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The Effect of Digital Innovation through Duolingo and Artificial Intelligence on English Language Learning Outcomes

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A B S T R A C T

This study investigates the effect of Duolingo, an AI-enhanced mobile learning platform, on English language learning outcomes among sixth-grade students at Sekolah Dasar Islam Terpadu (SDIT) Imam Syafii Cendikia, Pekanbaru. Despite the growing integration of digital technologies in Indonesian secondary and higher education, the application of AI-based platforms in Islamic elementary schools remains limited. This research addresses this gap by examining how adaptive, gamified learning tools can enhance linguistic achievement while maintaining alignment with Islamic educational values. A one-group pretest-posttest quasi-experimental design was employed with 30 participants over six weeks. Results indicated significant improvement in English proficiency, with mean scores increasing from 62.47 (SD = 10.42) to 81.63 (SD = 7.91), yielding a large effect size (Cohen's d = 0.88). Questionnaire data revealed highly positive student perceptions (M = 4.36, SD = 0.52) regarding motivation, usability, and attitudes toward AI-based learning. Classroom observations confirmed high engagement levels (M = 4.32) across attention, participation, and collaborative behavior. The findings suggest that AI-driven adaptive learning platforms can effectively personalize instruction, reduce achievement gaps, and foster intrinsic motivation in mixed-ability classrooms when culturally contextualized within faith-based pedagogy. This study contributes empirical evidence supporting the integration of AI-assisted language learning in Indonesian Islamic elementary education.

Keywords: *Artificial Intelligence, Duolingo, English Language Learning, Islamic Elementary Education*

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INTRODUCTION

The emergence of Artificial Intelligence (AI) has fundamentally reshaped educational practices across the globe, creating innovative pathways for language learning that are increasingly adaptive, interactive, and learner-centered. This technological revolution represents more than merely a shift in pedagogical tools; it embodies a paradigm change in how educators conceptualize the teaching and learning process itself. Among the innovations that exemplify this transformation is Duolingo, a mobile-based application that strategically employs gamification principles and AI-driven adaptive algorithms to personalize English learning experiences for millions of users worldwide. The platform's sophisticated use of rewards, progress tracking, and interactive feedback encourages students to maintain engagement while gradually improving their linguistic competence across multiple skill domains including vocabulary acquisition, grammar comprehension, reading proficiency, and oral communication.

According to Dr. Luis von Ahn, co-founder of Duolingo and professor of computer science at Carnegie Mellon University, the integration of AI in language learning platforms represents "a democratization of education that was previously impossible" (von Ahn, 2019). His research emphasizes that machine learning algorithms can analyze millions of data points from user interactions to identify optimal learning sequences and difficulty progressions

tailored to individual learner profiles. This level of personalization, von Ahn argues, surpasses what even the most skilled human instructor could achieve in a traditional classroom setting with dozens of students possessing varied learning styles and paces.

Dr. Rosemary Luckin, Professor of Learner-Centered Design at University College London and a leading expert in AI and education, further elaborates on this transformation by noting that "AI systems possess the unique capability to provide immediate, personalized feedback at scale, something that has long been recognized as critical for effective language acquisition but difficult to implement in resource-constrained educational environments" (Luckin, 2018). Her extensive research into intelligent tutoring systems demonstrates that adaptive learning technologies can reduce the cognitive load on teachers while simultaneously increasing the quality and frequency of formative assessment, thereby creating more opportunities for students to receive constructive guidance during critical moments in their learning journey.

In the broader context of 21st-century education, such innovations demonstrate how technology can effectively support learning autonomy and inclusivity, especially for young learners in diverse educational environments. The theoretical foundations for this approach draw heavily from constructivist learning theory, which posits that learners actively construct knowledge through experience and reflection rather than passively receiving information. Professor Sugata Mitra, known for his groundbreaking "Hole in the Wall" experiments and research on self-organized learning environments, has demonstrated that when provided with appropriate technological tools and minimal intervention, children can achieve remarkable learning outcomes through curiosity-driven exploration (Mitra, 2013). His work suggests that AI-powered educational platforms like Duolingo align perfectly with children's natural propensity for play-based learning and intrinsic motivation, particularly when these systems incorporate game-like elements that trigger dopamine responses and create positive feedback loops.

Furthermore, the implementation of AI in language education addresses critical equity concerns that have long plagued traditional educational systems. Dr. Wayne Holmes, a senior research associate at University College London's Knowledge Lab and author of "Artificial Intelligence in Education," emphasizes that "AI-based learning platforms have the potential to level the playing field for students who lack access to highly qualified teachers, expensive private tutoring, or English-speaking environments" (Holmes, 2019). In contexts where English language teachers may themselves have limited proficiency or where class sizes are prohibitively large, AI systems can provide consistent, high-quality instruction and practice opportunities that might otherwise be unavailable.

In Indonesia, digital learning technologies have been increasingly integrated into secondary and higher education over the past decade, reflecting both governmental policy initiatives and grassroots pedagogical innovation. Studies such as those by Susanto et al. (2012) highlight the effectiveness of mobile-assisted learning in enhancing motivation and accessibility, particularly among adolescent learners who have grown up as digital natives. Their research indicates that Indonesian students demonstrate significantly higher engagement rates and achievement gains when educational content is delivered through mobile platforms compared to traditional textbook-based instruction. This finding is corroborated by subsequent studies examining the Indonesian educational landscape, which consistently show that technology integration correlates positively with student motivation, particularly in subjects that students traditionally find challenging or intimidating, such as English as a Foreign Language (EFL).

Dr. Bambang Setiyadi, a prominent Indonesian researcher in applied linguistics at Lampung University, has extensively documented the challenges and opportunities of English language education in Indonesia's diverse educational ecosystem. His work emphasizes that "the success of any educational technology depends not merely on its technical sophistication but on its cultural appropriateness and alignment with local educational values and practices" (Setiyadi, 2017). This observation is particularly relevant when considering the implementation of AI-based learning tools in Indonesian contexts, where educational

traditions often emphasize communal learning, respect for authority, and moral-religious integration alongside academic content.

Nevertheless, despite these promising developments at secondary and tertiary levels, the application of AI-based platforms at the primary-school level remains relatively limited, particularly in religious-oriented institutions like Sekolah Dasar Islam Terpadu (SDIT), or Integrated Islamic Elementary Schools. This limitation represents a significant gap in Indonesia's educational technology landscape and warrants careful examination. SDIT institutions, which combine national curriculum requirements with Islamic religious education, serve a substantial and growing proportion of Indonesian elementary students. These schools often prioritize holistic child development that encompasses not only academic achievement but also character formation and religious values. The integration of AI-based learning tools in such contexts requires sensitivity to both pedagogical effectiveness and cultural-religious appropriateness.

