Educational Administration: Theory and Practice
2024, 30(5), 3156-3163
ISSN: 2148-2403
https://kuey.net/

Research Article

Development Of Augmented Reality Application Centered On Fundamental English Vocabulary Learning

Piyanan Pannim Vipahasna[1], Kitipoom Vipahasna[2*], Thosporn Sangsawang[3]

[1]Educational Technology and Communications Division, Faculty of Technical Education, Rajamangala University of Technology Thanyaburi, Pathum Thani, 12110, Thailand https://orcid.org/0009-0003-5889-3059
[2*]Educational Technology and Communications Division, Faculty of Technical Education, Rajamangala University of Technology Thanyaburi, Pathum Thani, 12110, Thailand https://orcid.org/0000-0002-7795-9776 Email: kitipoom_v@rmutt.ac.th
[3]Educational Technology and Communications Division, Faculty of Technical Education, Rajamangala University of Technology Thanyaburi, Pathum Thani, 12110, Thailand https://orcid.org/0000-0002-7926-6949

***Corresponding author:** Email: kitipoom_v@rmutt.ac.th

Citation: Piyanan Pannim Vipahasna et al. (2024), Development Of Augmented Reality Application Centered On Fundamental English Vocabulary Learning *30*(5), 3156-3163
Doi: 10.53555/kuey.v30i5.3402

ARTICLE INFO

ABSTRACT

The acquisition of English language skills is crucial, especially for Thai students facing challenges in this area. Early introduction of English language instruction, focusing on basic vocabulary memorization, is essential at the elementary school level. The lack of effective learning technologies to improve English vocabulary retention has been noted previously. Therefore, this study aims to address this gap by developing an Augmented Reality (AR) Application for Basic English Vocabulary. The primary goal is to assess its impact on academic achievement before and after application use and to evaluate user satisfaction levels. The research involved 80 primary school students from a Thai government school, divided into two groups: an experimental group (n=40) exposed to the AR application and a control group (n=40) using traditional rote learning methods. Findings indicate: 1) The Augmented Reality Application on Basic English Vocabulary successfully underwent expert evaluation, yielding a content validity index 0.93. 2) Students in the experimental group showed significantly enhanced academic performance after using the application compared to pre-application levels, achieving statistical significance at the .05 level. 3) Furthermore, post-study satisfaction scores among students in the experimental group exceeded pre-study levels across various domains, including memorization, attention, enthusiasm, confidence, and overall satisfaction. These results highlight the potential efficacy of AR technology in improving English language learning outcomes and increasing student engagement.

Keywords: *Augmented Reality, English Vocabulary, Multimedia Learning, Academic Achievement, User Satisfaction.*

1. Introduction

The evolution of educational innovations should be tailored to accommodate individual requirements (Personalization). Learning innovations must be designed in alignment with the unique conditions of individual learners. Li et al. emphasized that in personalized educational settings, educators should be able to monitor and adapt to the progress of high-level learning [1]. One transformative aspect of modern technological education pertains to supervising learning content within personalized learning. This paradigm promotes a student-centric approach to learning, fostering self-directed acquisition of knowledge with a strong emphasis on information gathering and encouraging active participation among teachers, students, and learning materials. Additionally, this approach encompasses educational assessments, examinations, and various forms of knowledge evaluation.

Augmented reality (AR) technology represents an emerging technological advancement integrating the physical world (real-world) environment with virtual dimensions. AR exhibits distinct attributes, enabling direct and indirect interaction with the real-world environment. This integration relies on computer technology and virtual systems to establish a symbiotic relationship with the tangible world. The terminology of AR is attributed to its capacity to provide an enriched, computer-generated perspective of reality. AR offers a real-time presentation and contextual incorporation of elements within the environment.

