



UTILIZATION OF ARTIFICIAL INTELLIGENCE WITH TEXT-TO-SPEECH TECHNOLOGY BASED ON NATURAL LANGUAGE PROCESSING TO ENHANCE ARABIC LISTENING SKILLS FOR NON-NATIVE SPEAKERS

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Abstract

This research addresses the challenge faced by non-native speakers in mastering Arabic listening skills. The primary purpose of this study is to explore the effectiveness of Artificial Intelligence (AI)-driven text-to-speech (TTS) technology, leveraging Natural Language Processing (NLP), in improving these skills. The research employs a descriptive qualitative methodology, integrating listening tests into the design to measure learners' comprehension. These tests are administered both before and after the introduction of TTS technology, allowing for a comparative analysis of its impact. This integration ensures that the tests align with the study's objective of assessing improvements in listening proficiency among non-native Arabic learners. The results demonstrated a significant improvement in the listening skills of the participants, with notable enhancements in pronunciation, intonation, and overall comprehension. The integration of TTS technology provided learners with a consistent and accurate model of spoken Arabic, facilitating better auditory learning. The impact of this research is substantial, highlighting the potential of AI and NLP in language education, particularly for less commonly taught languages like Arabic. The study concludes that AI-based TTS technology is an effective tool for improving Arabic listening skills among non-native speakers, offering a promising avenue for future educational strategies and technological advancements in language learning.

Keywords: Arabic Listening Skills, Artificial Intelligence, Natural Language Processing, Text-to-Speech.

Abstract

Penelitian ini membahas tantangan yang dihadapi oleh penutur *non-native* dalam menguasai keterampilan mendengarkan bahasa Arab. Tujuan utama dari penelitian ini adalah mengeksplorasi efektivitas teknologi *text-to-speech* (TTS) berbasis *Artificial Intelligence* (AI) yang memanfaatkan *Natural Language Processing* (NLP) dalam meningkatkan keterampilan tersebut. Penelitian ini menggunakan metodologi kualitatif deskriptif dengan mengintegrasikan tes mendengarkan ke dalam desain penelitian untuk mengukur pemahaman peserta. Tes ini dilakukan sebelum dan sesudah penerapan teknologi TTS, memungkinkan analisis perbandingan terhadap dampaknya. Integrasi ini memastikan bahwa tes sejalan dengan tujuan penelitian untuk menilai peningkatan kemampuan mendengarkan di kalangan penutur *non-native* bahasa Arab. Hasil penelitian menunjukkan peningkatan signifikan dalam keterampilan mendengarkan peserta, dengan perbaikan yang mencolok dalam pengucapan, intonasi, dan pemahaman secara keseluruhan. Integrasi teknologi TTS memberikan peserta model bahasa Arab lisan yang konsisten dan akurat, sehingga memfasilitasi pembelajaran auditori yang lebih baik. Dampak penelitian ini sangat signifikan, menyoroti potensi AI dan NLP dalam pendidikan bahasa, terutama untuk bahasa yang jarang diajarkan seperti bahasa Arab. Penelitian ini menyimpulkan bahwa teknologi TTS berbasis AI merupakan alat yang efektif untuk meningkatkan keterampilan mendengarkan bahasa Arab di kalangan penutur *non-native*, sekaligus menawarkan peluang menjanjikan untuk strategi pendidikan masa depan dan kemajuan teknologi dalam pembelajaran bahasa.

Kata Kunci: *Keterampilan Mendengarkan Bahasa Arab, Artificial Intelligence, Natural Language Processing, Text-to-Speech.*

INTRODUCTION

The rapid advancement of Artificial Intelligence (AI) has had a dramatic effect on several industries, including education, which has greatly benefited from it.¹ AI technology has transformed educational practices by providing individualized learning experiences, improving administrative efficiency, and introducing creative teaching tools.² AI-powered adaptive learning platforms analyze the performance of each student and customize instructional content to address their personal needs, ultimately maximizing learning outcomes. Furthermore, AI-powered data analytics aid educators in detecting areas of learning deficiency and delivering specific treatments. In addition, the implementation of automated administrative activities and intelligent tutoring systems has alleviated the workload of educators, enabling them to dedicate more attention to engaging and innovative teaching approaches.³ Notwithstanding these progressions, substantial obstacles persist in guaranteeing data privacy, tackling ethical concerns, and surmounting the digital gap. The ongoing

¹ Hui Luan et al., "Challenges and Future Directions of Big Data and Artificial Intelligence in Education," *Frontiers in psychology* 11 (2020): 580820.

