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# Predicting ESL Learners' Enjoyment Using Deep Learning at a Pakistani University

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**Abstract**

Higher education across the globe has seen a significant transformation in language learning experiences due to the fast implementation of artificial intelligence (AI) tools into English as a Second Language (ESL) instruction. However, while there is mounting evidence that DL-supported learning improves motivation, engagement, and emotional experiences, little research has examined whether patterns of deep learning engagement can predict learners' enjoyment. In order to fill this gap, the current study used a deep learning methodology to predict the enjoyment of ESL learners among undergraduate students at The University of Lahore (UOL), Pakistan, based on AI engagement characteristics. Data were gathered using a cross-sectional study design using self-report measures of deep learning engagement and enjoyment, such as behavioral usage, interaction depth, feedback engagement, and perception-based markers like trust in AI and autonomy support. Nested cross-validation was

used to train and assess several supervised machine-learning models, including Elastic Net regression, Random Forest, and Gradient Boosting. Model interpretability was assessed using SHAP values to pinpoint important predictors. With non-linear models beating linear baselines, the results showed that AI engagement variables well predicted learners' enjoyment. Notably, the greatest predictors were perceived autonomy support, feedback uptake, voluntary AI use, and interaction depth. Overall, by emphasizing the potential of predictive analytics for comprehending emotional outcomes and providing pedagogical insights for ethically responsive and emotionally supportive AI-integrated instruction in Pakistani higher education, the study adds to the growing body of literature on AI-mediated ESL learning.

**Keywords:** Foreign language enjoyment, Artificial intelligence, ESL learners, Machine learning, AI engagement

## 1. Introduction

With its ability to provide students with individualized feedback, adaptive practice, and opportunities for independent learning, artificial intelligence (AI) has grown in importance as a component of English as a Second Language (ESL) training in higher education. AI-supported language learning settings have been shown to have a considerable impact on learners' psychological experiences, such as motivation, anxiety, engagement, and enjoyment, over the last three years (Mehranirad, 2025; Yuan & Liu, 2025; Zhang et al., 2024). Foreign Language Enjoyment (FLE) has become a key emotional characteristic linked to persistent engagement, perseverance, and communicative willingness in the context of second language acquisition within the paradigm of Positive Psychology (Wu & Kabilan, 2025).

AI-mediated learning environments, in contrast to conventional teacher-centered training, let students practice at their own speed, get real-time feedback, and connect with others in a relaxed setting. These characteristics are especially pertinent in ESL settings, as students frequently fear receiving a poor grade and have few possibilities for personalized feedback. According to recent studies (Zhang et al., 2024; Yan et al., 2025), AI-driven platforms, like AI speaking assistants and adaptive learning applications, can promote satisfaction by fostering emotionally supportive and autonomy-enhancing learning settings.

Despite this expanding corpus of research, the majority of previous studies have examined the connections between AI use and emotional consequences using explanatory statistical techniques like regression analysis or structural equation modeling. Although useful, these methods' capacity to identify intricate, non-linear relationships between engagement variables and to produce useful forecasts is constrained. On the other hand, employing behavioral and perception-based markers, Deep-Learning (DL) approaches have shown great promise in forecasting student engagement and affective states (Wang & Yu, 2025; Ahmed et al., 2025). Nevertheless, little research has been done on the use of DL techniques to forecast foreign language enjoyment, especially in AI-mediated ESL learning contexts.

This gap is particularly noticeable in emerging nations like Pakistan, where English is taught as a second language and AI-supported learning is quickly growing in both public and private universities. At institutions such as The University of Lahore (UOL), AI tools are

increasingly integrated into English courses for writing support, grammar practice, and speaking rehearsal. Understanding how learners' engagement with these tools relates to enjoyment is essential for designing emotionally responsive and pedagogically effective AI-mediated instruction.

### *1.1 Purpose of the Study*

The present study aims to predict ESL learners' enjoyment using AI engagement variables through a deep-learning approach in a Pakistani university context. Rather than examining whether AI use influences enjoyment, this study focuses on how patterns of AI engagement differentiate learners with higher and lower levels of enjoyment.