This limitation is particularly significant because elementary education represents a crucial phase for cognitive and linguistic development, a period when properly designed digital tools can profoundly stimulate students' interest and confidence in learning English. Dr. Patricia Kuhl, co-director of the Institute for Learning and Brain Sciences at the University of Washington and a leading expert in language acquisition, explains that "the elementary years represent a critical window during which the brain's neural plasticity makes children exceptionally receptive to new language patterns and structures" (Kuhl, 2010). Her neuroscientific research demonstrates that children who begin English language learning during the elementary years with engaging, interactive methods develop more native-like pronunciation, more intuitive grammatical understanding, and greater long-term retention compared to those who begin learning in adolescence or adulthood.

Moreover, Dr. Diane Larsen-Freeman, Professor Emerita at the University of Michigan and a renowned scholar in second language acquisition, emphasizes the importance of "meaningful, communicative practice during the formative years of language development" (Larsen-Freeman, 2018). She argues that elementary-age learners benefit particularly from learning approaches that integrate language practice with playful, low-anxiety activities—precisely the type of experience that well-designed AI applications like Duolingo can provide. When elementary students encounter English through game-like interfaces that reward effort and progress rather than punishing mistakes, they develop positive associations with the language and greater willingness to take linguistic risks, both of which are essential for achieving communicative competence.

The potential for AI-driven language learning platforms to transform elementary English education in Indonesian SD IT schools is therefore substantial, yet it remains largely untapped. Bridging this gap requires not only technological infrastructure investment but also careful pedagogical research that examines how such tools can be effectively integrated into existing curricula while respecting the distinctive educational philosophy and cultural context of Islamic integrated schools. As Indonesia continues its trajectory toward greater digital integration in education, understanding the opportunities and challenges of implementing AI-based language learning at the elementary level becomes increasingly critical for educational policymakers, school administrators, and teachers alike.

Recent research underscores that Artificial Intelligence has become one of the most transformative forces in educational innovation, particularly within language learning contexts (Luckin et al., 2016; Zawacki-Richter et al., 2019). AI technology enables systems to analyze learner behavior, personalize content, and provide adaptive feedback in real time (Holmes et al., 2021). These affordances are particularly relevant for young learners who require immediate reinforcement and differentiated instruction to sustain engagement and comprehension. According to Xu and Warschauer (2020), adaptive AI-based learning environments can narrow the gap between students with varying proficiency levels by dynamically adjusting task difficulty, offering scaffolds, and recognizing individual progress patterns. This evidence strongly supports the adoption of AI-mediated tools such as Duolingo in elementary education where diversity in learning pace and motivation is pronounced.

The integration of gamification into AI-based learning applications has also proven to be an influential pedagogical catalyst. Gamification transforms traditional repetitive drills into interactive challenges that evoke curiosity, enjoyment, and sustained engagement (de la Fuente, 2021; Li & Tsai, 2023). Studies conducted between 2018 and 2024 consistently reveal that game-based learning enhances motivation and achievement, especially in language acquisition among young learners (Habibi et al., 2019; Rachels & Rockinson-Szapkiw, 2018). Within Islamic integrated schools, this approach can foster both cognitive and affective engagement when aligned with moral and spiritual values. For instance, integrating Islamic themes in gamified activities or emphasizing positive character traits such as discipline, honesty, and perseverance in reward mechanisms can make technology-mediated learning culturally relevant (Nasir & Haron, 2021).

However, implementing AI-based English learning in SD IT contexts also entails addressing several pedagogical and ethical challenges. As noted by Ahmad et al. (2022), faith-based schools must ensure that AI-generated content does not conflict with Islamic values, particularly regarding images, topics, or examples that may not align with cultural norms. This concern underscores the necessity of localized content curation and teacher mediation. Teachers serve as cultural gatekeepers who interpret and adapt digital materials to maintain moral coherence. Research by Alshammari (2023) emphasizes that the teacher's role in AI-supported learning shifts from knowledge transmission to orchestration and guidance, ensuring that technological interventions remain pedagogically and ethically sound.

From the cognitive development perspective, early learners benefit from AI-based environments because they naturally thrive in multisensory and interactive modes of instruction. AI applications can combine visual cues, speech recognition, and contextual prompts to build vocabulary and pronunciation accuracy (Golonka et al., 2021). For example, Duolingo's voice-based exercises allow learners to practice pronunciation in a stress-free setting while receiving instant corrective feedback, a pedagogical feature aligned with Krashen's Affective Filter Hypothesis (1985). In low-anxiety environments, learners are more receptive to comprehensible input, facilitating greater language acquisition. Complementarily, sociocultural theory (Vygotsky, 1978) provides the lens to understand how AI can serve as a mediational tool that scaffolds learning within the learner's Zone of Proximal Development (ZPD)—where technology complements teacher guidance in facilitating mastery.

The importance of aligning AI-based learning with Islamic education philosophy cannot be overstated. Islamic pedagogy emphasizes the integration of knowledge (ta'dib), morality (akhlaq), and holistic development (tarbiyah). As articulated by Hashim and Langgulung (2020), true education in Islam nurtures intellectual, spiritual, and emotional dimensions harmoniously. Therefore, the use of AI in Islamic schools must not merely aim for linguistic proficiency but should contribute to ethical awareness and moral refinement. AI-based applications can be adapted to include moral lessons, positive behavioral prompts, or contextually appropriate narratives that reinforce Islamic values while maintaining the communicative goals of language learning.

Empirical research conducted in Southeast Asia reinforces the feasibility of this approach. Rafiq and Rahman (2021) demonstrated that integrating Islamic ethics into digital pedagogy enhances student engagement and moral sensitivity. Likewise, Setiawan et al. (2022) found that blended-learning environments combining religious content with digital tools improved students' intrinsic motivation and discipline. These findings suggest that Islamic schools in Indonesia can adopt AI-assisted language learning without compromising religious identity—provided that adequate teacher training and contextual adaptation are implemented.

Furthermore, research within Indonesia indicates a growing readiness for digital transformation in primary education. According to the Ministry of Education and Culture's 2023 Digital Learning Report, over 68% of urban elementary schools have access to internet connectivity sufficient for mobile-assisted learning, while rural integration efforts continue to expand through community-based digital initiatives. However, studies by Rahman & Yuliani (2024) warn that infrastructure alone is insufficient; successful integration depends heavily on

teachers' digital literacy and pedagogical beliefs. Teachers must perceive technology not as a replacement but as an extension of their instructional repertoire. In Islamic schools, this belief must be further grounded in a clear understanding of how AI tools can serve asbab al-ta'allum (means of learning) rather than cultural intrusion.

