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AR²: Augmented Reality for Enhanced Reading Comprehension

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Abstract: Despite ongoing efforts by the Philippines government to enhance literacy rates, reading challenges persist among Filipino students, as evidenced by declining international assessments. Although technology integration is a global trend in education, its application to reading instruction in the Philippine context remains underexplored. This paper presents the design phase of an innovative research initiative aimed at exploring the potential of augmented reality (AR) technology for augmented reading (AR²) to enhance elementary students' reading comprehension. This study follows a phased approach, emphasizing the design and evaluation of AR content at its initial stage. The study employed Assemblr Studio, a platform for AR content creation, in the design of researcher-made AR collaborative reading tasks. This phase involves the creation of AR content derived from a short story for elementary students, carefully designed for contextualized learning. Accordingly, the evaluators remarked that the potential of the AR content to enhance reading comprehension was enjoyable, interesting, engaging, and interactive. These results necessitate an empirical investigation of the transformative potential of AR technology in the Philippine educational setting. This phased approach ensured a comprehensive exploration of AR's impact on reading instruction. This study contributes to an understanding of technology integration in education and the design considerations crucial for effective AR implementation. Hence, this study aimed to inform educational policies and practices, provide evidence-based strategies to address literacy challenges, and promote 21st-century skills among Filipino learners.

Keywords: augmented reality, educational technology, reading comprehension, instructional design, AR collaborative reading

1. Introduction

Reading literacy remains a challenge among Filipino students, despite government efforts to improve the country's literacy rate (Idulog et al., 2023). Reports from large-scale international assessments have shown a declining trend in reading proficiency in the country (Philippine News Agency, 2022). Several factors can be attributed to these results, such as a lack of resources, socioeconomic factors, early literacy programs, teacher training, and the development of culturally relevant reading materials (Idulog et al., 2023). Furthermore, learners imbued with 21st-century literacy skills increasingly reflect on technology use and problem-solving, communication, and multimodal information dissemination (Pilgrim & Martinez, 2013, p. 60).

The use of technology, such as computers, the Internet, iPads, smartphones, and other electronic or digital products or systems, in the delivery of teaching and learning is also increasing (Haiston & Nafukho, 2015). In fact, several studies have investigated the use of emerging technologies such as augmented reality (AR), virtual reality (VR), digital game-based language learning, and virtual field trips for language instruction (Dixon et al., 2022; Esteban, 2024; Hung et al., 2018; Lee & Park, 2020; Pilgrim & Pilgrim, 2016; Rau et al., 2018). Therefore, the integration and potential of technological tools can provide support for reading, especially in this digital age (Biancarosa & Griffiths, 2012). Unfortunately, this research area is under-investigated in the Philippines. Therefore, this study explores the potential of AR content for collaborative reading among elementary school students by designing a researcher-made short story using an AR platform.

2. Collaborative Reading in AR

Reading alone can be taxing, especially for young learners (Bus et al., 2015; Rai et al., 2011). Several reading strategies can help with such daunting tasks. Some teachers facilitate whole group reading, peer discussions, and book clubs to address this issue (Lin et al., 2017; Moses et al., 2015) and reading approaches may provide scaffolding for students (Maloch, 2002). Drawing on social constructivist theory (Kiili et al., 2012), Abuhasnah (2015) defined collaborative strategic reading (CSR) as an activity that takes place in small collaborative groups and includes activities such as previewing the text, clicking and clunking, getting the gist, and wrapping up. Momtaz and Garner (2010) reported that such an approach to reading instruction resulted in consistently higher scores among learners. The collaborative nature of such an approach reinforces comprehension strategies for reading (Vaughn et al., 2011).

