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Comparative Study on the Effectiveness of Real Case Teaching and AI-Generated Case Teaching in Speech Rehabilitation Education

Running title: Real vs. AI Cases in Speech Rehab Education

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Abstract: This study compared the effectiveness of real clinical cases versus AI-generated cases in speech rehabilitation professional education. Using a quasi-experimental design, 45 sophomore students majoring in rehabilitation therapy were randomly divided into real case (n = 23) and AI case (n = 22) groups. The intervention lasted two weeks, with pre-test and post-test assessments measuring students' theoretical knowledge and practical skills across four dimensions: diagnostic, intervention, treatment, and comprehensive abilities. Results showed significant overall improvement in both groups ($p < 0.001$, $d = 0.92$). While the real case group demonstrated greater improvement in intervention skills (25.7% vs. 14.6%), therapeutic skills (19.7% vs. 8.8%), and comprehensive abilities (17.4% vs. 5.7%), both groups showed comparable performance in diagnostic skills (13.0% vs. 12.0%). The findings suggest that real cases are more effective in developing advanced professional competencies, while AI-generated cases show promise in basic skill training. This study provides empirical evidence for implementing a staged approach to case-based teaching in speech rehabilitation education, combining the advantages of both real and AI-generated cases.

Keywords: Speech rehabilitation Education; Case-based Teaching; Artificial Intelligence; Professional Competency; Teaching Effectiveness; Educational Innovation; AI-generated cases; Mixed Teaching Method

1. Introduction

In recent years, with societal advancements and increased public health needs, the demand for speech rehabilitation services has grown rapidly [1,2]. As an essential platform for cultivating professional speech rehabilitation talent, higher education institutions face dual challenges of improving education quality and innovating teaching methodologies [3,4]. Especially in the post-pandemic era, innovative applications of educational technology provide new avenues for reforming professional training models [5,6].

Traditional speech rehabilitation education primarily relies on real clinical cases for teaching [7]. While this method offers advantages such as authenticity and contextualization [8], it has several limitations: a scarcity of high-quality teaching resources, a lack of diversity in case types that fails to cover the breadth of teaching content, and constraints from time, space, and ethical considerations in clinical teaching [9]. These limitations hinder improvements in teaching effectiveness [10]. Recently, the rapid development of artificial intelligence (AI) technologies has introduced new solutions, such as AI-generated teaching cases [11]. These systems can quickly produce personalized teaching cases based on specific educational objectives and adaptively recommend cases tailored to learners' knowledge levels and learning characteristics. This innovation presents new opportunities for reform and innovation in speech rehabilitation education [12].

However, educators face challenges in choosing and integrating these two teaching methods [13]. Specifically, they must address the following three core questions: how effective are real case teaching and AI case teaching in enhancing students' professional competencies? What differences exist between the two methods in developing specific dimensions of professional skills [14]? How can educators select the appropriate teaching mode based on learners' characteristics and stages of learning?

This study adopts an experimental approach to compare and analyze the application of real cases and AI-generated cases in speech rehabilitation education [15]. It aims to provide empirical evidence for optimizing the selection and integration of teaching methodologies, ultimately contributing to continuous improvements in educational quality for speech rehabilitation programs.

2. Research Methods

2.1. Study Design and Participants

This quasi-experimental study was conducted with sophomore students majoring in rehabilitation therapy at Zhejiang Oriental Vocational and Technical College. Using cluster sampling, 52 students were initially recruited, and 45 valid datasets were ultimately collected (completion rate: 86.5%). All participants voluntarily participated and signed informed consent forms. The study was approved by the Ethics Committee of Zhejiang Oriental Vocational and Technical College. Participants were randomly divided into two groups: a real case group (n = 23) and an AI case group (n = 22).

2.2. Teaching Intervention

The teaching intervention spanned two weeks, comprising two class sessions per week. During the first week, participants attended theoretical lectures and engaged in clinical skills practice, which was accompanied by a pre-test to establish baseline knowledge and competencies. In the second week, case-based teaching sessions were conducted, culminating in a post-test to measure the effectiveness of the intervention. Both groups were instructed by the same teacher, an experienced speech rehabilitation professional with six years of clinical expertise, to eliminate teacher-related variability as a confounding factor.

