Week
Group Assignment	Pre assessment	(Course orientation) Introductory session to the course	A Training session on how to use AR app	Implementation and teaching the two groups	Post -assessment

IV. RESULTS

To compare the vocabulary acquisition outcomes between the experimental (EG) and control (CG) groups, quantitative data from pre-and post-test assessments were analyzed using t-tests.

A. Pre-Test Results

(a). The Independent Samples T-Test Results

TABLE 2
INDEPENDENT SAMPLES T-TEST OF THE PRE-TEST OF THE OVERALL VOCABULARY ACQUISITION

Group	N	Mean	SD	T-value	DF	*Sig.
EG	20	4.95	3.56	0.811	30.77	0.423
CG	20	4.20	2.09			

*P > 0.05

For the pre-test of overall vocabulary acquisition (Table 2), the significance value ($p = 0.423$) is greater than 0.05, indicating no statistically significant difference between the mean scores of the EG and CG.

(b). The Pre-Test Results of the Components of Vocabulary Acquisition

TABLE 3
INDEPENDENT SAMPLES T-TEST OF THE PRE-TEST OF COMPREHENSION AND PRODUCTION OF VOCABULARY

	Group	N	Mean	SD	T-value	DF	*Sig.
Comprehension	EG	20	4.47	3.13	1.032	38	.308
	CG	20	3.62	1.95			
Production	EG	20	.475	.785	0.107	38	.915
	CG	20	.450	.686			

*P > 0.05

As indicated in Table 3, the mean scores between the EG and CG show no significant differences in the pre-test. The p -values for comprehension (0.308) and production (0.915) are greater than 0.05.

B. Post-Test Results

(a). The Overall Vocabulary Acquisition Results

TABLE 4
INDEPENDENT SAMPLES T-TEST OF THE POST-TEST OF OVERALL VOCABULARY ACQUISITION

Group	N	Mean	SD	T-value	DF	*Sig.
EG	20	6.90	4.07	2.941	24.56	.007
CG	20	4.02	1.56			

*P < 0.05

The t-test results for the post-test of overall vocabulary acquisition indicate significant differences between the groups. The mean score of the EG (6.90) was significantly greater than that of the CG (4.02), with a t-value of 2.941 and a significance level of $p < 0.05$.

(b). The Post-Test Results of the Components of Vocabulary Acquisition

TABLE 5
INDEPENDENT SAMPLES T-TEST OF THE POST-TEST OF COMPREHENSION AND PRODUCTION OF VOCABULARY

	Group	N	Mean	SD	T-value	DF	Sig.
Comprehension	EG	20	5.55	3.18	2.859	26.05	.008*
	CG	20	3.32	1.39			
Production	EG	20	1.35	1.30	2.128	28.33	.042*
	CG	20	0.65	0.67			

*P < 0.05

For comprehension, the EG had a higher mean score (5.55) compared to the CG (3.32), with a t-value of 2.859 and $p < 0.05$. For production, the EG also outperformed the CG, with a mean score of 1.35 compared to 0.65, and a t-value of 2.128 with $p < 0.05$.

C. Results of the Questionnaires

Quantitative data from pre-and post-test assessments were analyzed using t-tests.

TABLE 6
INDEPENDENT SAMPLES T-TEST OF THE PRE-TEST OF THE FOUR DIMENSIONS OF THE QUESTIONNAIRE

Dimension	Group	N	Mean	SD	T-value	DF	Sig.
1. Participative engagement	EG	20	4.12	.390	0.756	38	*0.456
	CG	20	4.01	.555			
2. Emotional engagement	EG	20	4.07	.589	0.164	38	*0.871
	CG	20	4.04	.512			
3. Cognitive engagement	EG	20	4.15	.634	0.042	38	*0.966
	CG	20	4.14	.404			
4. Agentic engagement	EG	20	3.29	.688	3.018	38	**0.005
	CG	20	3.87	.529			

*P > 0.05

**P < 0.05

No significant differences were found between the EG and CG in the first three dimensions of the pre-assessment. The p-values for participative engagement (.456), emotional engagement (.871), and cognitive engagement (.966) confirm the similarity between the groups in these areas. However, a significant difference was observed in the fourth dimension, agentic engagement ($p = .005$), indicating that differences in this aspect existed between the groups before the treatment or intervention.