While CSR leverages the social dimension of reading instruction, technology-driven tools such as AR can revolutionize such instruction through immersion (Stănică et al., 2020). AR offers immersive, interactive experiences that blend digital content with the physical environment, engaging multiple senses and allowing students to interact with 3D objects, participate in quizzes, and engage in storytelling (Kirkyakova, 2020; Ro et al., 2018; Handa et al., 2012). AR can also foster collaborative reading and peer interaction (Kiili et al., 2012; Campos et al., 2019). By utilizing context-aware technologies, AR adapts to learners' environments, creating personalized and relevant experiences that integrate real-world contexts (Hu et al., 2021; Krings et al., 2020). Furthermore, gamification elements such as vibrant visuals, sound effects, and interactive storylines can also enhance engagement and motivation (Esteban, 2024; Ke & Hsu, 2015). Additionally, real-time feedback mechanisms and assessments help track progress and evaluate the effectiveness of AR in improving reading comprehension (Lin et al., 2017; Moses et al., 2015).

Context-aware AR scenes can provide learners with a more stimulating and interactive reading experience (Krings et al., 2020; Olsson et al., 2012). Lee and Park (2019) posited that context-aware AR technologies provide learners with unique and rich contexts for language learning, addressing the limited decontextualized classroom learning, lack of interaction, and authentic opportunities for language learning. Most importantly, AR fosters motivation, engagement, creativity, imagination, and collaboration among learners. Teachers see AR as a way to get students' attention, collaboration, and enjoyment (Belda-Medina, 2022; Passarelli & Kolb, 2012 as cited in Roopa et al., 2021). Therefore, this study discusses the design and evaluation phases of AR for augmented reading (AR2), which aims to promote the potential benefits of integrating AR technology into reading instruction.

3. Design Consideration

3.1 AR Platform Used: Assemblr Studio

Assemblr Studio is a versatile platform known for its easy-to-use interface and comprehensive AR content creation tools. It allows educators to easily design and deploy interactive and immersive AR experiences. Several studies have used such a platform for educational purposes (Donally, 2021; Jadán-Guerrero, 2022; Nadita et al., 2023). Lin and Yu (2023) investigated the usefulness of Assemblr Studio in creating interactive AR content, making education more accessible and engaging. Roopa et al. (2021) found that using Assemblr Studio in the classroom transformed ordinary lessons into engaging experiences, increasing student participation and learning. Assemblr Studio's compatibility with smartphones and tablets, and its ability to incorporate 3D models, animations, and multimedia elements that are readily available on the platform or can be uploaded, make it an ideal choice for developing AR reading content.

3.2 The Story: The Great Garden Race

Figure 1. The *Great Garden Race* front scene and characters

The characters *Garden Guard, Kamatis* (tomato), *Talong* (eggplant), *Pipino* (cucumber), and *Kalabasa* (squash) were chosen to reflect the common garden vegetables in the Philippines, particularly those found in rural areas. The selection aimed to make the story relatable while also addressing the common dislike children have for these vegetables by portraying them in a fun and engaging manner (Siegel, 2019). The story revolves around a race in a garden, where vegetable characters compete in various challenges that teach moral lessons, teamwork, and the importance of healthy eating. The narrative is designed to be interactive, allowing students to engage with the characters and plot them using AR features. (See https://bit.ly/4cZr4b9).

3.3 Steps Undertaken

Figure 2 illustrates the steps undertaken during the AR^2 content development stage. This process comprises five stages: story creation, platform selection, initial presentation, final presentation, and evaluation.

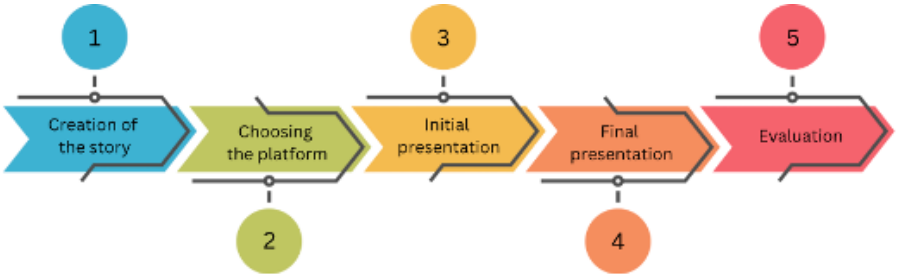

Figure 2. Steps considered in AR^2 content development

The story of *The Great Garden Race* was designed to be engaging and culturally relevant. The AR content included interactive elements such as student participation in dialogue. It should be noted that the initial AR content design was presented for evaluation in a metaverse and educational content development course. After considering feedback from the initial presentation, the professor and peers evaluated the usability, engagement, educational value, and effectiveness of the AR content in improving reading comprehension.

