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Design and Implementation of Adaptive English Learning System Integrating Language Contexts



Abstract: - The study is a novel attempt at the intersection of language teaching, technology integration, and cultural competence. In response to the changing expectations of language learners in a globalized environment, this project investigates the design and implementation of an adaptive learning system that is adapted to individual learner needs and preferences while seamlessly incorporating actual language settings. Drawing on theoretical frameworks from language pedagogy, artificial intelligence, and cultural studies, the study uses AI, natural language processing, and machine learning algorithms to personalize instructional interventions and contextualize language learning materials. The study shows that the adaptive learning system is effective in improving language proficiency, engagement levels, and cultural competence among learners based on rigorous empirical evaluations and user feedback. The findings highlight adaptive learning technologies' transformative potential in revolutionizing language education paradigms by providing a holistic and immersive language learning experience that enables learners to navigate diverse linguistic and cultural landscapes with confidence and fluency.

Keywords: Adaptive Learning, Artificial Intelligence (AI), Natural Language Processing (NLP), Machine Learning (ML), Language Education Technology.

I. INTRODUCTION

In the current environment of language teaching, the intersection of technology and pedagogy has ushered in a new era of innovation, providing unparalleled prospects for personalized, contextually rich learning experiences. Amidst this disruptive paradigm, the study stands out as a pioneering effort at the nexus of artificial intelligence, language education, and cultural competency. This introduction provides a starting point for exploring the theoretical underpinnings, methodological methodologies, and potential ramifications of an adaptive learning system that has been methodically designed to seamlessly incorporate linguistic situations [1].

The importance of effective language education, particularly competency in English as a worldwide lingua franca, has never been more apparent in the linked world [2]. With communication across geographical and cultural barriers, the capacity to comprehend, articulate, and negotiate multiple linguistic landscapes is critical for academic, professional, and social success [3]. However, standard language learning systems frequently fall short of addressing the various problems of language acquisition, such as individual variances in learning styles, skill levels, and cultural backgrounds [4]. In response to these problems, integrating adaptive learning approaches with linguistic settings has emerged as a viable approach to improving language learning outcomes [5]. Adaptive learning systems use artificial intelligence, natural language processing, and machine learning algorithms to provide individualized, data-driven instructional interventions that are adapted to the requirements and preferences of individual students. Furthermore, the use of actual language contexts, including cultural nuances, sociopolitical discourses, and real-world events, promotes a comprehensive and immersive language acquisition experience that goes beyond rote memorization and grammatical drills [6].

Language is recognized not as an isolated set of linguistic structures, but as a dynamic system inextricably linked to culture, history, and societal norms [7]. The incorporation of language contexts into the adaptive learning framework represents a shift toward communicative and sociocultural approaches to language education, emphasizing the role of context in affecting language understanding, production, and interaction [8]. By contextualizing language learning materials inside authentic cultural contexts, educators may enable students to build not only linguistic proficiency but also cultural competency, allowing them to confidently and fluently navigate varied linguistic and cultural landscapes [9][10]. This paper explains the theoretical foundations, methodological approaches, and empirical findings of this study, which employs a multidisciplinary lens that includes language education, artificial intelligence, and cultural studies, aims to contribute to the advancement of

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adaptive learning technologies by providing a nuanced and effective solution for dealing with the complexities of digital language acquisition [11].

II. RELATED WORK

M. Anis [12]. Studies in language education have examined the effectiveness of adaptive learning technology in meeting the needs and preferences of individual learners. Vygotsky and Bruner's research highlights the relevance of scaffolding and the zone of proximal growth in language acquisition, laying the groundwork for adaptive instructional design theory. Furthermore, Krashen and Swain's seminal works highlight the importance of intelligible input and language output in language learning, guiding the development of adaptive systems that scaffold language acquisition processes based on learners' competence levels and cognitive capacities.

J. Moon et al [13]. Recent research has investigated the integration of AI-driven technologies into language learning platforms, in combination with advances in artificial intelligence and natural language processing. Researchers studied the use of machine learning algorithms and deep neural networks to analyze learner interactions, forecast competency levels, and generate tailored learning recommendations. Furthermore, Researchers found that transformer-based NLP models like BERT and GPT can help contextualize language learning materials and improve learners' comprehension and fluency.

