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Exploring the effectiveness of the VAK-Augmented reality learning model on English-Speaking fluency and comprehension among nursing students

Athia Fidian[1,2]*, Nur Hidayanto Pancoro Setyo Putro[3], Arif Rohman[4]

[1,3,4]Universitas Negeri Yogyakarta, Yogyakarta, Indonesia
[2]Universitas Muhammadiyah Magelang, Magelang, Indonesia

Abstract

This study explores the effectiveness of the Visual Auditory Kinesthetic (VAK) learning model assisted by Augmented Reality (AR) in improving nursing students' English-speaking fluency and comprehension. The research employed a quasi-experimental design involving 155 students from three nursing programs in Indonesia, divided into three experimental and one control group. The experimental groups were taught using the VAK-AR learning model, while the control group received conventional instruction. Data were collected using a standardized speaking performance rubric assessing pronunciation, grammar, vocabulary, fluency, and comprehension. The Kruskal–Walli's test revealed significant differences across all speaking components ($p < .001$), with large effect sizes for fluency ($\varepsilon^2 = 0.330$) and moderate for comprehension ($\varepsilon^2 = 0.229$). The findings indicate that the VAK-AR learning model enhances multimodal engagement and contextual learning, leading to improved communicative competence among nursing students. The study contributes to the growing body of research on technology-enhanced language learning (TELL) and English for Nursing Purposes (ENP), demonstrating that AR-based multimodal approaches can bridge the gap between linguistic knowledge and real-world communication.

Keywords: Visual auditory kinesthetic, Augmented reality, English for nursing, Fluency, Comprehension, Multimodal learning

1.Introduction

The ability to communicate effectively in English has become an indispensable skill for nursing professionals working in globalized healthcare settings, where language accuracy influences patient safety and interprofessional collaboration (Jiang et al., 2024). Within English for Nursing Purposes (ENP), emphasis is placed not merely on grammar and vocabulary but on the development of communicative competence that allows nurses to engage empathetically and efficiently with patients and healthcare colleagues (Q. Huang & Yu, 2023). Despite its significance, traditional English instruction for nursing students dominated by grammar-translation and memorization that has been criticized for producing learners who are theoretically competent yet communicatively limited (X. Wu, 2024).

Recent advances in educational technology have transformed traditional classrooms into immersive multimodal environments, where tools such as Augmented Reality (AR) enable context-driven, interactive learning experiences (Chang et al., 2020; Duyen & Nhia, 2025). AR facilitates the overlay of virtual elements onto the physical world, allowing learners to visualize, manipulate, and interact with 3D nursing-related objects in real time (Yoo et al., 2024). In language education, AR has been shown to increase student engagement, improve pronunciation accuracy, and reduce speaking anxiety (Yoo et al., 2024).

For nursing students, AR's ability to simulate real clinical communication scenarios offers an innovative approach to practice English in authentic, risk-free settings (Choi, 2021; Yoo et al., 2024). However, for AR to be pedagogically effective, it requires integration within an instructional model that supports multisensory learning. The Visual Auditory Kinesthetic (VAK) model, proposed by Fleming and Mills (1992), provides a robust theoretical foundation for such integration by engaging multiple sensory modalities during learning. This model enhances retention and comprehension by aligning instructional input with learners' dominant sensory channels (Tene et al., 2024). When applied in language learning contexts,

Correspondence: Athia Fidian, Universitas Negeri Yogyakarta, Yogyakarta, Indonesia, **e-mail:** athiafidian.2022@student.uny.ac.id, **Received:** October 19, 2025 **Accepted:** December 6, 2025

the VAK model enables students to see, hear, and physically enact communicative tasks, leading to more durable learning outcomes (Li et al., 2025).

The theoretical underpinning of the VAK-AR framework aligns with Dual Coding Theory (Clark & Paivio, 1991) and Embodied Cognition Theory (Barsalou, 2012). Dual Coding posits that cognitive processing is strengthened when verbal and visual representations interact synergistically, while Embodied Cognition emphasizes that learning is grounded in bodily experience and sensorimotor activity. Together, these theories explain why multimodal and kinesthetic learning environments enhanced by AR, can effectively reinforce linguistic memory and communication competence (Akcayir & Akcayir, 2017; Duyen & Nhia, 2025).