4. Evaluation and Discussion

The instrument used by the evaluators to assess the AR content for reading was a 17-item questionnaire developed by the researcher using a 5-point Likert scale (see Appendix) ranging from 1 (strongly disagree) to 5 (strongly agree). The evaluators included peers majoring in metaverse and English education and a professor who is an expert in educational technology.

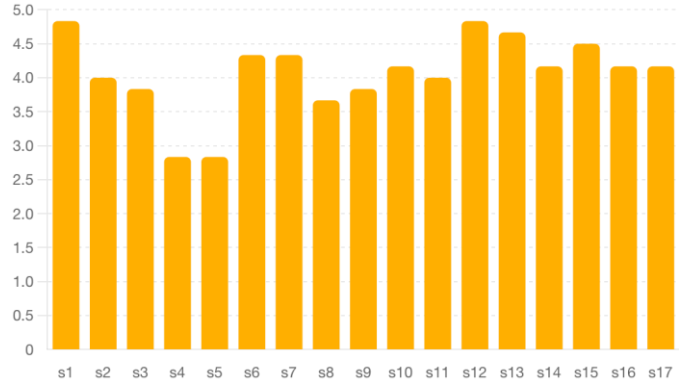

Figure 3. Visualization of the average responses for each statement

Figure 3 shows the average response to each statement, which generally indicates positive feedback from the evaluators. The average responses to the 17 statements on a Likert scale (1-5) indicate strong agreement. Evaluators expressed a significant preference for reading with classmates (S1, average response: 4.83), indicating a highly enjoyable collaborative reading experience in AR2. They also strongly agreed that they would like to read more with AR (s6, mean response: 4.50) and found that AR technology made reading more enjoyable (s7, mean response: 4.50). These responses echoed the agreement that AR makes reading more interesting (s13, mean response: 4.67) and engaging (s16, mean response: 4.33). They also strongly agreed that AR technology actively participates in the reading activity (s12, mean response: 4.83) and that reading together is more enjoyable with AR (s15, mean response: 4.50).

The results of the evaluation support the transformative potential of AR for improving reading comprehension. AR's ability to overlay digital content in a physical environment creates immersive and interactive experiences (Kirkyakova, 2020), making learning more engaging (Roopa et al., 2021). The collaborative nature of AR can potentially provide a social and immersive reading experience among learners (Campos et al., 2019; Sutherland et al., 2023). In addition, AR technologies have been found to increase student motivation, engagement, and collaboration (Ke & Hsu, 2015; Perez-Lopez et al., 2010), as evidenced by the strong positive feedback from evaluators in this study.

5. Conclusion

The initial design and evaluation phases of the AR2 project showed promising results. The evaluation provided positive feedback, highlighting the effectiveness of AR in making reading enjoyable, engaging, and collaborative. This project stresses the potential of AR2 to address literacy challenges and support the development of 21st century skills among young Filipino learners. Nevertheless, there are some limitations to this study. It should be noted that this study is only at the design and evaluation stage. At the same time, the evaluators were not intended users of the content. Therefore, another phase of evaluation was suggested to test the content validity for young learners. In addition, the study suggests its practical implementation in reading classes for young Filipino learners. Technical difficulties in accessing AR content should also be considered. The quality of devices (e.g., smartphones, tablets, and laptops) may affect the accessibility and efficiency of reading content on Assemblr Studio.

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References

Abuhasnah, R. (2015). Collaborative Strategic Reading (CSR): A comprehension Strategy to enhance content area learning. *Edutopia.* George Lucas Educational Foundation.

Belda-Medina, J. (2022). Using augmented reality (AR) as an authoring tool in EFL through mobile computer-supported collaborative learning. *Teaching English with Technology*, *22*(2), 115-135.