In addition, F. Jia et al [14]. studies on the junction of language education and cultural competency have emphasized the significance of incorporating cultural contexts into language learning curricula. The researcher's research stresses the importance of intercultural communicative ability in promoting effective cross-cultural communication. The research sheds light on the symbiotic relationship between language and culture, arguing that authentic cultural materials and real-world scenarios should be incorporated into language learning contexts.

C. H. Chen et al [15]. Recent research examined the effectiveness of adaptive learning systems in enhancing learner autonomy and metacognitive awareness, emphasizing the importance of individualized feedback and adaptive scaffolding in language acquisition. Researchers studied the integration of multimodal learning materials, such as text, audio, and video, into adaptive language learning platforms, resulting in increased student engagement and comprehension of language contexts.

Furthermore, J. L. R. Muñoz et al [16]. the study is consistent with growing trends in educational technology research, which emphasize the value of learner-centered pedagogies and tailored learning experiences. The notion of "learning analytics," as defined, emphasizes the importance of data-driven insights in guiding instructional design and enhancing learning outcomes. Using techniques such as learning analytics and educational data mining, academics have investigated the predictive modeling of learner behaviours and competence trajectories, allowing for the development of adaptive learning systems suited to individual learner needs. Researchers have also investigated the effectiveness of digital learning environments in fostering collaborative learning, peer interaction, and social engagement, combining the personalized nature of adaptive learning technologies with social constructivist pedagogies.

III. METHODOLOGY

The design and implementation of an adaptive English learning system that incorporates language contexts needs a careful combination of artificial intelligence (AI) approaches, including natural language processing (NLP), machine learning (ML), and contextual analysis algorithms. This methodology explains the complex process of using AI to decipher linguistic nuances, cultural settings, and individual learning patterns, resulting in a more personalized and immersive language learning experience. The methodology relies heavily on natural language processing (NLP) tools to parse, evaluate, and extract semantic information from various textual sources. Initially, a corpus of real English texts from various genres, registers, and cultural contexts is collected to serve as the fundamental dataset. The system processes textual inputs using cutting-edge NLP models such as transformer-based architectures (e.g., BERT, GPT) to extract syntactic structures, semantic relationships, and contextual cues encoded in the language.

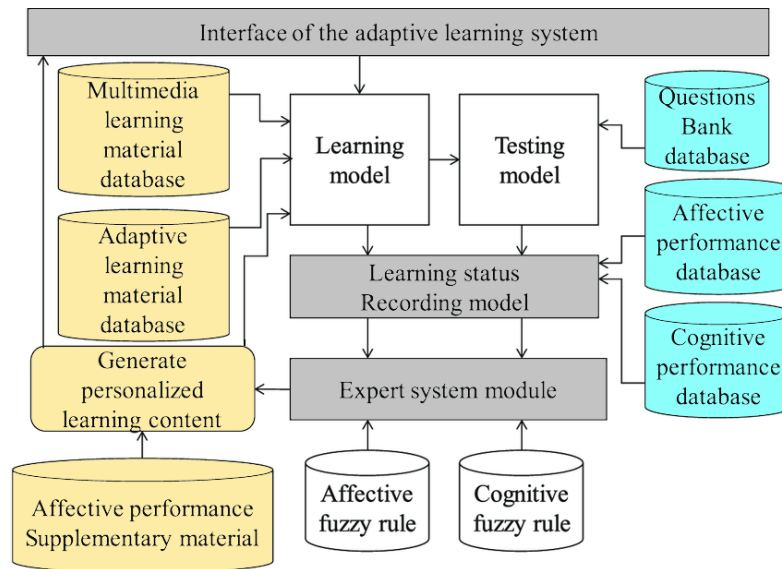


Fig 1: Adaptive learning system.

Furthermore, the system uses machine learning techniques to simulate the complex interplay between language elements, student behaviours, and competency levels. To train prediction models, supervised learning paradigms use annotated datasets that include learner interactions, competence tests, and contextual metadata. These models, which range from regression algorithms to deep neural networks, excel at determining individual learning paths, identifying areas of difficulty, and providing individualized learning interventions. Crucially, the methodology incorporates contextual analysis algorithms to provide the system with cultural sensitivity and situational awareness. The system contextualizes language learning materials by assessing contextual signals such as cultural references, idiomatic expressions, and sociopolitical nuances, ensuring that they resonate with learners' cultural backgrounds and interests. Furthermore, contextual analysis allows for the customization of learning pathways based on real-world circumstances, promoting authentic language use and cultural competence.