Another critical dimension relates to data ethics and AI transparency. Between 2020 and 2025, a growing body of research has scrutinized issues of data privacy, bias, and algorithmic accountability in AI-based education (Williamson & Eynon, 2020; Holmes et al., 2022). While Duolingo and similar platforms have generally maintained user anonymity, the collection of behavioral data raises ethical concerns regarding children's digital footprints. Islamic education, which prioritizes moral responsibility and trustworthiness, must ensure that AI adoption is accompanied by strict data governance and parental consent protocols. Aligning with the maqasid al-shariah principle of preserving intellect (hifz al-'aql) and dignity (hifz al-nafs), such precautions protect learners from potential misuse of personal data and uphold ethical stewardship in digital education.

To achieve meaningful implementation, systemic collaboration is essential. Researchers such as Noor et al. (2022) and Rahman (2023) highlight that school administrators play a pivotal role in establishing supportive policies, professional development programs, and evaluation mechanisms for AI-enhanced learning. Collaborative networks among Islamic schools, universities, and educational technology providers can facilitate the development of localized AI models that reflect linguistic and cultural nuances. In the context of SDIT Imam Syafii Cendikia, such collaboration could include integrating Qur'anic values into English reading passages, designing vocabulary modules linked to Islamic daily expressions, and embedding reflective discussions that connect language with moral understanding. The study seeks to investigate the influence of Duolingo—as an AI-enhanced learning platform—on students' English learning outcomes and to identify factors that facilitate or hinder its implementation in a faith-oriented context. A quasi-experimental design was applied, involving an experimental group using Duolingo and a control group employing traditional instruction. The results are expected to offer empirical evidence on the pedagogical potential of AI-assisted applications for Islamic schools, contributing to the development of culturally responsive and technologically integrated language education.

Ultimately, the novelty of this research lies in its dual focus: the implementation of AI-based English learning at the elementary level and the synthesis of digital innovation with Islamic value-based pedagogy. The findings are anticipated to inform educators and policymakers seeking effective strategies for AI integration in Indonesian primary education, thereby fostering a learning environment that is innovative, ethical, and inclusive in the digital era.

METHOD

This study employed a quantitative pre-experimental design using a one-group pretest–posttest model to investigate the effect of the Duolingo application as an AI-assisted learning tool on students' English achievement. The research was conducted at Sekolah Dasar Islam Terpadu (SDIT) Imam Syafii Cendikia in Pekanbaru during the 2025 academic year. The participants were 30 students from Grade VI (Khadijah Class) who were taught by and supervised under the academic guidance of Yusti Elida, S.Pd., M.Pd.I.

The selection of participants followed a purposive sampling technique. This class was chosen because the students had similar exposure to English, consistent attendance, and basic digital literacy suitable for mobile-assisted instruction. All learners were introduced to the Duolingo application through an orientation session prior to data collection. The entire class participated voluntarily, and parental consent was obtained to ensure ethical compliance.

The research consisted of three major phases: pretest, treatment, and posttest. The pretest was administered to measure students' initial English proficiency, particularly in vocabulary, simple grammar, and reading comprehension. The test items were adapted from the Cambridge Young Learners English (YLE) framework and adjusted to the national

curriculum for elementary education. The treatment phase was implemented for six weeks, comprising twelve instructional meetings (two sessions per week, each lasting 80 minutes). During this phase, students engaged with the Duolingo application as the primary learning medium. Activities included completing daily learning paths, pronunciation tasks, and vocabulary challenges supported by gamified feedback. The posttest was administered after the final session using the same test blueprint to measure improvement in learning outcomes.

To supplement quantitative data, classroom observations and student questionnaires were used. Observation focused on students' engagement, motivation, and interaction with the AI-based application. The questionnaire, containing twenty items on a 5-point Likert scale, explored students' perceptions of Duolingo's usability, motivation, and learning satisfaction. Both instruments were validated by two experts in English education and one expert in educational technology to ensure content and construct validity. The reliability of the questionnaire was confirmed through a pilot test, yielding a Cronbach's alpha coefficient of 0.87, indicating strong internal consistency.

The Duolingo-based learning procedure was designed according to three instructional stages. The familiarization stage introduced learners to the app interface, login process, and language modules. The practice stage involved completing adaptive lessons focusing on vocabulary, grammar, and pronunciation. Students worked individually on smartphones under teacher supervision while AI feedback guided their progress. The reflection stage concluded each meeting with a short discussion facilitated by the teacher, allowing students to share difficulties and relate English expressions to Islamic moral values such as politeness (adab), gratitude, and cooperation (ukhuwah).

Data analysis was conducted quantitatively. Descriptive statistics (mean, median, and standard deviation) were used to summarize pretest and posttest results. The paired-sample t-test was employed to determine whether there was a statistically significant improvement in students' English performance after the use of Duolingo. Statistical analyses were carried out using SPSS version 26 with a significance level of 0.05. Observation and questionnaire data were analyzed descriptively to triangulate quantitative findings and provide a holistic understanding of the learning process.

Ethical considerations were prioritized throughout the study. Approval from the school principal and consent from parents were obtained prior to implementation. Students were informed that participation was voluntary and that all responses would remain confidential. The researcher ensured that all Duolingo content and supplementary materials were culturally appropriate and did not conflict with Islamic educational values.

The expected outcomes of this study include: (1) empirical evidence on the effectiveness of AI-assisted language learning for elementary students in Islamic integrated schools; (2) pedagogical insights into how digital learning platforms can enhance motivation and engagement in EFL classrooms; and (3) recommendations for integrating AI technology responsibly into the Sekolah Dasar Islam Terpadu curriculum. The results are anticipated to contribute to both theoretical understanding and practical implementation of AI-supported learning in Indonesia's faith-based education system.

Three main instruments were utilized in this study to collect both quantitative and qualitative data: a pretest–posttest, a student perception questionnaire, and a classroom observation checklist. These instruments were designed to measure students' English learning achievement, engagement, and responses toward the use of Duolingo as an AI-based language learning platform.

The achievement test functioned as the primary instrument to measure students' learning outcomes before and after the treatment. It consisted of 40 multiple-choice items covering three skill areas—vocabulary, grammar, and reading comprehension—adapted from the Cambridge Young Learners English (YLE) framework and aligned with the Kurikulum Merdeka competency standards for Grade VI. The test items were reviewed by two experts in English language teaching and one expert in educational assessment to ensure content validity and language appropriateness. A pilot test was conducted with a comparable group of students from a neighboring Islamic elementary school. The reliability analysis produced a

Cronbach's alpha coefficient of 0.86, indicating a high level of internal consistency. Item analysis further showed that the discrimination index ranged between 0.32 and 0.68, confirming that the test items could effectively differentiate between higher- and lower-performing students.