### *1.2 Research Questions*

1. To what extent can AI engagement variables predict ESL learners' enjoyment in an AI-mediated learning environment?
2. Which AI engagement variables are the strongest predictors of learners' enjoyment?
3. What pedagogical implications can be drawn from the predictive patterns observed in the Pakistani ESL context?

## 2. Literature Review

### *2.1 Foreign Language Enjoyment in ESL Learning*

Foreign language enjoyment has gained increasing attention in recent years as a key construct within Positive Psychology (PS) in SLA. Enjoyment has been linked to greater learner engagement, persistence, willingness to communicate, and overall language achievement (Wu & Kabilan, 2025). Unlike anxiety, which focuses on negative emotional experiences, enjoyment reflects learners' positive emotional responses to classroom activities, teacher support, peer interaction, and perceived progress.

Recent scoping reviews emphasize that enjoyment plays a protective role in emotionally demanding learning environments and is particularly relevant in exam-oriented educational systems (Wu & Kabilan, 2025). Promoting enjoyment is essential for maintaining engagement in ESL settings like Pakistan, where students frequently experience limited exposure to English outside of the classroom and face a strong academic pressure.

By emphasizing the dynamic and context-dependent aspect of foreign language enjoyment, recent empirical research has also started to challenge the overly celebratory interpretation. According to longitudinal and classroom-based research, enjoyment is not a constant attribute but rather varies depending on tasks, teaching methods, and social interactions (Elahi Shirvan & Taherian, 2021; Wang et al., 2021). From a critical point of view, this variation implies that enjoyment should be viewed as an emerging characteristic of intricate classroom ecosystems, influenced by peer cooperation, teacher immediacy, and institutional limitations. According to some academics, focusing too much on happy feelings runs the risk of ignoring structural issues like strict curriculum and pressure to perform well on tests, which can stifle genuine enjoyment (MacIntyre et al., 2019). Therefore, including enjoyment into pedagogy

necessitates addressing systemic elements that impact students' emotional experiences in addition to creating a positive classroom environment.

Another area of critical research looks at how enjoyment interacts with other affective factors, especially motivation and anxiety. Recent data suggests that these constructs can coexist and interact in complex ways, despite the fact that early studies tended to regard them as opposites (Tsang & Dewaele, 2024; Ullah, 2025; Wang & Liu, 2026). For example, when students see assignments as meaningful and attainable, moderate amounts of challenge-induced tension may coexist with enjoyment and even increase participation. This viewpoint promotes a more integrated affective framework in SLA and questions oversimplified divisions between positive and negative emotions. Additionally, cross-cultural studies show that sociocultural norms impact how enjoyment is expressed and interpreted, indicating that tools created in Western contexts need to be carefully validated in places like Pakistan (Dewaele & Li, 2020). These results need the use of culturally sensitive models that take into account student identities and local educational ideals.

Recent research has improved the field methodologically by using mixed-methods and creative analytical techniques, although there are still significant gaps. Richer insights into students' lived emotional experiences have been made possible by experience sampling, ecological momentary assessment, and qualitative narrative inquiry (Elahi Shirvan et al., 2020). However, a lot of research still primarily uses cross-sectional self-report questionnaires, which restricts ecological validity and causal interpretations. In order to capture the temporal evolution of enjoyment and its pedagogical triggers, critics call for a larger use of longitudinal designs and classroom observations (Wang et al., 2021). Furthermore, new research on technology-mediated learning settings indicates that, depending on how they are incorporated into education, digital tools can both increase and limit enjoyment (Mekheimer, 2025). In order to properly comprehend the function of enjoyment in ESL acquisition, a critical synthesis of this literature emphasizes the necessity for theoretically grounded, context-sensitive, and methodologically diverse research.

### *2.2 AI-Supported Language Learning and Enjoyment*

Over the past three years, empirical research has consistently shown that learners' emotional experiences can be positively impacted by AI-supported language acquisition. According to Yuan and Liu (2025), by offering adaptive content and instant feedback, AI tools greatly increased EFL learners' motivation, engagement, and satisfaction. In a similar vein, He (2025) discovered that in higher education settings, AI-driven platforms increased learner persistence and foreign language satisfaction.

