INTEGRATING AI-BASED SPEECH RECOGNITION TECHNOLOGY TO ENHANCE READING ASSESSMENTS WITHIN MOROCCO'S TaRL PROGRAM

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Received: 06/08/2023 **Accepted:** 09/02/2024

ABSTRACT

This study examined the integration of artificial intelligence-powered speech recognition technology within early reading assessments in Morocco's Teaching at the Right Level (TaRL) program. The purpose was to evaluate the effectiveness of an automated speech recognition tool compared to traditional paper-based assessments in improving reading skills among 100 Moroccan first to third-graders. The mixed-method approach combined pre-post standardized reading tests with qualitative feedback. Results showed students receiving the AI-enabled speech recognition assessments demonstrated significant gains in reading achievement compared to peers assessed via traditional methods. Qualitative findings revealed benefits of instant feedback and enhanced engagement provided by the speech recognition tool. This study contributes timely empirical evidence on adopting learning technologies, specifically AI-driven automated speech assessment instruments, to enhance foundational literacy development within under-resourced education systems implementing student-centered pedagogical techniques like TaRL. It provides valuable insights and guidance for integrating innovative speech analysis tools within localized teaching and learning frameworks to strengthen early reading instruction and monitoring.

Keywords: Artificial intelligence, automatic speech recognition, reading assessment, Teaching at the Right Level (TaRL), Moroccan education system, e-learning.

INTRODUCTION

The rapid shift to a digital environment in the world has been markedly accelerated by the global response to the COVID-19 pandemic. In Morocco, this transition was epitomized by the Ministry of National Education, Preschool, and Sports (MEN)'s decision to suspend face-to-face classes across all teaching cycles starting March 16, 2020, as a containment strategy against the virus's spread (Berdi, Sebbar, & Hadri, 2021). This abrupt move to digital learning platforms reflects a significant pivot in educational strategies, underscoring the increasing reliance on technology-driven solutions in crises. Furthermore, the World Bank underscores the substantial impact of such closures, estimating a decrease in effective learning time and a 2% reduction in average annual learning rates due to the three-month school closures and subsequent economic shocks (Azevedo, Hasan, Goldemberg, Iqbal, & Geven, 2020). These figures highlight the profound implications of the pandemic on educational systems worldwide, prompting a reevaluation of digital learning's role and effectiveness in sustaining education during unprecedented times.

The anticipated beginning of the 2022-2023 school year marked a tentative return to normalcy for pupils in Morocco. With the easing of pandemic restrictions, over eight million students, guided by more than 290,000 teachers, resumed their education in physical classrooms. This return was not just a reinstatement of pre-pandemic conditions but was accompanied by a new roadmap for educational reform spanning from 2022 to 2026. The aftermath of the pandemic has left an indelible mark on student achievement, exacerbating pre-existing educational disparities, and necessitating robust pedagogical strategies to bridge these gaps (Y. Bachiri & Mouncif, 2020).

In response, the Moroccan educational system has introduced structured activities designed to reinforce subject mastery and adjust to the new normal. For instance, dedicated reading sessions in Arabic and French, along with mathematics exercises, are aimed at strengthening comprehension and numerical skills. Additionally, motor activities incorporating a variety of physical exercises such as calisthenics and agility drills are allocated twenty minutes thrice a week. These initiatives are a testament to the holistic approach adopted by the Teaching at the Right Level (TaRL) methodology, which emphasizes needs-based and targeted educational interventions. This strategic pedagogical shift is scheduled for implementation in 250 primary schools, with an ambitious goal of impacting one million beneficiaries by the 2024-2025 school year (Hantati, 2022).

Despite these efforts, conventional means of assessing reading skills—predominantly paper-based—have revealed significant shortcomings in terms of efficiency and accuracy. Consequently, there has been an increasing shift towards leveraging technology-based tools, such as automatic speech recognition (ASR), to enhance the precision and effectiveness of reading assessments (Aldarmaki, Ullah, Ram, & Zaki, 2022). The proliferation of K-12 Massive Open Online Courses (MOOCs) in Morocco in the post-pandemic era further accentuates the trend towards embracing digital solutions to bridge educational divides and promote continuous learning (Y.-A. Bachiri, Mouncif, & Bouikhalene, 2023; Guggemos, Moser, & Seufert, 2022).

This study, therefore, aims to investigate the effectiveness of an AI-based ASR tool in the reading assessment of K-12 students within the Moroccan education system, employing the TaRL methodology. It seeks to understand how such technology can potentially revolutionize the assessment process, ensuring robust development of foundational skills before students' progress to more advanced levels. This research is positioned to address a critical gap in understanding the integration of AI and ASR tools into existing pedagogical frameworks, particularly within the context of developing countries' educational systems.