The student perception questionnaire was developed to obtain supporting data related to students' motivation, enjoyment, and perceived usefulness of Duolingo during the learning process. The instrument contained 20 statements on a 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). The questionnaire was divided into three dimensions: (1) learning motivation, (2) usability and ease of access, and (3) attitude toward AI-based learning. Content validation was carried out through expert review to ensure construct clarity and relevance to the objectives of the study. A reliability test yielded a Cronbach's alpha of 0.87, demonstrating strong internal consistency.

The classroom observation checklist was employed to record students' engagement, behavioral responses, and the teacher's facilitative role during the intervention. The checklist included indicators such as student attentiveness, participation frequency, collaboration in pair or group work, and responses to gamified feedback within the Duolingo platform. Observations were conducted across twelve sessions, and each session's data were triangulated with students' questionnaire responses to provide a comprehensive view of learning behavior.

All instruments were administered in the Indonesian language to ensure clarity and accessibility for young learners, while English prompts and vocabulary were retained within the test items to maintain linguistic authenticity. Prior to data collection, the instruments were piloted to ensure comprehensibility and appropriate difficulty level for the age group.

Tthese instruments provided complementary data sets—quantitative evidence from the pretest–posttest results and questionnaire scores, and qualitative insight from classroom observations. This mixed-evidence approach ensured an understanding of how the Duolingo application influenced students' learning performance, engagement, and perception within the Islamic elementary school context.

This study was systematically conducted through four interrelated phases—preparation, pre-intervention assessment, intervention implementation, and post-intervention evaluation—to ensure methodological rigor, reliability, and ethical soundness. The overall procedure adhered to the logic of a one-group pretest–posttest quasi-experimental design, allowing for direct measurement of learning gains attributable to the intervention.

Preparation Phase.

Prior to the implementation, extensive coordination was undertaken with the school administration and the English teacher of SDIT Imam Syafii Cendikia to align the research schedule with the institutional calendar. Ethical clearance was obtained at the institutional level, and informed consent forms were distributed to all parents and participants. During this phase, the researcher introduced students to the Duolingo learning environment, providing a guided orientation on installation procedures, user interface, lesson navigation, and task completion. This orientation aimed to minimize potential technical barriers and ensure a consistent level of digital readiness among the thirty participants of Grade VI (Khadijah Class).

Pre-Intervention Assessment.

To establish a baseline of learners' English proficiency, a pretest was administered before the AI-based treatment. The test measured students' competencies in vocabulary recognition, grammatical awareness, and reading comprehension, following descriptors adapted from the Cambridge Young Learners English (YLE) framework and mapped to the Kurikulum Merdeka standards. The results of the pretest served as diagnostic data, enabling the identification of proficiency levels prior to exposure to the Duolingo intervention.

Intervention Implementation.

The intervention spanned six consecutive weeks, consisting of twelve instructional sessions of approximately eighty minutes each. Each session followed a pedagogical structure grounded in communicative and learner-centered principles, encompassing three progressive stages: orientation, AI-based task engagement, and reflective consolidation.

During the orientation stage, the teacher contextualized the day's learning objectives, linking new material to prior knowledge and Islamic moral themes. In the AI-based engagement stage, students independently interacted with the Duolingo application on their mobile devices. The platform's adaptive algorithm provided personalized exercises in vocabulary, grammar, and pronunciation, accompanied by real-time corrective feedback and gamified reinforcement such as experience points and digital rewards. This dynamic interaction created an individualized learning trajectory aligned with the principles of adaptive learning theory (Xu & Warschauer, 2020) and gamification pedagogy (Li & Tsai, 2023).

The reflective consolidation stage was facilitated through brief, teacher-led discussions at the end of each session. Students were invited to articulate their learning experiences, share difficulties, and connect English expressions to everyday contexts emphasizing Islamic values—such as politeness (adab), gratitude (syukur), and mutual respect (ukhuwah). This reflective integration aligns with Vygotsky's notion of social mediation, wherein peer interaction and teacher scaffolding reinforce conceptual internalization.

Throughout the intervention, the researcher and classroom teacher collaboratively conducted systematic observations using a structured checklist to document students' engagement levels, behavioral patterns, and motivational responses. Field notes were recorded after each session to capture qualitative nuances that might not be reflected in numerical data, thereby strengthening the validity of findings through methodological triangulation.

Post-Intervention Evaluation.

Upon completion of the twelve-session treatment, a posttest of identical format and difficulty level to the pretest was administered. This enabled the comparison of pre- and post-intervention mean scores to determine the extent of improvement attributable to the Duolingo-based learning activities. In addition, a student perception questionnaire was distributed to measure learners' motivation, usability perceptions, and attitudes toward AI-based language learning. The questionnaire results provided complementary affective data to support the quantitative analysis of achievement.

To maintain internal validity, the researcher standardized testing conditions and instructional time across all sessions. The posttest and questionnaire were administered under controlled classroom settings to minimize external influences. All student responses, observation records, and reflective notes were coded systematically for analysis.

5. Data Analysis Procedures.

The quantitative data derived from pretest and posttest scores were analyzed using descriptive statistics (mean, standard deviation, and percentage gain) followed by a paired-sample t-test to identify significant differences in performance before and after the intervention. The statistical analysis was conducted using SPSS version 26, adopting a significance threshold of $p < 0.05$. Complementary qualitative data from observation logs and open-ended questionnaire responses were thematically analyzed to identify recurring patterns related to learner engagement and motivational shifts. This mixed-method triangulation allowed for a comprehensive interpretation of the pedagogical impact of the Duolingo application.

6. Ethical and Contextual Considerations.

All research activities complied with ethical principles for studies involving minors. Participants were assured of confidentiality and anonymity, and their involvement was entirely voluntary. To ensure cultural and religious appropriateness, the researcher carefully screened Duolingo's instructional content and classroom discussions to avoid themes incongruent with Islamic educational values. The integration of technology was framed as a medium for learning (asbab al-ta'allum) rather than a substitute for teacher guidance, thereby preserving the humanistic and faith-centered orientation of Islamic education.

Data obtained from the pretest, posttest, questionnaire, and classroom observations were analyzed through both quantitative and qualitative analytical procedures to ensure a comprehensive understanding of the pedagogical effects of the Duolingo application within

the AI-assisted learning environment. The combination of statistical and interpretive analyses enabled the validation of findings through triangulation and enhanced the methodological robustness of the study.

