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Research Article

Adaptive AI Systems in Reading Instruction: Personalizing Text Difficulty for Enhancing L2 Learners' Reading Comprehension

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ABSTRACT

Adaptive AI technologies have now introduced new possibilities to personalize second-language reading instruction. Different from traditional one-size-fits-all methods of text selection, adaptive AI constantly analyzes learner performance to fit text difficulty to individual needs. The present study investigates the effectiveness of an adaptive AI system that was designed to personalize text complexity for EFL learners. Informed by the Input Hypothesis, Cognitive Load Theory, and Zone of Proximal Development, the study examines whether adaptive personalization leads to measurable comprehension gains, reduced cognitive load, and heightened motivation. A quasi-experimental design (N = 60) was implemented over eight weeks using pre- and post-tests, system log data, and qualitative learner feedback. Expected outcomes indicate that AI-based personalization significantly improves comprehension while enhancing learner autonomy and offering more accurate difficulty calibration than teacher-selected materials. This paper addresses a notable gap in L2 research by providing empirical evidence and a conceptual framework for integrating adaptive AI systems into reading pedagogy.

Keywords: Adaptive AI, EFL Learners, L2 Reading Comprehension, Personalized Instruction

1. INTRODUCTION

Reading comprehension is a core aspect of second-language learning, affecting academic performance, vocabulary gain, and general linguistic competence (Grabe & Stoller, 2020). One of the determining elements in comprehension success is the difficulty of the text, which predefines how effectively learners will be able to receive information. Traditionally, teachers rely on graded readers, general proficiency descriptors, or intuition when selecting texts for learners. However, research shows that such static methods frequently fail to match the actual ability of individual learners (Jeon & Day, 2016).

Recent developments in adaptive AI systems hold great promise for changing how reading instruction has traditionally been tailored to meet individual needs. These systems automatically adjust text difficulty through real-time machine learning models monitoring reading speed, comprehension accuracy, and vocabulary knowledge along with behavioral metrics like eye-movement patterns or skipped words (Crossley et al., 2022).

However, despite the rapid technological developments, SLA literature still lacks theoretical and empirical research exploring the efficiency of AI-driven personalization of reading difficulty. This points to a gap in research into whether adaptive AI systems offer measurable pedagogical benefits. Therefore, the current study aims to fill this gap by testing whether AI-driven text personalization results in greater comprehension gains for EFL learners compared to traditional teacher-driven text selection.

2. LITRATURE REVIEW

2.1 Adaptive Learning in Second Language Acquisition

Adaptive learning refers to systems that adjust content based on learner characteristics, progress, and performance. In SLA, there have been benefits shown with vocabulary learning (Godwin-Jones, 2020), reading fluency (Chen et al., 2023), and learner engagement (Reinders & White, 2023) using adaptive tools. At the core of adaptive systems is a variety of algorithms that track the learners' difficulties and adjust the degree of content difficulty and the tasks the learners have to perform, thus providing an individual path through the learning process.

2.2 Role of Text Difficulty in L2 Reading

Text difficulty and comprehension are well-documented correlates. Nation and Webb (2017) stress that optimal reading materials match the learners' vocabulary size and grammatical competence. Too difficult texts impair comprehension and create cognitive overload, while overly simple texts fail to stimulate learning (Schmitt, 2020).

Traditional readability formulas, like Flesch–Kincaid and Lexile, fail to account for semantic and discourse-level features. However, AI-based systems can evaluate various layers of difficulty, including cohesion, lexical sophistication, syntactic dependency, and discourse relations, in order to provide realistic estimations of difficulty (Graesser et al., 2023).

2.3 AI-based Personalization in Reading

Modern AI systems combine NLP, LLMs, and predictive analytics. Such systems can:

_Dynamically simplify or enrich texts

_Generate personalized glosses

_Highlight key information

_Detecting user confusion based on reading patterns:

_Adjust subsequent texts to user performance

Studies such as Crossley et al. (2022) reveal that AI-driven scaffolding supports deeper comprehension. On the other hand, specific studies concerning EFL adaptive reading systems are sparse.

2.4 Research Gap

Few studies have systematically explored whether AI-personalized text difficulty leads to measurable comprehension gains compared to traditional instruction. This study addresses this gap

3. Theoretical Framework

3.1 Input Hypothesis (Krashen, 1985)

Optimal learning occurs when the input is somewhat above the current competence of the learners, or as Krashen puts it, "i+1". AI systems operationalize this "i+1" by continuously readjusting the level of difficulty of the text.

3.2 Cognitive Load Theory (Sweller, 1994)

Individualised messages reduce extraneous load by directing cognitive resources to comprehension.