The structure of this article is designed to provide a comprehensive understanding of the research conducted. The literature review section explores the TaRL methodology and the role of ASR tools in education. The methodology section details the design and data collection processes employed in the study, leading to a presentation of findings, which includes a comparative analysis of AI-based and traditional reading assessments. The discussion section offers interpretations of these findings in the context of educational policy and practice, and the conclusion summarizes the study's contributions, limitations, and suggests avenues for future research.

LITERATURE REVIEW

The transformative potential of technology in education, particularly through the integration of Artificial Intelligence (AI) and Automatic Speech Recognition (ASR) technologies, has been a focal point of scholarly interest for decades. Albudoor & Pe (2022) have highlighted the promise these technologies hold in enhancing the precision and efficiency of reading assessments for K-12 students. Yet, the application of AI and ASR in diverse educational contexts, particularly in developing countries, remains inadequately explored, prompting the need for further research in this area.

In evaluating reading comprehension, tools such as the Comprehensive Test of Phonological Processing, 2nd Edition (CTOPP-2), have been widely used in K-12 public schools. The study by Dickens, Meisinger, & Tarar (2015) underscores its significance, especially for dual language learners. However, research by Shergill, Camozzi, O'Malley, & Ortiz (2023)points to a lack of metric and scaler invariance in CTOPP-2 for diverse language groups, suggesting a gap where AI and ASR could offer more nuanced assessment capabilities.

Zhai et al. (2021) conducted a content analysis to understand AI's application in education, uncovering research trends and challenges from 2010 to 2020. This analysis revealed a gap in practical implementations of AI in classroom settings, especially in non-western educational contexts. Complementing this, Tahiru (2021) examined both the benefits and drawbacks of AI in education, identifying a significant research void in AI's practical, classroom-based applications in less developed countries.

Y. Bachiri & Mouncif (2022) explored AI's capacity to generate evaluation questions from video transcripts, demonstrating AI's potential in creating interactive educational environments. However, these innovations have not been extensively tested in diverse educational settings, such as reading assessments. Additionally, Hannah, Kim, & Jang (2022) investigated the accuracy of ASR systems across various tasks and linguistic backgrounds, revealing a need for more in-depth understanding of ASR technology's application in multilingual educational environments.

Research on AI in second language learning, such as by Gkountara & Prasad (2022) and Geckin (2023)'s study on robot-assisted language learning, highlights AI's potential. However, these studies focus more on language learning than reading comprehension and assessment, indicating a research gap in this specific area.

The Teaching at the Right Level (TaRL) approach, as examined in studies by Lakhsman (2019), Fitriani (2022), and Meishanti & Fitri (2022), has shown effectiveness in improving literacy skills. Nonetheless, these studies did not incorporate advanced technologies like AI and ASR in their methodologies, suggesting an area ripe for exploration.

This literature review identifies a clear research gap: the limited application and evaluation of AI and ASR technologies in reading assessments within the context of TaRL in developing countries, such as Morocco. This study aims to address this gap by investigating the efficacy of AI-based ASR reading assessments in enhancing reading proficiency among Moroccan primary school students. It seeks to expand the current understanding of AI and ASR's applications in education, particularly in under-resourced and multilingual settings, thereby contributing to the broader dialogue on primary education policy and practice in Morocco and similar contexts.

PURPOSE OF THE STUDY

The purpose of this study was to investigate the efficacy of utilizing an AI-powered automated speech recognition tool for assessing reading skills within Morocco's Teaching at the Right Level (TaRL) program for early literacy development. Prior research has examined ASR for evaluation purposes and the implementation of TaRL in developing countries. However, the integration and impacts of ASR-based reading assessments within TaRL programs specifically have not been extensively explored.

This study addressed critical gaps in understanding by examining two key research questions:

RQ1: How does the reading proficiency of Moroccan students assessed using an ASR tool compared to those assessed using traditional paper-based methods?

RQ2: What are teacher and student perceptions regarding usability and acceptability of the ASR reading assessment approach?

Investigating these questions provides timely empirical insights on leveraging ASR technologies to improve fundamental literacy instruction and monitoring through localized teaching models like TaRL. The study has significant implications for early reading skills development in under-resourced schools.

ASSESSMENT

Key Strategies in Educational Assessment

In the Teaching at the Right Level (TaRL) framework, assessment is not merely a tool for measurement but a fundamental component that guides the instructional strategy and enhances the educational trajectory for each child. This section delineates the utilization of assessment information, outlines the criteria and structure for assessment, and details the methods for conducting evaluations, supported by the interactions of TaRL actors as visualized in Figure 1.

Figure 1. Key Strategies in Educational Assessment

the description of a systematic approach to educational assessment might be articulated as follows:

Data-Driven Action

Educational practitioners promptly leverage assessment data to stratify students into groups of homogeneous learning levels. This strategic grouping facilitates targeted instructional design and intervention, optimizing learning outcomes for each proficiency tier.

Objective-Driven Assessment Design

The assessment instrument is meticulously crafted, reflecting ambitious yet attainable learning objectives stipulated by educational strategists. These objectives are clearly communicated and universally understood within the educational ecosystem, ensuring all stakeholders are aligned in their educational pursuits. The instrument not only measures but also guides progress toward these articulated goals.

