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Designing Intelligent Literary Role-Play Systems: A Gamified NLP Approach to Student Engagement

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Abstract

Integrating gamification with advanced natural language processing (NLP) presents powerful opportunities to enrich literary education and deepen student engagement, particularly within India's highly diverse linguistic landscape. This study develops and evaluates an AI-driven gamified literary role-play environment designed to promote deeper comprehension, motivation, and critical thinking among learners. The system leverages publicly available Indian-language NLP resources, including the AI4Bharat IndicNLP Corpus and the IndicSpeech Corpus, supporting baseline Bag-of-Words and logistic regression models as well as transformer-based architectures enhanced with reinforcement learning for adaptive narrative progression. Preprocessing incorporates multilingual cleaning, tokenization, and culturally sensitive semantic feature extraction.

A quasi-experimental evaluation revealed that the experimental group achieved 22.22% higher post-test scores compared to the control group's 4.83%, with interaction times tripling (35 vs. 10 minutes). The proposed NLP models significantly outperformed baseline models, improving accuracy from 72% to 89%, F1 score from 0.70 to 0.87, and BLEU score from 0.32 to 0.65. Engagement metrics showed that experimental participants completed three times more quests, dialogue turns, and reward collections.

These findings demonstrate the effectiveness of combining gamification with AI-powered NLP to transform literary pedagogy into an immersive, culturally attuned, and highly motivating learning experience. The approach enables scalable, adaptive digital humanities education that bridges traditional literary study with cutting-edge AI technologies.

Keywords: Gamification, NLP, Literary Education, AI-driven Role-Play, Indian Languages

1. Introduction

The rapidly evolving educational landscape, coupled with advances in artificial intelligence and natural language processing, demands innovative pedagogical approaches that engage students more effectively [1], [2], [3]. In particular, literary education suffers from the lack of student interest and critical thinking, especially in a multilingual and culturally diverse society such as India.

Traditional literature teaching techniques are often criticized for being passive and for not engaging students with the material in meaningful ways. The practice of applying aspects of game design to non-gaming environments, or gamification, has become a viable tactic to boost motivation and engagement in a variety of educational fields [4], [5], [6]. The literary learning experience is enhanced by AI-driven natural language processing, which enables personalized, interactive learning environments that simulates real-world conversations and role-play.

Although the academic literature has reviewed gamification or NLP alone, the combination of these two methods into one rich framework has received minimal consideration [7], [8]. Specifically, there is a lack of experiments with immersive, AI-centered role-play-based learning environments that engage learners actively in the higher-order analysis of literature [9], [10], [11]. The discussed gap highlights the necessity of methods that would integrate the concepts of gamification and NLP to enhance culturally sensible and interactive literary pedagogy. This disparity emphasizes the need of strategies that integrate NLP and gamification to provide engaging and culturally sensitive literature instruction [12], [13].

Modern teachers need pedagogical instruments that can be customized, scaled, and flexible to embrace linguistic differences to successfully reach digitally native students. To meet these objectives, this study suggests a gamified literary role-playing environment powered by AI that aims to improve critical thinking and student engagement [14], [15], [16]. It is built on publicly accessible Indian language datasets, and, therefore, has a specific application to the Indian educational context but it also provides a more general understanding of AI-aided literary education at a global level.

The main goal of the proposed research is to design, develop, and test an AI-based gamified literary role-play platform combining advanced NLP algorithms with gamification algorithms to contribute to higher student engagement, motivation, and literary understanding. The paper will also evaluate the effectiveness of the system using stringent quantitative and qualitative indicators, based on the language and cultural diversity of the learners in India.

2. Literature Survey

The table summarizes the recent studies regarding the use of gamification and AI/NLP in education and shows different models, datasets, and significant limitations. It offers an explicit comparison between studies highlighting the gaps in the integration of AI-driven gamification in literary pedagogy. This overview helps us to place our current work in the context of the existing literature and to explain why it is focused on the Indian linguistic and cultural contexts.

