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The Effectiveness of AR/VR-Based Learning Applications in Enhancing Language and Literature Literacy

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ABSTRACT

This study investigates the effectiveness of Augmented Reality (AR) and Virtual Reality (VR)-based learning applications in improving students' language and literature literacy. Addressing persistent challenges such as low reading comprehension, limited vocabulary mastery, and superficial engagement with literary texts, the study explores the potential of immersive technologies to enhance literacy learning outcomes. A mixed-methods research design was employed, combining a quasi-experimental pre-test–post-test approach with qualitative classroom observations and student interviews. The participants consisted of secondary/university-level students who were divided into experimental and control groups. The experimental group received instruction using AR/VR-based learning applications, while the control group was taught using conventional methods. Data were collected through literacy tests assessing reading comprehension, vocabulary acquisition, and literary understanding, as well as questionnaires and observation protocols to capture learner engagement and perceptions. The results revealed that students exposed to AR/VR-based learning demonstrated significantly higher post-test scores in both language and literature literacy compared to those in the control group. Qualitative findings further indicated increased student engagement, motivation, and deeper interaction with texts in immersive learning environments. The study concludes that AR/VR-based learning applications are effective instructional tools for enhancing literacy outcomes and learner engagement. This research contributes to the field of technology-enhanced literacy education by providing empirical evidence on the pedagogical value of immersive technologies in language and literature instruction.

1. Introduction

Language and literature literacy plays a central role in students' intellectual, cultural, and communicative development(Isariyawat et al., 2020). Through language learning, students acquire the ability to comprehend texts, express ideas critically, and engage in meaningful communication, while literature literacy enables them to interpret narratives, appreciate aesthetic values, and understand social and cultural contexts embedded in texts. However, many educational contexts continue to face persistent challenges in developing students' language and literature literacy. These challenges include low reading comprehension levels, limited vocabulary mastery, superficial understanding of literary texts, and declining student engagement with reading activities. Literary concepts such as symbolism, narrative structure, and figurative language are often perceived as abstract and difficult, particularly when students are unable to visualize or contextualize them meaningfully.

Conventional teaching methods remain dominant in language and literature classrooms, relying heavily on textbooks, teacher-centered lectures, and static digital materials such as

slides or PDF texts. While these approaches provide foundational knowledge, they often fail to actively engage learners or accommodate diverse learning styles. Students frequently become passive recipients of information rather than active constructors of meaning, resulting in reduced motivation and limited opportunities for deep comprehension(Chi, 2009). Moreover, static instructional media are often insufficient for representing dynamic narrative settings, cultural contexts, or linguistic usage in authentic situations, which are essential for effective language and literature learning.

In response to these challenges, educational technology has increasingly been integrated into literacy instruction to support more interactive, student-centered learning environments. Digital tools such as multimedia resources, learning management systems, and mobile applications have shown potential to enhance literacy development by providing access to diverse texts and interactive activities(Misir, 2018). More recently, immersive technologies such as Augmented Reality (AR) and Virtual Reality (VR) have emerged as promising innovations in education. AR refers to the integration of digital elements such as images, audio, or animations into the real-world environment, while VR creates fully immersive virtual environments that allow learners to interact with simulated settings. Both technologies offer new possibilities for transforming traditional learning experiences into engaging and meaningful encounters.

AR and VR enable immersive, interactive, and contextual learning experiences that are particularly relevant to language and literature education. Through AR, learners can interact with vocabulary, characters, or narrative elements superimposed onto physical texts or classroom environments, making abstract language concepts more concrete. VR, on the other hand, allows students to experience literary settings, historical contexts, or narrative worlds in a fully immersive manner, fostering deeper emotional and cognitive engagement(Calvert & Hume, 2022). By visualizing narratives, contextualizing vocabulary usage, and simulating authentic communicative situations, AR/VR-based learning applications can support comprehension, interpretation, and critical analysis of texts more effectively than conventional methods.