The continual advancement of information technology has given rise to various types of modern educational media, one of which is multimedia applications integrated with AR. In particular, AR is a viable method for enhancing learning experiences [2]-[6]. AR achieves this by seamlessly blending the physical (real) world with the digital (virtual) world through mobile devices, such as smartphones and tablet computers, facilitated by specialized software. This synthesis creates three-dimensional images, engendering an environment that harmonizes real and virtual elements. Through multimedia learning applications, AR technology has gained significant traction and finds applications in diverse domains, including advertising, tourism, healthcare, industrial sectors, and educational contexts. Its capacity to captivate student engagement has been well-documented [2], [3], [7].

English is the most widely spoken foreign language and is a common global communication tool. Approximately 2,000 million people worldwide use English as their primary mode of communication, representing one in three of the world's population. Therefore, Thailand needs to encourage Thai citizens to attain a level of English proficiency that enables effective communication, knowledge acquisition, livelihood, and participation in economic and societal negotiations on the international stage. In recent years, Thailand has endeavored to enhance its English language proficiency by implementing initiatives to integrate English instruction into the educational curriculum. This includes introducing a policy allowing students to begin studying English as a foreign language from the elementary level. Despite implementing these strategies, they have yet to significantly impact the English proficiency of Thai students to the desired extent. Interviews with English educators reveal a notable reluctance among Thai students to memorize vocabulary and the inherent challenges associated with this task. This observation is further substantiated by the outcomes of English proficiency assessments, such as the Ordinary National Educational Test (O-Net), administered during the academic year 2023. The analysis revealed subpar achievement scores, with English attainment lagging behind that of other subjects, as indicated by the lowest academic achievement score recorded in English according to the National Institute of Educational Testing Service [4]-[6], [8].

Recognizing the imperative of adopting English as a global lingua franca, the Thai government has formulated policies to leverage information technology for effective teaching and learning practices, complemented by robust support from diverse governmental agencies. Notably, the quality of this endeavour's media, equipment, and personnel is commendable. Hence, this study has innovated a multimedia application employing AR technology to facilitate engaging learning experiences for children. This application harnesses the captivating features of AR to provide a more realistic introduction to fundamental English vocabulary, specifically focusing on the lexicon associated with various animals. By integrating AR technology, this application enhances the presentation of vocabulary content, providing novel insights and augmenting traditional learning methods to enrich educational experiences [9]-[11].

2. Theoretical Review

2.1. The Cognitive Theory of Multimedia Learning

Mayer introduced the Cognitive Theory of Multimedia Learning, which delves into how visual and verbal information is processed and retained within human memory systems [15]. This theory elucidates that visual and verbal information undergo separate encoding and retention processes and are managed by distinct cognitive systems. Visual input, received through ocular input, generates visual symbols, while auditory input results in the formation of word-based symbols.

In the context of information and communication technology systems, the theory of multimedia learning highlights three crucial systems in the learning process: the sensory memory system, the working memory system, and the long-term memory system. When information is presented in visual or auditory formats, it initially enters the sensory memory system. Subsequently, select images and sounds are retained in the working memory, where they undergo organization into smaller units. These units are then grouped together to form meaningful knowledge through a fusion of visual and auditory elements. This newly acquired knowledge may integrate with existing information stored in long-term memory or amalgamate with other knowledge clusters, as applicable. Therefore, the presentation of information through both visual channels (such as letters and images) and auditory cues (such as sound) enhances vocabulary learning more effectively than presenting information in isolation [19], [20].

2.2. Augmented Reality (AR)

The integration of multimedia theory is fundamental to understanding Augmented Reality (AR) technologies. As per the multimedia principle, which asserts that individuals learn more effectively when instructional materials combine words, sounds, and pictures rather than relying solely on text, this principle serves as a critical guideline for developing successful AR applications for language acquisition. By merging words, sounds, and visuals, AR applications facilitate the development and integration of verbal and nonverbal representations, fostering more profound learning experiences than any single mode alone due to the triple channel assumption [16], [18].