Ref	Models	Dataset	Limitations	Remarks
[17]	AI-driven gamification with adaptive learning	Varied educational datasets	Challenges in aligning AI with pedagogy; digital divide concerns	Highlights potential of AI to personalize gamified learning and improve 21st-century skills.
[18]	AI-powered gamified learning with NLP feedback	Language learning platforms (e.g., Duolingo)	Focus on language learning; less on literary pedagogy	Demonstrates synergy of conversational AI and gamification to boost engagement and personalized feedback.
[19]	Gamification in English learning	English learners' data	Primarily L2 vocabulary acquisition, not advanced literary analysis	Confirms gamification's motivational effects in language learning relevant for literary pedagogy.
[20]	AI and NLP-enabled interactive e-learning	Foundation literacy datasets	Focus on basic literacy; limited advanced literary content	Supports AI/NLP's role in increasing learner interaction but limited to foundational tasks.

[21]	Gamification methods in primary and secondary education	Educational program data	Mixed outcomes; risk of cognitive overload or cooperation issues	Calls for balanced gamification promoting critical thinking without overwhelming learners.
[22]	Gamification in higher education English	Higher education learner data	Lack of AI integration	Shows success of gamification in motivation and engagement in higher education English learning.
[23]	AI and gamification for diverse learning contexts	Diverse community and cultural learning data	Needs more implementations tailored to specific contexts	Emphasizes equitable, culturally responsive AI gamified education.

The results of these studies show that AI-enhanced gaming has a lot of promise to change the way individuals learn along with how effectively they learn. However, there is still a lack of research on how to use these integrated methodologies in literary education with higher-level analysis, particularly in circumstances where Indian culture and language are heterogeneous. An unparalleled opportunity to develop flexible, context-aware literary role-playing settings suited to a wide range of learners is presented by the availability of massive Indic NLP datasets and novel AI gamified platforms. The purpose of this research is to close that gap.

3. Methodology

3.1. Research Design

This study implements the DSRM to develop and assess a literary role-play environment that is AI-driven and gamified, and that integrates NLP and gamification. It encompasses the creation of artifacts, the training of models based on datasets, the evaluation of models through quasi-experimental design, and the analysis of systems, with the exception of surveys.