The real case group participated in learning activities based on authentic clinical cases. These sessions utilized group-based simulations and structured discussions, where participants analyzed and deliberated on one representative clinical scenario. In parallel, the AI case group engaged with AI-generated teaching cases designed to follow the same group learning framework. The content and difficulty levels of these AI-generated cases were carefully aligned with those used in the real case group to ensure consistency.

The AI-generated cases were developed using ChatGPT-4 (OpenAI) through a rigorous, systematic process consisting of three key steps. First, detailed prompts were designed based on course learning objectives and real clinical case templates [16]. These prompts defined essential elements, such as patient demographics, presenting symptoms, diagnostic findings, and proposed intervention plans. Second, the generated cases underwent a thorough review by three certified speech therapists (each with an average of six years of clinical experience) to ensure clinical relevance, accuracy, and educational value. Finally, iterative refinement was conducted to adjust the complexity and scope of the AI-generated cases to match the real cases utilized in the control group.

In total, a single representative AI-generated case was developed, covering a range of speech disorder categories, including articulation, fluency, voice, and language domains. To further validate the educational effectiveness of the AI-generated case, its difficulty level was calibrated through pilot testing with senior students who were not part of the primary study.

2.3. Evaluation Tools

The evaluation tools consisted of a standardized assessment and a structured questionnaire. The standardized assessment was developed through a systematic process of expert consultation and refinement. Based on the core competency model for speech rehabilitation, the assessment tool was created to measure students' theoretical knowledge through a series of multiple-choice questions, which were drawn from the official guidance books for the China Rehabilitation Therapy Qualification Exam. These questions were designed to evaluate students' understanding of key concepts and principles in speech rehabilitation. The assessment was further refined through expert review and pilot testing with students who were not part of the main study.

The tool integrated both theoretical and practical components, focusing on key areas such as diagnostic skills, intervention planning, therapeutic techniques, and comprehensive problem-solving. These skills were measured using case-based scenarios and practical demonstrations to assess students' ability to apply theoretical knowledge in clinical contexts.

In addition to the standardized assessment, a structured questionnaire was developed to capture students' learning experiences. The questionnaire, based on a 5-point Likert scale, gathered insights on students' satisfaction with the teaching methods, their level of engagement, and their perceptions of the effectiveness of case-based teaching. This provided valuable qualitative data that enriched the overall evaluation of the teaching methods.

2.4. Data Analysis

Paired sample t-tests analyzed pre- and post-test score changes within groups, while independent sample t-tests compared between-group differences. Effect sizes (Cohen's d) were calculated to evaluate the magnitude of teaching effectiveness. Statistical analyses were performed using R software, with a significance level set at $\alpha = 0.05$. Open-ended responses from the questionnaires were thematically coded and analyzed using content analysis to gain deeper insights into students' perceptions and suggestions regarding the two teaching methods.

2.5. Quality Control

To ensure objectivity and reliability, assessments were independently scored by two experienced instructors. Data from participants who did not complete all evaluations (pre-test, post-test, and questionnaire) were excluded. Double data entry methods were used during data processing to ensure accuracy.

3. Results

3.1. Sample Characteristics

This study initially recruited 52 sophomore students majoring in rehabilitation therapy at Zhejiang Oriental Vocational and Technical College. After data cleaning, 45 complete datasets were collected, with a response rate of 86.5%. Participants were randomly assigned into two groups: a real case group ($n = 23$) and an AI case group ($n = 22$).

3.2. Overall Teaching Effectiveness

At the pre-test stage, the average score of all participants was 71.75 (SD = 15.36), indicating variability in baseline knowledge and skills. After the intervention, the post-test average score rose to 88.51 (SD = 15.97), with a mean improvement of 16.76 points. Paired sample t-test analysis revealed a statistically significant improvement in performance ($t(44) = 6.16$, $p < 0.001$, Cohen's $d = 0.92$), demonstrating a large effect size for the teaching intervention.

3.3. Group-Based Comparative Analysis

Real Case Group

The real case group had a pre-test average score of 64.86 (SD = 8.07) and a post-test average score of 85.74 (SD = 16.86), with a mean improvement of 20.89 points. Paired sample t-test results confirmed this improvement as statistically significant ($t(22) = 6.02$, $p<0.001$, Cohen's $d = 1.26$), indicating a large effect size.