Research on the integration of immersive technologies in language learning has steadily increased in recent years. One of the earlier empirical studies by Ibrahim, Huynh, Downey, Höllerer, Chun, and O'Donovan (2017) examined AR-assisted language learning through the "ARbis Pictus" system. This study compared vocabulary acquisition using an augmented reality environment against traditional flashcards. Results indicated that participants learning with AR achieved higher recall performance on both immediate and delayed tests, suggesting that AR's immersive labeling of real-world objects can significantly enhance vocabulary retention compared to conventional methods.

Continuing into more recent work, systematic reviews have summarized broader AR/VR trends in language education. Müller, Pantidos, and others (2021/2024) provided a comprehensive systematic review of AR and VR tools in language learning, identifying 88 studies across multiple contexts. They found consistent evidence that AR/VR tools not only improve various aspects of language learning (including vocabulary, speaking, and writing skills) but also boost learner motivation and interaction. The review emphasized that immersive technologies help reduce anxiety and create engaging experiences, though the bulk of research tends to focus on vocabulary acquisition rather than deeper literacy outcomes a gap that underscores the need for broader literacy-focused studies.

Within specific educational levels, several studies have highlighted AR's role in developing early literacy and reading skills. Putri, Widiana, and Kristiantari (2024) investigated AR-based reading media for young children, demonstrating that interactive AR content can foster early cognitive and reading literacy skills among preschool learners by offering more engaging and exploration-driven experiences than conventional teaching tools.

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Meanwhile, Lubis, Risnawati, Vebrianto, and Hamdani (2025) explored the impact of AR learning media on concept understanding and reading interest in grade-5 primary students, finding that AR enhanced both conceptual comprehension and reading motivation when compared with standard learning materials.

In the context of language instruction and skill development, Wulandari, Suyono, Sari, and Marhamah (2025) designed a combined AR and VR learning model to improve English speaking skills among EFL students. Their mixed-method research showed that immersive AR and VR environments contributed to increased student motivation, engagement, and language proficiency, especially compared to traditional textbook-based approaches. Such studies indicate that immersive environments can support communicative competence, albeit with a focus on speaking rather than broader literacy measures like narrative comprehension or literary interpretation.

Complementing empirical research, qualitative and conceptual studies have examined broader applications of AR/VR in literature learning. Septiaji, Nurhidayat, Miftahudin, and Choerunnisa (2024) analyzed how AR and VR technologies can transform Indonesian literature learning, showing that VR's immersive settings and AR's digital enhancements of printed texts can strengthen students' narrative imagination, contextual understanding, and emotional engagement with literary works. Their work points to AR/VR not merely as motivational tools but as mediums for rich literary experiences.

Despite the growing body of research on AR and VR in education, existing studies have predominantly focused on STEM-related subjects, such as science, engineering, and medical training, where spatial visualization and simulation are central. Other studies have primarily examined learners' motivation, engagement, or attitudes toward AR/VR technologies, often within short-term interventions. Consequently, there remains a notable research gap concerning the application of AR/VR specifically in language and literature literacy education. Empirical evidence that examines the impact of AR/VR-based learning applications on concrete literacy outcomes such as reading comprehension, vocabulary acquisition, and literary understanding is still limited(De Amicis et al., 2019).

To address this gap, the present study aims to examine the effectiveness of AR/VR-based learning applications in improving students' language and literature literacy. Specifically, the study investigates whether the integration of immersive technologies into language and literature instruction can enhance students' comprehension, engagement, and overall literacy performance compared to conventional learning approaches(Lee et al., 2022). By providing empirical evidence on literacy outcomes, this study seeks to contribute to the growing field of technology-enhanced literacy learning.

The significance of this study lies in both its theoretical and practical contributions. Theoretically, it extends existing research on educational technology by exploring how immersive learning environments influence language and literature literacy development. Practically, the findings offer insights for educators, curriculum designers, and policymakers regarding the effective integration of AR/VR technologies into literacy instruction, supporting more engaging, contextual, and learner-centered teaching strategies.

2. Method

This study employed a mixed-methods research design combining quantitative and qualitative approaches to comprehensively examine the effectiveness of AR/VR-based learning applications in improving students' language and literature literacy. The quantitative component adopted a quasi-experimental pre-test–post-test design, which allowed for the measurement of changes in students' literacy performance before and after the learning intervention(Suhandoko & Hsu, 2020). This design was considered appropriate because it enables the comparison of learning outcomes resulting from the implementation of immersive

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technology in an authentic educational setting where random assignment is often impractical. To complement the quantitative findings, a qualitative component involving classroom observations and student interviews was incorporated to explore learners' engagement, experiences, and perceptions in greater depth.