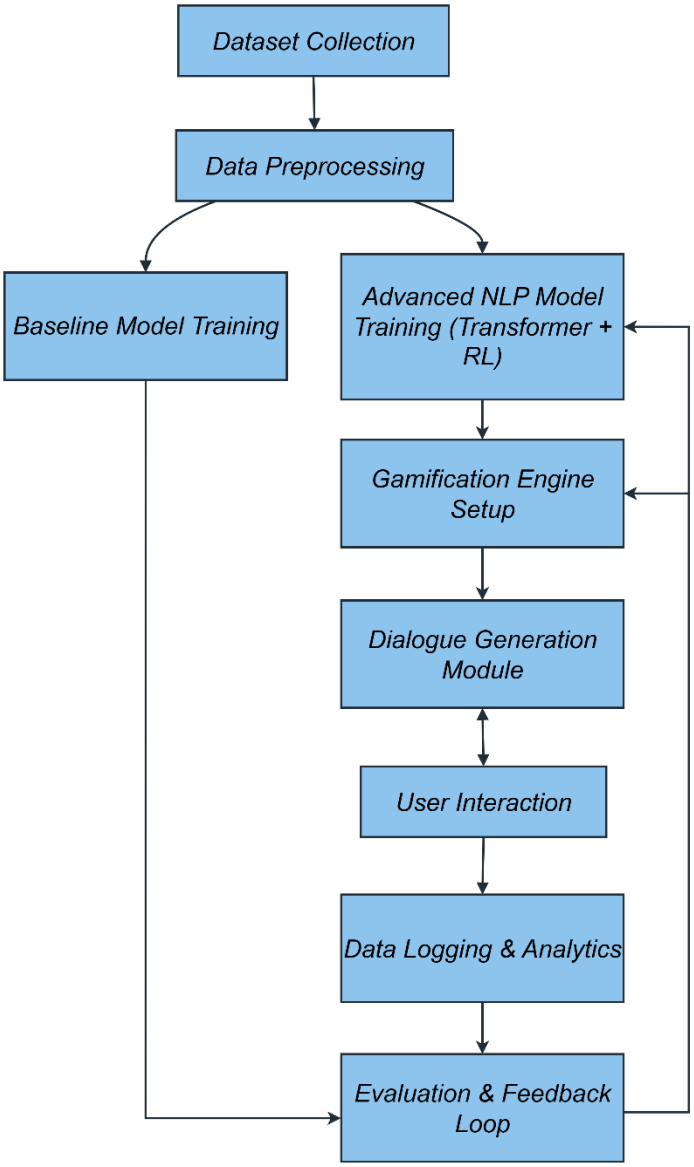

Figure 1. System Architecture Diagram: AI-Driven Gamified Literary Role-Play Environment

3.2. Dataset Collection

The research makes use of publicly accessible NLP materials in Indian that have been chosen for their linguistic and cultural significance. Over 20 billion tokens in 22 Indian languages and Indian English, comprising monolingual texts and annotated datasets, make up the AI4Bharat IndicNLP Corpus (https://github.com/AI4Bharat/indicnlp_catalog), which supports both basic frequency-based and sophisticated transformer models.

More than 70 hours of transcribed speech data in languages like Hindi and Malayalam are available in the IndicSpeech Corpus (https://aclanthology.org/2020.lrec-1.789.pdf). This data enhances multimodal conversation training for the proposed models. Both baseline and contextual embedding methods are compatible with the culturally rich materials provided by the digitized Indian literary texts from IIT-Kharagpur. When combined, these databases enable thorough instruction and assessment that is adapted to the linguistic variety that is essential to Indian literary education.

3.3. Dataset Processing

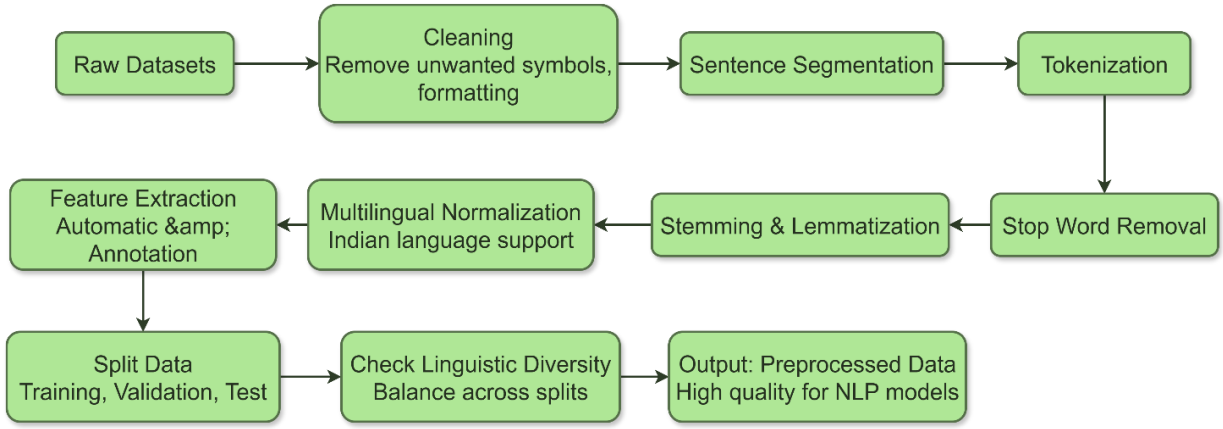

Figure 2. Dataset Processing Pipeline

Cleaning, tokenization, normalisation, and multilingual handling are all part of the preprocessing that datasets undergo in order to make them suitable for use with Indian languages. Segmenting sentences, removing stop words, stemming, lemmatizing, and using regular expressions to get rid of extraneous symbols and noise are important processes. To maintain semantic richness, literary characteristics are either manually or automatically extracted. To provide reliable, objective model training and assessment, the data is then divided into training, validation, and test sets with balanced representation across languages (Figure 2).