Biancarosa, G., & Griffiths, G. G. (2012). Technology tools to support reading in the digital age. *The Future of Children*, 139-160. https://www.jstor.org/stable/23317415

Bus, A. G., Takacs, Z. K., & Kegel, C. A. (2015). Affordances and limitations of electronic storybooks for young children's emergent literacy. *Developmental Review*, *35*, 79-97. https://doi.org/10.1016/j.dr.2014.12.004

Campos, C., Ducasse, J., Čopič Pucihar, K., Geroimenko, V., & Kljun, M. (2019). Augmented imagination: Creating immersive and playful reading experiences. *Augmented Reality Games II: The Gamification of Education, Medicine and Art*, 57-81. https://doi.org/10.1007/978-3-030-15620-6_3

Dixon, D. H., Dixon, T., & Jordan, E. (2022). Second Language (L2) Gains through Digital Game-based Language Learning (DGBLL): A Meta-analysis. *Language Learning & Technology*, 26(1), 1–25. http://hdl.handle.net/10125/73464

Donally, J. (2022). *The immersive classroom: Create customized learning experiences with AR/VR*. International Society for Technology in Education.

Esteban, A. J. (2024). Theories, principles, and game elements that support digital game-based language learning (DGBLL): A systematic review. *International Journal of Learning, Teaching and Educational Research*, *23*(3), 1-22. https://doi.org/10.26803/ijlter.23.3.1

Handa, M., Aul, E. G., & Bajaj, S. (2012). Immersive technology–uses, challenges and opportunities. *International Journal of Computing & Business Research*, *6*(2), 1-11.

Hu, C. H., Barrett, N. E., & Liu, G. Z. (2021). The development and construction of an AR-guided learning model with focused learning theories. *Journal of Computer Assisted Learning*, *37*(5), 1423-1440. https://doi.org/10.1111/jcal.12583

Hung, H. T., Yang, J. C., Hwang, G. J., Chu, H. C., & Wang, C. C. (2018). A scoping review of research on digital game-based language learning. *Computers & Education*, *126*, 89-104. https://doi.org/10.1016/j.compedu.2018.07.001

Idulog, M. V., Gadiano, R., Toledo, E., Hermosada, M., Casaldon, H., Mariposa, M., & Bautista, R. (2023). Filipino students' reading abilities: A note on the challenges and potential areas for improvement. *International Journal of Education and Teaching Zone*, *2*(2), 233-242. https://doi.org/10.57092/ijetz.v2i2.128

Jadán-Guerrero, J., Zurita-Mena, M., & Murillo-Morera, J. (June 2022). Using Augmented Reality to Reinforce the Learning of Installation of Electrical Equipment and Machines. In *International Conference on Human-Computer Interaction* (pp. 542-549). Springer. https://doi.org/10.1007/978-3-031-19679-9_68

Ke, F., & Hsu, Y. C. (2015). Mobile augmented-reality artifact creation as a component of mobile computer-supported collaborative learning. *The Internet and Higher Education*, *26*, 33-41. https://doi.org/10.1016/j.iheduc.2015.04.003

Kiili, C., Laurinen, L., Marttunen, M., & Leu, D. J. (2012). Working on understanding during collaborative online reading. *Journal of Literacy Research*, *44*(4), 448-483. https://doi.org/10.1177/1086296X12457166

Krings, S., Yigitbas, E., Jovanovikj, I., Sauer, S., & Engels, G. (2020, June). Development framework for context-aware augmented reality applications. In *Companion Proceedings of the 12th ACM SIGCHI Symposium on Engineering Interactive Computing Systems* (pp. 1-6).

Lee, S. M., & Park, M. (2020). Reconceptualization of the Context in Language Learning with a Location-based AR App. *Computer Assisted Language Learning*, *33*(8), 936-959. https://doi.org/10.1080/09588221.2019.1602545

Lin, T. J., Justice, L. M., Emery, A. A., Mashburn, A. J., & Pentimonti, J. M. (2017). Impacts of teacher–child managed whole-group language and literacy instruction on the depth of preschoolers' social interaction. *Early Education and Development*, *28*(4), 457-474. https://doi.org/10.1080/10409289.2016.1246287

Lin, Y., & Yu, Z. (2023). A meta-analysis of the effects of augmented reality technologies in interactive learning environments (2012–2022). *Computer Applications in Engineering Education, 31*(4), 1111-1131. https://doi.org/10.1002/cae.22628