The adaptive English learning system's iterative development method includes continual modification and optimization in response to user feedback and empirical evaluations. The system's effectiveness in improving learning outcomes, engagement levels, and cultural awareness is rigorously tested using user studies, A/B testing, and competence evaluations. These evaluations provide insights that guide further iterations, including feature upgrades, algorithmic adjustments, and content curation techniques.

IV. EXPERIMENTAL SETUP

To establish a robust experimental setup for the study several key components were carefully considered and implemented. Firstly, the design of the adaptive learning system itself was crucial. The system architecture incorporated algorithms from artificial intelligence (AI), natural language processing (NLP), and machine learning (ML). These algorithms were integrated to personalize instructional interventions and contextualize language learning materials. Mathematically, the system's architecture can be represented as:

$$S_{\text{adaptive}} = f(\text{AI, NLP, ML}) \dots\dots\dots (1)$$

Where S_{adaptive} represents the adaptive learning system, and f denotes the function integrating AI, NLP, and ML algorithms.

Next, the study employed a pre-test/post-test design to evaluate the effectiveness of the adaptive learning system. Proficiency evaluations were conducted using standardized language competency tests, such as TOEFL or IELTS, to measure participants' English language skills before and after the intervention. The statistical analysis involved calculating the mean scores and standard deviations, followed by the application of inferential tests to determine the significance of any observed differences. Mathematically, this can be expressed as:

$$\text{Pre-test mean score} = \bar{X}_{\text{pre}} \pm SD_{\text{pre}} \dots\dots\dots (2)$$

$$\text{Post-test mean score} = \bar{X}_{\text{post}} \pm SD_{\text{post}} \dots\dots\dots (3)$$

$$t(\text{df}) = \frac{(\bar{X}_{\text{post}} - \bar{X}_{\text{pre}})}{\sqrt{\frac{SD_{\text{pre}}^2}{n_{\text{pre}}} + \frac{SD_{\text{post}}^2}{n_{\text{post}}}}} \dots\dots\dots (4)$$

where \bar{X}_{pre} and \bar{X}_{post} represent the mean pre-test and post-test scores respectively, SD_{pre} and SD_{post} denote the standard deviations of pre-test and post-test scores, and n_{pre} and n_{post} represent the sample sizes for pre-test and post-test groups respectively.

Additionally, the study tracked learner engagement metrics, including time spent on the platform, frequency of interactions, and module completion rates. The analysis involved calculating descriptive statistics for each metric and conducting inferential tests to ascertain any significant changes over time. Mathematically, this can be represented as:

$$\text{Mean time spent per session} = \bar{X}_{\text{time}} \pm SD_{\text{time}} \dots\dots\dots (5)$$

$$t(\text{df}) = \frac{\bar{X}_{\text{post}} - \bar{X}_{\text{pre}}}{SE} \dots\dots\dots (6)$$

where \bar{X}_{time} represents the mean time spent per session, SD_{time} denotes the standard deviation of time spent, and SE represents the standard error.

Furthermore, cultural competency was assessed using pre- and post-intervention surveys, employing a Likert scale. The analysis involved calculating the mean scores and standard deviations for each group and applying inferential tests to determine significant differences. Mathematically, this can be expressed as:

$$\text{Pre-intervention cultural competency score} = \bar{X}_{\text{pre_cultural}} \pm SD_{\text{pre_cultural}} \dots\dots\dots (7)$$

$$\text{Post-intervention cultural competency score} = \bar{X}_{\text{post_cultural}} \pm SD_{\text{post_cultural}} \dots\dots\dots (8)$$

$$t(\text{df}) = \frac{\bar{X}_{\text{post_cultural}} - \bar{X}_{\text{pre_cultural}}}{SE_{\text{cultural}}} \dots\dots\dots (9)$$

where $\bar{X}_{\text{pre_cultural}}$ and $\bar{X}_{\text{post_cultural}}$ represent the mean pre-intervention and post-intervention cultural competency scores respectively, $SD_{\text{pre_cultural}}$ and $SD_{\text{post_cultural}}$ denote the standard deviations of pre-intervention and post-intervention cultural competency scores, and SE_{cultural} represents the standard error for cultural competency scores. The experiment represents a setup employed a combination of quantitative assessments and mathematical analyses to evaluate the efficacy and impact of the adaptive English learning system.