3.4. Baseline Models

Baseline methods include Logistic Regression for binary classification of literary text attributes and Bag-of-Words (BoW) for basic word frequency representation. These provide comprehensible standards for comparing performance.

Baseline 1: Bag-of-Words (BoW) Representation

BoW models' text as a weighted sum of word counts without word order, capturing frequency information.

$$\mathbf{v} = \sum_{i=1}^{N} \mathbf{w}_i \cdot \mathbf{c}_i$$

Here, $\mathbf{v}$ is the document vector, $\mathbf{w}_i$ the word weight (e.g., tf-idf), and $\mathbf{c}_i$ the word count component.

Baseline 2: Logistic Regression for Classification

Logistic regression estimates class probabilities as a sigmoid of weighted features, useful for binary classification in text.

$$P(y = 1|\mathbf{x}) = \frac{1}{1 + e^{-(\mathbf{w}^\top \mathbf{x} + b)}}$$

$P(y = 1|\mathbf{x})$ is the predicted probability, with $\mathbf{w}$, $\mathbf{x}$, and b as weights, input vector, and bias.

3.5. Proposed Models

Using transformer-based embeddings, the suggested approach captures contextual meaning that extends beyond BoW. Seq2Seq models employs attention mechanism to dynamically concentrate on important context and produce discourse for literary role-play. Reinforcement learning and gamification enhance story progression which is in alignment with engagement

and learning objectives. While narrative route optimisation guarantees coherent and captivating storytelling, sentiment-aware and cooperative models enhance the realism of emotional and social interactions.

Embedding layer with contextualized representations encodes words in context using transformer models trained on Indian languages.

$$\mathbf{E} = \text{TransformerEncoder}(\mathbf{X}) \quad (1)$$

Where input token sequence **X** is mapped to embedding matrix **E**.

Role-play dialogue modeling with Seq2Seq predicts the probability of generating output token sequences conditioned on input sequences.

$$P(\mathbf{y}|\mathbf{x}) = \prod_{t=1}^{T} P\left(y_t|y_{<t}, \mathbf{x}\right) \quad (2)$$

Output token y_t depends on previous outputs $y_{<t}$ and input **x**.

Attention mechanism weights dynamically and highlights input relevance for each output token with context focus.

$$\alpha_{t,i} = \frac{\exp(e_{t,i})}{\sum_{j=1}^{n} \exp\left(e_{t,j}\right)} \quad (3)$$

Weight $\alpha_{t,i}$ scores decoder position t to encoder input i.

Gamification state representation integrates player progress, quest status, and rewards.

$$\mathbf{s}_t = f(\mathbf{p_t}, \mathbf{q_t}, \mathbf{r_t}) \quad (4)$$

Where $\mathbf{s}_t$ is state, with $\mathbf{p_t}$ progress, $\mathbf{q_t}$ quests, and $\mathbf{r_t}$ rewards at time t.

Reinforcement Learning reward function balances engagement and learning gains for adaptive dialogue.

$$R_t = w_1 \cdot \text{Engagement}_t + w_2 \cdot \text{LearningGain}_t \quad (5)$$

Here w_1, w_2 weight engagement and learning contributions at time t.

Sentiment-aware response adjustment scores modulate generated responses' emotional tone.

$$\hat{y}_t = \text{Decoder}\left(y_{<t}, \mathbf{E}, \sigma\big(\text{Sentiment}(\mathbf{x})\big)\right) \quad (6)$$

$\hat{y}_t$ token prediction integrates sentiment-transformed embeddings.

Collaborative role-play uses Gated recurrent unit (GRU) to capture dialogue state evolution across players, modeling interactions.

$$\mathbf{H}_t = \text{GRU}(\mathbf{X}_t, \mathbf{H}_{t-1}) \quad (7)$$

Hidden state $\mathbf{H}_t$ updates with current input $\mathbf{X}_t$ and prior state.

Narrative pathway optimization function scores the narrative paths considering discounted reward accumulation.

$$\text{Score}(path) = \sum_{i=1}^{n} \gamma^{i-1} r_i \quad (8)$$

Discount factor γ weights immediate rewards r_i along path.