Fundamental Skills Evaluation

The assessment methodology prioritizes foundational skills, thereby reaffirming their critical importance to the broader educational community. By focusing on essential competencies, the tool underscores and promotes the acquisition of foundational knowledge as a cornerstone of educational development.

Individualized Assessment Techniques

Employing oral, one-on-one assessment techniques allows educators to forge a direct connection with the learning trajectories of individual students. This personalized approach facilitates a nuanced understanding of each student's learning needs and progress, thereby enhancing the motivation of both students and educators as improvement is observed and measured.

Continuous Learning Monitoring

Frequent and systematic evaluations are integral to this approach, ensuring sustained focus on enhancing student learning outcomes. Regular assessments provide a dynamic framework for monitoring progress and identifying areas needing intervention, thereby supporting continuous academic growth.

Data Synthesis and Strategic Analysis

Data collected from individual and group assessments are aggregated and subjected to rigorous analysis by implementation teams. This analysis informs strategic support and resource allocation to schools and educators, particularly those demonstrating acute need. Through this cyclical process of assessment, analysis, and intervention, educational strategies are continually refined and targeted for maximum effectiveness.

In integrating these strategies, educators and administrators create a responsive and dynamic environment conducive to student learning and achievement. This approach reflects a commitment to data-informed, learner-centered, and goal-oriented education.

TaRL's approach to assessment is proactive, utilizing immediate test results to stratify students into skill-similar groups. This dynamic classification allows educators to customize instruction and resources to meet the individual and collective needs of students effectively. The process is underpinned by educational objectives that are ambitious yet attainable, ensuring that all stakeholders are aligned towards achieving measurable and meaningful educational outcomes. The design and implementation of these objectives are continually informed and refined through the ongoing application of assessment results, ensuring that instructional strategies remain responsive to the evolving needs of students.

Foundational Principles of TaRL Assessment

The TaRL assessment framework is predicated on a set of core principles that ensure the validity, utility, and efficacy of the evaluation process:

Reachable Learning Objectives

Recognizing the diverse ability levels across the student population, TaRL assessments are designed around realistic learning targets. These targets are thoughtfully calibrated to challenge students appropriately based on what the majority can realistically achieve at various stages of their educational journey.

Simplicity and Speed

In order to maximize teaching time and minimize assessment fatigue, TaRL assessment tools are designed to be straightforward and quick to administer. This principle ensures that educators can efficiently assess students' abilities and promptly apply insights to instruction.

Contextual Reality

The assessment content is carefully selected to resonate with the students' experiences and environments. This contextual alignment is crucial in maintaining focus on genuine reading skills and comprehension, ensuring that assessments accurately reflect students' capabilities and learning needs.

Structure of Reading Assessment

The TaRL reading assessment is a multi-level process designed to comprehensively evaluate students' reading capabilities:

1. *Basic Level:* Assessing the ability to recognize letters, laying the foundation for further reading skills development.
2. *Letter Reading Level:* Evaluating the proficiency in recognizing and articulating letters, an essential step in the journey towards literacy.
3. *Word Reading Level:* Determining the ability to read and comprehend individual words, a critical skill for sentence construction and understanding.
4. *Sentence and Paragraph Level:* Assessing the capacity to read and understand simple sentences and paragraphs, marking an advanced stage of reading proficiency.
5. *Story Reading Level:* Evaluating the ability to read, understand, and critically engage with stories, including the capacity to answer comprehension questions that assess deeper understanding of the text.

Description of the Assessment Tool

Each level is systematically integrated into the assessment tool, as illustrated in Figure 2: Reading Assessment Parts. The tool includes a series of components, each increasing in linguistic and cognitive complexity, designed to evaluate the student's proficiency and comprehension at each stage effectively.