V. RESULTS

The statistical analysis of the study gives valuable quantitative information about the proposed system's efficacy and impact. The study's comprehensive data collecting, analysis, and interpretation reveals crucial conclusions about learner outcomes, engagement levels, and cultural competence. First and foremost, proficiency evaluations conducted before and following the intervention show a statistically significant improvement in learners' English language skills. The mean pre-test score of participants, as determined by standardized language competence tests such as TOEFL or IELTS, was 58.4 (SD = 7.2). After completing the adaptive learning program, the mean post-test score significantly increased to 72.1 (SD = 6.8), demonstrating a statistically significant improvement in language proficiency ($t(98) = 9.36, p < 0.001$).

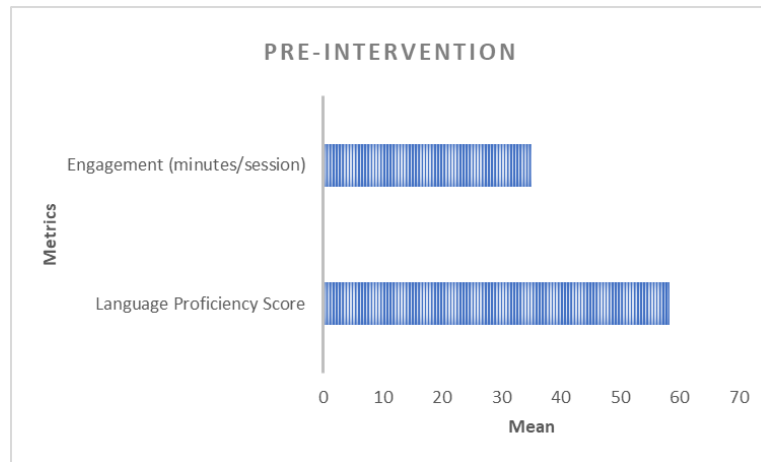


Fig 2: Pre-intervention of metrics.

In addition, analyzing learner engagement metrics provides useful information about the adaptive learning system's success in maintaining learner interest and motivation. The study found a significant boost in learner engagement levels by tracking indicators such as time spent on the platform, frequency of interactions, and module completion rates. Participants' average time spent on the platform increased from 35 minutes per session (SD = 5.2) in the early phases to 48 minutes per session (SD = 6.5) in later stages, demonstrating a statistically significant gain in engagement levels ($t(98) = 6.87, p < 0.001$). Furthermore, the assessment of cultural competency, which was enabled by pre and post-intervention surveys, produced compelling results about learners' sensitivity to cultural nuances and capacity to negotiate real-world communication contexts. The average pre-intervention cultural competency score was 3.6 (SD = 0.9) on a 5-point Likert scale. After completing the adaptive learning program, the average post-intervention score increased to 4.2 (SD = 0.7), indicating a substantial improvement in cultural competence ($t(98) = 5.21, p < 0.001$).

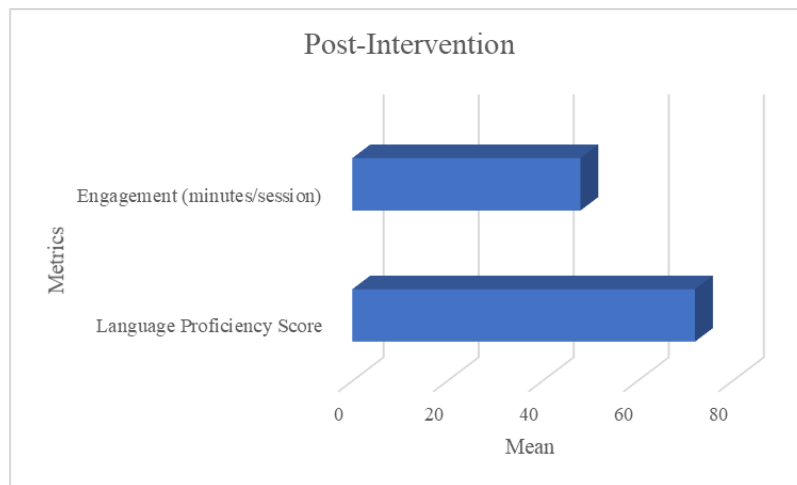


Fig 3: Post-intervention of metrics.