In the realm of instructional applications, Cavanagh et al. discussed that multimedia components can be systematically categorized into four distinct categories [20]:

1) Decorative elements are intended to captivate learners' attention but lack substantive contributions to instructional content.
2) Figurative elements, wherein images serve to depict singular elements elucidated in accompanying narration.
3) Organizational elements, wherein multimedia serves the purpose of elucidating interrelationships among conceptual elements.
4) Explanative multimedia is strategically employed to elucidate the operational mechanisms of a system.

Regrettably, conventional textbooks predominantly rely on decorative and symbolic images, which may not effectively enhance the learning experience. However, with advancements in technology, particularly the emergence of Augmented Reality (AR), educators are urged to prioritize the integration of organizational and explanative visuals [13], [14]. These include three-dimensional models and interactive simulations, which can explicitly reinforce and elaborate upon the concepts conveyed through instructional narration. By leveraging information and communication technology systems like AR, educators can create more immersive and dynamic learning experiences, fostering deeper understanding and engagement among students [15], [5].

AR technology represents a captivating instructional approach. The underlying concept of AR involves seamlessly integrating the physical and virtual realms by employing hardware devices in conjunction with diverse software applications. This combination facilitates the visualization of images, transforming them into 3D objects that seemingly hover above physical surfaces when viewed on the screen. The display showcases dynamic object movements, creating a three-dimensional and engaging visual experience. This innovative presentation format, characterized by genuine interactivity, captivates students' interest and provides them with a unique learning encounter [7].

Since disruptive technology is one of the key components that help with teaching and learning, AR technology can be used in language instruction to bring real-life objects that make learning more convenient. However, this can also impact how well students understand the material they are studying. One of the difficulties in education is guiding students through the process [16], [17]. Thus, educators must use new technologies to their benefit. One such tool is AR in the classroom [18]. Students struggle to understand the subject being taught when less interactive instructional media is used in the learning process. Students' attention will increase with the interest and communication of the media used [8], [19]-[21].

Using learning media in the classroom has several benefits, including boosting students' interests and desires, motivating and stimulating learning activities, and even psychologically impacting them [22]–[25]. The ability to employ technology to make learning more effective, efficient, and creative is one of the advantages of technological development. AR is one technology that can be created for educational purposes. AR, in the form of 3D objects that blend the virtual and the real world so they appear to coexist in the same space, is only one of the many uses for AR in teaching and learning environments.

AR is the integration of virtual or physical objects from the internet into the physical world. These objects can be seen, heard, and touched. Learning a language not utilized for communication in one's context is known as foreign language learning. English is a foreign language that needs to be mastered, and it is taught from early childhood education through college. Proficiency in oral communication is crucial for individuals learning English as a second language. Language, knowledge, and support techniques are needed to assist oral communication effectively. Pupils must acquire a sufficient vocabulary, which can be accomplished through reading or listening exercises [26].

Cai et al. argued that the significance of developing a sufficient vocabulary to facilitate the effective use of the English language for communication is highlighted by the fact that two factors prevent learning and communicating in English from being successful: first, students lack the necessary vocabulary, and second, they are unable to apply their newfound vocabulary in written and spoken language discourse [27].

The main objective of this study is to develop an Augmented Reality (AR) application focused on basic English vocabulary for elementary students. This application aims to provide an engaging and interactive learning experience, utilizing AR technology to improve vocabulary acquisition among young learners. By tailoring the AR application to the specific needs and learning preferences of elementary students, the study aims to address challenges commonly encountered in traditional language learning approaches.

Furthermore, the study seeks to evaluate the effectiveness of the AR application by comparing the learning achievements of students who use the application. This will involve administering pre-tests and post-tests to assess the students' vocabulary knowledge before and after using the AR application. Through analysis of the test scores, the study aims to evaluate the impact of the AR application on students' vocabulary learning outcomes and determine its contribution to improved language proficiency among elementary students.