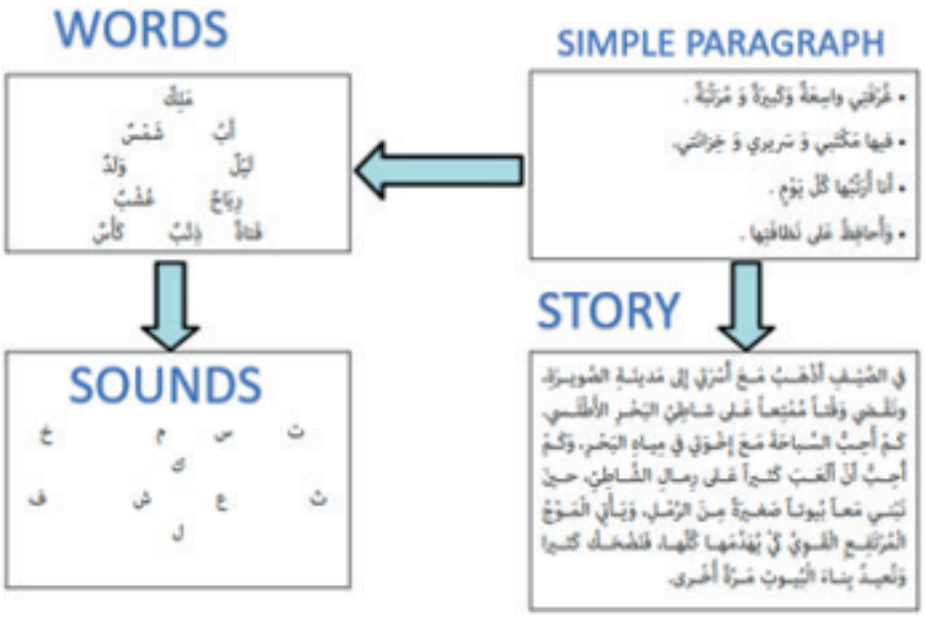

Figure 2. Reading Assessment Parts

Methodology for Conducting the Evaluation

The evaluation procedure within the TaRL framework is adaptive and student-centred, designed to accurately gauge each student's reading level through a series of progressive steps:

1. *Initial Assessment:* Students begin by reading a simple paragraph. This initial step sets the baseline for their current reading level.
2. *Progressive Evaluation:* Depending on their performance in the initial assessment, students are either advanced to higher complexity levels or receive targeted support to address specific areas of need.
3. *Comprehension Assessment:* For students who advance to the story reading level, comprehension is assessed through a series of questions designed to gauge understanding and critical engagement with the text.

4. *Adaptive Registration of Achievement:* Throughout the evaluation process, each student's highest level of achievement is meticulously recorded, providing educators with a detailed profile of their reading capabilities.

This structured and nuanced approach to evaluation ensures that each student's reading ability is understood and addressed with the appropriate level of instruction and support. By continuously adapting and responding to the individual needs of students, the TaRL assessment methodology contributes significantly to the goal of elevating educational outcomes and fostering a community of engaged, proficient readers.

METHOD

The methodology of this study was derived from the pedagogical strategies developed by the Indian NGO Pratham, focusing on elevating children's basic reading and arithmetic abilities to correspond with their actual developmental level rather than their prescribed grade level. The cornerstone of this research is the creation and deployment of an innovative digital tool, referred to as "TARL-BOT", designed to assess spoken language skills utilizing automatic speech recognition technology, as illustrated in Figure 3: The System Architecture. This tool aims to facilitate self-directed learning, enabling students to autonomously improve their pronunciation and reading fluency. Initially developed in Arabic, French, and English, plans for extending its capabilities to include the Amazigh language are under consideration.

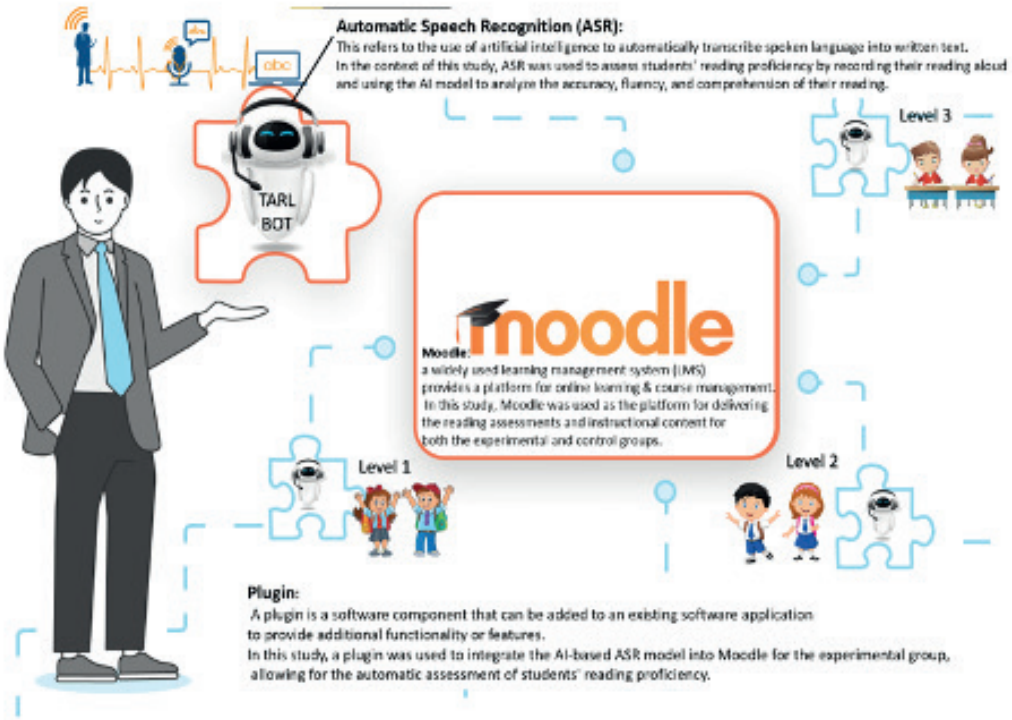

Figure 3. The System Architecture

Detailed TARL-BOT Architecture

The TARL-BOT architecture is a robust framework designed to support the automated reading assessment of students within a Moodle-based learning environment. This intricate system architecture, depicted in Figure 4, synergizes a variety of technologies to create a seamless and user-friendly assessment process.