TABLE 7
INDEPENDENT SAMPLES T-TEST OF THE PRE-TEST OF THE OVERALL DIMENSIONS OF THE QUESTIONNAIRE

Group	N	Mean	SD	T-value	DF	*Sig.
EG	20	3.91	.477	0.756	38	0.454
CG	20	4.01	.433			

*P > 0.05

Table 7 shows no significant difference in the total engagement score between the EG and CG. The p-value of .454 confirms that the overall engagement levels of both groups were similar before any treatment or intervention.

D. Post Assessment

Students' engagement questionnaire results

TABLE 8
INDEPENDENT SAMPLES T-TEST OF THE POST-TEST OF THE FOUR DIMENSIONS OF THE QUESTIONNAIRE

Dimension	Group	N	Mean	SD	T-value	DF	Sig.
1. Participative engagement	EG	20	4.2143	.64307	4.015	38	*.000
	CG	20	3.2571	.85035			
2. Emotional engagement	EG	20	4.3786	.46181	2.533	38	*.016
	CG	20	3.8357	.83977			
3. Cognitive engagement	EG	20	4.2571	.53372	2.561	38	*.015
	CG	20	3.7286	.75294			
4. Agentic engagement	EG	20	4.5143	1.85477	2.657	38	*.011
	CG	20	3.3000	.85827			

*P < 0.05

Table 8 shows that the EG scored significantly higher than the CG across all engagement dimensions: participative ($M = 4.2143$ vs. 3.2571 , $p = .000$), emotional ($M = 4.3786$ vs. 3.8357 , $p = .016$), cognitive ($M = 4.2571$ vs. 3.7286 , $p = .015$), and agentic ($M = 4.5143$ vs. 3.3000 , $p = .011$). These results indicate that students in the EG reported significantly greater engagement following the intervention.

TABLE 9
INDEPENDENT SAMPLES T-TEST OF THE POST-TEST OF THE OVERALL DIMENSIONS OF THE QUESTIONNAIRE

Group	N	Mean	SD	T-value	DF	*Sig.
EG	20	4.3411	.69663	3.847	38	*.000
CG	20	3.5304	.63490			

*P < 0.05

Table 9 further highlights the post-test results for overall engagement. The EG ($M = 4.3411$, $SD = .69663$) scored significantly higher than the CG ($M = 3.5304$, $SD = .63490$), with a p-value of .000. This finding reinforces the superior overall engagement levels of the experimental group after the intervention.

V. DISCUSSION

The results from Tables 2 and 3 indicate no significant differences in vocabulary acquisition between the two groups before the treatment (i.e., before implementing the AR app training session). Therefore, any observed differences in the post-test results can be attributed to the intervention itself.

Tables 4 and 5 address the first question: "How does AR affect ESP college students' acquisition of vocabulary in terms of comprehension and production?" The post-test results reveal that integrating AR tools into vocabulary classes

significantly influences vocabulary acquisition components such as comprehension and production. These findings align with previous studies by Yangin Ersanli (2023), Guamán et al. (2023), Tyson (2021), and Solak and Cakır (2015), which also demonstrated the effectiveness of AR. These studies identified several benefits, including improved vocabulary retention, increased motivation, enhanced engagement, and positive attitudes toward AR integration. For example, Chen and Chan (2019) concluded that AR flashcards effectively facilitated vocabulary acquisition in early childhood education. McMahon et al. (2016) highlighted AR's role in enhancing students' comprehension of scientific concepts. Additionally, Dabrowski (2023) demonstrated that AR methods effectively enhance vocabulary retention and engagement, with potential applications in distance education. Although Belda-Medina and Marrahi-Gomez (2023) did not find significant differences in vocabulary learning outcomes, they reported positive attitudes toward AR in language learning. Together, these studies, along with the current research, suggest that AR offers benefits that extend beyond direct vocabulary acquisition.

The present study findings are consistent with Majid and Salam's (2021) research on vocabulary comprehension. However, they differ in terms of vocabulary production. While Majid and Salam highlighted AR's effectiveness in language learning for basic skills like word identification and understanding meaning, this study indicates a further AR effect when applied to more advanced language competencies such as writing.

The pre-test questionnaire results indicate no differences between the EG and the CG groups in participative, emotional, and cognitive engagements. This suggests that any initial differences in engagement between the two groups are likely due to random chance or factors unrelated to the treatment or intervention. However, the difference observed in the fourth dimension suggests existing disparities in agentic engagement between the groups before treatment. Nevertheless, the overall results indicate no significant differences between the two groups. This implies that the variances observed in the fourth dimension may not significantly impact the overall engagement levels at this pre-assessment stage.

Post-test results from Tables 8 and 9 indicate that the intervention administered to the experimental group effectively increased various dimensions of student engagement compared to the control group, highlighting its potential to improve learning outcomes.

