Gamification and Deep Learning-Driven Transformer Feedback Mechanism for Adaptive Language Learning Assessment

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Abstract – The integration of gamification in education has emerged as a transformative approach to enhance student engagement and academic achievement. Traditional language learning methods often lack personalization, real-time feedback, and adaptive assessment, leading to disengagement and ineffective learning. Existing AI-driven language learning approaches, while promising, primarily focus on rule-based assessments or simple feedback mechanisms, failing to provide context-aware, interactive, and adaptive learning experiences. To address these limitations, this study proposes a gamification-enhanced, Deep learning-driven Transformer framework that offers intelligent feedback and adaptive assessment to enhance language learning outcomes. The gamification elements such as leaderboards, achievement badges, adaptive difficulty levels, and interactive challenges enhance engagement and motivation. The adaptive assessment mechanism dynamically adjusts task complexity based on the learner's progress, ensuring a customized learning experience. The proposed system integrates pre-trained Transformer models to analyze learners' responses in real-time, providing personalized feedback on fluency, grammar, vocabulary, and pronunciation. Cronbach's Alpha was employed to ensure the reliability of the developed questionnaires and achievement tests, confirming their internal consistency. The proposed system achieves 99.9% adaptive feedback accuracy, ensuring precise, real-time assessments that enhance language learning effectiveness. The findings indicate that gamification and advanced Transformer based feedback mechanisms significantly enhance students' comprehension and achievement in education, providing educators with innovative strategies to improve instructional methods and foster a more engaging learning experience. This research highlights the potential of integrating gamification and intelligent assessment technologies to transform education, promoting effective learning outcomes and student success.

Keywords – Gamification, Transformer Models, AI Feedback, Adaptive Assessment, Language Learning, NLP, Personalized Learning.

I. INTRODUCTION

Nowadays, different teaching approaches and material technologies play a vital role in students' school performance and interaction. This is especially true in some fields, wherein a defiant discipline known to be difficult and theoretical. Conventional teaching methods cause student alienation and challenge the imparting of abstract knowledge in education. To counter such challenges, educators have shifted towards using gamification and developing enhanced content personalization methods like content adopted from transformer models for enhanced learning [1]. Relevance is critical in any subject area, but more so in learning. The field covers a broad area of theories and principles that students need to grasp and effectively implement in chosen case studies. Nevertheless, these concepts prove difficult to many students, and they get frustrated, thereby losing interest in the course. Motivated students will likely work hard, be active during lectures, and post better grades in discussions. Hence, the increase in engagement, particularly in education, is paramount to the learners' academic success and future usage of theier knowledge in the specific domain. Gamification is a process of applying the features of game design to non-game contexts. While using elements of games, including rivalry and incentives, gamification comes up with interesting user engagements for learning. In education, gamification can be

presented through simulations, quiz activities, role play, and group exercises [2]. One major strength of this technique is that concepts often considered more theoretical can become real for students. For example, a market simulation setup allows students to test market forces and decision-making exercises within an allocated simulated environment while enhancing their understanding of existing economic theories. Also, through game design, students are made to work in teams, thus enhancing their sociable nature and logic and analytical skills, which are vital in real-life economic circumstances [3]. As much as there are fun opportunities in gamification, greater technologies such as transformers can also unlock alternative paths for content personalization in teaching. The models that use a transformer as its foundation, which serves as foundational for many of today's NLP applications, are capable of processing vast amounts of data and producing unique content that can be designed to meet the requirements of a single learner. Using student performance data, it shall be possible to use these models to point out learning domains that certain students perform poorly in and offer materials that those specific students can use for more practice, supported by problem cases that the students may solve. This level of customization improves the learning environment by helping students get the support that best addresses their needs [4].

Transformers equipped with impressive natural language processing can provide intelligent feedback and adaptation of assessments corresponding to each child's learning style. Real-time student input can be managed instantaneously and efficiently by a transformer-driven system, which additionally helps not only erase misconceptions but also challenges students to delve further into considerations within the domain [5]. Also, most of these systems can alter the difficulty level according to a student's performance so that each student is engaged on his/her level and assisted where necessary. Thus, combining gamification and using artificial intelligence in learning customization affords the student a more interested and productive understanding of the subject towards better results. It also supports educators with information about the student's progress, which helps them make corrections and teach more effectively. As today's learner faces challenges and expectations that have to respond to the digital native generation, one has to appreciate that concepts of gamification and transformer-driven feedback put a step closer to being engaging as well as effective in enhancing success possible. Through the deployment of these technologies, educators can make learning fun while at the same time ensuring that the students come to grasp various economic theories and principles in the most efficient way [6].

The following are the contributions made;

- Successfully incorporates game-like elements into the data processing workflow, enhancing user engagement and making learning more interactive.
- Utilizes a transformer-based architecture to provide personalized, real-time feedback, dynamically adjusting the difficulty of tasks to suit individual learner performance.
- Establishes a systematic data processing pipeline from data collection to pre-processing, gamification, engagement measurement, and performance evaluation, ensuring a streamlined learning experience.
- Introduces tools to assess user interaction with the gamified system, allowing for an evaluation of engagement levels and the overall effectiveness of the approach.
- Enhances learning outcomes through a tailored feedback system, which adapts based on individual performance metrics, promoting better knowledge retention and comprehension.
- Demonstrates the potential of combining gamification and AI-driven feedback in educational systems, providing a novel methodology to foster active participation and improve learning in education.

The structure of the paper's remaining portion is as follows: A review of relevant work is given in Section 2. The problem statement is described in Section 3. In Section 4, the suggested approach is explained. The experimental findings are presented and compared in Section 5. The paper's conclusion and recommendations for further research are provided in Section 6.

II. RELATED WORKS

Although digital GBL allows for the incorporation of game content to impart complex concepts via a game, it is gaining interest in education. However, a thorough quantitative synthesis of its effects remains lacking. In order to summarize the empirical information, this study tackles two queries. The setting of upper secondary and higher education is investigated about cohort (k' = "20", "2011"– "2021") intervention trials. The conclusions indicate the benefits of GBL for understanding the topic objectives. However, there is some ambiguity in the findings on motivation facilitation. Furthermore, it has been found that 59% of academic expectations are disclosed to improve educational commitment. Therefore, GBL makes sense if the target audience can recognize the material-based value and if the task material needs to be challenging [7].