Additionally, the study aims to assess elementary students' satisfaction levels regarding using the AR application. Satisfaction levels will be measured through feedback surveys or interviews with participating students. These surveys or interviews will gather insights into students' experiences with the AR application, including their perceived usefulness, engagement, and enjoyment of the learning process. By comparing satisfaction levels between students who use the AR application and those who do not, the study aims to determine the application's overall effectiveness and user experience in enhancing elementary students' English vocabulary learning.

3. Research Method

An AR application designed to facilitate the acquisition of fundamental English vocabulary proves to be an effective educational tool. This medium plays a valuable role in aiding the learning and retention of English vocabulary, with a particular focus on foundational lexicon related to various animal species. Tailored for early elementary school learners aged 7 to 10 years, the development of the application comprises two integral components: the AR application itself and the accompanying AR book.

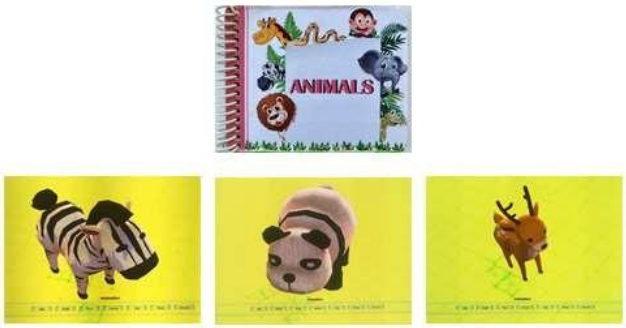

Figure 1. The Proposed AR Book with 3D Models

Furthermore, the AR application incorporates interactive features that engage learners in semi-immersive experiences, fostering a dynamic and participatory learning environment. The integration of interactive elements within the AR application not only enhances motivation but also encourages sustained engagement among young learners. Additionally, the application aligns with contemporary pedagogical approaches by leveraging technological advancements to enhance language acquisition and cognitive development in the early stages of education.

In developing this application, the researchers conducted three experiments involving a single group of students. Initially, a One-To-One try-out was conducted, which included observations and interviews to identify deficiencies and weaknesses in basic English vocabulary knowledge and challenges related to vocabulary memorization. Subsequently, adjustments were made to the application based on the feedback received, including modifications to cartoon images and audio descriptions tailored to address the identified student needs. The experiment was scaled up to a small group of 9 participants, followed by a second round of observations and interviews to assess progress and identify any ongoing weaknesses in the learning process. The user interface, characterized by cartoon images, was further refined through alterations in size and color based on feedback. Finally, 5 experts, comprising 3 experienced English teachers and 2 application development specialists, were interviewed to evaluate the quality of the research tools, including the proposed AR application, and the content validity index was obtained at 0.93.

This study's sample consisted of 80 elementary school students enrolled in a public school in Thailand. The experiment took place during regular class sessions, with the sample group divided into two distinct groups: an experimental cohort comprising 40 individuals who engaged with an AR application focusing on basic English vocabulary and a control group of 40 students who utilized traditional rote learning methods for vocabulary memorization without the use of an AR application. Participants were selected through a simple random sampling technique, specifically employing a lottery method. Due to ethical considerations, parents were notified of the activity, and participation required parental consent.

Table 1. Distribution of Sample Groups for the Experimental Plan

Sample Group	**Module for Developing Basic English Vocabulary**	**Number of Students**
Experimental Group	AR Application on Basic English Vocabulary (AR Book with Multimedia and Interaction)	40
Control Group	Traditional Text-Based Learning Material (Book without Multimedia and Interaction)	40
Total (Students)		**80**

4. Results and Discussion

Table 2 provides a detailed analysis of the pre-test and post-test scores obtained from the experimental and control groups. The statistical parameters examined include the mean score (Mean), standard deviation (SD), t-value, and p-value, which are essential for evaluating the effectiveness of the AR application compared to traditional learning methods.