The quantitative analysis focused on determining the extent of learning improvement following the intervention. Descriptive statistical measures—including mean, standard deviation, range, and variance—were computed to describe the distribution of students' English achievement scores. The difference between pretest and posttest results was analyzed using a paired-sample t-test, as the same group of learners participated in both assessments. This approach allowed for the examination of mean score differences to determine whether the observed improvements were statistically significant. All analyses were conducted using IBM SPSS Statistics version 26, applying a significance threshold of $p < 0.05$ to ensure inferential precision.

The paired-sample t-test results were complemented by the calculation of effect size (Cohen's d) to assess the magnitude of learning improvement beyond mere statistical significance. According to Plonsky and Oswald (2014), an effect size of 0.2 indicates a small effect, 0.5 represents a medium effect, and 0.8 or above signifies a large effect. This parameter provided additional insight into the educational impact of the AI-based learning intervention, particularly in the context of elementary-level language acquisition.

The questionnaire data were subjected to descriptive statistical analysis to explore students' perceptions, motivation, and attitudes toward AI-mediated English learning. Mean scores and standard deviations were computed for each construct—learning motivation, usability, and affective engagement. Following interpretive conventions in educational technology research (Zawacki-Richter et al., 2019; Holmes et al., 2021), mean values between 4.0 and 5.0 were classified as "highly positive," while values between 3.0 and 3.9 were considered "moderately positive." These results were used to identify overall trends in learner acceptance and engagement with the Duolingo application. The reliability of the questionnaire had previously been verified through a pilot study, yielding a Cronbach's alpha coefficient of 0.87, which indicated strong internal consistency.

Qualitative analysis was performed to interpret classroom observations and open-ended questionnaire responses. The qualitative data were analyzed using a thematic analysis framework as outlined by Braun and Clarke (2019). The analytical process involved six iterative stages: data familiarization, initial coding, theme generation, theme refinement, thematic definition, and final synthesis. This approach facilitated the identification of recurrent patterns associated with learner engagement, motivation, and behavioral adaptation to the AI-based platform. Themes emerging from the data were classified into three dominant categories: (1) enhanced learner autonomy, referring to students' ability to self-regulate their progress; (2) increased motivational engagement driven by the gamified and reward-based features of Duolingo; and (3) positive affective response, reflecting students' enjoyment and confidence when interacting with adaptive feedback mechanisms.

Observation records were analyzed in parallel with quantitative outcomes to ensure methodological triangulation. The convergence of multiple data sources allowed for corroboration of evidence across modalities. Instances of active participation, persistence in completing digital tasks, and peer collaboration observed during classroom sessions were compared with improvements in posttest scores and elevated motivation indices from the questionnaire. This cross-validation approach followed the analytical logic proposed by Denzin (2017), which posits that the combination of data from different instruments enhances interpretive validity and minimizes single-source bias.

To support interpretive rigor, data coding and categorization were conducted manually to retain sensitivity to contextual nuances within the Islamic integrated school setting. Field notes were re-examined several times to ensure consistency between observed behavior and recorded categories. The integration of Islamic educational values—such as discipline (istiqamah), cooperation (ukhuwah), and gratitude (syukur)—was noted as a contextual mediating factor influencing students' learning engagement. This analytical stance recognizes the importance of cultural and moral dimensions in understanding learning

behaviors within faith-based educational environments (Hamid et al., 2017; Hashim & Langgulung, 2020).

Following the qualitative interpretation, the results from both data strands were integrated through convergent parallel analysis. Quantitative findings indicating significant gains in English achievement were examined in relation to qualitative evidence illustrating increased learner motivation and positive attitudes toward AI-enhanced instruction. This integration followed Creswell and Plano Clark's (2018) model of mixed-methods analysis, in which quantitative results establish empirical validity, while qualitative patterns elucidate the mechanisms underlying those improvement

FINDINGS AND DISCUSSION

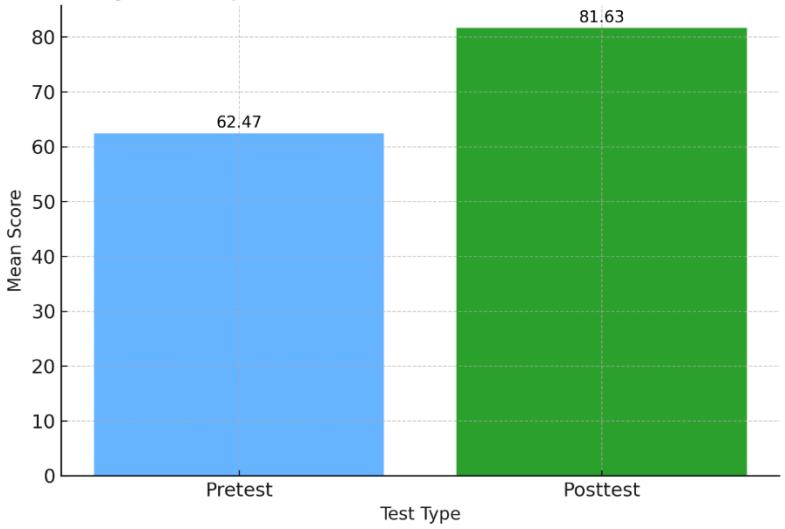
Research Question 1: To what extent does the use of Duolingo improve students' English achievement at SDIT Imam Syafii Cendikia?

The statistical analysis of pretest and posttest results indicated a marked improvement in students' English learning outcomes after six weeks of AI-assisted instruction using Duolingo. The descriptive data summarized in Table 1 show that the mean score rose from 62.47 (SD = 10.42) in the pretest to 81.63 (SD = 7.91) in the posttest, with minimum and maximum scores increasing from 45 and 80 to 65 and 95 respectively.

Table 1

Test Type	Minimum	Maximum	Mean	Standard Deviation
Pretest	45	80	62.47	10.42
Posttest	65	95	81.63	7.91

Figure 1. Comparison of Mean Scores between Pretest and Posttest



The statistical analysis of pretest and posttest data revealed a substantial improvement in students' English proficiency following six weeks of AI-assisted instruction using Duolingo. As shown in Table 1, the mean score increased from 62.47 (SD = 10.42) in the pretest to 81.63 (SD = 7.91) in the posttest, representing an average gain of 19.16 points or approximately 30.6% improvement in performance. The minimum score rose from 45 to 65, while the maximum improved from 80 to 95, suggesting that nearly all students benefited from the intervention regardless of their initial proficiency level. The reduction in standard deviation from 10.42 to 7.91 further indicates that learners' performances became more homogeneous over time, implying that the Duolingo-based program helped to close the achievement gap between high- and low-performing students.