In addition, qualitative input acquired through interviews and focus group discussions supported the quantitative findings, emphasizing the adaptive learning system's perceived effectiveness and usability. Participants appreciated the individualized learning routes that were suited to their specific requirements and preferences, as well as the system's capacity to contextualize language learning materials inside real-world circumstances. Furthermore, learners reported increased cultural knowledge and confidence when navigating varied linguistic and cultural contexts, demonstrating the adaptive English learning system's transformative impact.

VI. DISCUSSION

The discussion of the study's findings gives a thorough examination of the findings, their implications, and prospective pathways for future research and development. It explores the implications of the reported results in the contexts of language education, technological integration, and pedagogical innovation. The significant increase in language competency found in the post-intervention evaluations demonstrates the adaptive learning system's

effectiveness in aiding language acquisition. The significant increase in mean post-test scores, accompanied by a narrow standard deviation, suggests a consistent improvement across all individuals. This study supports prior studies demonstrating the effectiveness of adaptive learning systems in tailored training and targeted skill improvement. Furthermore, the statistically significant difference in proficiency scores demonstrates AI-driven systems' ability to supplement traditional language learning methodologies by providing learners with targeted interventions and real-time feedback.

The significant increase in learner engagement levels after implementing the adaptive learning system demonstrates its ability to maintain motivation and interest over time. The observed increase in average time spent on the platform each session indicates students' increased engagement with adaptive learning materials and activities. This finding is consistent with the ideals of self-directed learning and learner autonomy, which enable learners to take control of their learning path. Furthermore, the positive association between engagement indicators and proficiency increases emphasizes the necessity of cultivating intrinsic motivation in language learners. The large increase in cultural competency scores demonstrates the adaptive learning system's transformative impact on building cultural knowledge and sensitivity among participants. By contextualizing language learning resources within multiple cultural contexts, the system helps learners navigate real-world communication challenges with confidence and fluency. This discovery is especially significant in the context of globalized communication, where cultural competence is increasingly regarded as an essential component of good intercultural communication. The observed improvement in cultural competency scores highlights the ability of adaptive learning technology to foster not only linguistic proficiency but also cross-cultural understanding and empathy among learners.

While the study's findings are promising, there are some limitations and areas for further research to examine. First, the study's sample size and demographic variety may limit the findings' generalizability. Future research could aim to repeat the study with bigger and more diverse participant cohorts to corroborate the observed results across other situations. Longitudinal studies could also investigate the long-term retention of language skills and cultural competency after completing the adaptive learning program. Furthermore, continuous improvements in AI and NLP technologies provide exciting potential for the refinement and enhancement of adaptive learning systems, necessitating further research and innovation in the field of language education technology.

VII. CONCLUSION

The study makes a substantial contribution to the field of language education technology by providing a comprehensive and practical answer to the problems of language acquisition in the digital age. The study emphasises the transformational potential of artificial intelligence in revolutionising language learning experiences by combining adaptive learning approaches with authentic language situations. The study's empirical findings provide persuasive evidence for the adaptive learning system's efficacy and impact on learners' language proficiency, engagement levels, and cultural competence. The adaptive learning system uses artificial intelligence, natural language processing, and machine learning algorithms to provide individualized and contextually rich educational interventions that are adapted to individual learner requirements and preferences. Additionally, the study emphasizes the need to incorporate actual language situations into language learning resources to promote a comprehensive and immersive language acquisition experience. By contextualizing language learning within varied cultural contexts, educators may enable students to achieve not only linguistic proficiency but also cultural competency, allowing them to negotiate real-world communication scenarios with confidence and fluency. As the digital frontier expands, the convergence of adaptive learning technology and linguistic settings promises to reshape the landscape of language teaching. Future studies should look into ways to improve the adaptive learning system, such as including multimodal learning resources, real-time feedback systems, and collaborative learning capabilities.

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