In health-related English instruction, the adoption of multimodal pedagogy has been found to promote both linguistic and professional skills (Rahmatullah & Kadarwati, 2024; Yeo et al., 2024; Yoo et al., 2024). Recent empirical research indicates that Augmented Reality (AR)-enhanced English for Specific Purposes (ESP) modules have substantially improved nursing students' situational awareness, communicative confidence, and speaking fluency within professional healthcare contexts. Furthermore, emerging studies have contributed empirical and theoretical insights into the pedagogical potential of AR-assisted multimodal learning, highlighting its capacity to foster deeper engagement and linguistic retention. Through the integration of visual, auditory, and kinesthetic sensory pathways, multimodal environments promote embodied interaction and authentic communicative practice, thereby advancing ESP pedagogy in healthcare education.

This convergence between AR technology and multimodal learning theory underscores the transformative potential of sensory integration in bridging linguistic competence with professional communication skills essential for nursing practice (Lampropoulos et al., 2025; Mansour et al., 2025; Quqandi et al., 2023).

2. Method

2.1 Research design

This study adopted a quasi-experimental, non-equivalent control group design, a methodology commonly applied in educational research where random assignment is impractical (Creswell & Creswell, 2023). This design enabled the comparison of speaking performance outcomes between students who received the VAK–Augmented Reality (VAK-AR) intervention and those taught using conventional methods. The experimental phase lasted six instructional sessions covering English for Nursing topics such as patient admission, describing symptoms, and physical assessment dialogues.

This design ensured ecological validity while maintaining comparability across conditions, following best practices in AR-enhanced and multimodal learning research (Rahmatullah & Kadarwati, 2024; Yeo et al., 2024; Yoo et al., 2024) (Rahmatullah et al., 2024; Yoon & Park, 2024). Both the experimental and control classes were taught by the same instructors to ensure instructional consistency, and identical rubrics and content were applied to minimize instructor bias (Pallant, 2020).

2.2 Participants

The participants consisted of 155 nursing students drawn from three higher education institutions in Indonesia:

1. STIKES Surya Global Yogyakarta (n = 33), representing a health sciences college emphasizing clinical practice;
2. Universitas Muhammadiyah Magelang - D3 Nursing Program (n = 47), a vocational-level nursing diploma program; and
3. Universitas Muhammadiyah Magelang- S1 Nursing Program (n = 39), an undergraduate nursing program.

Additionally, a control group of 36 students from the STIKES Surya Global participated in regular English for Nursing classes using traditional teaching methods. All participants were enrolled in mandatory English courses with similar proficiency levels, as determined by institutional placement tests. Participation was voluntary, and informed consent was obtained in accordance with ethical research guidelines for educational settings (BERA, 2021).

The diversity of institutional and academic backgrounds was intended to ensure that the study could assess the consistency of the VAK-AR model's effectiveness across varying educational contexts. Similar cross-institutional sampling strategies have been employed in studies of multimodal learning to enhance external validity (Li et al., 2025) (Li & Zhang, 2025).

2.3 Instruments

Data collection utilized a Speaking Performance Rubric adapted from Brown (2004), covering five indicators: pronunciation, grammar, vocabulary, fluency, and comprehension. Each criterion was scored on a 5-point Likert scale ranging from "very poor" (1) to "excellent" (5). The rubric's internal consistency was confirmed with a Cronbach's alpha of 0.87, indicating strong reliability.

In addition to performance scores, student perception data were collected using a structured questionnaire based on the System Usability Scale (SUS) (Brooke, 1996), to explore learner engagement and perceived usefulness of the AR component. The inclusion of both performance and perceptual measures aligns with recent AR-based language education studies emphasizing the importance of both outcome and experience (Anggraini, 2025; X. Huang et al., 2021; Schorr et al., 2024).