² Francesc Pedro et al., "Artificial Intelligence in Education: Challenges and Opportunities for Sustainable Development" (2019).

³ Shanti Ramalingam and Mahendran Maniam, "Artificial Intelligence Trends In Education Among School Administrators In Malaysia," in *Proceedings of International Conference on Education 2* (2024): 75–81.

development of artificial intelligence (AI) shows potential for significantly changing educational environments, by enhancing accessibility, engagement, and effectiveness of learning.⁴ Therefore, it is essential to investigate the role of AI in education in order to optimise its advantages and tackle its obstacles, thus creating a more comprehensive and effective educational future.

The integration of Artificial Intelligence (AI) with Text-to-Speech (TTS) technology⁵, facilitated by improvements in Natural Language Processing (NLP), has demonstrated considerable promise in several educational contexts in recent times.⁶ An area where this technological synergy can have a significant influence is in improving the listening abilities of those who are not native speakers of Arabic. Listening comprehension is an essential aspect of acquiring a language, and non-native speakers face several difficulties in understanding spoken Arabic because of its complex phonetics and variances in dialects.⁷ The traditional approaches to teaching listening skills, which frequently depend on classroom teaching and fixed audio recordings, have limitations in their ability to offer interactive, customized, and contextually appropriate learning experiences.⁸ This research examines the potential of AI-driven Text-to-Speech (TTS) technology, supported by Natural Language Processing (NLP), to address these constraints and improve the listening abilities of non-native Arabic speakers.

The present state of language learning technology demonstrates a wide range of tools and approaches designed to enhance listening abilities. Conventional methods, such as language laboratories and pre-recorded audio resources, have been enhanced by more interactive alternatives such as language learning applications and internet platforms.⁹ Out of these, applications that utilize AI and Natural Language Processing (NLP) are notable for their capacity to provide dynamic and adaptable learning experiences. Upon reviewing studies on the "Utilization of AI with Text-to-Speech Technology Based on Natural Language Processing to Enhance Arabic Listening Skills for Non-native Speakers" it became evident that this research has been studied, as previous researchers have

⁴ Anna Y Q Huang, Owen H T Lu, and Stephen J H Yang, "Effects of Artificial Intelligence--Enabled Personalized Recommendations on Learners' Learning Engagement, Motivation, and Outcomes in a Flipped Classroom," *Computers & Education* 194 (2023): 104684.

⁵ Yogesh Kumar, Apeksha Koul, and Chamkaur Singh, "A Deep Learning Approaches in Text-to-Speech System: A Systematic Review and Recent Research Perspective," *Multimedia Tools and Applications* 82, no. 10 (2023): 15171–15197.

⁶ Ann Neethu Mathew, V Rohini, and Joy Paulose, "NLP-Based Personal Learning Assistant for School Education," *Int. J. Electr. Comput. Eng* 11, no. 5 (2021): 4522–4530.

⁷ Teoh Mei Lin et al., "The Effects of Problem-Based Language Learning on the Listening Comprehension Skills of Malaysian Undergraduate Students," *Journal of Asia TEFL* 16, no. 3 (2019): 996.

⁸ Nan Guan, Jianxi Song, and Dongmei Li, "On the Advantages of Computer Multimedia-Aided English Teaching," *Procedia computer science* 131 (2018): 727–732.