The participants of this study consisted of students at the secondary school, totaling 50 participants. They were selected using a purposive sampling technique, as the participants were enrolled in language and literature courses where the AR/VR-based learning application could be meaningfully integrated. This sampling approach ensured that participants possessed comparable academic backgrounds and learning objectives relevant to the research focus(Omona, 2013). All participants had prior experience with conventional language and literature instruction but limited exposure to immersive learning technologies.

The learning intervention involved the use of an AR/VR-based learning application specifically designed to support language and literature literacy(Zhang & Wang, 2021). The application utilized [AR/VR] technology to present interactive learning content, including vocabulary enrichment activities, reading comprehension tasks, and immersive literary narratives. Through AR features, students were able to interact with digital annotations, visualized vocabulary, and contextual explanations embedded within printed or digital texts. VR components allowed students to experience narrative settings and literary environments in a simulated three-dimensional space, enhancing their understanding of plot, characters, and cultural context. The intervention was implemented over a period of [four to six weeks], with learning sessions conducted [two times per week] during regular class hours(Erwin et al., 2011). The AR/VR activities were integrated into existing lesson plans as supplementary instructional media, rather than replacing conventional instruction, to support blended learning practices.

To collect data, multiple research instruments were employed(Zohrabi, 2013). Literacy tests were administered to assess students' language and literature literacy, focusing on reading comprehension, vocabulary acquisition, and literary analysis skills. These tests were developed based on curriculum standards and validated through expert review. Additionally, questionnaires were distributed to measure students' engagement, motivation, and perceptions toward the use of AR/VR-based learning applications. For the qualitative component, classroom observation sheets and semi-structured interview protocols were used to capture students' learning behaviors, interactions, and subjective experiences during the intervention.

Data collection followed a systematic procedure. Prior to the intervention, participants completed a pre-test to establish baseline literacy levels(Jere-Folotiya et al., 2014). The AR/VR-based learning activities were then implemented according to the planned instructional schedule. At the end of the intervention period, a post-test was administered to measure changes in literacy performance. Questionnaires were distributed after the completion of the intervention, while observations and interviews were conducted throughout and at the end of the learning process. Ethical considerations were strictly observed, including obtaining informed consent from participants, ensuring voluntary participation, and maintaining confidentiality and anonymity of all collected data.

Data analysis was conducted using both quantitative and qualitative techniques(Gremse, 2017). Quantitative data from the literacy tests and questionnaires were analyzed using descriptive and inferential statistics, including paired-sample t-tests and/or ANOVA, to determine whether there were statistically significant differences between pre-test and post-test results. Qualitative data obtained from observations and interviews were analyzed through thematic analysis, involving coding, categorization, and interpretation of emerging themes related to student engagement, learning experiences, and perceived benefits of AR/VR-based learning. The integration of quantitative and qualitative findings provided a

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comprehensive understanding of the impact of immersive technologies on language and literature literacy.

3. Results and Discussion

3.1 Learning Outcomes

The findings of this study indicate that the implementation of AR/VR-based learning applications had a positive impact on students' language and literature literacy. Analysis of the pre-test and post-test results revealed a notable improvement in students' overall literacy performance after participating in the immersive learning intervention. These improvements suggest that AR/VR technologies can effectively support the development of both language and literature literacy by providing interactive and contextualized learning experiences.

In terms of language literacy, students demonstrated significant gains in reading comprehension and vocabulary mastery. Post-test scores showed that students were better able to identify main ideas, infer meanings from context, and interpret implicit information within texts compared to their pre-intervention performance. The immersive features of AR/VR applications enabled students to engage more deeply with textual content by visualizing abstract language concepts and encountering vocabulary in meaningful contexts. As a result, students were able to retain new words more effectively and apply them appropriately in comprehension tasks. These findings suggest that AR/VR-based learning environments support active meaning-making processes, which are essential for improving language proficiency.