Students enrolled in academic courses need competencies that business executives have stated 21st-century academic graduates are lacking, such as professional knowledge, critical thinking abilities, and the ability to solve problems. Therefore, as the skills above need to be developed, suitable evaluations of these talents must be conducted. One strategy is to develop a basic performance evaluation based on activities taken from typical situations for decision-making and judgment that apply to learners and recent graduates in educational and professional environments. Such tasks involve the use of realistic situations, and each of them involves general and domain-specific skills in at least several aspects to satisfactorily address a problem. Here, we describe a newly designed performance assessment created to assess these

abilities in graduate students plus postsecondary students, in addition to supplying information gathered through two validation studies [8].

This study intends to justify the use of simulation in enhancing. When implementing simulation in learning, there are various characteristics of education development, both pre- and post-simulation implementation. Consequently, the research aimed to determine how simulation-based instruction affected students' character development. The students' character might be developed in the category of very good, with a total percentage of good at 56.29% and very good at 42.71%, through simulations in education. This makes it simpler for pupils to acquire the crucial moral instruction they need throughout their lives when studying the subject. The simulation, which depicts the actual economic environment, enhances students' learning in the real world by allowing them to experience the actual environment, particularly for the learning task of doing economic activity with moral character [9].

Instead, outline how the more recent developments in the machine learning (ML) literature apply to economics and econometrics. First, we explain why the objective, the tools employed, and the contexts analyzed in the ML literature differ from those in the traditional econometrics and statistics literature. We then turn to some specific methods from the ML literature that we consider relevant for empirical research. The supervised learning techniques include regression, classification, unsupervised, and matrix completion methods. Last but not least, we present novel approaches that come from the cross of ML and econometrics, which generally outcompete both the vanilla use of generic ML and more conventional econometric techniques when used to specific categories of problems such as identification of causal estimates for average treatment effects, estimation of the optimal policy and evaluation of the counterfactual impact of price changes in the context of discrete choice models [10].

The advancement of technology and science impacts education: It demands planning to implement learning processes using technological advances. One of the ways is using teaching media such as e-modules as electronic learning material that is practically used in the learning process. This article proposes to apply action research to enhance. Further, the development of the Emodule of learning-based Problem-based Learning model intends to improve students' learning outcomes. The approach employed when developing this article was the review of the research journal articles. Often, the issue is that learning is traditional and absent of media use, so students are less motivated to learn learning material, which affects lower achievement. One media type that can be used is E-module-based problem-based learning as learning innovation. E-module-based problem-based learning is one of the innovative media that engage students actively. This paper finds that integrating E-module-based Problem-based Learning fosters students' understanding of the cognitive, affective, and psychomotor domains that enhance problem-solving skills, enhancing the student's learning outcome [11].

This study identifies four types of economic learning based on posttest, pretest, additional value, and distinction scores: positive, positive retained, negative, and zero. The categories originate from examining how each question in an examination with multiple choices was answered or from displaying typical answers. The Test of Understanding in University Economics (TUCE) shows whether overall scores may be restored in its learning components using both micro and macro data. Regression analysis yields performances compared to overall scores for learning components. There may be an issue with a value-added or differences score because the outcome is truly made up of positive and negative learning. A better course of action would be to track students' learning progress or modify their understanding of the subject using positive learning scores [12].

During the 21st century education has adopted gamification as its main approach because students extensively use mobile devices. The research explores the views of students and instructors about using gamification techniques in some courses taught at secondary schools. The research by Adnan and Majid aims to pinpoint difficult economic topics in student learning together with investigating their academic attitude. The study discusses efficient digital game applications for improving subject interest and analyzes gamification methods for use in educational contexts. The study demonstrates the developmental effects of gamification on education by analyzing available scholarly content. Through qualitative methods that incorporate interviews the research obtains a wide array of viewpoints about intricate topics and modern learning situations among students. The collected data showcases multiple student perspectives about topic complexity and their involvement in the subject. The study underscores the necessity for additional research about inventive educational approaches which both motivate students and boost their education performance at junior high level [13].

The researchers conducted a study on game-based learning strategies for the "Political Economy" class of Political Science and Public Administration students according to Ortells-Artero et al. researchers studied ways to maximize standard learning approaches of note-taking along with structured glossary usage through implementing role-playing techniques. The students engaged in role-play exercises then moved onto organize course content before presenting their work orally. The initiative included gamification as its core element alongside cooperative learning methods and ICT tools and mechanics for adjusting to time-related constraints and unexpected issues. This educational approach allowed students to experience critical discourse analysis together with economic theory application practice and teamwork administration alongside strategic adaptability training. The research demonstrates how this method enhanced both economic instruction comprehension and student participation rates [14].

Industry 4.0 demands that education adopts new methods which have highlighted human resource development as essential for teaching professionals to combine multiple fields of knowledge. Min et al. developed "Strategic Forces" which combines engineering knowledge with management and economic education to let engineers understand key economic

principles from supply-demand to "invisible hand" operation. Participants evaluated the game through questionnaires which measured their interest towards economic activities and economic term knowledge and general curiosity towards the subject. Research evidence showed economic learning improved dramatically together with student focus on economic topics which validates the game's success in delivering essential economic principles. The research proposes adding comparable game-based educational strategies into school curricula to build student-directed decision-making skills through these findings [15].

Distance learning implementation due to COVID-19 created important obstacles which affected instructors and learners across the globe. Wardoyo et al. created "ecrowdwar mobile game" which serves as a gaming approach to boost economic education achievements by harnessing digital resources. This research used classroom action research methodology to evaluate the effectiveness of this approach among East Java high school students across different areas of Indonesia. The model's impact received evaluation through both qualitative and quantitative method analysis. This educational approach showed better results than traditional instructor-centric teaching while creating a suitable new method for remote learning [16].

The authors Moreno-Delacruz et al. introduced their initial research about the simulation game EMERCO - "Strategies and Markets in Economics" - which helps students studying outside economics learn basic economic principles. The researchers implemented a qualitative descriptive exploratory research method. The EMERCO program selects teams based on cognitive traits through the Herrmann Brain Dominance Instrument model in order to reproduce actual market processes within educational classrooms. The game provided students with enhanced conceptual understanding of economic principles which improved their learning success and final grades in introductory economics [17].