The answer to the second question, 'What is the engagement level with augmented reality in vocabulary classes, considering participation, initiative, cognitive involvement, and emotional aspects?' is summarized in Table 9. It indicates that the EG students have higher levels of engagement compared to the CG students. This result aligns with Belda-Medina and Marrahi-Gomez (2023) and Solak and Cakır (2015). Their results emphasize positive perceptions toward AR in language learning, as indicated by students' overall satisfaction and engagement. Furthermore, the studies by Yangin Ersanli (2023) and Tyson (2021) further support the effectiveness of AR tools in pedagogical settings because of the direct impact of AR on vocabulary retention and academic engagement.

The results confirm that AR significantly enhances students' vocabulary acquisition and engagement compared to traditional methods. In conclusion, integrating AR into ESP enhances vocabulary acquisition and enriches engagement.

VI. CONCLUSIONS AND RECOMMENDATIONS

AR can significantly enhance ESP students' vocabulary acquisition through contextually relevant learning experiences. Teachers should receive training in integrating AR tools into their language classrooms to ensure effective implementation. Additionally, students should be encouraged to actively engage with augmented reality tools, exploring their features to create interactive vocabulary learning experiences.

Integrating AR into ESP vocabulary acquisition aligns with the principles of context-based learning and learner-centered pedagogy, focusing on real-world application and active student engagement. However, it is important to understand learners' needs and language requirements while using AR in language classrooms. The results highlight the importance of considering different dimensions of engagement in educational interventions. Teachers and educators should consider these aspects of engagement to design more effective instructional approaches that enhance students' overall engagement in learning activities.

VII. SUGGESTIONS FOR FURTHER RESEARCH

Further longitudinal studies could examine the effects of AR integration on ESP students' achievements. Future research might explore appropriate strategies for AR implementation across various subject areas. Other studies could assess the transferability of vocabulary learned through AR to real-world contexts. Moreover, research could investigate the impact of AR on reading, writing, and speaking skills within ESP settings. Additionally, comparative studies might evaluate the effectiveness of different AR tools and platforms for vocabulary acquisition in ESP environments.

APPENDIX A

Engagement Questionnaire (Post-Assessment) - Experimental Group

		SA	A	N	D	SD
Participative engagement (7 items)						
Using the augmented reality app helps Me to:						
P1	be an active student in class					
P2	“Do my best regarding my responsibilities in group work.”					
P3	be excited to participate in activities involving augmented reality.					
P4	“Work on a class assignment with other students.”					
P5	contribute ideas during class discussions involving the augmented reality app .					
P6	encourages me to participate in interactive learning games and exercises.					
P7	be engaged in collaborative learning activities facilitated by the augmented reality app .					
Emotional engagement (motivation & interest). (7 items)						
E1	Using the augmented reality app motivates me to engage in vocabulary learning.					
E2	The features of augmented reality make me more eager to engage in vocabulary activities.					
E3	I feel a sense of motivation when using augmented reality for vocabulary acquisition.					
E4	The augmented reality app makes vocabulary learning more interesting for me.					
E5	Augmented reality enhances my interest in exploring and acquiring new vocabulary.					
E6	I enjoy the vocabulary learning activities facilitated by the augmented reality app .					
E7	The interactive nature of the augmented reality app makes learning vocabulary enjoyable.					
Cognitive engagement. (7 items)						
C1	“I try to do my best during classes because of using augmented reality.”					
C2	The augmented reality app enhances my ability to recall and apply vocabulary in different contexts.					
C3	Augmented reality helps me see the practical applications of vocabulary in real-life scenarios.					
C4	“Besides doing my lessons, I further study for my lessons using augmented reality.”					
C5	“I spend enough time and make enough effort to learn vocabulary using augmented reality.”					
C6	I enjoy the vocabulary learning activities facilitated by the augmented reality app .					
C7	Vocabulary lessons with Augmented reality stimulate my creativity in understanding and using new vocabulary words.					
Agentic engagement. (7 items)						
A1	During vocabulary learning activities with the augmented reality app , I ask questions to enhance my understanding.					
A2	I communicate my preferences and dislikes to the teacher, specifically related to vocabulary activities using the augmented reality app .					
A3	I inform my teacher about my specific interests related to vocabulary topics explored through the augmented reality app .					
A4	I actively provide suggestions on how to enhance and improve vocabulary learning activities facilitated by the augmented reality app .					
A5	During vocabulary learning sessions with the augmented reality app , I actively express my preferences and opinions on the learning materials.					
A6	I collaborate with my peers to learn new vocabularies using the augmented reality app .					
A7	I seek feedback from the teacher on my performance in vocabulary activities using the augmented reality app .					