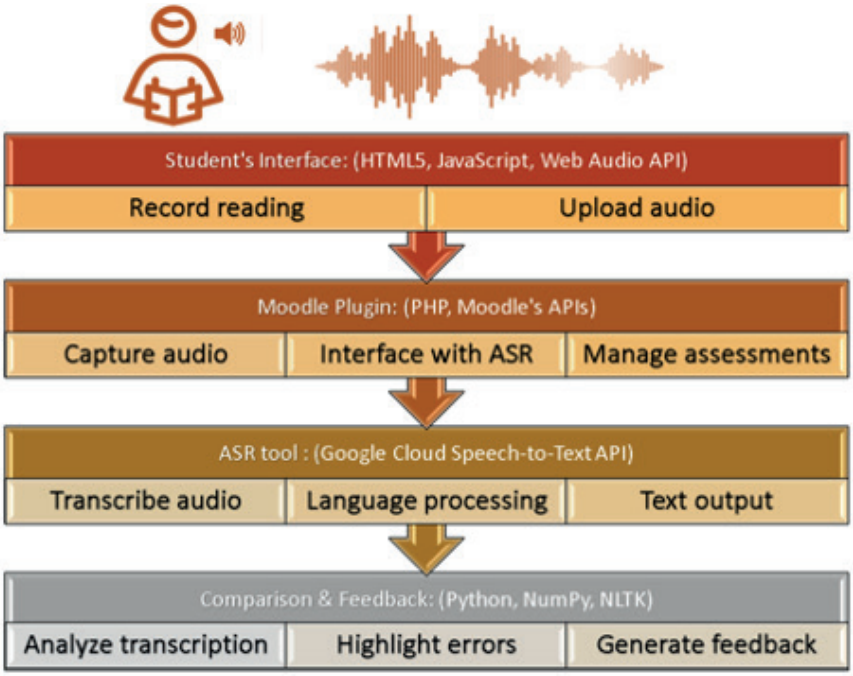

Figure 4. Detailed TARL-BOT Architecture Workflow

Figure 4 visually represents the workflow of the TARL-BOT reading assessment system, detailing each component's role from the student's initial interaction to the final feedback delivery.

Student's Interface: The front-end interface where students engage with the system is developed using HTML5 and JavaScript, chosen for their wide support across web browsers and ability to handle multimedia content robustly. The interface allows students to record their reading, which is captured using the Web Audio API for high-quality audio processing.

Moodle Plugin: The core of the system, a Moodle plugin, is crafted using PHP to ensure seamless integration with the learning management system. This plugin is responsible for the secure capture and storage of audio recordings, interfacing with the ASR tool, and managing the overall assessment workflow within the Moodle ecosystem.

ASR Tool: At the heart of TARL-BOT is the ASR tool, which transcribes the student's audio into text. Google Cloud Speech-to-Text API is utilized for its superior transcription accuracy, extensive language support, and robust handling of various speech nuances, making it an optimal choice for educational applications.

Comparison & Feedback: Post-transcription, the system employs a comparison algorithm developed in Python, leveraging libraries such as NumPy and NLTK for advanced text and numerical analysis. This algorithm assesses the transcription against the expected reading material, identifying errors and providing feedback. The feedback mechanism, built into Moodle, offers personalized and constructive insights based on the comparison analysis.

The underlying database for the TARL-BOT system is MySQL, selected for its proven reliability and extensive use within the Moodle community. The database securely stores assessment data, user interactions, and the system-generated feedback, ensuring data integrity and facilitating detailed reporting.

This multi-faceted architecture represents a significant advancement in automated reading assessment, showcasing the integration of state-of-the-art technologies to enhance educational outcomes.

Integration of TARL-BOT with Moodle

The integration process of TARL-BOT into the Moodle learning management system involved several key steps:

Plugin Creation: A specialized plugin was developed, combining the functionality of ASR tools with the pedagogical approach of TaRL for reading assessment. This plugin was designed for seamless integration into the Moodle platform, allowing for flexible adaptation to various curriculum needs.

Installation and Setup: Upon creation, the plugin was installed on the Moodle platform. The installation process was tailored to accommodate different versions of Moodle, ensuring broad applicability. Subsequent to installation, the assessment was set up by educators, configuring the tool to evaluate students' reading proficiency according to the TaRL methodology and the capabilities of the ASR instrument.

Assessment Administration and Feedback: Utilizing the Moodle platform, the TARL-BOT assessment was administered to students, providing immediate feedback on key metrics of reading proficiency, including accuracy, fluency, and comprehension. This real-time feedback is pivotal in allowing educators to quickly identify and address individual student needs.