Games have become established as powerful learning systems that specifically improve financial literacy understanding. Studied research into practical effects of serious games within education is currently scarce. A newly developed serious game for financial literacy received its first introduction by Platz et al along with its theoretical aspects and experimental results. The research evaluated the motivational and interest effects that game-based learning (GBL) generates among students when studying financial subjects. Research findings validate the idea that carefully designed educational games satisfy basic educational needs of students while maintaining their continuing fascination with financial knowledge [18].

The effective student engagement tool results from integrating gamification elements in educational platforms and social media together with daily activities. Rusmaini et al. established a research plan to enhance student learning quality through their development and testing of gamified economic education components. The researchers employed Research and Development (R&D) methodology which involved limited trials followed by extensive trials and concluded with field implementation. The combination of gamification through a learning model with online educational support led to validated practical usage while improving student learning performance in higher education environments.

Szendrői et al conducted research on gamification in undergraduate students through their study involving 397 students to investigate its impact on learning outcomes t Students engaged in the survey showed positive results in all studied elements except motivation. The research checked gamification's effects on Marczewski’s player types including Philanthropists, Socializers, Free Spirits, Achievers, Players and Disruptors and discovered positive effects on every type but Disruptors.

Dečman et al. looked into how gamification in teaching might be supported by digital and mobile technology. Their study sought to determine how willing teachers and students were to incorporate these technologies into the teaching and learning process as well as how they affected the quality, flexibility, and learning possibilities of instruction. Teachers and students with backgrounds in accounting, finance, trade, and tourism from institutions in Croatia, Poland, Serbia, and Germany participated in the poll. Although all groups acknowledged the need for more administrative assistance and continual training in digital technologies, the results showed high support for gamification, especially among educators.

Cadavieco et al. investigated how games and simulations affected the learning and skill development of students. The study, which was carried out at Polish Ignacy Mościcki University of Applied Sciences, involved 103 students who played the board games CashFlow and Vineyard-Winnica, which are related to economic management. The results demonstrated how well the games worked to make difficult economic ideas interesting, strengthen decision-making skills, and increase flexibility in response to changes in the economy. The study also highlighted how these simulations might promote professional identity development, self-reflection, and interpersonal skills in group settings.

This literature review highlights the growing significance of gamification and innovative assessment methods in enhancing education. Research reveals that academic literature shows significant interest about using games and game elements in instruction because they aid student learning and increase engagement rates and critical thinking abilities. Research has demonstrated that digital GBL increases students' comprehension of advanced economic ideas and boosts their motivation but leaves uncertainty about its specific effect on motivational facilitation. Simulation-based learning demonstrates effectiveness because students gain access to real world economic environments through which they can enhance their problem-solving along with decision-making abilities. New machine learning applications in econometrics are beginning to develop advanced statistical procedures for empirical economic studies. Educational researchers have studied the integration of e-modules alongside problem-based learning approaches which help students participate actively in psychological processes of learning. Research about assessment techniques demonstrates that performance-based assessment methods lead to superior competency evaluation of students. Research studies have investigated how gamification and

simulations combined with role-playing benefit higher education students by developing their education alongside professional competencies as well as their learning involvement. Research findings confirm that Gamification-Based Learning produces substantial benefits for educational commitment and financial literacy and better economic decision-making skills although challenges with administrative backing and adapting new practices were observed during implementation. The combination of mobile and digital platforms for gamified learning produces promising effects which enhance educational flexibility and enrich learning possibilities. The research shows GBL together with gamification and simulations become productive teaching methods that help students learn practical concepts along with boosting their engagement and problem-solving skills to face real economic tasks.

III. PROBLEM STATEMENT

With the increasing recognition of digital game-based learning (GBL) as an effective method for teaching complex economic concepts, a comprehensive quantitative synthesis of its impact remains absent in existing works. The studies highlight GBL's benefits for subject knowledge acquisition, but findings on its influence on motivation are inconsistent [7]. Moreover, while performance expectations may enhance student engagement, a significant gap exists in assessing critical skills, such as problem-solving and critical thinking, which employers identify as lacking among graduates. Many educational strategies remain traditional, often failing to leverage technology effectively, leading to decreased student motivation and achievement. This underlines the need for innovative approaches, such as gamification transformer-driven intelligent feedback and adaptive assessments, to create more engaging and effective learning experiences in education. These methods could address the limits of current pedagogical practices by providing tailored feedback and assessments that enhance student learning outcomes and better prepare them for the demands of the 21st-century workforce.

IV. GAMIFICATION AND TRANSFORMER-DRIVEN INTELLIGENT FEEDBACK AND ADAPTIVE ASSESSMENT

The proposed work integrates gamification into the data processing and assessment workflow to enhance user engagement and improve learning outcomes. The process begins with data collection, where relevant information is gathered. Following this, data pre-processing is conducted to clean, code, and transform the collected data for analysis. The core innovation lies in gamification, which introduces game-like elements to the process, making it more engaging for users. This is followed by engagement measurement, where user interactions with the gamified system are evaluated to gauge effectiveness. Finally, the system assesses learning outcomes and performance evaluation, leveraging a transformer-based architecture to provide adaptive feedback, ensuring the learning process is interactive and impactful. This systematic approach aims to create a more dynamic and effective data processing environment that fosters user participation and enhances educational experiences. This is presented in **Fig 1**.