Table 2. Comparison of Pre-test and post-test scores between Experimental and Control Groups

Group	n	Test Type	Mean	SD	t-value	p-value
Experimental group	40	Pre-test	3.42	3.11	-19.15	.000*
		Post-test	8.10	2.83		
Control Group	40	Pre-test	3.50	2.75	-.935	.355
		Post-test	5.33	2.27		

In the experimental group of 40 students, the mean pre-test score was 3.42 with a standard deviation of 3.11, while the mean post-test score was 8.10 with a standard deviation 2.83. The t-value obtained was -19.15, indicating a significant difference between the pre-test and post-test scores. Additionally, the p-value was less than .05, denoted by the asterisk (*), signifying a statistically significant result.
Conversely, in the control group of 40 students, the mean pre-test score was 3.50 with a standard deviation of 2.75, and the mean post-test score was 5.33 with a standard deviation of 2.27. The t-value obtained was -.935, suggesting no significant difference between the pre-test and post-test scores. Furthermore, the p-value was greater than .05, indicating a lack of statistical significance.
These findings indicate that using the AR application, which included multimedia and interaction, significantly improved vocabulary memorization skills among students in the experimental group compared to those in the control group who utilized traditional text-based learning materials.

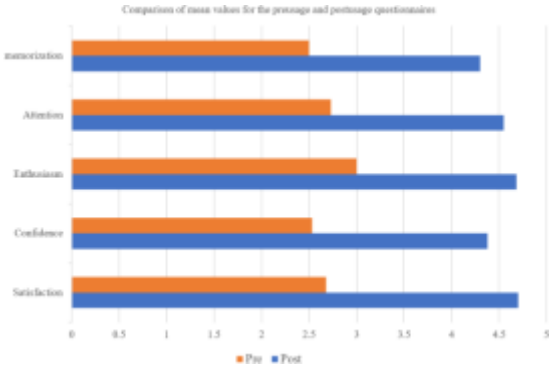

Figure 2. Comparison of Mean Values for Pre- and Post-Usage Questionnaires

Figure 2 compares mean values for pre- and post-usage questionnaires, focusing on student satisfaction before and after using the AR application. The results show a notable increase in satisfaction levels across all measured aspects following the implementation of the AR application. This enhancement in satisfaction underscores the effectiveness of AR applications in creating engaging and enjoyable learning experiences for elementary school students, thereby contributing to a positive user experience.
The findings of this investigation underscore the significant impact of utilizing an Augmented Reality (AR) application focused on Basic English Vocabulary to address the challenges associated with memorizing basic English vocabulary among primary school students, ultimately leading to enhanced academic performance in English. Through meticulous data collection and analysis, genuine issues within the user group were identified, highlighting early primary school Thai students' struggles in vocabulary memorization stemming from a lack of motivation and the necessity for substantial stimulation or rewards to reinforce learning. In response to these identified challenges, the intervention was meticulously conceptualized and developed based on the Cognitive Theory of Multimedia Learning [15].
The application strategically integrates multimedia elements, such as textual (Text) and visual (Image) stimuli, along with auditory components (Sound) aimed at enriching the learning experience. This multimodal approach aligns with the principles advocated by Clark and Mayer [19] and Cavanagh et al. [20], indicating that presenting content through various sensory channels enhances vocabulary retention. The application captures attention and elevates the learning process by incorporating multimedia content. Furthermore, the study employed AR technology as the instructional medium for the sample group to foster an enjoyable and

motivating learning environment conducive to interactive engagement and comprehensive vocabulary comprehension. This approach is consistent with previous research by Chen et al. [28] and Ibáñez et al. [29], which supports the idea that AR technology enhances student enjoyment, motivation, and comprehension during learning.