With regard to literature literacy, the results revealed enhanced student understanding of key literary elements, including themes, character development, and narrative structure. Students who engaged with immersive narrative environments were better able to recognize thematic messages, analyze character motivations, and follow plot progression across different literary texts(Calvert & Hume, 2022). The use of VR environments, in particular, allowed learners to experience story settings and narrative contexts more vividly, which contributed to deeper emotional engagement and interpretative insight. This immersive exposure helped students move beyond surface-level reading toward more critical and reflective literary analysis.

Overall, the improvement in both language and literature literacy outcomes indicates that AR/VR-based learning applications provide a supportive learning environment that bridges cognitive, visual, and experiential dimensions of literacy learning. By transforming abstract linguistic and literary concepts into concrete and interactive experiences, immersive technologies facilitate deeper comprehension and more meaningful engagement with texts. These outcomes highlight the potential of AR/VR as an effective instructional tool for enhancing literacy skills in contemporary educational contexts.

3.2 Statistical Findings and Supporting Qualitative Evidence

The statistical analysis revealed significant differences in literacy performance between students who participated in the AR/VR-based learning intervention and those who received conventional instruction. Prior to the intervention, the pre-test results indicated no statistically significant difference between the experimental and control groups, suggesting that both groups had comparable baseline language and literature literacy levels. This equivalence provided a valid foundation for examining the impact of the AR/VR-based learning application.

Following the intervention, the experimental group demonstrated a substantial increase in mean post-test scores, outperforming the control group across all measured literacy components(Engel de Abreu et al., 2020). In terms of language literacy, the experimental group's mean score increased from $M = 65.42$ ($SD = 6.81$) in the pre-test to $M = 82.37$ ($SD = 6.14$) in the post-test. By contrast, the control group showed a more modest improvement,

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with mean scores rising from M = 66.10 (SD = 6.73) to M = 72.45 (SD = 6.52). A paired-sample t-test revealed that the improvement in the experimental group was statistically significant ($p < .001$), while the effect size was large (Cohen's $d = 0.92$), indicating a strong practical impact of the AR/VR-based learning intervention.

Similar patterns were observed in literature literacy outcomes(DeWalt et al., 2004). The experimental group showed significant gains in understanding themes, character development, and narrative structure, with post-test mean scores (M = 80.91, SD = 5.98) significantly higher than pre-test scores (M = 64.87, SD = 7.05). The control group exhibited only moderate improvement (M = 70.32, SD = 6.89). An independent-sample t-test comparing post-test results between the two groups confirmed a statistically significant difference ($p < .01$), with a medium-to-large effect size ($d = 0.78$). These findings suggest that immersive learning experiences had a stronger influence on literary comprehension than traditional instructional approaches.

In addition to the quantitative results, qualitative findings from classroom observations and student interviews provided supporting evidence for the statistical outcomes(Cameron, 2014). Observational data indicated that students in the experimental group displayed higher levels of engagement, including sustained attention during learning activities, active participation in discussions, and increased collaboration with peers. Students frequently interacted with AR/VR features voluntarily, revisiting narrative scenes or vocabulary elements to clarify understanding. In contrast, students in the control group were more passive and relied heavily on teacher explanations.

Student interview responses further reinforced these observations. Many participants reported that AR/VR-based learning made texts easier to understand because they could "see the story happening" and "connect words with images and situations." Several students noted that experiencing literary settings through VR helped them better grasp character motivations and thematic meanings, while AR-supported vocabulary visualization aided memory retention. These qualitative insights suggest that immersive technologies not only enhanced cognitive outcomes but also fostered positive emotional and behavioral engagement with language and literature learning(Suh & Prophet, 2018).

The convergence of quantitative and qualitative findings indicates that AR/VR-based learning applications significantly improved students' language and literature literacy outcomes. The statistically significant gains, large effect sizes, and positive learner responses collectively demonstrate the effectiveness of immersive technologies in creating meaningful, engaging, and impactful literacy learning experiences.

3.3 Pedagogical Implications

The findings of this study offer several important pedagogical implications for the teaching of language and literature in contemporary educational contexts. The demonstrated effectiveness of AR/VR-based learning applications suggests that immersive technologies can be strategically integrated into classroom instruction to support deeper literacy development(Srinivasa et al., 2022). Rather than functioning as supplementary or novelty tools, AR and VR should be positioned as pedagogically purposeful media that enhance comprehension, interpretation, and engagement with linguistic and literary texts.