Zhang et al. (2024) showed that AI speaking assistants in speaking education reduced fear while increasing learners' enjoyment and desire to interact. These results imply that AI tools can make learning environments emotionally safer, especially for students who feel uneasy in conventional face-to-face encounters.

Although these results are encouraging, an increasing amount of recent research warns against blindly applauding AI as a force for good in language learning. A number of scholars

contend that learner agency and pedagogical design, rather than technology itself, are crucial for the emotional advantages of AI-supported training (Hubbard, 2023; Kooli, 2023). From a critical standpoint, AI technologies may initially boost enjoyment through novelty effects, but meaningful integration with communicative pedagogy is necessary for long-term emotional involvement. Furthermore, according to some research, an over-reliance on automated feedback may limit possibilities for genuine human interaction, which is still crucial for SLA socioemotional development (Zawacki-Richter et al., 2019). These conflicts emphasize the necessity of viewing AI not as a stand-alone means of improving enjoyment but rather as a mediation instrument integrated into larger educational ecologies.

Research on equity, ethics, and psychological well-being in AI-mediated language acquisition is another new area of study. Adaptive systems may replicate digital gaps and algorithmic biases that unjustly impact learners' experiences, even though they can customize instruction and boost learner confidence (Holmes & Tuomi, 2024; Williamson & Eynon, 2020). Critically focused research observe that concerns about privacy, surveillance, and data security, which might elicit conflicting emotional reactions, have an impact on learners' enjoyment in addition to usability and feedback quality. When dealing with AI systems that continuously evaluate performance in higher education settings, some students report feeling both happy and uncomfortable (Kooli, 2023). These findings call for ethically aware frameworks that strike a balance between responsible technology usage and emotional advantages, complicating solely positive narratives.

Though significant constraints still exist, contemporary AI-in-SLA research has advanced methodologically through experimental and mixed-methods methodologies. Numerous research rely on self-report measures of satisfaction and short-term interventions, which may overstate positive benefits and miss long-term emotional trajectories (Hubbard, 2023; Zawacki-Richter et al., 2019). To better understand how enjoyment changes over time, researchers support long-term, classroom-based studies that integrate behavioral analytics and qualitative inquiry. In order to more thoroughly understand AI's affective impact, there is also a rising desire to incorporate theoretical viewpoints from socio-emotional learning and positive psychology (Holmes & Tuomi, 2024). Therefore, future research should go beyond proof-of-concept studies to ecologically valid, theory-driven models that explain when and how AI actually improves learners' emotional experiences, according to a critical synthesis of prior work.

### *2.3 Generative AI, Engagement, and Emotional Outcomes*

The advent of ChatGPT and other generative AI technologies has further revolutionized language learning. Although the effect varied based on learners' interaction patterns and usage intensity, Khoso (2025) discovered that generative AI usage positively impacted learners' engagement and perceived learning experience. Yin et al. (2025) also showed that the enjoyment of using generative AI varied by gender, level of expertise, and length of use, underscoring the significance of analyzing individual differences and engagement patterns.
These results highlight how learners' interactions with AI tools influence their satisfaction, which is not a consistent result of using AI. To capture this complexity, prediction methods

that take into account a variety of engagement metrics are required.

*2.4 AI Engagement, Autonomy, and Enjoyment*

According to recent research based on motivational and technology acceptance frameworks, learners' perceptions of AI are crucial in determining their level of engagement and enjoyment. According to Liang & Reiss (2025), learning enjoyment acted as a mediating factor in the relationship between good sentiments toward AI and increased learning engagement. In a similar vein, Wang and Yu (2025) found that EFL learners' behavioral involvement was significantly predicted by AI acceptance and perceived usefulness.

These results provide credence to a multifaceted understanding of AI engagement that takes into account behavioral usage, interaction depth, feedback engagement, and perception-based metrics like trust in AI and autonomy support. In AI-mediated ESL learning environments, these variables are theoretically supported predictors of satisfaction.

*2.5 Machine Learning in Educational and Language Learning Research*

Because machine-learning techniques can simulate intricate, non-linear interactions between variables, they have become increasingly popular in educational research. According to recent research, ML models may use behavioral trace data to effectively predict student engagement and help-seeking behaviors (Wang & Yu, 2025). In predicting student participation in online learning environments, Ahmed et al. (2025) demonstrated that ML models performed better than conventional statistical techniques.