The comparison of mean scores between the experimental and control groups in both pre-test and post-test assessments reveals a statistically significant increase in the post-test scores of the experimental group at the 0.05 significance level. This emphasizes the effectiveness of an AR application for basic English vocabulary learning, as it facilitates improved learning and memorization. The multimedia format, comprising text, images, animations, and sound, is a compelling instructional approach that enhances children's motivation and engagement in the learning process. Moreover, integrating AR technology is crucial in cultivating interest in vocabulary acquisition by stimulating learners' cognitive processes, drawing upon their prior experiences to establish connections with new knowledge.

This finding is consistent with previous research by Pannim et al. [30] and Enzai et al. [31], demonstrating that multimedia and AR technologies effectively capture children's attention and contribute to vocabulary training by promoting accessibility, flexibility in usage and fostering unrestricted practice opportunities. The assessment of students' satisfaction indicates a remarkably high level of contentment, indicating that students have derived positive experiences and recognized the application's utility in making learning enjoyable.

The vibrant colors of the illustrations and modern design contribute to the overall appeal, highlighting the importance of aesthetic elements in educational applications. Given the significance of vocabulary memorization as a crucial skill in daily life and academic pursuits, it is a fundamental tool for knowledge acquisition, cognitive development, and effective reading experiences. The prevalence of challenges in memorizing English vocabulary among early elementary school students underscores the imperative of employing innovative pedagogical approaches, such as multimedia teaching and AR technology.

Incorporating cartoons and multimedia elements has proven beneficial in facilitating comprehension and addressing the issue of monotony in the learning process. Furthermore, integrating AR technology within applications represents a fusion of mobile application technology and AR, significantly aiding student learning. This amalgamation promotes comfort and ease of understanding, consistent with the findings of Aboudahr et al. [32], who observed high student satisfaction and acceptance of AR technology's utilization in educational settings. Overall, the study demonstrates the potential of AR applications in enhancing vocabulary acquisition and providing a positive learning experience for elementary school students.

5. Conclusion

The implementation of an Augmented Reality (AR) application aimed at Basic English Vocabulary has emerged as a highly effective educational intervention for addressing challenges related to memorizing basic English vocabulary among primary school students. Through a systematic approach to identifying and addressing genuine issues encountered by early primary school Thai students, this study emphasizes the importance of motivation and stimulation in reinforcing vocabulary learning. The developed AR application strategically integrates multimedia elements, including textual, visual, and auditory stimuli, to create an engaging and immersive learning experience aligned with contemporary pedagogical principles. The findings demonstrate a significant increase in post-test scores among the experimental group compared to the control group, indicating the effectiveness of utilizing an AR application for basic English vocabulary learning. Additionally, the assessment of students' satisfaction highlights a notably high level of contentment, emphasizing the positive impact of the AR application in enhancing learning enjoyment and fostering motivation and engagement among students. Overall, integrating multimedia elements and AR technology not only addresses challenges in vocabulary memorization but also enhances motivation, engagement, and satisfaction among elementary school students, ultimately leading to improved academic performance in English.

Looking ahead, this study emphasizes implementing an AR application designed for elementary school students to improve their proficiency in basic English vocabulary. While the application focuses on vocabulary memorization, it could be further enhanced to support basic sentence construction and incorporate a broader range of linguistic elements, such as verbs. Moreover, future investigations could broaden their focus to assess additional facets beyond academic achievement, particularly analytical thinking skills. This expanded evaluation aims to strengthen learners' abilities in essential 21st-century skills, contributing to their overall skill development and preparedness for future educational challenges. These initiatives aim to provide students with expanded learning opportunities, fostering their readiness for diverse educational contexts and enhancing their lifelong learning capabilities.

Acknowledgements

The institutional revenue budget funded this study. The authors thank the Faculty of Technical Education at the Rajamangala University of Technology Thanyaburi, Thailand, for supporting this research.

Author contributions

Piyanan Pannim Vipahasna: Conceptualization, Methodology, Supervision, Writing-Original draft preparation and Editing.