AI Case Group

The AI case group achieved a pre-test average score of 78.95 (SD = 17.88) and a post-test average score of 91.40 (SD = 14.82), with a mean improvement of 12.45 points. Paired sample t-test results also indicated statistically significant progress ($t(21) = 3.04$, $p = 0.006$, Cohen's $d = 0.65$), reflecting a moderate effect size.

Between-Group Comparison

Comparative analysis (Table 1). revealed that the AI case group had a higher baseline pre-test score compared to the real case group. However, the real case group exhibited a significantly larger improvement margin (20.89 vs. 12.45 points). Both groups demonstrated statistically significant gains ($p < 0.01$), but the effect size for the real case group ($d = 1.26$) was notably larger than that of the AI case group ($d = 0.65$).

Table 1 Group performance improvement (Pre-Test vs. Post-Test)

Group	Pre-test Average (SD)	Post-test Average (SD)	Improvement (Points)	Effect Size (Cohen's d)	P-value
Real Case Group	64.86 (8.07)	85.74 (16.86)	20.89	1.26	P<0.001

AI case Group	78.95 (17.88)	91.40 (14.82)	12.45	0.65	P=0.006

3.4. Dimension-Specific Skill Analysis

Diagnostic Skills

The real case group demonstrated a 13.0% improvement in diagnostic skills ($t(22) = 3.58$, $p < 0.01$, Cohen's $d = 0.75$). Similarly, the AI case group showed a 12.0% improvement ($t(21) = 2.25$, $p < 0.05$, Cohen's $d = 0.48$). The between-group difference (0.010) indicated comparable performance in this dimension (Table 2, Figure 1).

Table 2 Group-based improvements across skill dimensions

Skill Dimension	Group	Improvement (%)	Effect Size (Cohen's d)	P-value
Diagnostic Skills	Real Case Group	13	0.75	<0.01
	AI Case Group	12	0.48	<0.05
Intervention Skills	Real Case Group	25.7	1.28	<0.001
	AI Case Group	14.6	0.69	<0.01
Therapeutic Skills	Real Case Group	19.7	0.81	<0.01
	AI Case Group	8.8	0.43	0.058
Comprehensive Skills	Real Case Group	17.4	1.1	<0.058
	AI Case Group	5.7	0.43	0.057

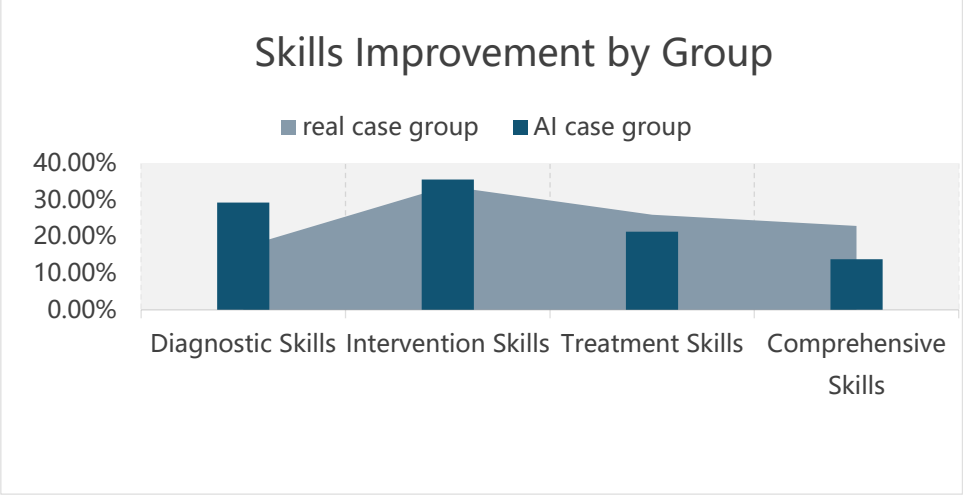

Figure 1. Skill improvement by group

Intervention Skills

The real case group achieved a 25.7% improvement in intervention skills ($t(22) = 6.15$, $p < 0.001$, Cohen's $d = 1.28$), significantly outperforming the AI case group's 14.6% improvement ($t(21) = 3.24$, $p < 0.01$, Cohen's $d = 0.69$). The between-group difference (0.110) highlighted the superior effectiveness of real cases in this area.