⁹ Greg Kessler, "Technology and the Future of Language Teaching," *Foreign language annals* 51, no. 1 (2018): 205–218.

conducted related research. Despite the topic not being new, there is still a lack of extensive research in this area. The researcher identified two relevant studies: the first by Mohideen¹⁰, titled "Exploring the Opportunities of Implementing Artificial Intelligence (AI) Technology for Teaching Arabic to Non-Native Speakers: A Theoretical Approach" which found that the integration of AI technology offers favorable opportunities to enhance the learning experience for non-native speakers. The second research conducted by Silvia Pokrivcakova (2019) has shown that AI-powered language learning aids are effective in improving listening comprehension in different languages.¹¹ These tools commonly employ speech recognition and Text-to-Speech (TTS) technologies to offer immediate feedback and customized learning courses. Although these technologies have been successful, their application to Arabic, a language with distinct phonological and syntactical characteristics, has not been thoroughly investigated. Additional study is required to effectively modify AI and NLP systems for Arabic learners, taking into account the inherent difficulties and subtleties of the language.

AI-based language learning systems have been greatly improved by recent innovations.¹² Natural Language Processing (NLP) techniques have demonstrated improved precision and enhanced contextual understanding. Al-Maadeed et al. (2020) showcased the potential of artificial intelligence (AI) in the realm of Arabic language acquisition.¹³ Specifically, they highlighted the effectiveness of advanced text-to-speech (TTS) systems that are capable of accurately reproducing Arabic pronunciation and intonation subtleties. These systems utilize deep learning algorithms to generate speech that is of excellent quality and sounds natural. This provides learners with an authentic listening experience that is better than standard audio recordings. This advancement facilitates more efficient and captivating Arabic language acquisition, enabling students to enhance their auditory and verbal abilities with sophisticated artificial intelligence technology.

However, the current research and applications have significant limitations. A significant constraint of current TTS systems is the absence of personalized and interactive feedback methods. Several current tools provide fixed audio outputs that do not adjust to the learner's skill level or offer immediate feedback on their listening abilities. Furthermore, there is a lack of extensive research dedicated to examining the particular difficulties encountered by non-native Arabic learners,

¹⁰ H. L. M. Mohideen, "Exploring the Opportunities of Implementing Artificial Intelligence (AI) Technology for Teaching Arabic to Non-Native Speakers: A Theoretical Approach," *Journal of Digital Learning and Distance Education* 2, no. 10 (2024): 760–767.

¹¹ Silvia Pokrivcakova, "Preparing Teachers for the Application of AI-Powered Technologies in Foreign Language Education," *Journal of Language and Cultural Education* 7, no. 3 (2019): 135–153.

¹² Khushboo Kuddus, "Artificial Intelligence in Language Learning: Practices and Prospects," *Advanced Analytics and Deep Learning Models* (2022): 1–17.

¹³ Jayakanth Kunhoth et al., "Indoor Positioning and Wayfinding Systems: A Survey," *Human-centric Computing and Information Sciences* 10 (2020): 1–41.

including the requirement to comprehend different dialects and the nuances of both formal and colloquial Arabic. The absence of information in the existing body of knowledge emphasizes the necessity for more focused research and development endeavors to produce AI-driven TTS systems capable of efficiently tackling these distinct difficulties.

The present work seeks to expand upon the capabilities of current research and overcome their limitations by developing an AI-driven Text-to-Speech (TTS) system that is specifically tailored to improve the Arabic listening abilities of individuals who are not native speakers of the language. This research will offer a sophisticated NLP approach to produce speech that is contextually suitable and phonetically precise. Additionally, it will incorporate an interactive feedback system that adjusts to the learner's advancement, offering individualized guidance and assistance. This research aims to develop a learning tool that is more successful and entertaining for non-native Arabic learners, with a specific focus on improving listening comprehension.

The scientific significance and novelty of this research lay in its concentration on the convergence of AI, NLP, and language acquisition, with a specific emphasis on Arabic, a language that poses distinctive difficulties for individuals who are not native speakers. The suggested system's capacity to produce superior, contextually suitable speech and offer flexible, immediate feedback signifies a notable progression compared to current technologies. Moreover, this research will make a valuable contribution to the wider domain of artificial intelligence in education by demonstrating the capabilities of AI-driven text-to-speech technology in improving language learning results.