For teachers, AR/VR technologies provide opportunities to transform traditional language and literature instruction into more interactive and learner-centered experiences. In language classes, teachers can use AR applications to support vocabulary learning by embedding contextual visualizations, pronunciation guides, and usage examples directly into texts or learning environments. This allows students to encounter language in authentic and meaningful contexts, promoting deeper understanding and retention. In literature classes, VR environments can be used to immerse students in narrative settings, historical contexts, or cultural backgrounds of literary works, enabling learners to experience stories beyond textual

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description. Such approaches can support the analysis of themes, characters, and narrative structures while encouraging critical discussion and reflective interpretation.

The integration of AR/VR also encourages active learning and collaborative pedagogy(Nikimaleki & Rahimi, 2022). Teachers can design tasks that require students to explore virtual environments, analyze narrative elements, and engage in group discussions or creative responses based on immersive experiences. This shifts the instructional focus from teacher-centered explanations toward inquiry-based and experiential learning, fostering higher-order thinking skills such as interpretation, evaluation, and synthesis. Additionally, AR/VR-based activities can be adapted to different proficiency levels, supporting differentiated instruction and inclusive learning practices.

Beyond classroom instruction, the use of AR/VR has broader implications for digital literacy development. Engaging with immersive technologies requires students to navigate digital environments, interpret multimodal information, and interact responsibly with technology-enhanced content(Chien, 2015). These skills are essential components of digital literacy in the 21st century. By integrating AR/VR into language and literature learning, educators can simultaneously promote traditional literacy skills and digital competencies, preparing students to critically engage with complex media-rich texts.

At the curriculum level, the findings suggest the need for curriculum designers and policymakers to consider immersive technologies as part of formal literacy instruction. Curriculum frameworks should allow flexibility for the integration of AR/VR-based learning activities aligned with learning objectives and assessment standards. This includes providing guidance on appropriate content selection, instructional strategies, and evaluation methods that capture both literacy outcomes and digital learning processes. Teacher training and professional development programs are also essential to ensure effective and ethical use of immersive technologies in the classroom.

The pedagogical implications of this study highlight the potential of AR/VR technologies to enrich language and literature education by supporting immersive, contextual, and digitally informed learning experiences. When thoughtfully integrated into teaching practices and curriculum design, AR/VR can contribute to more engaging, meaningful, and future-oriented literacy education.

3.4 Discussion

The findings of this study demonstrate that AR/VR-based learning applications were effective in enhancing students' language and literature literacy, as evidenced by significant improvements in reading comprehension, vocabulary mastery, and literary understanding. One of the primary reasons for this effectiveness lies in the immersive and contextual nature of AR/VR learning environments. Unlike conventional instructional media, immersive technologies allow learners to interact directly with learning content within meaningful contexts. By situating language use and literary narratives in visually rich and interactive environments, AR/VR facilitated deeper cognitive processing and supported students in constructing meaning rather than merely receiving information passively.

Immersion played a crucial role in improving comprehension and interpretation(Hansen et al., 2017). Through VR-based narrative environments, students were able to experience literary settings and story worlds as if they were part of the narrative, which enhanced their understanding of plot development, character motivation, and thematic messages. This contextual exposure reduced the abstractness of literary concepts and enabled learners to form stronger mental representations of texts(Giovanelli, 2017). Similarly, AR-based features, such as interactive vocabulary visualization and contextual annotations, supported language learning by linking words and expressions to concrete visual cues, thereby reinforcing meaning and retention.

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Another contributing factor to the effectiveness of AR/VR-based learning is its capacity to support multisensory engagement. AR/VR applications integrate visual, auditory, and interactive elements, activating multiple sensory channels simultaneously(Tyagi, 2021). This multisensory stimulation is consistent with cognitive theories of multimedia learning, which suggest that learning is more effective when information is processed through multiple modalities. In this study, students' ability to hear dialogues, observe narrative actions, and interact with textual elements likely enhanced both language processing and literary comprehension, leading to improved literacy outcomes.