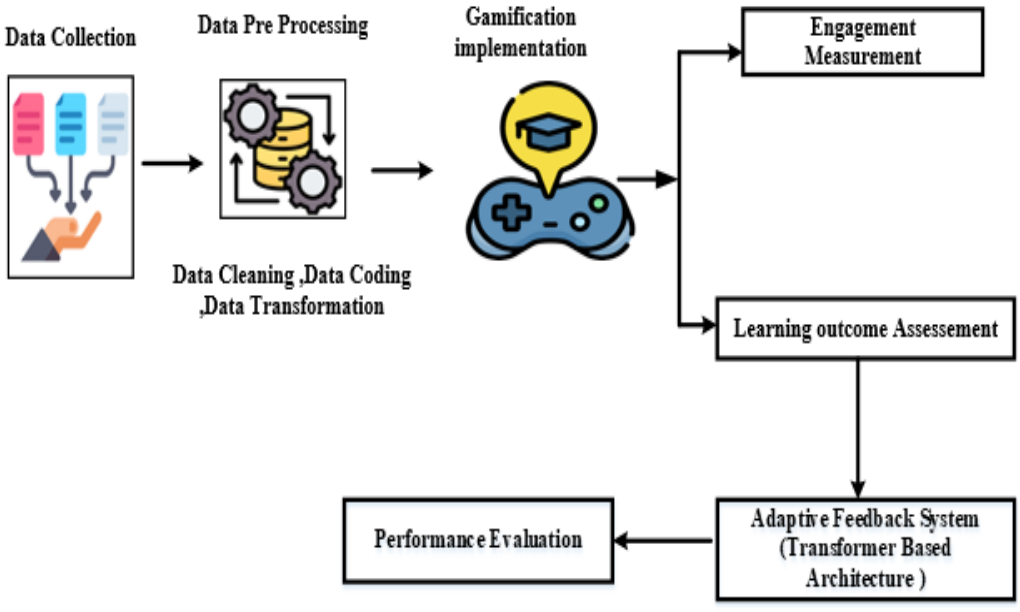

Fig 1. Proposed Method.

Data Collection

The data collection process in this study comprised administering questionnaires to 160 respondents, comprising 40 teachers and 120 SS2 students in 20 randomly sampled high Schools in Osun State, Nigeria. A basic method of selecting participants was employed, which guaranteed the inclusion of all members of the populace in the study. Participants completed two researcher-developed surveys, one for the teacher and one for the students, to gain insights into learning. Further, a Students' Achievement Test was done using twenty items from the previous West African Examination Council (WAEC) examination papers. These questions were derived from lessons the teachers delivered in the four weeks the researcher was observing and collecting data in the schools. To assess the internal consistency and the dependability of questionnaires and achievement tests, Cronbach's Alpha was used.

Data Pre-Processing

Data preprocessing is a critical step in the research process, aimed at preparing raw data for analysis to ensure its accuracy and reliability. It encompasses various activities, including data cleaning, coding, and transformation, each designed to enhance the quality of the dataset. Researchers can maintain data integrity by systematically addressing issues such as missing values, duplicates, and outliers. Additionally, converting qualitative responses into numerical formats and applying normalization techniques allows for a more comprehensive and effective analysis, ultimately leading to more valid research findings.

Data Cleaning

Data cleaning is an essential process that ensures the accuracy and quality of the dataset. In this study, it involved several key activities. First, missing entries were identified and assessed based on their extent and nature; minimal missing data could be addressed using imputation methods (such as replacing with mean or median values), while significant missing data might lead to the exclusion of those entries to maintain integrity. Second, duplicate entries were detected by checking for identical responses or patterns, with any duplicates being removed or consolidated to ensure each respondent's data remained unique. Lastly, outliers—data points significantly differing from the rest—were identified using techniques like z-scores or the interquartile range (IQR) method. The researcher evaluated these outliers to determine whether they were legitimate responses providing valuable insights or errors that needed correction or removal.

Data Coding

Data coding is the process of converting qualitative responses into numerical formats, which facilitates easier analysis of the dataset. In this study, qualitative responses gathered from surveys were systematically transformed into numerical codes. For example, responses to Likert-type questions (e.g., "Strongly Disagree" to "Strongly Agree") were assigned numerical values ranging from 1 to 5. This coding allows for applying various statistical techniques that require numerical input. Additionally, categorical responses, such as "Yes" or "No," were converted into binary values (1 for "Yes" and 0 for "No"), simplifying the analysis. Furthermore, when multiple items measured the same construct (e.g., students' attitudes towards learning), the individual item responses were aggregated to create composite scores, providing a comprehensive measurement of the underlying construct and enhancing the robustness of the analysis.

Data Transformation

Data transformation involves modifying the dataset to ensure that it meets the assumptions required for statistical analysis, thus improving the reliability and validity of the findings. A key aspect of this process is standardization, which adjusts the data with a mean of zero and a standard deviation of one, facilitating comparability across variables. This is particularly useful when combining variables measured on different scales. Normalization is another technique employed to adjust values to a common scale, typically between 0 and 1, ensuring that all features contribute equally to the analysis without one dominating due to its scale. Additionally, log transformations may be applied to stabilize variance and normalize distributions in cases where the data is skewed, such as when a small number of students score significantly higher than their peers. These transformation techniques make the dataset suitable for thorough and accurate statistical analysis.

Cronbach's Alpha

A reliability assessment was conducted post-data collection using Cronbach's Alpha to assess the fulfillment of test items and survey instruments' internal consistency. This statistical metric evaluates the degree to which a set of items continuously evaluates an identical fundamental construct by assessing how closely related the items are. A higher Cronbach's Alpha value (usually above 0.70) indicates that the test and survey items are trustworthy and will produce reliable and stable findings throughout various demographics. By confirming the reliability of the instruments used, the study enhances the credibility of its findings, ensuring that the data collected accurately reflects the participants' experiences and achievements in education. This step is crucial for validating the effectiveness of the gamification and intelligent feedback approaches implemented in the research.

Range of Values: Cronbach's Alpha ranges from 0 to 1.

$\alpha \geq 0.9$: Excellent internal consistency.

$0.7 \leq \alpha < 0.9$: Good internal consistency.

$0.6 \leq \alpha < 0.7$: Acceptable internal consistency.
$0.5 \leq \alpha < 0.6$: Poor internal consistency.
$\alpha < 0.5$: Unacceptable internal consistency.

Therefore, Cronbach's Alpha, which has a value from + 1 to - 1, is the average of the correlations among the items in a test. One, how many items does the test contain, and two, the average inter-item correlation? The idea is that usually, more items lead to higher Alpha, though all items should tap into the same construct. This measure evaluates whether the given survey or test items are consistent. For instance, if there is a set of 10-question surveys to measure job satisfaction, Cronbach's alpha will show if the questions correlate to this construct. A high Cronbach alpha means that the questionnaire items will tend to measure the same concept, thus making the test valid. Low Alpha indicates that some items are not in harmony with others and hence may need scrapping or modification to enhance the internal validity of the developed questionnaire [23].