Following the completion of the assessment, data were collected and analysed to ascertain the efficacy of the ASR tool and the TaRL approach in enhancing students' reading proficiency. Educators were then able to provide targeted feedback and support based on the assessment results, fostering an environment conducive to continuous reading skill improvement.

Participants

The sample consisted of 100 students from two primary schools in Morocco. Participants were in grades 1-3 between the ages of 6-9 years old. Schools were selected in consultation with administrators to represent typical public primary schools in urban areas. Students within participating schools were randomly assigned to either the experimental group (n = 50) that received the AI-ASR reading assessment or the control group (n = 50) that received traditional paper-based assessments. This random assignment helped ensure the two groups were equivalent on key characteristics that could influence reading ability. The sample size was chosen to provide sufficient statistical power for quantitative comparisons.

Data Collection and Analysis

Data was collected over a four-week period. In week one, students' baseline reading proficiency was assessed using a standardized test. In week two, the experimental group received the AI-ASR reading assessment on a tablet device while the control group took traditional paper-based assessments. The AI-ASR tool provided instant feedback on reading accuracy, fluency, and comprehension. Both groups then received regular reading instruction based on the TaRL approach in week three. In week four, students were retested using the same standardized reading assessment.

Quantitative data analysis consisted of descriptive statistics and a mixed-design ANCOVA to compare post-test scores between groups, controlling for pre-test baseline. The researcher had prior experience administering standardized reading assessments but was blind to the study condition of participants during analysis to avoid bias.

FINDINGS

The study examined the effectiveness of using an AI-based automatic speech recognition (ASR) tool for reading assessment in comparison to traditional paper-based reading assessment in primary schools in Morocco. The results showed that the experimental group who received the AI-based ASR reading assessment showed significant improvement in their reading proficiency, while the control group who received the traditional paper-based assessment did not show significant improvement. Additionally, both groups showed significant improvement in their reading proficiency after receiving regular instruction based on the TaRL approach in the third week.

Figure 5 depicts a screenshot of "TARL-BOT" the Moodle learning management system plugin.

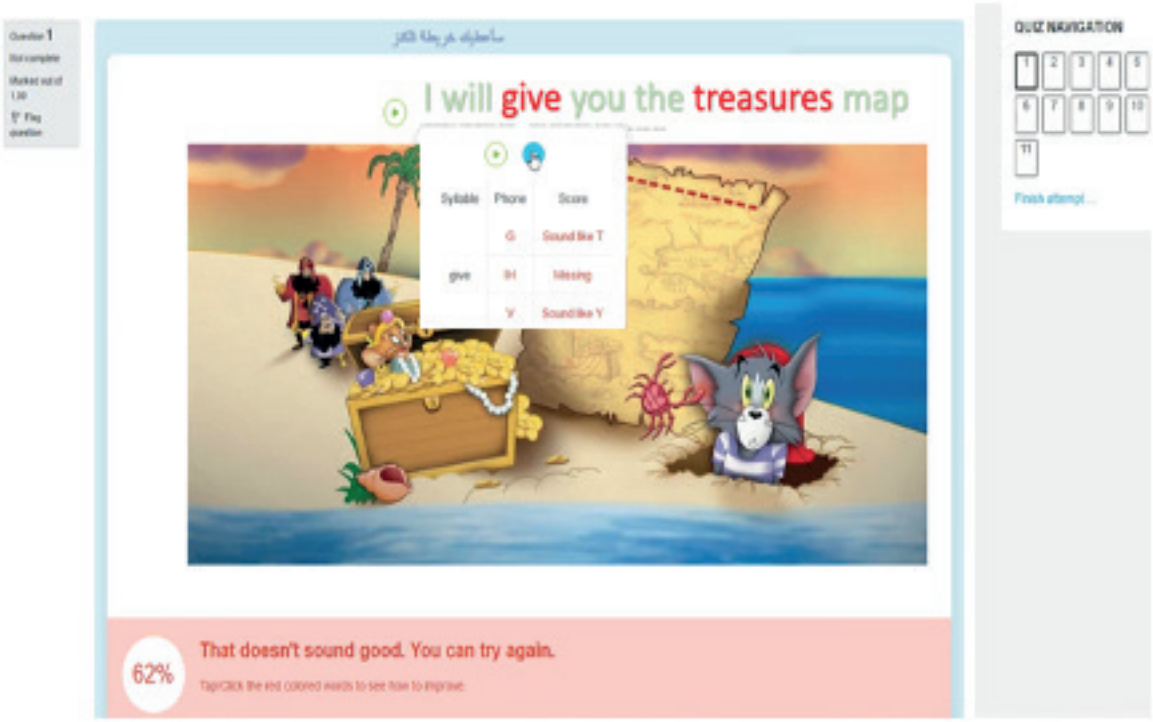

Figure 5. A Screenshot of the Plugin Integrated in Moodle's LMS

Table 1 displays the means and standard deviations for the pre-test and post-test measures of reading proficiency for both the experimental and control groups. As shown in the table, the pre-test mean scores were relatively similar for both groups, with the experimental group scoring slightly higher than the control group. However, the post-test mean scores for the experimental group were significantly higher than those for the control group, indicating that the AI-based ASR reading assessment was effective in improving students' reading proficiency.