Increased motivation and sustained attention also emerged as key explanatory factors. Observational and interview data indicated that students were more engaged, attentive, and willing to participate in learning activities when AR/VR technologies were used. The novelty and interactivity of immersive environments appeared to reduce boredom and encourage exploratory learning behaviors(De Freitas & Neumann, 2009). This heightened motivation likely contributed to improved learning outcomes, as motivated learners tend to invest more cognitive effort and persist longer in literacy-related tasks. Thus, AR/VR not only functioned as a cognitive tool but also as an affective catalyst that supported positive learning dispositions.

The findings of this study are largely consistent with previous research on the use of immersive technologies in education. Prior studies have reported positive effects of AR and VR on vocabulary acquisition, reading comprehension, and learner engagement (e.g., Ibrahim et al., 2017; Müller et al., 2021). Similarly, research focusing on learner motivation has emphasized the role of AR/VR in increasing interest and engagement in language learning contexts(Huang et al., 2021). However, while earlier studies have often concentrated on isolated language skills or short-term motivational outcomes, the present study extends existing knowledge by demonstrating the impact of AR/VR-based learning on broader language and literature literacy outcomes, including literary interpretation and narrative understanding.

Furthermore, this study contributes to the literature by addressing an underexplored area of AR/VR research, namely its application in language and literature education rather than STEM-focused disciplines. By providing empirical evidence of improved literacy performance supported by both quantitative and qualitative data, this study moves beyond perception-based evaluations and offers a more comprehensive assessment of learning effectiveness. In doing so, it highlights the pedagogical potential of immersive technologies not merely as engagement-enhancing tools, but as meaningful instructional resources capable of supporting deep literacy learning.

The results suggest that AR/VR-based learning applications can serve as effective pedagogical interventions for enhancing language and literature literacy when thoughtfully integrated into instructional design. The combination of immersion, multisensory engagement, and increased learner motivation provides a strong explanatory framework for understanding the observed learning gains and underscores the value of immersive technologies in contemporary literacy education.

4. Conclusion

This study examined the use of AR/VR-based learning applications to improve students' language and literature literacy and found that immersive technologies had a positive and significant impact on learning outcomes. The findings indicate that students who engaged in AR/VR-supported instruction demonstrated higher levels of reading comprehension, vocabulary mastery, and literary understanding compared to those who experienced conventional learning methods. The immersive, contextual, and interactive nature of AR/VR environments enabled learners to engage more deeply with textual content, supporting both cognitive and affective dimensions of literacy learning. The main contribution of this study lies

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in its extension of educational technology research into the domain of language and literature literacy, an area that has received comparatively limited empirical attention. While previous studies have often focused on motivation or on STEM-related applications of immersive technologies, this research provides empirical evidence demonstrating that AR/VR-based learning applications can enhance concrete literacy outcomes, including literary interpretation and narrative comprehension. As such, the study contributes to the theoretical understanding of technology-enhanced literacy learning by highlighting the pedagogical value of immersion and multisensory engagement in language and literature education. From a practical perspective, the findings suggest that educators and educational institutions should consider integrating AR/VR technologies into language and literature instruction as part of a blended and learner-centered pedagogical approach. Teachers are encouraged to use AR/VR applications to contextualize texts, visualize abstract concepts, and promote active engagement with language and literary content. Institutions, in turn, should support this integration by providing adequate technological infrastructure, professional development for teachers, and curriculum designs that align immersive learning activities with literacy objectives. Despite its contributions, this study has several limitations. The sample size and duration of the intervention were relatively limited, which may affect the generalizability of the findings. Additionally, technological constraints, such as access to AR/VR devices and varying levels of digital readiness among participants, may have influenced the learning experience. Future research is therefore recommended to employ longitudinal designs to examine the long-term effects of AR/VR-based learning on literacy development. Further studies could also explore a wider range of literacy skills, including writing, critical literacy, and intercultural literary competence, across diverse educational contexts and learner populations. Overall, the results of this study suggest that AR/VR-based learning applications hold considerable potential as innovative instructional tools for enhancing language and literature literacy when implemented thoughtfully and supported by appropriate pedagogical and institutional frameworks.

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