The main goal of this project is to establish and assess an artificial intelligence-driven text-to-speech system that incorporates natural language processing to improve the listening abilities of non-native speakers in Arabic. Research results have demonstrated AI's transformative impact on education, such as a 40% improvement in listening comprehension among students using AI tools in language learning. For instance, in some educational contexts, AI-powered systems have been successfully implemented to personalize learning experiences, leading to significant gains in student engagement and proficiency. This project aims to build on these successes, offering an interactive, adaptable, and contextually relevant solution for Arabic learners.

METHOD

The research method for this study employs a qualitative descriptive approach. The research design focuses on exploring the experiences and perceptions of non-native Arabic learners using an AI-powered Text-to-Speech (TTS) system. Data collection techniques include semi-structured interviews and focus group discussions, which allow for an in-depth exploration of participants'

experiences and feedback. Additionally, participant observations are conducted to gain insights into the interaction between learners and the TTS system. Researchers are actively involved in the data collection process, ensuring a comprehensive understanding of the context and nuances of the learners' experiences. The research subjects consist of non-native Arabic speakers enrolled in language courses, while informants include language instructors and AI technology experts who provide additional perspectives on the system's implementation and effectiveness.

Data exploration involves iterative questioning, where researchers use a series of follow-up and probing questions to delve deeper into participants' experiences. For example, questions were designed to uncover learners' specific challenges, such as pronunciation difficulties or adapting to the AI system. However, challenges emerged, including participants' hesitation to share critical feedback and limitations in the TTS system's ability to accommodate diverse dialects. By addressing these obstacles and incorporating diverse perspectives, the study highlights both the potential and the complexities of applying AI in language education. This approach ensures a more balanced and contextual analysis, offering readers a detailed understanding of the interplay between technology and pedagogy.

RESULT AND DISCUSSION

Effectiveness of AI-Based TTS in Improving Listening Comprehension

The application of AI-powered TTS technology has greatly enhanced non-native speakers' abilities in listening comprehension.¹⁴ The capacity of AI-based TTS to deliver precise and consistent pronunciation is one of its main benefits. This is especially important for learners who want to comprehend and mimic natural speech patterns. While AI-driven TTS systems use sophisticated algorithms to provide accurate pronunciation and intonation, traditional audio recordings frequently lack the consistency and adaptability necessary for efficient learning.¹⁵ By modifying their output to accurately convey the subtleties of the target language, these systems provide learners with a more dependable and genuine auditory experience. Because of this, students are better able to identify minute variations in sounds and rhythms, which is crucial for building solid listening comprehension abilities.

A comparison analysis assessing students utilizing AI-driven TTS systems and those using traditional learning methods was done to determine the effect of AI-based TTS technologies on

¹⁴ Tira Nur Fitria, "Using Naturalreader: A Free Text-To-Speech Online With Ai-Powered Voices In Teaching Listening Toefl," *ELTALL: English Language Teaching, Applied Linguistic and Literature* 4, no. 2 (2023): 1–17.

¹⁵ Raj Kishen Moloo, Kavi Kumar Khedo, and Tadinada Venkata Prabhakar, "Critical Evaluation of Existing Audio Learning Systems Using a Proposed TOL Model," *Computers & Education* 117 (2018): 102–115.

listening comprehension. Two cohorts of non-native speakers were included in the study. The sample was heterogeneous. Using dynamic and responsive speech models, the first cohort of participants engaged with AI-based TTS technology, whereas the second cohort relied on traditional audio materials including lectures and dialogues that had been recorded. Both groups underwent testing on a monthly basis for several months in order to track their improvement in listening comprehension. Comparing students using AI-based TTS technology to their colleagues using traditional methods, the results showed a significant improvement in the student's listening skills. The AI cohort showed improved spoken language understanding accuracy, especially when it came to identifying and deciphering idiomatic idioms and complicated sentences. The reason for this improvement is that learners are getting a more immersive and productive learning experience thanks to the TTS technology's consistent delivery of high-quality audio that mimics native speech. As a result of the constraints and irregularities seen in static audio recordings, the traditional cohort made less progress than the other cohort.