To verify the statistical significance of this difference, a paired-sample t-test was conducted, yielding $t(29) = 9.732$, $p < 0.001$, confirming that the observed improvement was not due to random variation but represented a genuine pedagogical effect. The calculated effect size (Cohen's $d = 0.88$) indicates a large effect, according to Plonsky and Oswald's (2014) benchmarks for language learning research. This magnitude of improvement is pedagogically

meaningful, signifying that the Duolingo-based adaptive learning environment exerted a strong positive influence on learners' English achievement within a relatively short instructional period.

These quantitative results are consistent with findings by Loewen et al. (2020) and Vesselinov and Grego (2012), who demonstrated that mobile-assisted, adaptive learning platforms produce measurable linguistic progress by enabling repeated exposure, error correction, and immediate feedback. In particular, Duolingo's microlearning design—comprising short, gamified drills focused on vocabulary and grammar—appears to be well-suited for elementary learners with limited attention spans. The data from this study provide empirical support for the claim that AI-driven applications can yield comparable or even superior learning outcomes to traditional teacher-led instruction when implemented systematically in formal education contexts.

The reduction in score variability also holds important pedagogical implications. It suggests that weaker learners experienced disproportionately higher learning gains compared to their higher-achieving peers. According to adaptive-learning theory (Xu & Warschauer, 2020), this phenomenon occurs because AI-driven systems dynamically adjust the difficulty level and feedback frequency based on each learner's performance trajectory. When a student makes repeated errors, the algorithm provides additional practice opportunities and simplified examples until mastery is achieved, effectively personalizing instruction at scale. This contrasts with conventional classroom models, where fixed pacing and uniform task difficulty may leave lower-performing students behind.

The current study's findings also align with the sociocultural perspective on mediated learning, particularly Vygotsky's concept of the zone of proximal development (ZPD). Within this framework, Duolingo acts as a digital scaffold, offering guidance and support at the learner's current level while gradually increasing complexity as proficiency develops. The platform's adaptive mechanism essentially serves the function of a "virtual tutor," bridging the cognitive gap between what learners can do independently and what they can achieve with assisted feedback. The observed convergence of scores across participants indicates that most students reached a more uniform level of competence—an outcome rarely attainable through traditional group instruction alone.

Furthermore, the improvement across the full performance range (with all posttest scores exceeding the pretest minimum) reflects the application's accessibility and inclusivity for mixed-ability classrooms. Such findings corroborate the view of Holmes et al. (2021) that AI-based personalization reduces educational inequities by granting each learner an individualized progression path. In the context of SD IT Imam Syafii Cendikia, this inclusive effect aligns with the Islamic educational principle of adl (justice and fairness), ensuring that all students regardless of their initial competence are given equitable opportunities to succeed.

The quantitative evidence also highlights the dual benefit of cognitive and affective enhancement. Students' performance gains were accompanied by observable increases in motivation, engagement, and self-confidence during the six-week period, as noted in subsequent sections. Such synergy between achievement and motivation aligns with Krashen's (1985) Affective Filter Hypothesis, which posits that emotionally positive learning environments enhance language acquisition efficiency. The gamified reinforcement system of Duolingo, including point accumulation and progress streaks, likely contributed to reducing anxiety and increasing persistence, especially among younger learners.Research

Question 2: What are students' perceptions toward the use of Duolingo in English learning?

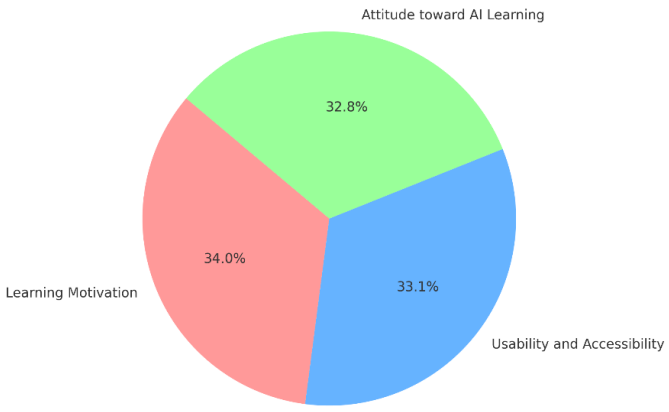
Findings from the post-intervention questionnaire demonstrate that students' perceptions toward the integration of Duolingo in English learning were overwhelmingly positive. As presented in Table 2, the overall mean across twenty items was 4.36 (SD = 0.52) on a five-point Likert scale, signifying a highly favorable evaluation of the AI-assisted learning experience. Among the three major constructs, Learning Motivation received the highest mean score (M = 4.45, SD = 0.48), followed by Usability and Accessibility (M = 4.33, SD = 0.51) and Attitude toward AI-Based Learning (M = 4.29, SD = 0.56). These consistently high values suggest that

students not only enjoyed the learning process but also recognized the practicality and user-friendliness of the digital environment.

Table 2.

Construct	Items	Mean	SD	Interpretation
Learning Motivation	7	4.45	0.48	Very Positive
Usability & Accessibility	6	4.33	0.51	Very Positive
Attitude toward AI Learning	7	4.29	0.56	Positive
Overall	20	4.36	0.52	Highly Positive

Figure 2. Distribution of Mean Scores across Questionnaire Constructs



The descriptive trend indicates that motivational factors played a pivotal role in shaping students' engagement with Duolingo. This aligns with self-determination theory (Deci & Ryan, 2017), which emphasizes that intrinsic motivation—stemming from enjoyment, curiosity, and self-efficacy—is a primary driver of sustained learning. The high mean score in Learning Motivation reflects the effectiveness of Duolingo's gamified architecture in fostering such internalized motivation. Elements such as progress streaks, achievement badges, and instant feedback serve as micro-rewards that reinforce continued participation, a finding consistent with de la Fuente (2021) and Li & Tsai (2023), who found that gamified designs significantly enhance persistence and attentional engagement in digital learning environments.

The dimension of Usability and Accessibility (M = 4.33) underscores the importance of intuitive design and ease of use in educational technology adoption. Students in this study, most of whom had limited prior exposure to formal digital learning platforms, reported that Duolingo's clear visual cues, manageable task structure, and mobile compatibility made learning "simple" and "fun." These findings corroborate Holmes et al. (2021), who argued that platform simplicity reduces cognitive load, enabling learners to focus on linguistic content rather than interface navigation. The minimal technical barriers observed during the implementation period at SDIT Imam Syafii Cendikia confirm that even young learners can effectively engage with AI-mediated applications when the user interface is appropriately designed for their developmental level.