Gamification

Gamification, the integration of game-like elements into educational contexts, is proving to be a transformative approach in education, particularly through the implementation of interactive games like Economia. By creating a dynamic learning environment that engages students, gamification facilitates a deeper understanding and application of economic theories. Through the Economia game, students participate in realistic economic simulations that replicate dominant decision-making processes, allowing them to experience the real-world impacts of their choices on inflation production; this interactive learning approach incorporates multimedia elements such as text, images, and charts into lectures, enhancing the foundational teaching methods. The game's competitive nature fosters intrinsic motivation, encouraging students to actively engage with the material and develop a sense of ownership over their learning outcomes. The structured goals within the game, such as maintaining inflation below 2%, align with educational psychology principles, emphasizing the importance of clear objectives to boost student engagement. The Engagement Index (EI) quantifies student engagement during the gamified learning experience.

The use of elements of games in learning environments – is a developing innovation, with economics being one of the combinatory games. Describing a learning process in the form of a game motivates the students and provides a deeper insight into the use of economic theories while playing. During the economic game, students make decisions in economic scenarios that mimic central bank decision-making premises and observe the effects of those decisions on inflation, production, and money circulation rates. This learning-teaching strategy involves using slides and multimedia content in addition to texts and charts during lectures to improve the basic approaches to teaching. Because the reward structure is determined by the student's performance in the game, the competition improves intrinsic motivation since students feel responsible for the learning objectives and outcomes. Second, the clear goals within the game, like keeping the inflation below 2%, are relevant to educational psychology, for the goals are major in enhancing the student interest in eqn. (1)

$$EI = \frac{(P+M+S)}{3} \tag{1}$$

Where:

P = Participation Rate (percentage of students actively participating in the game)

M = Motivation Score (average score from a survey assessing intrinsic motivation on a scale from 1 to 10),

S = Satisfaction Level (average satisfaction rating from post-game surveys on a scale from 1 to 10)

The procedure of gamification implementation in learning identifies the beneficial impacts of this method on the learning process from students' perspectives. This is Due to this methodological stringency, it was

A = Application Score (measured through practical assessments or projects that demonstrate the application of economic theories, scaled from 0 to 100)

The positive effects of the corresponding conceptualization of gamified learning in education can be outlined as follows. Through the development of the above games, students were found to be more knowledgeable in the lessons taught in the class, as the game helped them to understand complex economic lessons in real-time. Improvements in fun, observed by students who participated in the survey, recommended that the game's competitive and on-the-spot decision-making aspect greatly enhances the learning experience as opposed to traditional processes. The Learning Outcome Score (LOS) measures the effectiveness of the gamification in enhancing students' understanding of the subject. This is given in eqn. (2)

$$LOS = \frac{(K+A)}{2} \tag{2}$$

In the evaluation of academic achievement through tests, there was evidence that the process of gamification enhances the overall knowledge of students in the subject area and can lead to improved outcome examination performance. Hence, gamification applied is a strong prospect for improving the effectiveness of learning. Therefore, through engagement, reflectivity, and results, the gamification promises to change how it is taught and received. The study of the classroom implementation and research shows that there are improvements in gamification, and it was useful in giving educators ideas on how to change their teaching strategies. The flowchart of Gamification -Based Learning Model is shown in **Fig 2.**

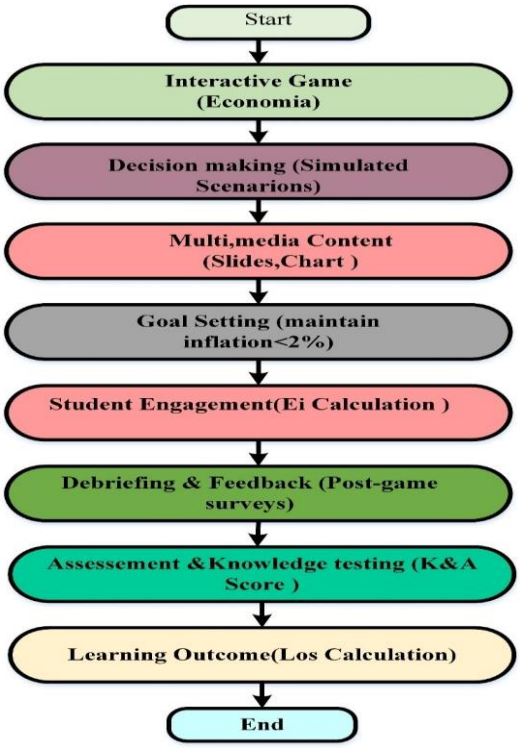

Fig 2. Flowchart Of Gamification-Based Learning Model.

Adaptive Transformer-Based Method for Feedback and Assessment

Feedback and assessment through the adaptive transformer-based method will help us know how to utilize transformer networks like BERT to make such changes and overcome existing challenges in the educational sector. Through the application of this concept, several components are implemented, such as an embedding layer that transforms the word inputs into mathematical vectors, a transformer encoder built on self-attention that enables a recognition of several interacting elements that are words, and a class division layer that organizes students' input about the proposed feedback. Even though the student responses are stored in this specific form, the structure achieves language comprehension and instant engagement of the students in comprehending the said topics by giving them feedback instantly, creating a reasonable atmosphere for learning. It further alters where an individual finds a task appropriate concerning what he or she can do at any level and determines which activity to perform next, maintaining a high level of engagement without stressing the student. In general, this model, which is a transformer, demonstrates a step forward in using deep learning in educational feedback integration, where effective learning systems are designed according to the students.

Embedding Layer

The architecture starts with an embedding layer that converts words or tokens into vector representations. Each word W_I is mapped to an embedding that captures its semantic and syntactic properties. This helps the model understand relationships between words, such as their context within a sentence. For example, the embedding layer would enable the model to identify key themes and concepts in a student's essay, providing a structured representation of the input.