2.4 Procedures

The research was implemented over six weeks. In the experimental groups, students engaged in VAK-AR sessions where each lesson integrated three modes of sensory engagement: visual (via AR-based animations and clinical vocabulary cards), auditory (listening to dialogues and pronunciation models), and kinesthetic (performing simulated nurse–patient interactions through AR role-play). In the control group, instruction was delivered using PowerPoint slides, textbook reading, and question–answer sessions without AR integration.

Each AR-based module was developed using Unity 3D and accessed via mobile devices. Students can choose and klick the picture in the application to trigger 3D nursing objects (e.g., patients, tools, or symptom illustrations) and engaged in speaking activities designed following the VAK syntax: visualization → auditory modeling → kinesthetic practice (Fleming & Mills, 1992). These design principles are consistent with multimodal learning frameworks used in recent AR research (Schorr et al., 2024; J. Wu, 2024; Zheng, 2024).

2.5 Data analysis

Data normality was assessed using the Shapiro–Wilk test, which indicated non-normal distribution ($p < .001$). Consequently, non-parametric tests were employed, following statistical conventions for small educational samples (Pallant, 2020). The Kruskal–Wallis test was used to identify overall differences across groups, followed by the Dwass–Steel–Critchlow–Fligner post-hoc test to examine pairwise comparisons. Effect sizes (ε^2) were computed to interpret the magnitude of the differences, where 0.01, 0.06, and 0.14 represented small, medium, and large effects respectively.

The quantitative analysis was supported by descriptive statistics to illustrate mean and median trends. Results were triangulated with qualitative observation notes to strengthen validity through methodological triangulation (Creswell & Creswell, 2023).

3. Results

3.1 Descriptive statistics

Descriptive analysis showed consistent improvement across all three experimental groups that applied the VAK–Augmented Reality (VAK-AR) learning model compared to the control group. As presented in Table 1, the mean scores of speaking fluency ranged between 3.91 and 4.06 for the experimental groups, while the control group's average was 2.81. Similarly, comprehension scores ranged from 3.89 to 4.09 among the experimental groups, compared with 3.14 in the control group.

This pattern confirms that multimodal learning enhanced by AR offers a measurable pedagogical benefit in developing both fluency and comprehension. Comparable results have been reported in recent studies on AR-assisted ESP learning, showing that the combination of multimodal exposure and contextual interactivity improves oral production (Schorr et al., 2024; J. Wu, 2024; Zheng, 2024).

Table 1. Mean scores of speaking fluency and comprehension across groups

Aspect	Int_SSGB	Int_UniD3	Int_UniS1	Control
Fluency	4.06	3.91	4.05	2.81
Comprehension	4.09	3.89	4.00	3.14

Note. Int_SSGB = STIKES Surya Global; Int_UniD3 = D3 Nursing Program, Universitas Muhammadiyah Magelang; Int_UniS1 = S1 Nursing Program, Universitas Muhammadiyah Magelang.

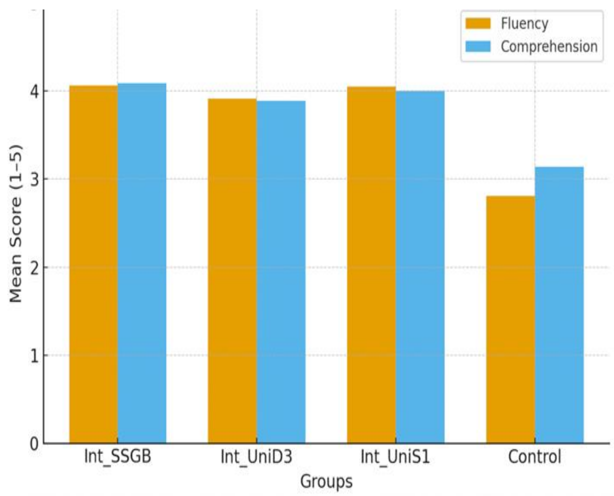

Figure 1. Comparison of mean scores for fluency and comprehension

The bar chart visually highlights the distinct gap between the experimental and control groups. All experimental groups achieved mean scores above 3.8 in both fluency and comprehension, indicating substantial performance enhancement, whereas the control group remained below 3.2. These differences suggest that AR-based VAK learning facilitated deeper cognitive encoding through multisensory engagement, consistent with findings by Li et al (2025).