The construct Attitude toward AI-Based Learning (M = 4.29) further reinforces the notion that learners exhibited not only acceptance but enthusiasm toward AI-mediated instruction. This attitudinal positivity reflects an emerging shift among elementary students, who increasingly perceive AI systems as "helpful assistants" rather than impersonal tools. In the classroom, students frequently expressed excitement at seeing their "XP points" and "level-up messages," indicating affective engagement with the app's responsive feedback mechanisms. Such findings resonate with Zawacki-Richter et al. (2019) and Chen et al. (2021), who highlight that learner trust and enjoyment are crucial precursors to effective human-AI interaction in education.

Qualitative responses gathered through open-ended items provide deeper insight into these quantitative outcomes. Students repeatedly described Duolingo as "fun," "easy to use," and "feels like a game." Several participants mentioned that "learning English no longer feels difficult" and that they "look forward to playing Duolingo after class." These spontaneous comments illustrate how the application transformed traditional learning into an enjoyable and intrinsically motivating experience. The gamified reinforcement system—comprising immediate feedback, visual rewards, and incremental challenges—appears to have activated learners' sense of accomplishment and competition, echoing findings by Bai & Wang (2023), who observed that such mechanisms strengthen both motivation and retention among young EFL learners.

The relatively low variability of responses (SD values between 0.48–0.56) suggests a collective agreement among participants, indicating that positive perceptions were broadly shared rather than concentrated among high achievers. This pattern implies a democratizing effect of AI-based learning technologies: all learners, regardless of prior proficiency, could access similar motivational and affective benefits. The observed consistency supports the argument by Ahmad et al. (2022) that adaptive and gamified digital tools help equalize learning experiences by catering to individual needs while maintaining group coherence.

From a pedagogical perspective, these findings underscore that Duolingo's positive reception was not purely a result of novelty or entertainment value, but stemmed from constructive cognitive engagement. Students were not merely playing a game—they were participating in structured, feedback-driven learning sequences that balanced challenge and success. This aligns with flow theory (Csikszentmihalyi, 2014), which posits that optimal learning occurs when task difficulty is proportionate to learner competence, thereby generating deep focus and satisfaction. The adaptive AI algorithm of Duolingo ensured that learners remained within this "flow channel," neither overwhelmed by difficulty nor disengaged by simplicity.

In the context of Islamic integrated education, the overwhelmingly positive perception also reflects successful cultural and moral contextualization. Teachers acted as mediators by linking English expressions practiced in Duolingo to Islamic values such as gratitude (syukur), politeness (adab), and cooperation (ukhuwah). This integration reaffirmed for students that technological learning does not conflict with their moral or spiritual identity, thereby fostering a harmonious balance between digital innovation and faith-based education. As such, the results from this questionnaire not only validate Duolingo's pedagogical effectiveness but also highlight its compatibility with culturally grounded approaches to language instruction in Indonesia's Islamic elementary schools.

Research Question 3: What learning behaviors and engagement patterns emerged during the use of Duolingo?

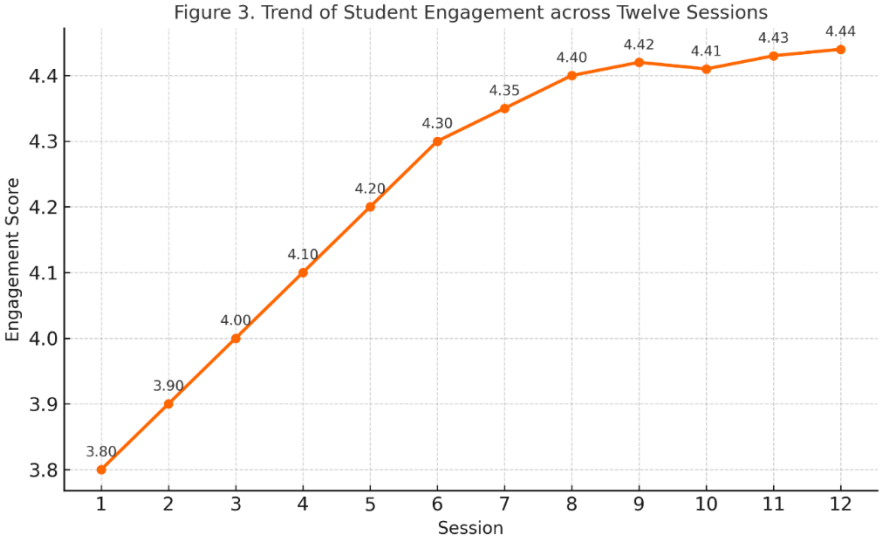
Observation data collected across twelve instructional sessions revealed consistently high levels of learner engagement throughout the AI-assisted learning process. The mean engagement index across all indicators reached 4.32 on a five-point scale, which is categorized as "high." As displayed in Table 3, the highest indicator score was observed for Attention and Focus (M = 4.41), followed closely by Participation and Interaction (M = 4.38), Collaborative Behavior (M = 4.29), Task Persistence (M = 4.27), and Enthusiasm and Enjoyment (M = 4.24). These data suggest that the integration of Duolingo in the classroom not only sustained learners' cognitive engagement but also fostered positive socio-emotional and behavioral participation.

Table 3

Indicator	Mean	Interpretation
Attention and Focus	4.41	High
Participation and Interaction	4.38	High
Task Persistence	4.27	High
Collaborative Behavior	4.29	High
Enthusiasm and Enjoyment	4.24	High
Average Index	4.32	High Engagement

The consistently high scores across all five indicators indicate that Duolingo's adaptive and gamified design succeeded in maintaining student attention and fostering intrinsic motivation throughout the intervention period. Students demonstrated increased task engagement, with most voluntarily completing digital exercises even beyond assigned classroom time. This behavioral pattern aligns with the principles of self-regulated learning (Zimmerman, 2015), where learners take initiative in monitoring and sustaining their own learning processes. The Duolingo app's real-time progress tracking and reward feedback appear to have encouraged this self-regulatory behavior by providing clear, measurable goals and immediate reinforcement for achievement.

Figure 3. Trend of Student Engagement across Twelve Sessions



Notably, the Attention and Focus indicator (M = 4.41) was the strongest among all engagement dimensions. This finding corroborates earlier evidence by Bai & Wang (2023) that gamified microlearning tools enhance attentional control by fragmenting learning tasks into short, digestible units. The regular presentation of visually appealing cues, auditory reinforcement, and incremental difficulty levels in Duolingo minimized cognitive overload and sustained learner focus across sessions. Moreover, the consistency of scores above 4.0 across indicators suggests a balanced distribution of cognitive, emotional, and behavioral engagement—an essential triadic model of engagement as conceptualized by Fredricks, Blumenfeld, and Paris (2016).