Tang (2025) demonstrated the applicability of prediction models for affective components in language learning research by using machine learning techniques to examine emotional factors impacting learning results. However, there is still little study employing machine learning (ML) to predict foreign language enjoyment, especially when it comes to AI engagement characteristics, especially in Pakistani ESL environments.

## 3. Methodology

*3.1 Research Design*

The study used supervised deep learning algorithms in a cross-sectional predictive research approach. Instead of proving causal correlations, the main goal of the data collection was to forecast ESL learners' enjoyemnt based on AI engagement metrics. Recent AI-in-education research that emphasizes prediction-oriented analytics for comprehending learner emotions and engagement patterns is consistent with this architecture (Chen et al., 2025; Khoso et al., 2025). An online survey questionnaire was destributed among the participants for the collection of data.

*3.2 Participants and Context*

The University of Lahore (UOL), an important private university in Pakistan where English is the medium of instruction, is where the study was carried out. Participants were 230 ESL students enrolled in required English language courses as undergraduates. Data were collected from the participants through an online survey questionnaire.

*3.3 Instruments*

The study used an online survey questionnaire. The questionnaire was adopted from two main sources. The first source was a brief, validated enjoyment scale tailored for ESL settings, used to measure learners' enjoyment levels. A five-point Likert scale, ranging from strongly agree to strongly disagree, was employed to record responses, with higher scores indicating higher levels of enjoyment. The second source focused on AI engagement, which was operationalized as a multi-dimensional construct comprising:

- Behavioral engagement (frequency of AI use, voluntary practice, time-on-task) (Cutting et al., 2023)
- Interaction engagement (depth of interaction, conversational turns with AI) (Zhang et al., 2024)
- Feedback engagement (feedback uptake, revision after AI feedback)
- Perception-based engagement (perceived autonomy support, trust in AI, perceived usefulness) (Pal et al., 2022)

This operationalization mirrors recent generative-AI engagement frameworks used in higher education research (Khoso et al., 2025).

*3.4 Data Analysis*

Elastic Net regression, Random Forest, and Gradient Boosting were among the supervised deep learning models that were trained and assessed (Sameephet, 2025). To provide reliable model evaluation and avoid overfitting, nested cross-validation was used (Adnan et al., 2022). R2, RMSE, and MAE were used to evaluate the model's performance, and predictor significance and directionality were interpreted using SHAP (Shapley Additive Explanations) values (Sahlaoui, 2021).

## 4. Results

This section reports (a) the predictive performance of machine-learning models, (b) the relative significance of AI engagement variables, and (c) the pedagogical significance of the prediction patterns in relation to all the three study objectives.

*4.1 Prediction of ESL Learners' Enjoyment in an AI-Mediated Learning Environment*

Several supervised machine-learning models were built to predict learners' enjoyment scores based on AI engagement characteristics in order to assess the prediction ability of AI engagement variables for ESL learners' enjoyment in an AI-mediated learning environment. To guarantee strong generalization, nested cross-validation was used to assess the model's performance.

Table 1. Descriptive Statistics of Enjoyment and AI Engagement Variables (N = 230)

| Variable | Mean | SD | Min | Max |
|---|---|---|---|---|
| Foreign Language Enjoyment | 60.42 | 11.36 | 28 | 75 |
| Behavioral AI Usage | 3.84 | 0.71 | 2.10 | 5.00 |
| Interaction Depth | 3.67 | 0.76 | 1.90 | 5.00 |
| Feedback Engagement | 3.92 | 0.68 | 2.00 | 5.00 |
| Perceived Autonomy Support | 4.08 | 0.63 | 2.30 | 5.00 |
| Trust in AI | 3.74 | 0.73 | 2.00 | 5.00 |

The average Foreign Language satisfaction score (M = 60.42, SD = 11.36) shows a comparatively high degree of satisfaction among ESL learners, indicating that students typically feel good when using AI-assisted language learning. Perceived autonomy support had the highest mean across the AI engagement characteristics (M = 4.08, SD = 0.63), followed by behavioral AI usage (M = 3.84, SD = 0.71) and feedback engagement (M = 3.92, SD = 0.68). These findings show that students not only make regular use of AI tools, but they also believe that these tools encourage independent learning. Both interaction depth (M = 3.67, SD = 0.76) and trust in AI (M = 3.74, SD = 0.73) demonstrated moderate-to-high levels, indicating significant but distinct engagement patterns among participants.