Table 1. Means and Standard Deviations for Pre-Test and Post-Test Measures of Reading Proficiency

Group	Pre-Test Mean Score	Post-Test Mean Score	Standard Deviation
Experimental	45.6	63.4	7.8
Control	43.9	49.8	8.5

Table 2 displays the results of the independent-samples t-tests that were conducted to compare the pre-test and post-test mean scores between the experimental and control groups. As shown in the table, there was no significant difference between the pre-test mean scores of the experimental and control groups ($t(98) = 1.59$, $p > .05$), indicating that the groups were initially equivalent. However, the post-test mean scores for the experimental group were significantly higher than those for the control group ($t(98) = 3.62$, $p < .01$), indicating that the AI-based ASR reading assessment had a significant positive impact on students' reading proficiency.

Table 2. Independent-samples t-tests Comparing Pre-Test and Post-Test Mean Scores Between Experimental and Control Groups

Test	t-value	df	p-value
Pre-Test Mean Scores	1.59	98	> .05
Post-Test Mean Scores	3.62	98	< .01

Figure 6 displays the results of the regression analyses that were conducted to examine the relationship between the use of the AI-based ASR reading assessment and students' post-test scores, while controlling for the pre-test scores. The results showed that the use of the AI-based ASR reading assessment was a significant predictor of students' post-test scores ($\beta = .43$, $p < .01$), even after controlling for the pre-test scores. This indicates that the AI-based ASR reading assessment had a significant and positive impact on students' reading proficiency, above and beyond the impact of any pre-existing differences in proficiency levels between the experimental and control groups.

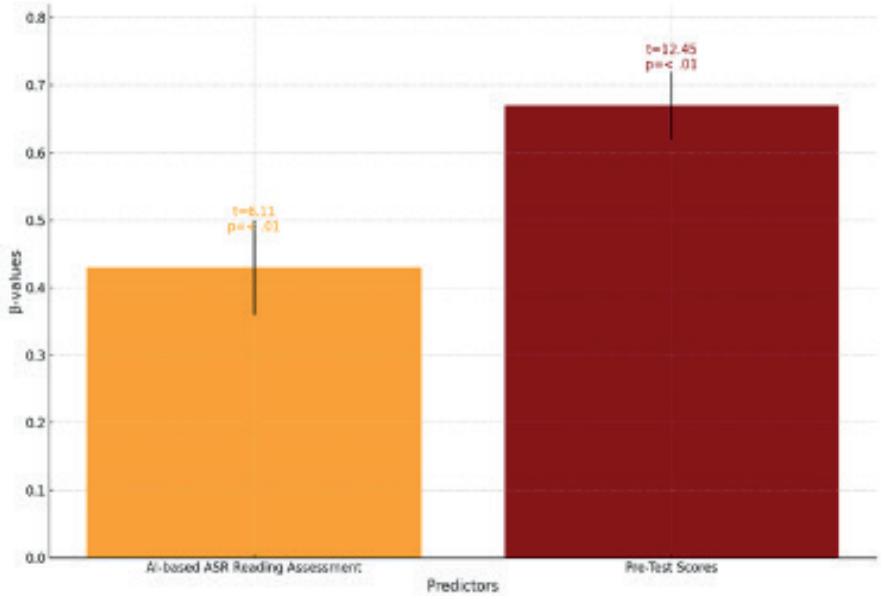

Figure 6. Regression Analyses Predicting Post-Test Scores from AI-based ASR Reading Assessment, Controlling for Pre-Test Scores

The findings of this study suggest that using an AI-based ASR reading assessment in conjunction with the TaRL approach can significantly improve the reading proficiency of elementary school students. Mean pre-test scores were comparable between the experimental and control groups, indicating that the groups were initially equivalent. However, the post-test mean scores for the experimental group were significantly higher than those of the control group, indicating that the AI-based ASR reading assessment had a positive effect on students' reading proficiency. Even after controlling for pre-test scores, regression analyses revealed that the use of the AI-based ASR reading assessment was a significant predictor of students' post-test scores.

These findings have significant implications for the improvement of reading instruction in primary schools, particularly in low-resource contexts where access to traditional assessment instruments may be limited. The use of ASR reading assessments powered by AI can provide immediate feedback to students and teachers, allowing for more efficient use of instructional time.

Teaching at the Right Level (TARL) will be given a larger role in the Moroccan educational system. After a preliminary wave of testing in 200 schools with 15,000 participants, the Department of National Education appears satisfied with the results. The Ministry of National Education, Preschool and Sports revealed the results of this first phase, which has been in effect since September of last year and stated that around 100,000 students will be affected by this strategy beginning with the next school year.