Maloch, B. (2002). Scaffolding student talk: One teacher's role in literature discussion groups. *Reading Research Quarterly*, *37*(1), 94-112. https://doi.org/10.1598/RRQ.37.1.4

Momtaz, E., & Garner, M. (2010). Does collaborative learning improve EFL students' reading comprehension. *Journal of Linguistics and Language Teaching*, *1*(1), 15-36.
Moses, L., Ogden, M., & Beth Kelly, L. (2015). Facilitating meaningful discussion groups in the primary grades. *The Reading Teacher*, *69*(2), 233-237. https://doi.org/10.1002/trtr.1392
Nadita, S. A., Maheswari, E. A. P., Santoso, K. A., Cahyono, M. A. D., & Permana, F. (2023, August). Utilization of Augmented Reality for Introducing Tongkonan Toraja Traditional House. In *2023 International Conference on Information Management and Technology (ICIMTech)* (pp. 837-842). IEEE. https://doi.org/10.1109/ICIMTech59029.2023.10277853
Olsson, T., Kärkkäinen, T., Lagerstam, E., & Ventä-Olkkonen, L. (2012). User evaluation of mobile augmented reality scenarios. *Journal of Ambient Intelligence and Smart Environments*, *4*(1), 29-47. https://doi.org/10.3233/AIS-2011-0127
Passarelli, A. M., & Kolb, D. A. (2012). Experiential Learning Theory. *Student Learning Abroad: What Our Students Are Learning, What They're Not, and What We Can Do About It*. Routledge.
Philippine News Agency. (2022). Pandemic, school disruption stunt learners' reading skills. Retrieved from https://www.pna.gov.ph/articles/1189522
Pilgrim, J., & Martinez, E. E. (2013). Defining literacy in the 21st century: A guide to terminology and skills. *Texas Journal of Literacy Education*, *1*(1), 60-69.
Pilgrim, J. M., & Pilgrim, J. (2016). The use of virtual reality tools in the reading-language arts classroom. *Texas Journal of Literacy Education*, *4*(2), 90-97.
Rai, M. K., Loschky, L. C., Harris, R. J., Peck, N. R., & Cook, L. G. (2011). Effects of stress and working memory capacity on foreign language readers' inferential processing during comprehension. *Language Learning*, *61*(1), 187-218. https://doi.org/10.1111/j.1467-9922.2010.00592.x
Rau, P. L. P., Zheng, J., Guo, Z., & Li, J. (2018). Speed reading on virtual reality and augmented reality. *Computers & Education*, *125*, 240-245. https://doi.org/10.1016/j.compedu.2018.06.016
Ro, Y.K., Brem, A., Rauschnabel, P.A. (2018). Augmented Reality Smart Glasses: Definition, Concepts and Impact on Firm Value Creation. In: Jung, T., tom Dieck, M. (eds) Augmented Reality and Virtual Reality. Progress in IS. Springer, Cham. https://doi.org/10.1007/978-3-319-64027-3_12
Roopa, D., Prabha, R., & Senthil, G. A. (2021). Revolutionizing educational systems using interactive augmented reality for quality education. *Materials Today: Proceedings*, *46*, 3860-3863.
Siegel, B. E. (2019). *Kid food: The challenge of feeding children in a highly processed world*. Oxford University Press.
Sutherland, J., Westbrook, J., Oakhill, J., & Sullivan, S. (2023). An immersive,'Faster Read': a pilot, mixed-method study, developing whole-text reading comprehension and engagement with adolescent struggling readers. *Research Papers in Education*, 1-23. https://doi.org/10.1080/02671522.2023.2238285
Vaughn, S., Klingner, J. K., Swanson, E. A., Boardman, A. G., Roberts, G., Mohammed, S. S., & Stillman-Spisak, S. J. (2011). Efficacy of collaborative strategic reading with middle school students. *American Educational Research Journal*, *48*(4), 938-964. https://doi.org/10.3102/0002831211410305

Appendix

AR^2 Evaluation Questionnaire (See https://bit.ly/4dWfZZz)