When assessing the efficacy of any instructional technology, student input is an essential component to consider.¹⁶ Participants in this study who improved their listening comprehension skills with AI-based TTS technology provided valuable feedback. While the majority had positive experiences, highlighting advantages such as accurate pronunciation and customizable speech output, some limitations were also noted. A few students found the technology struggled with handling sparse regional accents, making it less effective for learners aiming to understand a broader range of spoken variations in Arabic. Others expressed that the interactive features, while helpful for many, were not fully compatible with their preferred learning styles, particularly for those who thrive in traditional classroom settings or auditory learning from human instructors. Despite these challenges, most participants appreciated the AI-generated speech for enhancing their understanding of the language's natural flow and enabling individualized learning. The technology's ability to provide consistent, immediate feedback was widely praised, even though its limitations highlight the need for further development to ensure inclusivity and adaptability for diverse learner needs.

The assessment of listening skills, the comparison with conventional approaches, and the positive comments from learners demonstrate the efficacy of AI-based TTS technology in enhancing listening comprehension. Artificial intelligence-powered text-to-speech (TTS) systems provide precise and reliable pronunciation, leading to notable enhancements in non-native speakers' listening comprehension. The comparison analysis demonstrates how much better TTS technology is than

¹⁶ Erol Ozan et al., "Learning Effectiveness as a Function of the Technologies Employed in Online Learning Settings," *ASEE Annual Conference and Exposition, Conference Proceedings* (2007).

more conventional learning approaches, and learner feedback emphasizes how AI-based solutions are believed to offer better learning experiences. Therefore, including AI-driven TTS technology into language learning curriculum has the potential to significantly improve non-native speakers' listening comprehension abilities.

Role of Natural Language Processing in Enhancing TTS Quality

Recent advancements in NLP have been pivotal in improving the quality of TTS systems, making them more effective and natural-sounding.¹⁷ These advancements include the development of more sophisticated algorithms¹⁸, the application of deep learning techniques¹⁹, and the refinement of context-aware processing.²⁰ Modern NLP techniques leverage large datasets and neural networks to better understand and generate human-like speech.²¹ This results in a significant improvement in the naturalness of TTS outputs, enabling them to mimic the intricacies of human speech more accurately. For language learners, these enhancements mean that the TTS systems can provide a more realistic auditory experience. The systems are capable of understanding context, which allows them to generate speech that not only sounds natural but also conveys the correct meaning and emotion. This contextual awareness is crucial in language learning, where understanding the subtleties of language usage in different situations is essential. By providing learners with high-quality, natural-sounding speech, NLP advancements help in improving listening skills and pronunciation, making the language learning process more immersive and effective. One of the most critical aspects of TTS systems is their ability to accurately replicate the nuances of human speech²², particularly in languages like Arabic, which has complex pronunciation, intonation, stress, and rhythm patterns.²³ Traditional TTS systems often struggled with these aspects, resulting in robotic and unnatural-sounding speech. However, with the incorporation of advanced NLP techniques, the accuracy of speech synthesis has improved markedly.

¹⁷ Saadin Oyucu and Ferdi Dogan, "Improving Text-to-Speech Systems Through Preprocessing and Postprocessing Applications," in *7th International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT)* (2023): 1–5.

¹⁸ V Madhusudhana Reddy, T Vaishnavi, and K Pavan Kumar, "Speech-to-Text and Text-to-Speech Recognition Using Deep Learning," in *2nd International Conference on Edge Computing and Applications (ICECAA)* (2023): 657–666.

¹⁹ Noé Tits, Kevin El Haddad, and Thierry Dutoit, "Analysis and Assessment of Controllability of an Expressive Deep Learning-Based Tts System," in *Informatics* 8 (2021): 84.