3.2 inferential statistics

As the normality test (Shapiro–Wilk) indicated non-normal data ($p < .001$), the Kruskal–Wallis test was used to examine overall differences among the four groups. Results revealed statistically significant differences for both fluency and comprehension, as presented in Table 2.

Table 2. Kruskal–Wallis Test and Effect Size Results for Fluency and Comprehension

Variable	χ^2 (df = 3)	*p*	ε^2	Interpretation
Fluency	50.80	< .001	0.330	Strong effect
Comprehension	35.30	< .001	0.229	Moderate effect

Kruskal–Wallis test followed by Dwass Steel Critchlow Fligner post-hoc comparisons. The large effect size for fluency (ε^2 = 0.330) indicates that approximately one-third of the variance in students' fluency scores is attributable to the VAK-AR model implementation, demonstrating a strong practical impact. The moderate effect size for comprehension (ε^2 = 0.229) suggests meaningful but slightly less pronounced influence. These findings align with previous AR-based studies in health-related ESP contexts that reported medium-to-large effects on oral proficiency (Yeo et al., 2024; Yoo et al., 2024).

3.3 Post-hoc Analysis

Pairwise Dwass Steel Critchlow Fligner post-hoc tests revealed significant differences ($p < .001$) between the control group and all experimental groups, confirming that the VAK-AR learning model substantially improved speaking fluency and comprehension. However, no significant differences were observed among the three experimental groups ($p > .05$), indicating that the model's positive impact was consistent across different academic levels.

This consistency suggests that the model's design, rooted in the integration of visual, auditory, and kinesthetic modalities that is transferable and adaptable to varied educational contexts (Minh, 2024) (Nguyen & Chen (2024)). The uniform improvement across institutions also suggests that contextual or infrastructural differences did not substantially influence learning outcomes, a sign of the model's scalability and robustness (Rahmatullah & Kadarwati, 2024; Schorr et al., 2024; J. Wu, 2024; Yoo et al., 2024).

3.4 Interpretation and visual summary

The overall results provide compelling empirical evidence supporting the effectiveness of the VAK–AR learning model in enhancing nursing students' English-speaking performance. The observed gains in fluency and comprehension can be attributed to multimodal encoding, where simultaneous visual, auditory, and kinesthetic stimulation reinforces linguistic recall (Clark & Paivio, 1991; Fleming & Mills, 1992; Jam et al., 2025). Moreover, embodied interaction through AR role-play allows learners to simulate authentic nurse–patient dialogues, thereby promoting procedural fluency and contextual comprehension (Barsalou, 2012; Yeo et al., 2024; Yoo et al., 2024).

The distribution of median ranks, shown in Figure 2, further visualizes this pattern. Experimental groups are clustered at the higher end of the performance scale, while the control group lags significantly behind.

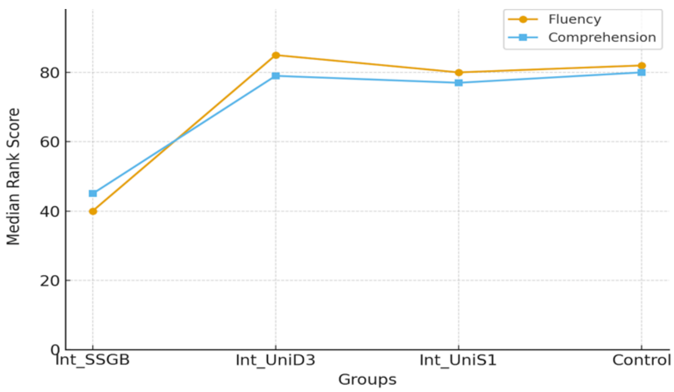

Figure 2. Median rank distribution for fluency and comprehension

The line chart illustrates the upward trend in performance across all experimental groups, showing consistent achievement and convergence near the upper quartile of scores. Both fluency and comprehension follow parallel patterns, confirming that the VAK-AR model consistently enhanced performance across contexts.