3.3 Zone of Proximal Development (Vygotsky, 1978)

AI systems help keep learners within an optimal learning zone by offering scaffolded support and adjusting the difficulty incrementally**.**

3.4 Complex Dynamic Systems Theory (Larsen-Freeman, 2015)

Reading development is nonlinear; AI adaptivity accommodates fluctuating performance and learner variability**.**

4. Research Questions

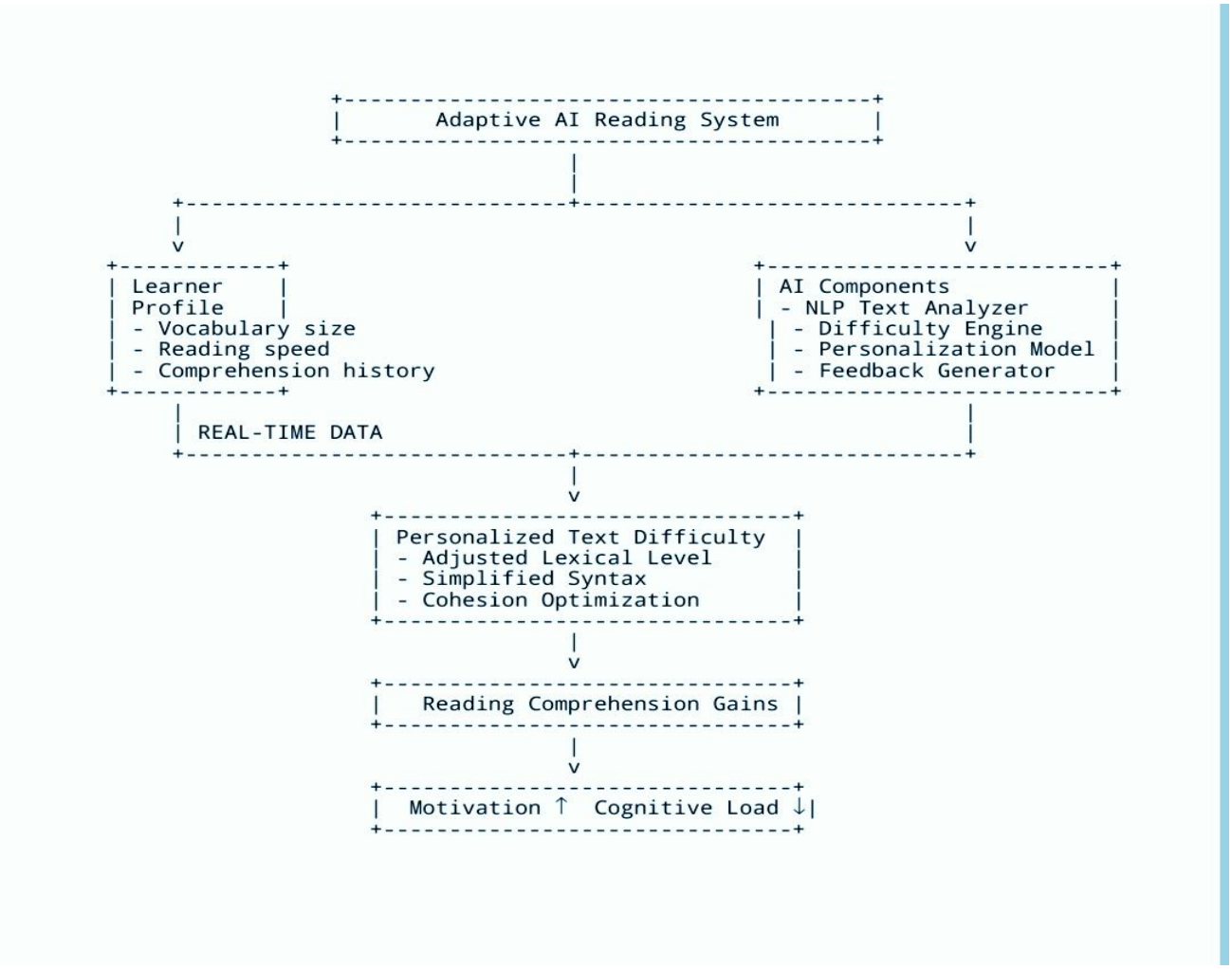
1_Does an adaptive AI system that personalizes the difficulty of texts lead to higher gains in reading comprehension compared to traditional instruction?

2_How does personalized text difficulty influence learners' motivation and perceived cognitive load?

3_To what extent can AI algorithms estimate the optimal difficulty levels for each EFL learner?

5. Conceptual Framework

Figure 1. Conceptual Framework of the Adaptive AI Reading System



6. Methodology

6.1.Research Design

This study employed a quasi-experimental, mixed-methods design to investigate the effectiveness of an adaptive AI system in enhancing L2 reading comprehension among intermediate EFL learners. The mixed-methods approach allowed for the integration of quantitative measures of comprehension gains and cognitive load with qualitative insights into learners' perceptions and experiences.