Kitipoom Vipahasna: Data curation, Software, Validation, Writing-Reviewing and Editing.
Thosporn Sangsawang: Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

References

[1] E. Li, "Development of P-TMDRE Blended Teaching Mode on E-Commerce Foundation Course in Secondary Vocational School," *Int. J. Recent Innov. Trends Comput. Commun.*, vol. 11, no. 10, pp. 2387–2400, 2023, doi: 10.17762/ijritcc.v11i10.9008.

[2] Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. Educational Research Review, 20, 1-11.

[3] Dünser, A., & Pivec, M. (2015). The future of augmented reality in education: A roadmap for its development. Educational Technology & Society, 18(4), 133-146.

[4] Johnson, L., Adams Becker, S., Cummins, M., Estrada V., Freeman, A. (2013). NMC Horizon Report: 2013 Higher Education Edition. The New Media Consortium.

[5] Johnson, L., Adams Becker, S., Cummins, M., Estrada V., Freeman, A. (2016). NMC Horizon Report: 2016 Higher Education Edition. The New Media Consortium.

[6] Bower, M., Howe, C., McCredie, N., Robinson, A., & Grover, D. (2014). Augmented reality in education–cases, places and potentials. Educational Media International, 51(1), 1-15.

[7] P. Subhashini, R. Siddiqua, A. Keerthana, and P. Pavani, "Augmented reality in education," *J. Inf. Technol. Digit. World*, vol. 2, no. 4, pp. 221–227, 2020, doi: 10.36548/jitdw.2020.4.006.

[8] NIETS, "NIETS Data Catalog," 2023. https://catalog.niets.or.th/

[9] Bacca, J., Baldiris, S., Fabregat, R., Graf, S., & Kinshuk. (2014). Augmented reality trends in education: A systematic review of research and applications. Educational Technology & Society, 17(4), 133-149.

[10] Gavrilova, T., & Lindh, J. (2019). Augmented Reality and Virtual Reality in Education: Global Market Insights by Application, Component, Degree of Immersion, and Region, Forecast to 2025. Research and Markets.

[11] Johnson, L., Adams Becker, S., Estrada V., & Freeman, A. (2015). NMC Horizon Report: 2015 K-12 Edition. The New Media Consortium.

[12] Wu, H. K., Lee, S. W. Y., Chang, H. Y., & Liang, J. C. (2013). Current status, opportunities and challenges of augmented reality in education. Computers & Education, 62, 41-49.

[13] Liarokapis, F., Voulodimos, A., Petridis, P., & Demestichas, P. (2015). Exploring the educational potential of augmented reality games: A systematic literature review. IEEE Transactions on Learning Technologies, 8(2), 110-133.

[14] Cheng, K. H., Tsai, C. C., & Yeh, Y. F. (2014). The effects of augmented reality interactive technology on students' learning of a socioscientific issue. Journal of Science Education and Technology, 23(5), 651-657.

[15] R. E. Mayer, *The Cambridge handbook of multimedia learning, second edition*. Cambridge University Press, 2014. doi: 10.1017/CBO9781139547369.

[16] Dunleavy, M., Dede, C., & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. Journal of Science Education and Technology, 18(1), 7-22.

[17] Billinghurst, M., & Duenser, A. (2012). Augmented reality in the classroom. Computer, 45(7), 56-63.

[18] Klopfer, E., & Squire, K. (2008). Environmental detectives: The development of an augmented reality platform for environmental simulations. Educational Technology Research and Development, 56(2), 203-228.

[19] R. C. Clark and R. E. Mayer, *e-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning: Third Edition*. john Wiley & Sons, 2012. doi: 10.1002/9781118255971.