Therapeutic Skills

The real case group recorded a 19.7% improvement in therapeutic skills ($t(22) = 3.89$, $p < 0.001$, Cohen's $d = 0.81$), compared to the AI case group's 8.8% improvement ($t(21) = 2.00$, $p = 0.058$, Cohen's $d = 0.43$). The between-group difference (0.109) further underscored the real case group's advantage.

Comprehensive Skills

In comprehensive skills, the real case group showed a 17.4% improvement ($t(22) = 5.25$, $p < 0.001$, Cohen's $d = 1.10$), whereas the AI case group demonstrated a 5.7% improvement ($t(21) = 2.02$, $p = 0.057$, Cohen's $d = 0.43$). The between-group difference (0.117) revealed the real case group's significant superiority in fostering advanced problem-solving abilities.

3.5. Student Feedback and Subjective Evaluation

Survey results provided insights into students' perceptions of the two teaching methods. In terms of case format preferences, 71.1% of students preferred text and image-based cases, 84.4% favored audio-visual materials, and 77.8% supported scenario-based simulations. Additionally, 75.6% of students expressed a preference for completing case exercises during class (Figure 2).

Regarding skill development (Figure 3), 88.9% of students reported improvements in self-directed learning and critical thinking abilities. Furthermore, 73.3% observed an enhancement in innovation skills, 75.6% noted improved verbal communication, and 91.1% recognized significant growth in teamwork abilities. However, 42.2% of students expressed dissatisfaction with the time allocated for simulated case exercises, indicating a need for adjustments in future interventions.

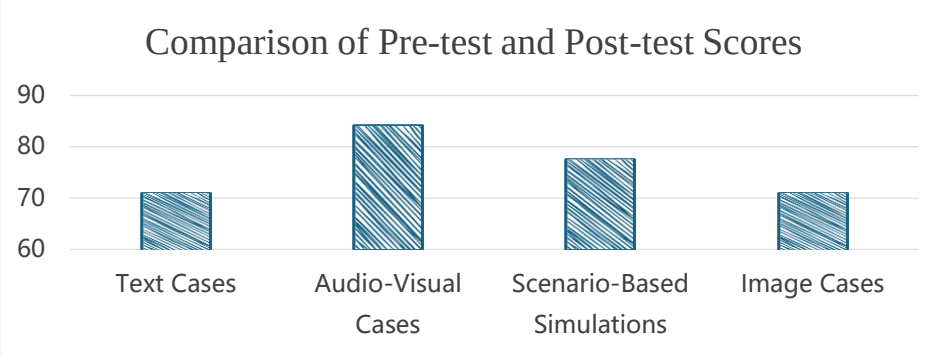

Figure 2. Comparison of pre-test and post_test

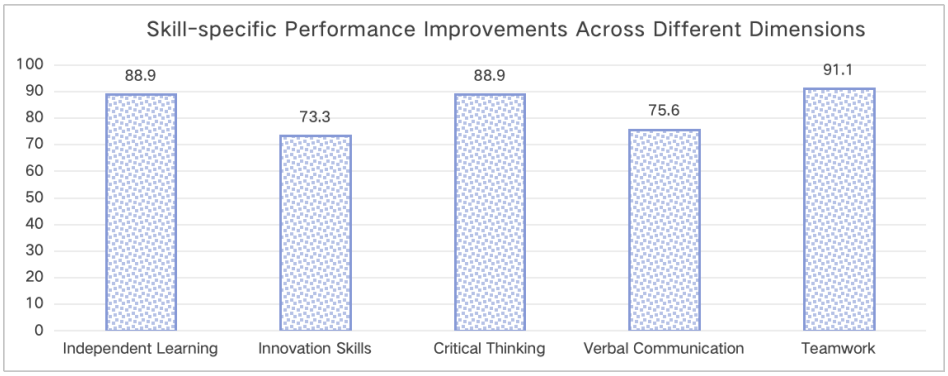

Figure 3. Skill-specific performance improvements across different dimension

4. Discussion

4.1. Theoretical Explanation of Differences in Teaching Effectiveness

Our findings demonstrate that the real case group achieved significantly greater improvements in advanced skills compared to the AI case group, with particularly notable differences in intervention skills (25.7% vs. 14.6%), therapeutic skills (19.7% vs. 8.8%), and comprehensive skills (17.4% vs. 5.7%). This aligns with situated cognition theory [17], which emphasizes the importance of authentic learning contexts.