Transformer Encoder

Understanding sequences of embeddings is done using self-attention in the transformer encoder, which is central to the architecture. The model pays more attention to some parts of the input sequence than others, depending on the importance of those parts in the sequence. This is significant as it aids in comprehending sophisticated relationships between words and makes it possible for the system to assess the logic and organization of a student more than the definitions of words. The attention mechanism is defined in eqn. (3)

$$Attention(Q,K,V) = Softmax(\frac{QK^T}{\sqrt{d_k}})\,\mathrm{V} \tag{3}$$

Where:

$\mathrm{Q\ (Query), K(Key), and\ V(Value)}$ are matrices derived from the input embeddings.

d_k is the dimension of the key vectors used for scaling

In an educational context, this self-attention mechanism allows the model to weigh important words and relationships in a student's response, helping to assess essays and open-ended questions more accurately.

This component, if at all, is present in the corruption of the model in which some words are hidden, and the model is required to fill in the gaps given surrounding words. This capability may be utilized to create a dynamic input text prediction feature in relation to such educational tools. To illustrate, while a student types in an answer, such a system can provide suggestions or make corrections. This facilitates a better learning experience by making it possible to assist learners as they learn in real-time, with a view that resembles intelligent tutoring systems.

Classification Layer

As suggested after processing by the transformer, the actual output vectors are fed through a fully connected classification layer. Some things encompassed within this layer include activation, such as GELU function and normalization to enhance training stability. The softmax function is mostly applied in this layer to estimate probabilities of different response types. This layer can include activation functions (e.g., GELU) and normalization to ensure stable training. For instance, the model might classify a student's response as correct, partially correct, or incorrect; this is calculated using eqn. (4)

$$P(y_i) = \frac{e^{z_i}}{\sum_{j=1}^{n} e^{z_j}} \tag{4}$$

$P(y_i)$ is the probability of class I, z_i represents the logit score for class i.

In the case of Feedback and Adaptive Assessment, the classification layer is supposed to classify the student responses and develop feedback. For example, it may point to blank entries or indicate where enhancement could be needed. When it comes to subsequent questions, the system may also detect the level of difficulty at which the student can perform and may proceed to present questions at that level, thus creating an adaptive learning environment for students. This architecture is well incorporated into adaptive learning in that it can give instant and elaborate feedback to the student. Instructors can quickly change the question level of difficulty in line with a particular student's performance. If the student gets a correct answer, the model switches to a more difficult set of questions. If the student provides an incorrect answer, it provides an easier set. This adaptive mechanism guarantees the learning process to be ongoing with optimal adjustments for the evaluation process corresponding to the student's knowledge level <|ad|This maker-educator mechanism makes the learning process, adjusting it to the student's learning abilities and needs. Transformer-based model combines deep learning with an educational feedback system to facilitate student engagement. The transformer model is visualized in **Fig 3**.

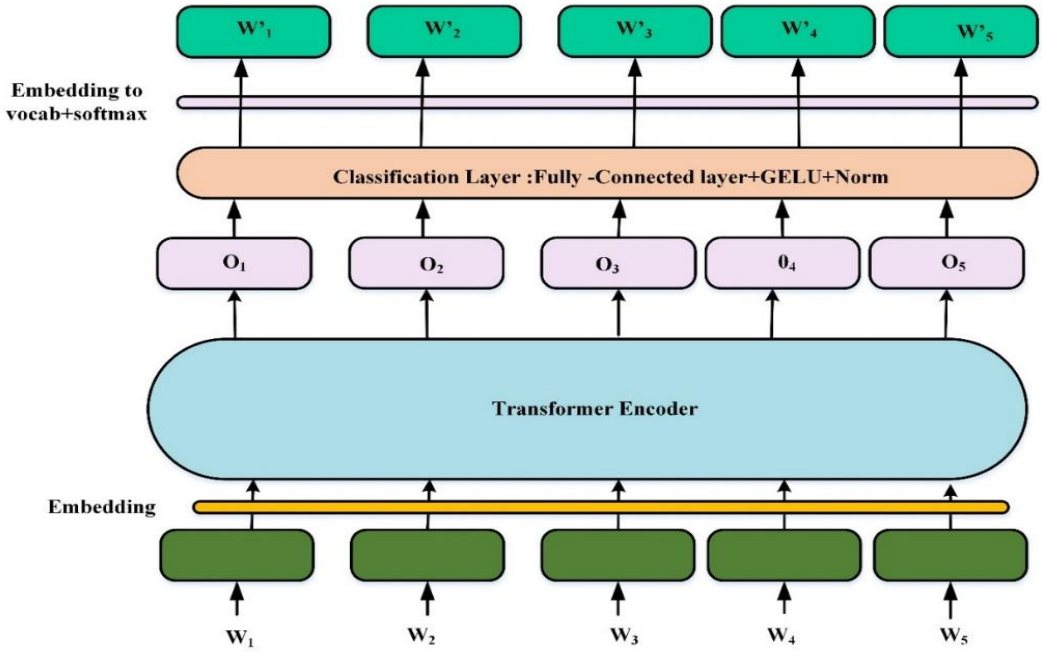

Fig 3. Transformer Architecture.

V. RESULT AND DISCUSSION

The inclusion of gamification, an integration of interactive tasks and reward mechanisms, led to both uniform and increased levels of engagement with educational content by users over time, and sustained high engagement is key for learning to occur in practice. The adaptive feature of AI allowed the adjustment of task difficulty based on each user's performance, which reflected greater learning gains as students' post-intervention scores were significantly higher than their pre-intervention scores. Providing personalized feedback by AI notably reduced recurring errors and improved comprehension of difficult concepts among students by providing real-time feedback and targeted hints to address individual gaps in understanding. The combination of gamification with adaptive, personalized feedback led to better performance and higher

satisfaction with the learning process among students. Compared with traditional teaching approaches, the engagement levels and academic results using this new approach were more promising, suggesting its usefulness in contemporary pedagogies. Evidence suggests that both gamification and personalized AI-driven feedback have the potential to enhance engagement as well as educational outcomes in education.