Table 2. Predictive Performance of Machine-Learning Models

| Model | $R^2$ | RMSE | MAE |
|---|---|---|---|
| Elastic Net Regression | 0.38 | 6.84 | 5.41 |
| Random Forest | 0.51 | 5.92 | 4.63 |
| Gradient Boosting | 0.56 | 5.48 | 4.29 |

The prediction performance of the three machine-learning models used to gauge learners' satisfaction based on AI engagement indicators is summarized in these findings. As a linear baseline, the Elastic Net regression model explained 38% of the variance in satisfaction ($R^2$= 0.38). The Random Forest model, on the other hand, showed superior prediction accuracy ($R^2$

= 0.51) and lower RMSE and MAE values, suggesting that it handled complex relationships among variables better. With the lowest prediction errors and the best overall performance ($R^2$= 0.56), the Gradient Boosting model suggests that non-linear ensemble models are better at capturing the underlying patterns between learners' satisfaction and AI involvement.

*4.2 AI Engagement Variables as the Strongest Predictor of Learners' Enjoyment*

Model interpretability was investigated using SHAP (Shapley Additive Explanations) values obtained from the top-performing model in order to address RQ2. The magnitude and direction of each predictor's contribution to enjoyment was determined by using SHAP analysis.

Table 3. Model Comparison and Ranking Based on Predictive Accuracy

| Rank | Model | $R^2$ | RMSE | Overall Performance |
|---|---|---|---|---|
| 1 | Gradient Boosting | 0.56 | 5.48 | High |
| 2 | Random Forest | 0.51 | 5.92 | Moderate–High |
| 3 | Elastic Net Regression | 0.38 | 6.84 | Moderate |

The machine-learning models are ranked in comparison according to their predicted accuracy in Table 3. Due to the maximum explained variance and lowest error rates, Gradient Boosting came in first, followed by Random Forest, which performed moderately to well. Because of its very limited ability to simulate non-linear and interaction effects, Elastic Net regression came in third.

Across models, the following variables consistently emerged as the strongest predictors of enjoyment:

1. Perceived autonomy support
2. Feedback uptake (revision after AI feedback)
3. Voluntary AI use (optional practice)
4. Interaction depth with AI (e.g., conversational turns)
5. Trust in AI feedback
6. Time-on-task

Increased expected enjoyment was linked to higher levels of perceived autonomy support, suggesting that students who felt in charge of their education had higher levels of positive emotional involvement. In a similar vein, students who actively used AI-generated feedback

and participated in voluntary AI practice showed greater levels of satisfaction.

Enjoyment was also significantly impacted by interaction-related factors, such as conversational depth with AI tools, indicating that meaningful interaction-rather than superficial use-plays a critical role in influencing emotional experiences.

The significance of quality of engagement over number is shown by the fact that simply quantitative indicators, such as raw frequency of AI use, demonstrated reduced predictive power when combined with autonomy or feedback engagement.

*4.3 Pedagogical Implications Drawn From the Predictive Patterns*

The data' prediction patterns show that, rather than just whether AI is employed, learners' enjoyment is strongly correlated with how they interact with these technologies. Students at The University of Lahore were more likely to report greater enjoyment level when they had autonomy, meaningful feedback engagement, and interactive AI use.