APPENDIX B

Engagement Questionnaire (Pre-Assessment) - EG and CG

		SA	A	N	D	SD
Participative engagement (7 items)						
Using the text and workbook helps Me to:						
P1	be an active student in class.					
P2	“Do my best regarding my responsibilities in group work.”					
P3	be excited to participate in vocabulary activities.					
P4	“Work on a class assignment with other students.”					
P5	contribute ideas during class discussions.					
P6	participate in interactive learning games and exercises.					
P7	be engaged in collaborative learning activities.					
Emotional engagement (motivation & interest). (7 items)						
E1	Using the text and workbook motivates me to engage in vocabulary learning.					
E2	The features of the text and workbook make me more eager to engage in vocabulary activities.					
E3	I feel a sense of motivation when using the text and workbook for vocabulary acquisition.					
E4	Using the text and workbook makes vocabulary learning more interesting for me.					
E5	Using the text and workbook enhances my interest in exploring and acquiring new vocabulary.					
E6	I enjoy the vocabulary learning activities facilitated by the using the text and workbook .					
E7	The interactive nature of the text and workbook makes learning vocabulary enjoyable.					
Cognitive engagement. (7 items)						
C1	“I try to do my best during classes because of using the text and workbook .”					
C2	Using the text and workbook enhances my ability to recall and apply vocabulary in different contexts.					
C3	Using the text and workbook helps me see the practical applications of vocabulary in real-life scenarios.					
C4	“Besides doing my lessons, I further study for my lessons using the text and workbook .”					
C5	“I spend enough time and make enough effort to learn vocabulary using the text and workbook .”					
C6	I enjoy the vocabulary learning activities facilitated by the the text and workbook .					
C7	Vocabulary lessons with text and workbook stimulate my creativity in understanding and using new vocabulary words.					
Agentic engagement. (7 items)						
A1	During vocabulary learning activities, I ask questions to enhance my understanding.					
A2	I communicate my preferences and dislikes to the teacher, specifically related to vocabulary activities.					
A3	I inform my teacher about my specific interests related to vocabulary topics explored through the text and workbook .					
A4	I actively provide suggestions on how to enhance and improve vocabulary learning activities facilitated by the text and workbook .					
A5	During vocabulary learning sessions, I actively express my preferences and opinions on the learning materials.					
A6	I collaborate with my peers to learn new vocabularies using the text and workbook .					
A7	I seek feedback from the teacher on my performance in vocabulary activities.					

APPENDIX C

The vocabulary acquisition test

Question 1 Morphological knowledge (5 marks)

A. Choose the correct suffixes to complete the missing letters.

1. Period.... table
(in- ic- isit)
2. Chemic.... Bond.
(ist- tion- al)
3. Kinet.... Energy
(ic -acl- tion)
4. Therm.... Energy
(al- tion - er)
5. Boil.... degree
(ing- er- list)

B. Match the following prefixes with their correct meaning.

Prefix			Meaning	
1. Mono			a) two	
2. DI			b) one	
3. Tri			c) four	
4. Tetra			d) three	
5. Penta			e) five	
1	2	3	4	5

Question 2.

Matching. Understanding vocabulary (word recognition) (5 marks) Collocational knowledge

C. Match the following words with their correct collocation:

word			collocation	
1. Rate			a. ___ solution	
2. Catalyst			b. ___ compound	
3. Ionic			c. ___ converter	
4. Molecular			d. ___ structure	
5. Acidic			e. ___ reaction	
1	2	3	4	5

Question 3.

Production of vocabulary (Word use and Production questions) (5 marks)

Writing

Write a sentence for each of the following terms, demonstrating your understanding of their meaning.

1. Catalyst.....
2. Periodic table
3. melting
4. freezing.....
5. condensation.....

Question 4.**Comprehension of the meaning of lexical knowledge (5 marks) Semantic knowledge**

Fill in each gap with the appropriate word or collocation from the list of words below.

Atom	evaporation	condensation	melting	freezing	interaction	chemical compound
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- The process of converting water from the liquid state to water vapor
- is the building the building blocks of matter, and cannot be chemically divided by ordinary means.
- Chemical reactions are the breaking of chemical bonds between molecules of reactants. To produce new links.
- is “a chemical substance consisting of two or more elements in a fixed ratio that determines its composition”.
- is “the process through which a substance changes from a liquid to a solid”.

Best Wishes

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