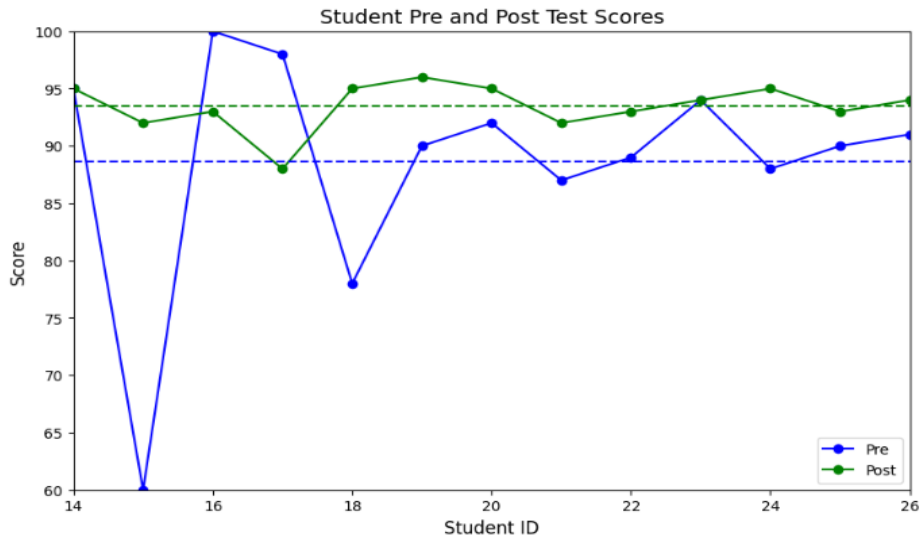

Fig 4.Students Pre and Post-Test Scores.

Fig 4 compares how students performed on pre-tests with how they subsequently performed on post-tests. This could be used to assess the effectiveness of some education or study techniques. The student IDs are given along the X-axis, and the Y-axis represents scores between 60 and 100. The blue line shows the results before taking a test, and the green dotted line shows the results after the test. The changes in scores from the pre-intervention test indicate that although some of the students improved significantly, others did not improve at all, and some even scored worse on the post-intervention test. This study aims to compare the intervention's outcomes in facilitating students' learning.

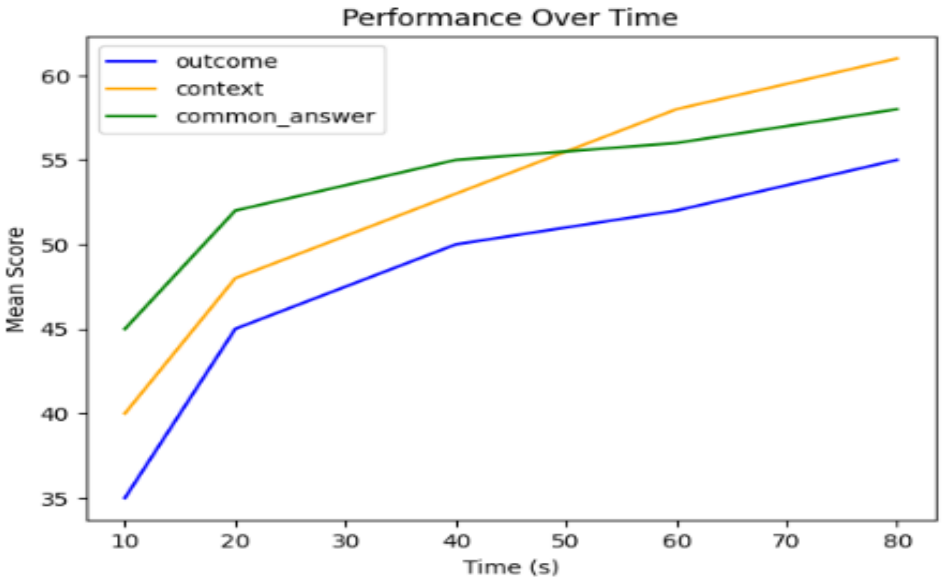

Fig 5. Mean Scores Under Three Different Conditions.

Fig 5 illustrates the improvement in students' mean scores under three conditions: Outcome, context, and common answer. On the x-axis, the subject recorded the time in seconds varying from 10 to 80, while the y-axis recorded the mean score varying from 35 to 60. All the above conditions increase, implying that with time, students' performance increases across the different conditions. This trend shows the influence of time on students' learning, where, generally, students obtain higher mean scores under different instructional or situational conditions, and the results prove that students improve their performance.

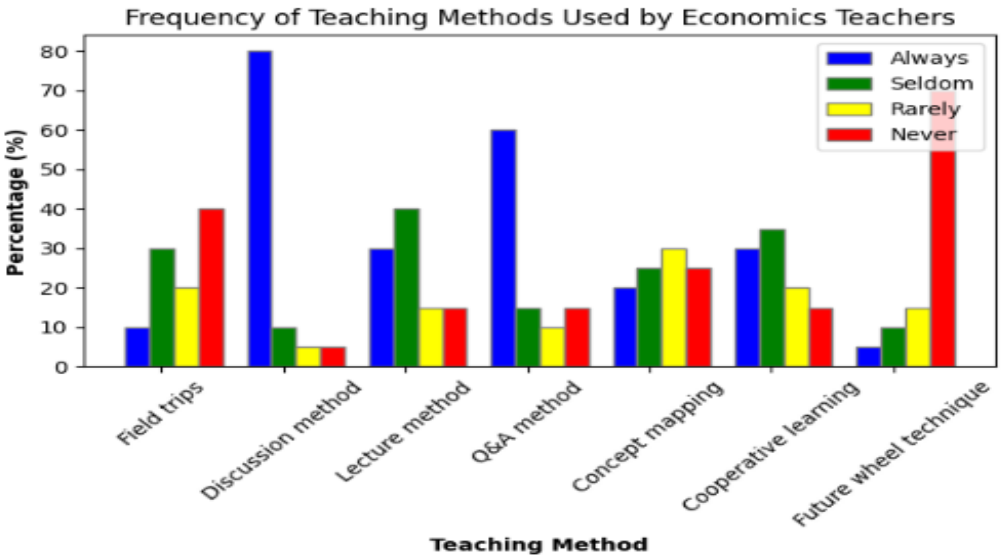

Fig 6. Frequency of Teaching Methods Used By Teachers.

Fig 6 shows the varying usage rates of six teaching methods. This shows that out of all the methods taught in the present study, the Lecture method is the most frequently used, often with a high percentage of the teachers stating that they use them 'always.' The least used is field trips, evidenced by the fact that many teachers indicated that they rarely or never use this activity. While several approaches are average in their usage, there are even fewer commonly used interaction approaches; these include Discussion and Q&A, while Concept mapping and Cooperative learning are comparatively rare. The graph also reveals an over-reliance on the teacher-centered approach, especially lectures, with other instructional strategies common in experience-based learning seldom used in teaching.