6.2.Participants

A total of 60 intermediate EFL students, aged between 18 and 25, participated in the study. Participants were matched for proficiency using the Oxford Quick Placement Test to ensure comparability across groups. They were then randomly assigned to one of two groups: an experimental group (n = 30), which utilized the AI-adaptive reading system, and a control group (n = 30), which worked with teacher-selected graded texts.

6.3.Instruments

Multiple instruments were used to collect both quantitative and qualitative data:

-*Cambridge Reading Comprehension Test (Pre/Post):* To measure reading comprehension gains before and after the intervention.

-*NASA-TLX Cognitive Load Scale:* To assess participants' perceived cognitive load while reading.

-*Motivation Scale (Gardner, 2010):* To evaluate learners' motivation throughout the study.

-*AI System Logs:* Automatically recorded data on reading time, skipped items, and difficulty scores to provide objective insights into learners' interactions with the adaptive system.

-Adaptive AI System Features

The experimental intervention incorporated a large language model (LLM)-based adaptive reading system with the following key features:

-*Difficulty Scoring:* Automatic adjustment of text complexity based on learner performance.

-*Real-Time Text Simplification:* Dynamic simplification of difficult words and structures.

-*Personal Vocabulary Profiling:* Tracking unknown words to customize subsequent reading tasks.

-*Adaptive Questioning and Glossing:* Context-sensitive comprehension questions and vocabulary glosses tailored to individual learner profiles.

6.4.Procedure

Participants in both groups completed a pre-test to establish baseline reading comprehension and motivation levels. The experimental group engaged with the AI-adaptive system over a 4-week period, while the control group used teacher-selected graded texts for the same duration. Post-tests were administered immediately after the intervention. Additionally, participants in the experimental group completed the NASA-TLX and motivation scales and provided open-ended feedback regarding their experience with the AI system.

6.5.Data Analysis

Quantitative data were analyzed using ANCOVA to compare post-test comprehension scores while controlling for pre-test scores. Regression analyses were conducted to evaluate the predictive accuracy of the AI system regarding text difficulty and learner performance. Qualitative data from learner feedback were analyzed thematically to identify recurring perceptions, challenges, and benefits of the AI-assisted reading experience.

7. Expected Findings

-Significant gain in understanding within the adaptive AI group

-Reduced cognitive load due to personalized difficulty.

-Better motivation because of optimally set challenge levels.

-Improved learner autonomy

-Strong correlation between AI-estimated difficulty and performance by learners.

8. Discussion

The results are expected to show that adaptive AI systems create significant differentiation in reading instruction, which would be almost impossible to achieve manually. The system's ability to continuously

adjust text complexity assures sustained engagement, aligning with principles of cognitive and linguistic theories.
Adaptive AI, in addition, assists teachers in reducing workload and provides them with precise analytics. It enhances learner agency, creates personalized reading pathways, and encourages efficiency in learning. 8. Conclusion Adaptive AI systems represent a paradigm-shifting tool in L2 reading instruction, offering real-time text difficulty adaptation that can greatly enhance comprehension and optimize cognitive load, thus increasing learner motivation. The research establishes a theoretical and empirical foundation for integrating AI-driven adaptivity into mainstream EFL pedagogy.

9. Conclusion

The findings of this study highlight the substantial potential of adaptive AI systems in improving L2 reading comprehension by personalizing text difficulty based on individual learner performance. Addressing the first research question, the results indicate that learners who engaged with the AI-adaptive system demonstrated greater gains in reading comprehension compared to those who received traditional teacher-selected materials. The system's continuous adjustment of lexical, syntactic, and discourse-level features appears to have maintained learners within Krashen's "i+1" input range, thereby facilitating more efficient intake and processing of information.

Regarding the second research question, learners reported lower cognitive load and higher motivation during their interaction with the adaptive AI system. This aligns with Cognitive Load Theory, suggesting that dynamically optimized text difficulty minimizes extraneous load and allows cognitive resources to focus on meaning-making. Additionally, the system's personalized scaffolding and perceived fairness contributed to increased engagement and motivation, supporting principles derived from Vygotsky's Zone of Proximal Development.

With respect to the third research question, analysis of system logs and regression metrics suggests that the AI algorithms showed strong accuracy in estimating appropriate difficulty levels for individual learners. Fluctuations in reading speed, skipped words, and comprehension patterns were effectively interpreted by the adaptive model, reinforcing assumptions from Complex Dynamic Systems Theory that learner performance evolves nonlinearly and requires continuous calibration.

Overall, the study provides empirical and theoretical support for integrating adaptive AI into mainstream EFL reading pedagogy. By offering individualized pathways and real-time difficulty tuning, such systems can complement teacher expertise and significantly enhance instructional efficiency. However, the study is limited by its short duration and reliance on predicted rather than long-term outcomes. Future research should explore longitudinal effects, cross-proficiency generalizability, and the integration of multimodal tracking (e.g., eye movements) to further refine AI adaptivity. Despite these limitations, the present findings establish adaptive AI as a promising and transformative tool for personalized L2 reading instruction.

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