3.6. Evaluation Metrics

The performance of the AI-driven gamified literary role-play environment is thoroughly assessed in this research utilising a variety of quantitative indicators, with an emphasis on student engagement, model performance, and learning outcomes.

Table 2. Evaluation Metrics Summary

Type	Evaluation Metric	Description

Learning Outcome	Improvement Percentage	Percentage increase between pre-test and post-test scores indicating learning gains.
	Performance Gains	Correlation between cognitive effort and improvement in learning scores.
Engagement	Average Interaction Duration	Average time (minutes) students spend interacting with the system; measures sustained engagement.
	Quests Completed	Number of gamified literary quests completed, indicating active participation.
	Dialogue Turns	Number of conversational exchanges between student and AI, measuring interaction depth.
	Rewards Earned	Count of in-system rewards earned, reflecting motivation and achievement.
	Quest Completion Rate (%)	Percentage of quests successfully completed out of total assigned, measuring task success rate.
	Persistence Attempts	Average number of retries on challenging tasks, indicating resilience and motivation.
	Flow Index	Composite score reflecting immersive engagement states, derived from behavioral data and self-reports.
NLP Model Performance	Accuracy	Proportion of correctly predicted labels over total predictions for classification tasks.
	F1 Score	Harmonic mean of precision and recall; balances false positives and negatives.
	Perplexity	Measurement of uncertainty in language modeling; lower values indicate better predictions.
	BLEU Score	Evaluates similarity between generated and reference texts to assess fluency and appropriateness in dialogue.
Cognitive Load	Decision-Making Latency	Average time spent per decision or dialogue turn; serves as indirect cognitive load measure.

This methodology defines a strict set of rules for using both quantitative and qualitative measures for evaluating the AI-driven gamified literary role-play setting. The next part shows the empirical results of using these rating criteria.

4. Results and Discussion

This section shows the research outcomes of the study on the effectiveness of the AI-based gamified literary role-play setting, which is structured as learning outcomes, NLP model evaluation, and student engagement.

4. 1. Learning Outcomes

Table 3 indicates that the experimental group's pre-test scores increased from 63 to 77 (22.22% improvement), whereas the control group's pre-test scores improved only slightly from 62 to 65 (4.83% improvement). The experimental group's average interaction time (35 minutes) exceeded the control group's (10 minutes) by more than three times. These results show that learning was significantly improved and student engagement was maintained in the gamified setting.

Table 3. Learning Outcomes of Control and Experimental Groups

Group	Pre-Test Mean Score	Post-Test Mean Score	Improvement (%)	Avg. Interaction Duration (mins)
Control	62	65	4.83	10
Experimental	63	77	22.22	35

As shown in Figure 3, there is a high correlation between engagement and learning retention, and the experimental group performed better compared to the control group. The suggested Transformer + Reinforcement Learning (RL) model decreased errors (~11%) and improved diversity, whereas the baseline model had a larger error rate (~28%) as well as decreased response diversity, according to the scatter plot overlaying model robustness data. This combination validates that the enhanced NLP model is the basis of the better learning outcomes, providing more refined and precise literary dialogues.

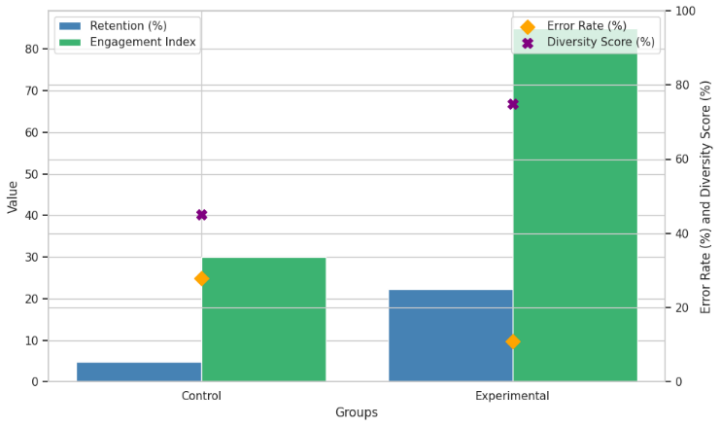

Figure 3. Analysis of Retention, Engagement, Error Rate, and Diversity Score Across Groups