3.5 Summary of findings

Overall, the findings demonstrate that the implementation of the VAK–Augmented Reality learning model produced substantial improvements in students' English-speaking fluency and comprehension. The experimental groups consistently outperformed the control group with statistically significant and pedagogically meaningful gains. The magnitude of improvement, represented by large and moderate effect sizes, affirms the strong influence of multimodal sensory integration on speaking performance.

Furthermore, the uniform outcomes across institutions suggest that the model is highly scalable and adaptable, regardless of learners' academic levels or institutional contexts. These findings substantiate the cognitive foundations of Dual Coding Theory and Embodied Cognition, reinforcing the notion that learning is optimized when sensory modalities interact dynamically during instruction. Consistent with previous findings in (Panda et al., 2021; Yoo et al., 2024), the results indicate that multimodal AR-based environments can bridge the gap between linguistic knowledge and real-world professional communication in nursing contexts.

In summary, the VAK-AR learning model provides an empirically supported framework for enhancing oral proficiency in English for Nursing Purposes. It effectively combines visual, auditory, and kinesthetic learning dimensions with AR-based simulation, leading to improved fluency, comprehension, and contextual communication skills crucial for professional healthcare interactions.

4. Discussion

The findings of this study confirm that integrating the Visual Auditory Kinesthetic (VAK) learning model with Augmented Reality (AR) significantly enhances nursing students' English-speaking fluency and comprehension.

This aligns closely with the results of Fidian et al. (2025), who reported that VAK-AR digital learning effectively transformed nursing students' speaking ability by combining multisensory engagement and contextual AR simulations.

Both studies emphasize that multimodal and immersive instruction promotes deeper cognitive processing and authentic language use within clinical communication tasks.

The present study extends these findings by involving a larger multi-institutional sample and by focusing specifically on fluency and comprehension as performance indicators.

This result also reinforces the theoretical assumptions underlying Dual Coding Theory (Clark & Paivio, 1991) and Embodied Cognition Theory (Barsalou, 2012), both of which emphasize that multimodal and sensorimotor experiences strengthen memory and language processing. When learners simultaneously visualize, listen, and act out communicative situations, they activate multiple cognitive pathways that facilitate deeper language internalization and automaticity in speaking (Minh, 2024).

The results demonstrate that AR-based multimodal learning increases engagement and motivation by creating immersive and contextually relevant experiences. The significant improvement in fluency suggests that kinesthetic and auditory elements, especially interactive role-play simulations that help reduce speaking anxiety and encourage spontaneous language use. This aligns with Yoo et al., (2024), which reported that nursing students using AR simulations showed higher self-efficacy and confidence in English-mediated clinical communication.

The improvement in comprehension can be attributed to the visual and contextual cues embedded in the AR activities, which support learners' understanding of medical vocabulary and patient dialogue patterns (Li et al., 2025). The combination of visual representations and auditory input allows learners to construct meaning dynamically, supporting the cognitive mechanisms proposed by Dual Coding Theory.

Similarly, embodied interaction through kinesthetic movement facilitates procedural learning and retention, as supported by Embodied Cognition frameworks.

In parallel, Fidian & Pradana (2017), highlighted that digital media can enhance learners' cognitive engagement and self-regulation, suggesting that technology-mediated multimodal environments, such as the VAK-AR model, empower students to manage their learning actively. This process likely contributed to the increased fluency and comprehension observed in this study, as students became more autonomous and intrinsically motivated in the AR-based speaking tasks.

Another crucial insight is the consistency of outcomes across academic levels, from diploma to undergraduate nursing programs. It suggests that the VAK-AR model provides an equitable learning experience. This scalability is particularly important in health education, where students with varied proficiency levels must achieve similar communicative competencies (Duyen & Nhia, 2025; Schorr et al., 2024; J. Wu, 2024). The use of multisensory and technology-assisted strategies thus promotes inclusivity and ensures that learning outcomes are not dependent on prior linguistic advantage.