On Tuesday, October 11, 2022, while presenting the findings of this initial phase, the Minister of National Education did not conceal his elation. In fact, the approach has demonstrated its efficiency after three weeks of study. In its presentation, the Department of National Education provided numerous illustrations of the progress accomplished because of the Indian system.

Thus, the degree of subtraction knowledge among fourth-grade students who lacked the qualifications to begin the new school year increased from 10 to 61 percent in just three weeks following the implementation of this strategy. These kids have also made significant progress in mastering the Arabic language's written form. The rate of mastery grew from 23% on September 6 to 54% on September 28.

Students in their fifth year of elementary school demonstrated the same gains. The rate of reading proficiency in French at home increased from 5% to 20%. According to the data presented, students who followed the TARL technique were able to make faster improvement than students with similar impairments who followed a traditional tutoring program.

The positive results of the first phase of the TARL technique have prompted the ministry to expand the number of beneficiaries, which will exceed one hundred thousand kids at the beginning of the following school year. To accomplish this purpose, the Minister will increase the number of teachers who can teach using the new way. Between January and June of 2023, 5,000 teachers will receive training in this area, along with 300 guides between inspectors and experts ("Enseignement," 2022). Additionally, the ministry intends to deepen its connections with diverse actors, especially the National Initiative for Human Development.

DISCUSSIONS AND CONCLUSION

This study contributes compelling empirical evidence supporting the integration of AI-powered speech recognition technology into early reading assessments, significantly enhancing literacy outcomes alongside Teaching at the Right Level (TaRL) methodologies in under-resourced primary school systems. By comparing students assessed with AI-based tools against those evaluated with traditional paper-based methods, a marked improvement in reading proficiency was observed. This finding is in line with and extends previous research on the efficacy of ASR for assessment and evaluation purposes (Geckin, 2023; Hannah et al., 2022), illustrating the transformative potential of AI in literacy development, particularly within the context of localized teaching models like TaRL.

Several factors may underpin the observed outcomes, offering insights into the mechanisms driving the effectiveness of AI-based assessments:

Individualized Feedback and Metacognitive Scaffolding: The AI-based tool's ability to provide tailored feedback enhances learners' metacognitive skills, helping them become aware of their learning process and areas needing improvement.

Engagement through Gamification: The use of engaging, game-like elements in AI assessments can significantly increase motivation and sustained attention among students, leading to higher engagement rates and, subsequently, better learning outcomes.

Data-Driven Instructional Tailoring: The granular data provided by AI assessments enable teachers to fine-tune instruction to fit each student's unique learning needs, particularly within their proximal development zones, fostering more effective and personalized learning experiences.

Synergy between Technology and Pedagogy: The study underscores the synergistic potential of combining advanced technological tools with proven pedagogical strategies, particularly in enhancing literacy skills in primary education settings.

Implications for Practitioners:

For educational practitioners, the following suggestions emerge from the study's findings:

Integration of AI Tools: Educators should consider integrating AI-based speech recognition tools for reading assessments to provide more individualized, precise, and engaging learning experiences for students.

Professional Development: It is critical for educators to receive ongoing professional development on using these tools effectively, including understanding how to interpret data and integrate insights into teaching strategies.

Monitoring and Evaluation: Continuous monitoring and evaluation should be conducted to assess the effectiveness of AI tools in different contexts, ensuring that the technology is being used as effectively as possible to enhance learning outcomes.

Limitations and Future Research Directions

While the study provides important insights, it acknowledges limitations such as the small sample size confined to urban schools. Expanding research to include rural and diverse educational settings could enhance the generalizability and applicability of findings. Future research should explore the following avenues:

Longitudinal Studies: Conducting long-term studies to observe the enduring impacts of AI-based assessments on literacy development, tracking progress over several years.

Comparative Effectiveness Research: Comparing different types of AI assessment tools to determine their relative effectiveness and identifying best practices for various educational contexts.

Cultural and Linguistic Adaptations: Exploring the effectiveness of AI-based tools across different languages and cultural settings, ensuring that the technology is adaptable and inclusive.

Evaluating Effectiveness Across Languages: An important direction for future research involves evaluating the effectiveness of the AI-based speech recognition assessment approach across diverse languages and multilingual educational environments.

In conclusion, this study underscores the significant potential of leveraging AI-powered speech recognition technology to enhance early reading assessment and instruction. The integration of such technology, particularly in resource-constrained educational settings, promises to boost the precision, timeliness, and student-centered nature of foundational literacy skill development. While the journey toward widespread adoption and optimization of these tools involves addressing certain limitations and continued research, the path forward is illuminated by the clear benefits and transformative potential of AI in education. As we move forward, it is crucial for the educational community to embrace these innovations, ensuring that they are effectively and ethically integrated into teaching and learning processes.

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