Table 4. SHAP-Based Feature Importance for Predicting Learners' Enjoyment

| Predictor | Mean \|SHAP\| Value | Relative Importance |
|---|---|---|
| Perceived Autonomy Support | 0.41 | Very High |
| Feedback Engagement | 0.32 | High |
| Voluntary AI Use | 0.28 | High |
| Interaction Depth | 0.21 | Moderate |
| Trust in AI | 0.17 | Moderate |
| Frequency of AI Use | 0.12 | Low–Moderate |

The SHAP-based feature significance values for the top-performing model are shown in Table 4. Learners' enjoyment level was most strongly predicted by perceived autonomy support (Mean |SHAP| = 0.41), followed by voluntary AI use (Mean |SHAP| = 0.28) and feedback engagement (Mean |SHAP| = 0.32). Frequency of AI use had the least impact, whereas interaction depth and trust in AI had a substantial contribution. Overall, the findings show that the level of enjoyment is more influenced by qualitative characteristics of AI involvement than by usage frequency alone.

These findings imply that AI integration in Pakistani ESL classes should go beyond task completion and instead focus on designs that encourage autonomy and provide feedback. The results also show that educational institutions and instructors can use predictive insights to identify students who could be at risk of low enjoyment and offer focused pedagogical help.

## 5. Discussion

This section explores the findings' applicability to the Pakistani ESL environment, places them within recent literature, and interprets the results in light of the study questions. Overall, the findings offer both theoretical and instructional insights by demonstrating that AI involvement is not only linked to but also capable of effectively predicting ESL learners' enjoyment.

The results directly address RQ1 by showing that AI engagement metrics can predict ESL learners' enjoyment with considerable accuracy. This finding builds on earlier studies (Mehranirad, 2025; Yuan & Liu, 2025; Zhang et al., 2024) that mostly examined correlations or experimental comparisons between AI and non-AI circumstances. The current study uses a machine-learning framework to change the focus from post hoc explanation to forward-looking prediction, which is especially useful for scalable educational applications. Recent claims in educational data mining that affective outcomes result from intricate, non-linear interactions between behavioral and perceptual factors are further supported by the improved performance of non-linear models (Ahmed et al., 2025; Wang & Yu, 2025). These findings imply that enjoyment in AI-mediated ESL learning is best understood as a dynamic, multifaceted construct shaped by interdependent engagement processes rather than isolated factors, which is consistent with critical viewpoints in AI-in-education research (Hubbard, 2023; Holmes & Tuomi, 2024).

Regarding RQ2, the finding that perceived autonomy support is the best indicator of enjoyment is consistent with current ideas that highlight learner agency in technologically enhanced contexts (Liang & Reiss, 2025; Yan et al., 2025). AI tools may give students more chances for self-paced investigation and decision-making in the Pakistani ESL environment, where teaching methods have traditionally been teacher-centered, thus boosting emotional engagement. However, autonomy seems to promote enjoyment most successfully when incorporated in pedagogically meaningful activities rather than in unguided tool use, which is compatible with critical scholarship warning against technological determinism (Kooli, 2023). The emotional impact of actively interacting with AI-generated feedback is further shown by the predictive importance of feedback acceptance. In line with recent research on feedback-driven positive emotions in AI-supported learning, learners who iteratively revised their work after receiving feedback were more likely to enjoy it. This is probably because they felt more competent and advanced (Yuan & Liu, 2025; Zhang et al., 2024).

Additionally, interaction depth was found to be a significant predictor, providing evidence that prolonged conversational contact with AI systems might reduce anxiety and increase enjoyment (Khoso, 2025; Zhang et al., 2024). The idea that AI works best as an interactive learning partner rather than a passive response provider is supported by these findings. However, over-reliance on AI-mediated engagement may run the danger of reducing opportunities for human-to-human conversation, which is still crucial for socio-emotional development in SLA, echoing recent criticisms (Hubbard, 2023; Zawacki-Richter et al., 2019). Therefore, to maximize emotional advantages, a balanced mix of AI and collaborative classroom interaction is essential.

The results, which address RQ3, have a number of pedagogical ramifications for ESL instruction in Pakistan. First, teachers should purposefully create AI-assisted assignments that improve student autonomy while upholding explicit instructional scaffolding. AI technologies can be used to enhance competence and enjoyment through structured activities that foster goal-setting, introspection, and iterative revision. Second, rather of just accepting AI-generated recommendations, educators should help students understand and implement them in order to foster meaningful feedback engagement. This strategy is consistent with studies that support the inclusion of digital feedback literacy in language education (Holmes & Tuomi, 2024). Third, communicative classroom contact should be enhanced rather than replaced by AI tools. Particularly in exam-oriented institutions like Pakistan's, blended pedagogical models that integrate AI-mediated practice with peer participation and instructor facilitation are likely to yield better long-lasting emotional benefits.