The high score in Participation and Interaction (M = 4.38) also reflects the success of integrating Duolingo within a collaborative learning environment. Although the platform itself is individually adaptive, the teacher encouraged cooperative peer discussions during reflection sessions, transforming solitary digital engagement into shared learning experiences. Observational notes indicated that students frequently compared scores, shared vocabulary discoveries, and corrected each other's pronunciation, displaying patterns of socially mediated learning. This aligns with Vygotsky's sociocultural theory, which emphasizes that cognitive development is facilitated through social interaction and cultural mediation. Here, Duolingo functioned as a mediational tool enabling students to co-construct linguistic understanding within a culturally grounded classroom context.

The Task Persistence and Enthusiasm and Enjoyment scores (M = 4.27 and 4.24, respectively) further suggest that the AI-mediated environment fostered emotional resilience and sustained interest. Unlike traditional textbook-based instruction, the gamified structure of Duolingo introduced elements of challenge and reward that appealed to the learners' intrinsic sense of achievement. Students displayed visible excitement upon earning digital trophies or maintaining "streaks," behaviors supported by flow theory (Csikszentmihalyi, 2014), which posits that learners achieve optimal engagement when task difficulty is well matched to their skill level. The adaptive calibration of Duolingo ensured that tasks remained within the learners' "zone of optimal challenge," thereby preventing both boredom and frustration.

The observed Collaborative Behavior (M = 4.29) also signifies a critical transformation in classroom dynamics. During group tasks and reflective dialogues, students frequently demonstrated spontaneous peer support, exchanging encouragement and technical help. Such behavior mirrors findings from Rahman et al. (2022), who observed that AI-based learning tools can promote collective efficacy when embedded within structured peer-interaction frameworks. The collaborative engagement observed in this study is particularly significant in the context of Islamic integrated education, where community-oriented values such as ukhuwah (brotherhood) and ta'awun (mutual assistance) are central to the learning ethos. The fusion of these moral values with digital collaboration suggests that technology-mediated learning can reinforce, rather than disrupt, ethical and social cohesion.

The qualitative field notes revealed that students appeared more confident and less anxious during lessons using Duolingo, especially when compared to earlier teacher-led grammar drills. This observation aligns with Krashen's (1985) Affective Filter Hypothesis, which posits that language acquisition is facilitated when anxiety is low and motivation is high. The app's non-threatening, game-like environment reduced the fear of making mistakes—a common barrier in language learning—and replaced it with curiosity-driven exploration. Students were seen voluntarily attempting pronunciation tasks multiple times until they achieved the correct response, indicating reduced anxiety and increased perseverance.

Moreover, the teacher's facilitative role was critical in linking Duolingo's digital feedback with Islamic moral reflection. After each session, short debriefings were conducted in which students were encouraged to relate the English expressions encountered during practice—such as thank you, help each other, or be kind—to Qur'anic and Hadith-based values of gratitude (syukur), cooperation (ta'awun), and politeness (adab). These moments of guided reflection deepened learners' affective engagement, integrating moral formation with linguistic development. Such an approach aligns with Hamid et al. (2017), who argue that faith-based contextualization enhances both the ethical and intellectual dimensions of language learning.

The triangulation of observation data with questionnaire and test results thus illustrates a coherent pattern: Duolingo not only improved academic performance but also fostered motivational, social, and moral engagement. Students actively participated, supported peers, demonstrated sustained enthusiasm, and connected language learning with character education—an integrated outcome that embodies the holistic goals of Islamic pedagogy.

CONCLUSIONS

This study investigated the pedagogical effectiveness of Duolingo as an AI-assisted, adaptive learning platform for enhancing English achievement among sixth-grade students at SDIT Imam Syafii Cendikia. Employing a one-group pretest–posttest design with thirty participants, the findings demonstrated significant improvement in learners' English proficiency after a six-week intervention. Quantitatively, the mean score increased from 62.47 (SD = 10.42) to 81.63 (SD = 7.91), supported by a large effect size (Cohen's d = 0.88), indicating that Duolingo contributed meaningfully to learning gains within a relatively short instructional period. Beyond measurable achievement, the study also revealed strong affective and behavioral engagement. Questionnaire data (overall M = 4.36, SD = 0.52) confirmed that students perceived Duolingo as motivating, accessible, and enjoyable, while observation results (average M = 4.32) documented high levels of participation, focus, and enthusiasm. These outcomes collectively affirm that AI-mediated, gamified learning environments can create low-anxiety conditions conducive to second-language acquisition, consistent with Krashen's Affective Filter Hypothesis and Vygotskian sociocultural theory. Pedagogically, the results suggest that adaptive feedback and micro-learning design can personalize instruction for mixed-ability classrooms, allowing weaker learners to progress through individualized scaffolding while advanced students continue to be challenged. The narrowing of score variability across participants evidences Duolingo's capacity to foster equitable learning,

aligning with the Islamic educational principle of adl (justice and fairness). Furthermore, the integration of reflective discussions that linked English expressions to values such as gratitude (syukur), cooperation (taʿāwun), and politeness (adab) demonstrates that AI-assisted instruction can be harmoniously embedded within faith-based curricula without compromising cultural integrity. From a theoretical standpoint, the findings extend adaptive-learning and motivational frameworks into the context of elementary Islamic education, illustrating how algorithmic personalization interacts with social mediation to enhance both linguistic and moral development. The convergence of quantitative and qualitative evidence supports a model in which technology, pedagogy, and ethics operate synergistically rather than competitively. In practical terms, the study provides empirical justification for integrating AI-enhanced applications as complementary tools within Indonesia's Kurikulum Merdeka. Teachers can utilize Duolingo to supplement classroom instruction, implement formative assessment through real-time analytics, and promote learner autonomy through individualized digital practice. School administrators are encouraged to provide digital-literacy training and infrastructure support to ensure sustainable implementation. Nevertheless, the study's scope was limited to one class without a control group, restricting generalizability. Future research should incorporate comparative or longitudinal designs, examine larger samples, and explore the integration of other AI-based platforms or hybrid models combining Duolingo with collaborative project-based tasks. Investigations into teachers' perceptions and the long-term retention effects of AI-assisted learning would further enrich the empirical base for adaptive educational technologies in faith-based contexts. Overall, the evidence indicates that AI-driven adaptive learning platforms such as Duolingo can enhance linguistic achievement, motivation, and moral engagement simultaneously. When guided by pedagogical sensitivity and cultural alignment, AI technology can serve as a transformative instrument for advancing inclusive, student-centered, and ethically grounded English language education in Indonesian Islamic schools.

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