The large effect size (d = 1.26) in the real case group further validates the effectiveness of this immersive learning approach in developing advanced professional competencies [18].

Interestingly, both groups showed comparable improvements in diagnostic skills (real case: 13.0%, AI case: 12.0%, difference: 0.010). This finding supports the effectiveness of AI-generated cases in developing foundational skills through standardized and repeatable learning experiences [19], consistent with precision teaching principles [20].

4.2. Integration of Quantitative and Qualitative Findings

The quantitative results are substantially enriched by student feedback data, offering deeper insights into the learning experience. Student survey responses revealed strong preferences for diverse case formats, with 84.4% favoring audio-visual materials and 77.8% supporting scenario-based simulations. This preference for multi-modal learning aligns with the higher performance improvements observed in the real case group, where students engaged with cases through multiple sensory channels [21].

The high percentage of students reporting improvements in self-directed learning and critical thinking (88.9%) corresponds with the quantitative improvements in comprehensive skills. Notably, 91.1% of students perceived enhanced teamwork abilities, suggesting that the collaborative aspects of case-based learning contribute significantly to skill development [22]. The finding that 42.2% of students felt insufficient time was allocated for case exercises, combined with 75.6% preferring in-class case completion, provides important context for understanding the learning process. This feedback might explain some of the variation in skill improvement rates and suggests the need for optimized time management in case-based teaching [23].

4.3. Comparison with Existing Research

Our findings align with and extend prior research in medical education and AI-assisted teaching while addressing notable gaps in the literature. Prior studies have established the effectiveness of traditional case-based learning in improving clinical reasoning skills [24], as well as the utility of AI-generated cases in foundational knowledge acquisition [16]. However, most existing research focuses on generalized learning outcomes, leaving the comparative impact of these methods across specific skill dimensions largely unexplored. Our study uniquely contributes by revealing these differential effects, demonstrating that AI cases are particularly effective in developing foundational diagnostic abilities, while real cases excel in fostering advanced therapeutic skills.

The unique demands of speech rehabilitation education present distinct challenges compared to general medical education. Unlike nursing or general medical education, where simulated cases often achieve comparable outcomes to real cases, speech rehabilitation requires complex contextualization and authentic patient interactions. Our findings support this distinction, with the real case group achieving significantly higher gains in advanced skills (Cohen's d = 1.26). This contrasts with previous studies in nursing education that found no significant differences between real and simulated cases [25], highlighting the importance of authentic clinical experiences in specialized, interaction-intensive disciplines.

Furthermore, our research addresses the understudied relationship between learning preferences and performance outcomes. While previous studies have documented student preferences for multimodal learning formats [26], few have examined how these preferences translate into measurable skill development. Our findings demonstrate that engaging multiple sensory channels through real case teaching not only aligns with student preferences (84.4% favoring audio-visual formats) but also correlates with significant performance improvements. These results extend beyond existing research by providing empirical evidence for the effectiveness of multimodal learning approaches in speech rehabilitation education.

To further enhance the adaptability and effectiveness of AI-generated cases, future implementations can explore the integration of multiple AI tools to produce multi-sensory teaching materials tailored to diverse student needs. For instance, natural language processing (NLP) models like ChatGPT can generate detailed textual cases, while image-generation models such as DALL·E can create realistic visual scenarios [27], and text-to-speech (TTS) systems can provide auditory simulations [28–30]. This multi-modal approach could offer students a richer and more immersive learning experience, engaging multiple senses to improve comprehension and retention. By combining these AI technologies, educators can design cases that simulate

real-world clinical environments more effectively, addressing a wider range of learning preferences and accommodating students with varying cognitive and perceptual strengths.