From a pedagogical standpoint, the integration of AR into VAK supports a constructivist and experiential approach. Learners engage in active meaning-making as they interact with authentic scenarios, rather than passively absorbing linguistic input (Creswell & Creswell, 2023). This experiential engagement aligns with the multimodal learning framework articulated by Fleming and Mills (1992), where learners who see, hear, and act simultaneously develop stronger cognitive associations. These principles are consistent with the results from Panda et al (2021), which found that extended reality methods enhance clinical reasoning and communication in nursing students.

In terms of professional application, the VAK-AR model serves as a bridge between language learning and clinical practice. Nursing students trained through this approach gain not only linguistic fluency but also situational awareness and empathy, two competencies central to patient-centered care. By replicating clinical environments through AR-based role-play, the model prepares students for real-world communicative demands while minimizing the risks associated with clinical inexperience (Yeo et al., 2024).

Overall, this study contributes to the growing body of evidence supporting the use of technology-enhanced multimodal learning in ESP education. It extends the scope of previous research by demonstrating that the fusion of AR and the VAK framework produces measurable improvements in two core aspects of oral performance; fluency and comprehension, while maintaining high levels of learner engagement and transferability across academic contexts (Li et al., 2025; Yoo et al., 2024).

5. Limitations and future work

Although the findings provide compelling evidence for the effectiveness of the VAK-AR model, several limitations should be acknowledged. First, the study employed a quasi-experimental design without random assignment, which may introduce potential group equivalence bias. Future studies could employ randomized controlled trials or mixed-method approaches to strengthen causal inferences and capture qualitative nuances of learner experience.

Second, the duration of the intervention (six sessions) may have limited the long-term observation of learning retention. Longitudinal studies are recommended to examine how sustained exposure to AR-supported multimodal instruction affects communicative competence over time.

Third, while this study focused on fluency and comprehension, other aspects of speaking performance such as pronunciation and grammatical accuracy warrant further exploration. Future research could integrate speech recognition and AI-based analytics to provide objective real-time feedback, which recent studies suggest can complement AR-driven multimodal learning (Akhtar et al., 2024; Li et al., 2025).

Lastly, although AR technology was well-received by participants, infrastructure and digital literacy remain challenges for broader implementation in resource-limited institutions (Wei et al., 2025). Future work should consider accessibility and scalability issues, particularly in low-resource educational environments, to ensure equitable integration of AR-based pedagogies.

Future researchers may also extend this model beyond nursing to other healthcare-related English programs such as pharmacy or midwifery, where context-specific language performance is equally essential. Doing so would contribute to establishing a comprehensive framework for AR-based multimodal ESP instruction.

6. Conclusion

This study provides empirical evidence that the Visual Auditory Kinesthetic-Augmented Reality (VAK-AR) learning model effectively enhances English-speaking fluency and comprehension among nursing students. By merging multisensory engagement with AR-based contextual learning, the model facilitates not only linguistic accuracy but also professional communicative competence essential for clinical environments.

The quasi-experimental results revealed significant group differences with large effect sizes, confirming the model's pedagogical impact. These findings substantiate the theoretical frameworks of Dual Coding and Embodied Cognition, demonstrating how multimodal stimuli and kinesthetic interaction strengthen learning retention and oral performance.

Pedagogically, the VAK-AR model bridges the gap between language learning theory and healthcare practice, providing a scalable and adaptable framework for ESP instruction. It contributes to the growing discourse on technology-enhanced, multimodal, and experiential learning, showing that when appropriately designed, AR can serve as both a cognitive and affective catalyst for communicative competence.

In conclusion, this research not only validates the VAK-AR model's effectiveness but also highlights the potential for future innovations at the intersection of education, technology, and healthcare communication. With continued exploration, the VAK-AR model could redefine English for Nursing education by transforming linguistic knowledge into meaningful, embodied communication practice.

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