[20] T. M. Cavanagh and C. Kiersch, "Using commonly-available technologies to create online multimedia lessons through the application of the Cognitive Theory of Multimedia Learning," *Educ. Technol. Res. Dev.*, vol. 71, no. 3, pp. 1033–1053, 2023, doi: 10.1007/s11423-022-10181-1.

[21] V. Geroimenko, *Augmented Reality in Education*. Springer, 2020.

[22] I. F. Rozi, E. Larasati, and V. A. Lestari, "Developing vocabulary card base on Augmented Reality (AR) for learning English," in *IOP Conference Series: Materials Science and Engineering*, IOP Publishing, 2021, p. 012061. doi: 10.1088/1757-899x/1073/1/012061.

[23] J. Garzón, "An overview of twenty-five years of augmented reality in education," *Multimodal Technol. Interact.*, vol. 5, no. 7, p. 37, 2021, doi: 10.3390/mti5070037.

[24] T. Khan, K. Johnston, and J. Ophoff, "The Impact of an Augmented Reality Application on Learning Motivation of Students," *Adv. Human-Computer Interact.*, vol. 2019, 2019, doi: 10.1155/2019/7208494.

[25] T. C. Hsu, "Effects of gender and different augmented reality learning systems on English vocabulary learning of elementary school students," *Univers. Access Inf. Soc.*, vol. 18, no. 2, pp. 315–325, 2019, doi: 10.1007/s10209-017-0593-1.
[26] J. López-Belmonte, A. J. Moreno-Guerrero, J. A. López-Núñez, and F. J. Hinojo-Lucena, "Augmented reality in education. A scientific mapping in Web of Science," *Interact. Learn. Environ.*, vol. 31, no. 4, pp. 1860–1874, 2023, doi: 10.1080/10494820.2020.1859546.
[27] Y. Cai, Z. Pan, and M. Liu, "Augmented reality technology in language learning: A meta-analysis," *J. Comput. Assist. Learn.*, vol. 38, no. 4, pp. 929–945, 2022, doi: 10.1111/jcal.12661.
[28] S. Y. Chen, C. Y. Hung, Y. C. Chang, Y. S. Lin, and Y. H. Lai, "A study on integrating augmented reality technology and game-based learning model to improve motivation and effectiveness of learning English vocabulary," in *Proceedings - 2018 1st International Cognitive Cities Conference, IC3 2018*, IEEE, 2018, pp. 24–27. doi: 10.1109/IC3.2018.00015.
[29] M. B. Ibáñez, A. Uriarte Portillo, R. Zatarain Cabada, and M. L. Barrón, "Impact of augmented reality technology on academic achievement and motivation of students from public and private Mexican schools. A case study in a middle-school geometry course," *Comput. Educ.*, vol. 145, p. 103734, 2020, doi: 10.1016/j.compedu.2019.103734.
[30] P. Pannim, P. Suwannatthachote, P. Manowan, and S. Numprasertchai, "Improving Reading Comprehension Skills Using Multimedia Storytelling with Mind Maps for Students with Learning Disabilities in Thailand," *Int. J. Emerg. Technol. Learn.*, vol. 17, no. 8, pp. 97–111, 2022, doi: 10.3991/ijet.v17i08.10931.
[31] N. I. M. Enzai, N. Ahmad, M. A. H. A. Ghani, S. S. Rais, and S. Mohamed, "Development of Augmented Reality (AR) for Innovative Teaching and Learning in Engineering Education," *Asian J. Univ. Educ.*, vol. 16, no. 4, pp. 99–108, 2020, doi: 10.24191/ajue.v16i4.11954.
[32] S. M. F. M. Aboudahr, M. V. A. Govindarajoo, A. Olowoselu, and R. M. Sani, "Investigating Moderating Influence of Gender on Augmented Reality and Students Satisfaction: Experiences in Cultures and Linguistic Diversity," *Asian J. Univ. Educ.*, vol. 19, no. 3, pp. 447–461, 2023, doi: 10.24191/ajue.v19i3.23328.