²⁰ Jerome Patrick Gonzalvo, "Mem2Speech: An Intelligent Character Recognition-to-Speech Application Using Long Short-Term Memory Networks," 2018.

²¹ Ming Zhou et al., "Progress in Neural NLP: Modeling, Learning, and Reasoning," *Engineering* 6, no. 3 (2020): 275–290.

²² Michelle Cohn and Georgia Zellou, "Perception of Concatenative vs. Neural Text-to-Speech (TTS): Differences in Intelligibility in Noise and Language Attitudes," in *Proceedings of Interspeech* (2020).

²³ Fitra Nanda, Rika Astari, and Haji Mohammad bin Seman, "The Pronunciation of Egyptian Arabic and Its Aspect of Sociolinguistic," *Jurnal Al Bayan: Jurnal Jurusan Pendidikan Bahasa Arab* 12, no. 2 (2020): 340–356.

Modern TTS systems, powered by deep learning algorithms, can capture the subtle variations in pitch, tone, and rhythm that are characteristic of natural speech. For Arabic, this means accurately reproducing the intricate intonations and stress patterns that are vital for proper pronunciation. These systems can differentiate between the various phonemes and sounds unique to Arabic, ensuring that the generated speech is not only clear but also authentic. This level of accuracy is essential for language learners, as it provides them with a precise model to emulate, thereby enhancing their speaking and listening abilities. Another significant advantage of using NLP in TTS systems is the ability to customize and personalize the generated speech to cater to individual learner needs. NLP allows for various adjustments, such as modifying speech speed, choosing different accents, and tailoring the complexity of the language used.²⁴ This customization is particularly beneficial in a language learning context, where different learners may have different requirements and preferences.

More experienced students may choose a faster tempo to imitate normal conversation, but beginners may prefer a slower pace to better understand how each word is spoken. The regional dialect that students are concentrating on, whether it be Modern Standard Arabic or a different dialect, may also influence their accent choice. A more customized and efficient learning experience is provided by the TTS system's ability to adjust to each user's individual learning style and speed thanks to this degree of personalization. Natural language processing (NLP) plays a complex and significant role in improving the quality of text-to-speech (TTS) in language learning. NLP developments have improved the naturalness and efficacy of TTS systems, resulting in an improvement in speech synthesis accuracy, especially in languages with complicated pronunciations like Arabic. These systems' usefulness is further increased by the capacity to personalize and customise them, which makes them an effective tool for meeting specific learning needs. The quality and efficacy of TTS systems in language instruction are anticipated to soar to even higher levels as NLP technologies develop further.

Integration of TTS Technology in Language Learning Platforms

The integration of Text-to-Speech (TTS) technology into language learning platforms presents significant advancements in the field of language education.²⁵ This technological incorporation can be examined through three main points: educational tools and applications, interactive learning, and accessibility and inclusivity. Firstly, the integration of TTS technology into existing educational tools

²⁴ Soumen Santra et al., "Development of GUI for Text-to-Speech Recognition Using Natural Language Processing," in *2nd International Conference on Electronics, Materials Engineering & Nano-Technology (IEMENTech)* (2018): 1-4.

²⁵ Aurore Patricia Mroz, "Integrating Mobile-Based Text-To-Speech (TTS) and Speech-To-Text (STT) to Advance Proficiency and Intelligibility in French," *S. McCrocklin "Technological Resources for Second Language Pronunciation Learning and Teaching: Research-based Approaches* (2022): 147-169.

and applications has the potential to revolutionize the language learning experience.²⁶ TTS technology can transform static text-based resources into dynamic auditory content, enhancing the multi-sensory engagement of learners.²⁷ This auditory enhancement is particularly beneficial for learning a phonetically rich language like Arabic, where pronunciation and auditory discrimination are critical. By embedding TTS features into language learning platforms, students can listen to accurate pronunciations and intonations of Arabic words and sentences, which aids in developing their listening and speaking skills. Additionally, TTS technology can be synchronized with written text, allowing learners to read along while listening, thereby reinforcing the connection between spoken and written language. This comprehensive learning approach not only enhances understanding and retention but also caters to different learning styles, making language acquisition more effective and enjoyable.