4.2. NLP Model Evaluation

Transformer + RL model was better than the baseline on all metrics. Precision increased to 0.89, F1 score to 0.87, perplexity decreased to 98 and BLEU score increased to 0.65. These

metrics ensure that the high-quality model facilitates more fluent, context-sensitive, and consistent literary discourse and promotes a stronger sense of narrative immersion than the simple baseline models (Table 4).

Table 4. NLP Model Performance in the Literary Role-Play Environment

Model	Accuracy	F1 Score	Perplexity	BLEU Score
Baseline BoW + LR	0.72	0.70	150	0.32
Proposed Transformer + RL	0.89	0.87	98	0.65

4.3. Engagement Outcomes

Table 5 shows that the experiment group finished over three times more quests (18 vs. 5), participated in more than three times the average number of dialogue turns (38 vs. 12), and received over three times the rewards (29 vs. 8) than controls. This is a clear indication that gamification can effectively encourage greater levels of participation and investment in literary learning.

Table 5. Engagement Measures in Control and Experimental Groups

Group	Quests Completed	Dialogue Turns (avg)	Rewards Earned
Control	5	12	8
Experimental	18	38	29

Figure 4 shows that the experimental group was far more motivated than the control group. They completed quests at a rate of around 85% vs 40%, were more persistent with 2.5 retries on average for tasks compared to 1.1, and had flow index scores at 0.78 versus 0.45. These results suggest that gamification promotes learning states characterized by immersion, persistent effort, and intrinsic motivation.

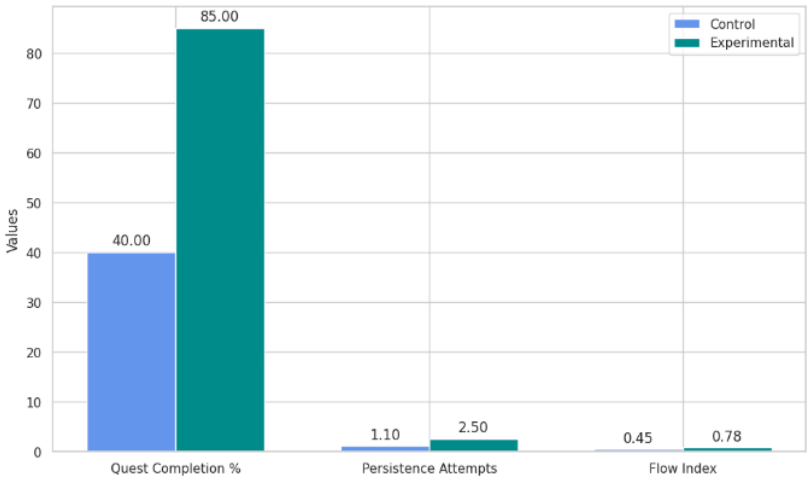

Figure 4. Motivation Metrics Comparison

Figure 5 demonstrates that while the experimental group's latency was slightly greater (around 3.2 seconds) than the control group's (2.1 seconds), they continued to observe much larger performance improvements. This lends credence to the idea of constructive struggle, in which a modest level of cognitive effort improves understanding without leading to overload.