These findings contribute new insights into the differential impacts of teaching methodologies, particularly within specialized educational contexts. By revealing the complementary strengths of AI-generated and real cases across different skill dimensions, our study provides a foundation for developing integrated teaching approaches that optimize learning outcomes in speech rehabilitation education.

4.4. Implications for Teaching Practice

Educators should adopt a structured and progressive approach to case-based teaching. In the early stages, AI-generated cases can effectively support the development of foundational skills, as seen in the comparable improvements in diagnostic abilities across groups. As students advance, real clinical cases become crucial for cultivating advanced competencies, with the real case group showing significantly larger gains in intervention, therapeutic, and comprehensive skills.

Teaching strategies should focus on leveraging multimodal delivery formats to enrich learning experiences. The findings demonstrate a clear preference among students for varied case presentation methods, with 84.4% favoring audio-visual materials and 71.1% preferring text and image-based formats. By integrating multimedia resources, interactive simulations, and hands-on demonstrations into case studies, educators can create a more engaging and effective learning environment.

Adequate time for hands-on practice is another critical factor in optimizing educational outcomes. With 42.2% of students reporting insufficient practice time, it is essential to extend practical sessions, incorporate routine skill-building exercises, and establish a balanced ratio between theoretical instruction and practical training. Offering supervised practice opportunities outside regular class hours can further reinforce skill development through direct application and experiential learning.

4.5. Study Limitations

Several limitations of this study should be noted. First, while our experimental study was conducted with sophomore students in rehabilitation therapy, the relatively small sample size (n = 45) and selection from a single institution may affect the generalizability of our findings to broader educational contexts. Second, the baseline differences between the two groups may have influenced the observed variations in score improvement. Specifically, the AI case group exhibited a higher baseline performance compared to the real case group, which likely contributed to the differences in their improvement margins. This discrepancy could, in part, be explained by the ceiling effect [31], where participants with higher initial scores have less potential for measurable improvement, limiting the observable impact of the intervention.

Thirdly, although we observed significant improvements in both teaching methods during the two-week intervention period, this timeframe may be insufficient to evaluate the long-term retention of knowledge and skills, particularly for complex professional competencies in speech rehabilitation. Fourth, despite employing a mixed-methods approach that combined quantitative assessments with student feedback, our qualitative data collection could have been more comprehensive. Additional methodological approaches, such as semi-structured interviews with students and instructors, classroom observations, and longitudinal follow-up assessments, would have provided deeper insights into the learning processes and outcomes. Furthermore, the study did not control for potential confounding variables such as students' prior exposure to clinical cases or their individual learning preferences, which might have influenced the results.

4.6. Future Research Directions

Future research should expand sample size and institutional diversity to enhance generalizability and conduct longitudinal studies to assess sustained learning outcomes. Development of hybrid teaching models that integrate both case types is essential, particularly considering the strong student preference for varied learning formats. Additionally, investigation into the relationship between perceived skill improvement and objective performance measures would provide valuable insights. Further research should also explore the optimal balance between in-class practice time and other learning activities, given the significant student feedback regarding time allocation.

5. Conclusion

This study employed an experimental design to compare the effectiveness of real case teaching and AI-generated case teaching in speech rehabilitation education. The findings reveal that case-based teaching methods significantly enhanced students' professional competencies. While the AI case group exhibited a higher baseline performance, the real case group demonstrated greater improvement, particularly in advanced skills such as intervention, therapeutic, and comprehensive application abilities. Both methods were equally effective in fostering foundational diagnostic skills.

The results suggest adopting a phased approach to case-based teaching. AI-generated cases can be utilized to build foundational skills in early learning stages, while real cases are better suited for developing advanced competencies and higher-order thinking. Balancing group collaboration and individual learning, along with allocating sufficient time for practical exercises, is crucial to maximizing teaching effectiveness and fostering student engagement.

Despite these promising findings, limitations such as the small sample size, short intervention duration, and focus on cognitive outcomes highlight the need for further research. Future studies should explore hybrid teaching models that integrate real and AI-generated cases, creating adaptive and authentic learning environments. Expanding evaluation frameworks to include affective outcomes, such as motivation and self-efficacy, would also provide a more comprehensive understanding of case-based teaching.