Secondly, TTS technology facilitates interactive learning experiences, significantly improving engagement and motivation among language learners.²⁸ Traditional language learning methods often lack interactive elements, making the process monotonous and less effective.²⁹ However, with TTS-enabled applications, learners can engage in interactive activities such as listening exercises, pronunciation practice, and conversation simulations. For instance, language learning apps can utilize TTS to create immersive dialogues where learners listen to spoken Arabic phrases and respond verbally. This interactive practice allows learners to apply their listening and speaking skills in real-time, receiving immediate auditory feedback, which is crucial for language acquisition. Furthermore, TTS technology can be used to develop gamified learning modules, where learners complete tasks and challenges that require listening and responding to spoken instructions. This gamification aspect not only makes learning more enjoyable but also encourages repeated practice, thereby improving proficiency.

Thirdly, the role of TTS technology in promoting accessibility and inclusivity in language learning cannot be overstated.³⁰ Language learning can be particularly challenging for individuals

²⁶ Tira Nur Fitria, "The Use Technology Based on Artificial Intelligence in English Teaching and Learning," *ELT Echo: The Journal of English Language Teaching in Foreign Language Context* 6, no. 2 (2021): 213–223.

²⁷ Dessy Rizky Nuraini Herawati, Wiwik Widajati, and Endang Pudjiastuti Sartinah, "The Role of Text To Speech Assistive Technology to Improve Reading Ability in E-Learning for ADHD Students," *Journal of ICSAR* 6, no. 2 (2022): 169.

²⁸ Ashanti Widyana, Mohammad Iqbal Jerusalem, and Budi Yumechas, "The Application of Text-to-Speech Technology in Language Learning," in *Proceedings of the Sixth International Conference on Language, Literature, Culture, and Education (ICOLLITE 2022)* (2022): 85–92.

²⁹ Saifon Songsingchai, Bang-on Sereerat, and Wirot Watananimitgul, "Leveraging Artificial Intelligence (AI): Chat GPT for Effective English Language Learning among Thai Students," *English Language Teaching* 16, no. 11 (2023): 1–68.

³⁰ Jason Rodolitz et al., "Accessibility of Voice-Activated Agents for People Who Are Deaf or Hard of Hearing," *Journal on Technology and Persons with Disabilities* 7 (2019): 144–156.

with visual impairments or reading difficulties.³¹ TTS technology addresses these challenges by converting written text into spoken language, making learning materials accessible to a broader audience. For visually impaired learners, TTS provides an essential auditory alternative to visual text, enabling them to access and engage with language learning content independently. Similarly, for individuals with dyslexia or other reading difficulties, TTS offers a supportive tool that allows them to hear and understand written text without the barriers posed by their reading challenges. This inclusive approach ensures that language learning platforms cater to the diverse needs of all learners, fostering an equitable learning environment.

Moreover, TTS technology can be utilized to support learners in multilingual environments. For instance, Arabic learners who are non-native speakers often face difficulties in understanding complex linguistic nuances. TTS can bridge this gap by providing clear and precise auditory input, which aids in comprehension and pronunciation. This feature is particularly beneficial in multilingual classrooms where students come from varied linguistic backgrounds and may require additional auditory support to grasp new language concepts. There are several advantages to integrating TTS technology into language learning systems, from better educational resources and interactive learning opportunities to increased accessibility and inclusion. Language learning systems may offer a thorough, interesting, and inclusive educational experience that meets the various needs of students by utilizing TTS technology. This technical development not only makes language learning more efficient, but it also encourages lifetime learning and is accessible for all people, irrespective of their learning styles or aptitudes.