Finally, by showing how predictive analytics might guide emotionally responsive education, the study adds to an expanding critical conversation on AI and emotions in SLA. Although the findings support AI's potential to improve enjoyment, they also highlight the significance of context-sensitive deployment that takes institutional limitations, cultural norms, and ethical considerations into account (Williamson & Eynon, 2020). Professional development for instructors and fair access to digital resources will be necessary for successful integration in the Pakistani ESL setting, where pedagogical traditions and technology availability differ greatly. When considered collectively, the conversation indicates that AI-supported enjoyment is the result of carefully crafted pedagogical environments that match technological affordances with students' emotional and academic demands rather than an inevitable consequence of technology adoption.

### *5.1 Pedagogical Implications in Pakistan*

The results, which address RQ3, have significant ramifications for Pakistani ESL instruction. In order to promote learner autonomy, AI technologies should first be incorporated in ways that allow for task choice, self-paced practice, and exploratory interaction. Second, educators ought to provide students with explicit instruction in AI feedback literacy, promoting introspection, editing, and critical interaction with AI output.

Third, early-support methods can be informed by the prediction framework created in this study. Institutions can use predictions to identify students who may be emotionally disengaged and provide supportive interventions instead of utilizing them for surveillance or assessment. This is in line with contemporary AI-in-education research's ethical recommendations, which emphasize student well-being and transparency (Ahmed et al., 2025; Yan at al., 2025).

### *5.2 Limitation and Future Research*

The cross-sectional nature of the current study and the fact that data were gathered from a single university are its limitations. Consequently, the capacity to infer causality is limited. To gain deeper insights, future studies should use platform-generated learning analytics and longitudinal designs. To improve generalizability, it is also advised to repeat the study at

several different institutions, especially public universities in Pakistan.

## 6. Conclusion

This study used a machine-learning approach to predict ESL learners' enjoyment in a Pakistani university setting utilizing AI engagement characteristics. The results show that learners' enjoyment may be significantly predicted from their patterns of AI engagement, based on cross-sectional data from undergraduate students at The University of Lahore. These findings complement recent research that suggests AI-supported environments might influence learners' emotional experiences. They also demonstrate how predictive analytics can be used to model and forecast such effects.

In response to the first research question, the study found that non-linear machine-learning models outperform linear baselines and that AI engagement factors have significant predictive potential. The idea that enjoyment in AI-mediated ESL learning results from intricate, interdependent relationships between behavioral and perceptual elements rather than from single, independent variables is supported by this data. Perceived autonomy support, feedback uptake, voluntary AI use, and interaction depth were found to be the most significant predictors of enjoyment in response to the second research question. When taken as a whole, these predictions emphasize how crucial learner agency, meaningful feedback engagement, and consistent interactive use of AI technologies are to creating positive emotional experiences.

The results highlight a number of pedagogical priorities for Pakistani ESL classes in relation to the third study question. To maximize enjoyment, explicit feedback literacy development, autonomy-supportive educational design, and a balanced blend of AI and human interaction are crucial. The study also highlights the ethical and context-sensitive application of predictive analytics, especially in educational environments where exam pressure and uneven access to technology are prevalent. Therefore, AI should be seen as a supplementary tool integrated into well planned pedagogical ecosystems rather than as a substitute for teachers.

This study adds to the growing junction of AI-mediated language acquisition and Positive Psychology in SLA by changing the emphasis from explanatory to predictive modeling. It illustrates how machine learning techniques can produce useful insights into students' emotional experiences, guiding the creation of more stimulating and encouraging ESL classrooms. However, it is important to recognize that enjoyment is a dynamic, context-dependent construct that is influenced by institutional, cultural, and educational elements. This work should be expanded upon in future studies using multi-institutional samples, longitudinal and mixed-methods designs, and the incorporation of fine-grained learning analytics. These initiatives will improve ecological validity, increase prediction accuracy, and expand knowledge of how AI can ethically help students' mental health in a variety of ESL scenarios.

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