In conclusion, this study provides evidence for the complementary benefits of real and AI-generated cases in speech rehabilitation education. Leveraging the strengths of both methods can enhance professional training and drive continuous improvements in teaching practices.

Ethical statement

This study was approved by the Ethics Committee of Zhejiang Dongfang Polytechnic (Approval No. 202501). All participants provided written informed consent prior to their participation in the study.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Data accessibility statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

Dan Zhou: Software, Data curation, Writing - original draft, Writing - review & editing; Jin Jin: Data curation, Writing - original draft,Project administration, Supervision; Hua Zhu: Data curation, Writing - original draft, Writing - review & editing; Shichong Lin: Data curation, Writing - original draft, Writing - review & editing; Shanshan Zhou: Writing - original draft, Writing - review & editing; Xin Guo: Writing - review & editing; Shuhao Du: Writing - review & editing; Shuihua Yang: Conceptualization, Methodology, Supervision; Xiaoding Chen: Formal analysis, Data curation, Writing - original draft, Writing - review & editing, Supervision

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Declaration of AI Tool Usage

In this study, ChatGPT-4o (OpenAI) was used for two specific purposes:

1. Virtual Case Generation: ChatGPT-4o was employed to generate simulated speech rehabilitation cases to ensure diversity and consistency in the case-based teaching approach. The research team thoroughly reviewed, validated, and adjusted the generated cases to align with professional standards and clinical relevance.

2. Language Enhancement: ChatGPT-4o was utilized to improve the clarity and readability of the manuscript. However, all key academic content, data analysis, and conclusions were independently written by the authors and rigorously reviewed to ensure accuracy.

This study strictly adheres to the journal's academic integrity and publication ethics. AI tools were used solely for content assistance and language refinement, while all scholarly decisions, research analyses, and final content remain the full responsibility of the authors.

Reference

1. Santos BD, Rockenbach SP, Donicht G, Santos CD. Epidemiological profile of users referred to speech therapy in a municipality in Rio Grande do Sul. *Audiol. Commun. Res.* **2022**, *27*, e2621.
2. McAuliffe MJ, Schluter PJ, Jamieson HA. An epidemiological profile of communication disability among older adults with complex needs: A national cross-sectional study. *Int. J. Speech-Lang. Pathol.* **2019**, *21*, 537–546.
3. Bachmann C, Pettit J, Rosenbaum M. Developing communication curricula in healthcare education: An evidence-based guide. *Patient Educ. Couns.* **2022**, *105*, 2320–2327.
4. Gerup J, Soerensen CB, Dieckmann P. Augmented reality and mixed reality for healthcare education beyond surgery: an integrative review. *Int. J. Med. Educ.* **2020**, *11*, 1–18.
5. Maatuk AM, Elberkawi EK, Aljawarneh S, Rashaideh H, Alharbi H. The COVID-19 pandemic and E-learning: challenges and opportunities from the perspective of students and instructors. *J. Comput. High Educ.* **2022**, *34*, 21–38.
6. Hu X, Chiu MM, Leung WMV, Yelland N. Technology integration for young children during COVID-19: Towards future online teaching. *Br. J. Educ. Technol.* **2021**, *52*, 1513–1537.
7. Sekhon J K, Oates J, Kneebone I, Rose ML. Counselling education for speech-language pathology students in Australia: a survey of education in post-stroke aphasia. *Aphasiology* **2022**, *36*, 1417–1446.
8. Donkin R, Yule H, Fyfe T. Online case-based learning in medical education: a scoping review. *BMC Med. Educ.* **2023**, *23*, 564.
9. Al-Balas M, et al. Distance learning in clinical medical education amid COVID-19 pandemic in Jordan: current situation, challenges, and perspectives. *BMC Med. Educ.* **2020**, *20*, 341.
10. Zhao W, et al. The effectiveness of the combined problem-based learning (PBL) and case-based learning (CBL) teaching method in the clinical practical teaching of thyroid disease. *BMC Med. Educ.* **2020**, *20*, 381.
11. Klimova B, Pikhart M, Kacetl J. Ethical issues of the use of AI-driven mobile apps for education. *Front. Public Health* **2023**, *10*.
12. Sapci AH, Sapci H A. Artificial Intelligence Education and Tools for Medical and Health Informatics Students: Systematic Review. *JMIR Med. Educ.* **2020**, *6*, e19285.
13. Cheung WS, Hew KF. Design and evaluation of two blended learning approaches: Lessons learned. *Australas. J. Educ. Technol.* **2011**, *27*.
14. Murdoch-Eaton D, Whittle S. Generic skills in medical education: developing the tools for successful lifelong learning. *Med. Educ.* **2012**, *46*, 120–128.
15. Cook DA, Beckman TJ, Bordage G. Quality of reporting of experimental studies in medical education: a systematic review. *Med. Educ.* **2007**, *41*, 737–745.
16. Scherr R, Halaseh FF, Spina A, Andalib S, Rivera R. ChatGPT Interactive Medical Simulations for Early Clinical Education: Case Study. *JMIR Med. Educ.* **2023**, *9*, e49877.
17. O'Brien BC, Battista A. Situated learning theory in health professions education research: a scoping review. *Adv. Health Sci. Educ. Theory Pract.* **2020**, *25*, 483–509.
18. Liu JYW, et al. The Effects of Immersive Virtual Reality Applications on Enhancing the Learning Outcomes of Undergraduate Health Care Students: Systematic Review With Meta-synthesis. *J. Med. Internet Res.* **2023**, *25*, e39989.
19. Benary M, et al. Leveraging Large Language Models for Decision Support in Personalized Oncology. *JAMA Netw. Open* **2023**, *6*, e2343689.
20. Triola MM, Burk-Rafel J. Precision Medical Education. *Acad. Med.* **2023**, *98*, 775–781.
21. Poort J, et al. Learning Enhances Sensory and Multiple Non-sensory Representations in Primary Visual Cortex. *Neuron* **2015**, *86*, 1478–1490.