Challenges and Future Directions

The integration of AI-driven Text-to-Speech (TTS) technology to improve non-native Arabic speakers' listening comprehension skills faces a number of obstacles and opportunities for further research and improvement. The main concerns about technology constraints, user acceptability and adoption, and potential paths for future research and development are covered in detail in this part. One of the primary challenges in deploying AI-based TTS technology for Arabic language learning is its current inability to accurately replicate the complexities of Arabic phonetics and dialects. Arabic is characterized by its rich phonetic system, which includes a variety of sounds that do not have direct equivalents in many other languages.³² These sounds are further complicated by the presence of

³¹ Denise Fazio et al., "Second-Language Learning Difficulties in Italian Children with Reading Difficulties," *British Journal of Educational Psychology* 91, no. 1 (2021): 63–77.

³² Judith Rosenhouse, "Modern Arabic Dictionaries: Phonetic Aspects and Implications," *Zeitschrift für Arabische Linguistik*, no. 67 (2018): 71–89.

numerous regional dialects, each with its own unique pronunciation patterns and lexical variations.³³ Current TTS systems, despite significant advancements, often struggle to capture these nuances accurately. The synthesis of speech tends to be overly generalized, leading to pronunciations that might be acceptable in one dialect but incorrect in another. This limitation can hinder the learning process, as learners may not be exposed to the authentic sounds of the language as spoken by native speakers. Additionally, the intonation and prosody in Arabic, which carry significant meaning and can alter the message conveyed, are often inadequately reproduced by existing TTS technologies. Addressing these technological limitations is crucial for the effective use of TTS systems in Arabic language education.

While AI-powered TTS technology offers innovative solutions for improving listening skills, it is important to compare its effectiveness with traditional and alternative methods commonly used in language learning. One such method is immersive learning through direct interaction with native speakers, either in-person or via language exchange platforms. This approach provides learners with exposure to authentic language use, including natural intonation, cultural nuances, and real-time feedback. Unlike TTS systems, which may struggle with capturing the subtleties of dialects and informal speech, interaction with native speakers ensures a richer and more dynamic learning experience. However, native speaker interactions are often limited by accessibility, scheduling challenges, and learners' anxiety in real-life conversational settings, which TTS technology can overcome by providing a controlled and private practice environment.

Another widely used method is the incorporation of multimedia resources such as audio recordings, podcasts, and language learning applications. These tools are highly effective in exposing learners to diverse accents and contexts, fostering a broader understanding of the target language. Unlike TTS technology, multimedia resources often feature human-recorded speech, which is more authentic and engaging. However, they lack the interactive and adaptive capabilities of TTS systems, such as real-time pronunciation feedback or personalized pacing based on learners' progress. Additionally, multimedia tools are static and do not allow for flexible adjustments to individual learners' needs. Combining the strengths of TTS technology, native speaker interactions, and multimedia resources could create a more holistic approach, balancing authenticity, accessibility, and adaptability to enhance Arabic listening skills comprehensively.

³³ Abdullah Hussein Ali Alnosairee and Ni Wayan Sartini, "A Sociolinguistics Study in Arabic Dialects," *Prasasti: Journal of Linguistics* 6, no. 1 (2020): 1–17.

CONCLUSION

By addressing these areas, the potential of AI-based TTS technology in facilitating Arabic language learning for non-native speakers can be fully realized. A key finding of this study is the superiority of AI-TTS over traditional methods in improving listening comprehension. However, understanding why traditional methods are less effective is crucial for contextualizing these results. One significant limitation of traditional approaches lies in their static nature, as audio materials used in conventional methods lack the dynamic adaptability required to meet diverse learner needs. These recordings often fail to offer interactive features, such as pace adjustment or real-time feedback, which are vital for personalized learning experiences. Additionally, traditional materials are typically limited in their ability to expose learners to variations in pronunciation and natural flow, leaving gaps in understanding language nuances. AI-TTS systems overcome these challenges by providing accurate and consistent pronunciation, real-time feedback, and the ability to customize the learning experience. Learners can adjust the pace and complexity of the speech output, creating a more individualized and engaging process. To further enhance the effectiveness of TTS technology, future research should continue exploring its advantages over traditional methods while addressing technological and user-related challenges, thereby offering an inclusive and transformative solution for Arabic language education.

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