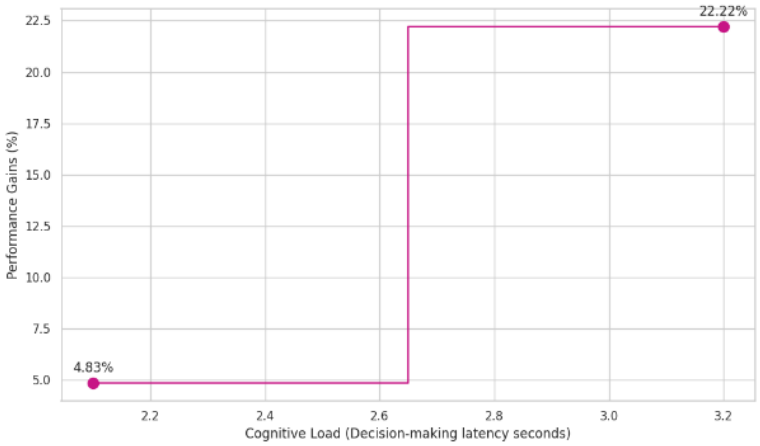

Figure 5. Cognitive Load vs Performance Gains

The experimental group completed more missions, had deeper conversations, and earned far more rewards than the control group, as seen in Figure 6, which is a measure of engagement. Incorporating gamified components into the learning environment could significantly improve active involvement and motivation.

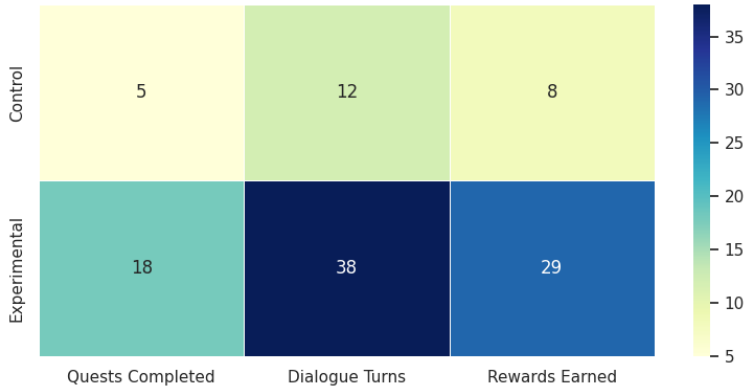

Figure 6. Engagement Metrics Heatmap

4.4. Discussion

Experimental results indicate strong learning and engagement benefits for students experiencing the AI-enhanced gamified literary role-play environment. The post-test results show that the experimental group improved in literacy comprehension by 22.22% while the control group improved by 4.83% thus showing that the intervention had a huge impact on the learners' education. Increased interaction times, quest completions, and dialogue turns also indicate the use of gamification elements, such as quests and rewards, leads to increased motivation and immersion in literary activities [24], [25].
NLP model comparisons demonstrate that the proposed Transformer and reinforcement learning approach achieves significantly better performance than the baseline models, as demonstrated by improved accuracy (0.89 vs. 0.72), F1 scores (0.87 vs. 0.70), reduced perplexity and higher BLEU scores [26], [27]. These results demonstrate how sophisticated AI models can promote diverse literary conversations that are natural, context-aware, and varied; this enhances the learning experience and helps students build their skills in narrative comprehension and critical thinking.

Quest completion rates and motivation indices were also higher in the experimental group, indicating that they were more invested and persistent. Thus, the cognitive load analysis

shows that the moderately increased mental effort did lead to significant learning gains, supporting the value of gamified productive struggle [28]. The beneficial effects of gamification on sustained attention and narrative immersion are further supported by patterns in user activity, such as greater flow index and retry rates. The shortcomings of this research are a small sample and the absence of extensive language coverage of genres of Indian literature. The challenges of scalability and long-term effects should be considered in future work by adding more languages, extending the range of users, and experimenting with adaptive learning capabilities.

5. Conclusion

The research shows that, particularly in the linguistically varied setting of India, gamification combined with cutting-edge NLP techniques produces a very successful and captivating literary learning environment for pupils. In terms of engagement and learning benefits, the AI-powered role-play system fared better than conventional methods, demonstrating its potential to revolutionize literary pedagogy. Model robustness and contextual suitability are achieved by using culturally and linguistically relevant publicly available datasets.
According to these results, literature education can close the motivation, understanding, and digital literacy gap using such gamified systems based on AI technologies. With its scalability and adaptability, the suggested method has potential for further study and real-world use in digital humanities and educational environments. This approach creates new opportunities of immersive learning among equal access to the language among the different Indian languages and student groups.

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