22. Pervaz Iqbal M, Velan GM, O'Sullivan AJ, Balasooriya C. The collaborative learning development exercise (CLeD-EX): an educational instrument to promote key collaborative learning behaviours in medical students. *BMC Med. Educ.* **2020**, *20*, 62.
23. Tender JAF, et al. Educating pediatric residents about breastfeeding: evaluation of 3 time-efficient teaching strategies. *J. Hum. Lact.* **2014**, *30*, 458–465.
24. Dong H, et al. Effectiveness of case-based learning in Chinese dental education: a systematic review and meta-analysis. *BMJ Open* **2022**, *12*, e048497.
25. Raymond L, Castonguay A, Doyon O, Paré G. Nurse practitioners' involvement and experience with AI-based health technologies: A systematic review. *Appl. Nurs. Res.* **2022**, *66*, 151604.
26. Bisbe M, et al. Comparative Cognitive Effects of Choreographed Exercise and Multimodal Physical Therapy in Older Adults with Amnestic Mild Cognitive Impairment: Randomized Clinical Trial. *J. Alzheimers Dis.* **2020**, *73*, 769–783.
27. Zhu L, et al. ChatGPT's ability to generate realistic experimental images poses a new challenge to academic integrity. *J. Hematol. Oncol.* **2024**, *17*, 27.
28. Keelor JL, Creaghead NA, Silbert NH, Breit AD, Horowitz-Kraus T. Impact of text-to-speech features on the reading comprehension of children with reading and language difficulties. *Ann. Dyslexia* **2023**, *73*, 469–486.
29. Matre ME, Cameron DL. A scoping review on the use of speech-to-text technology for adolescents with learning difficulties in secondary education. *Disabil. Rehabil. Assist. Technol.* **2024**, *19*, 1103–1116.
30. Tan X, et al. NaturalSpeech: End-to-End Text-to-Speech Synthesis With Human-Level Quality. *IEEE Trans. Pattern Anal. Mach. Intell.* **2024**, *46*, 4234–4245.
31. Eriksson K, Sorjonen K, Falkstedt D, Melin B, Nilsonne G. A formal model accounting for measurement reliability shows attenuated effect of higher education on intelligence in longitudinal data. *R. Soc. Open Sci.* **2024**, *11*, 230513.