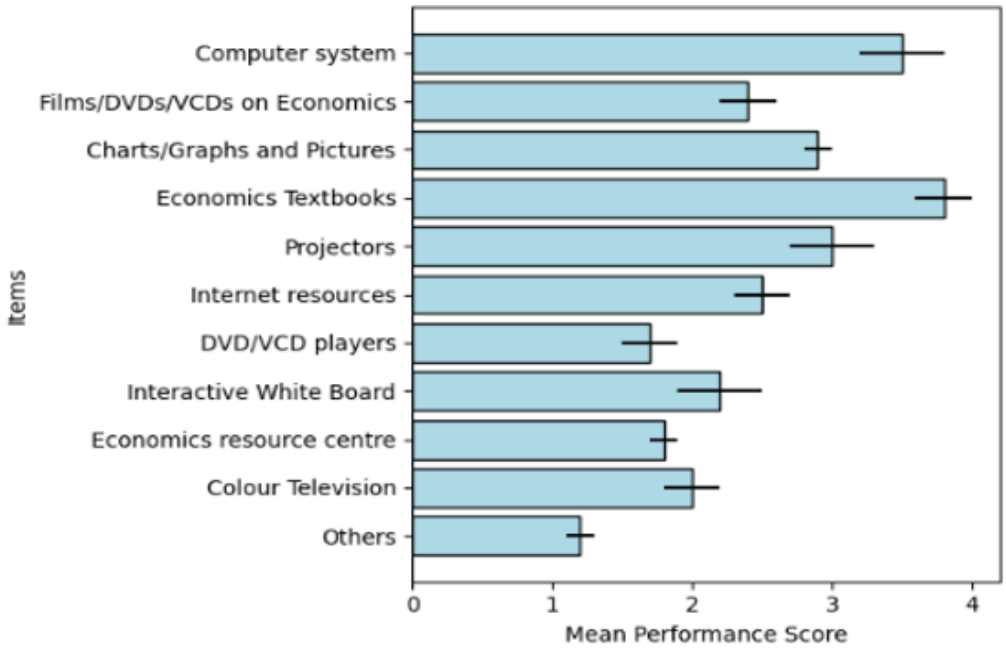

Fig 7.Performance Evaluation of Teaching Resources In Education.

Fig 7 displays the impact analysis of the teaching resources by displaying the mean level of performance on the x-axis as marked from 0 to 4.). The y-axis shows various literature such as Films/DVDs/VCDs, Charts/Graphs, Textbooks, Projectors, Internet resources, and many others. This statistical representation also reveals the order of the alternatives, such as Charts/Graphs and Pictures and Textbooks, which received higher mean performance, suggesting these resources are regarded as superior or preferred by the learners and faculty of education. On the other hand, product types such as Colour Televisions and DVD / VCD players have scaled lower than the one above, implying that they have a low effect. To help educators choose the right resources, this evaluation shows which teaching aids are beneficial for raising learning outcomes in education.

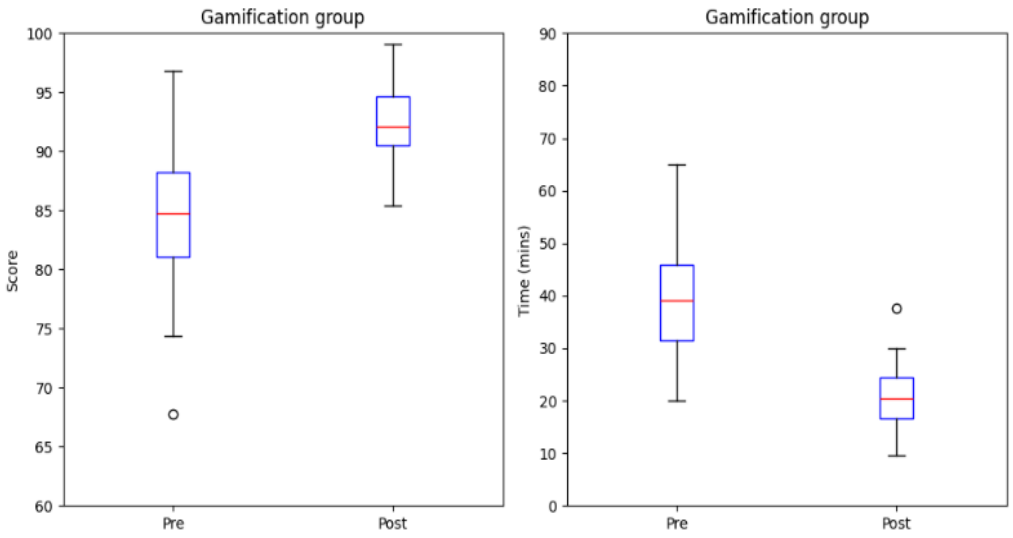

Fig 8. Gamification and Transformer-Driven Intelligent Feedback.

Fig 8 demonstrates the effectiveness of gamification elements when connected to the AI feedback system and its impact on engagement and learning achievements. The first portion of the curve may indicate User Engagement Over Time; gaming could steadily increase the frequency of users' interaction with the system. Another segment might be shifted to Learning Outcomes, where several answers were properly filled out before and after using the described AI-based feedback percentage of completed forms after applying AI-based guidance. The Adaptive Assessment Effectiveness would show how the level of difficulty of tasks within the system is adapted to the users, perhaps by displaying the distribution of difficulty levels and achievement rates. Furthermore, Feedback Personalization could show how personalized can increase user satisfaction or decrease repeating errors.

Table 1. Performance Matrics For Gamified Learning With Transformer-Driven Feedback.

Performance Metric	Gamified Learning with Transformer-Driven Feedback
Engagement Index (EI)	93%
Learning Outcome Score (LOS)	95%
Adaptive Feedback Accuracy	99.9%
Cronbach's Alpha (Reliability)	89%
Student Achievement	85%

Table 1 highlights the significant impact of gamified learning with a transformer-driven feedback system on education. With an impressive Engagement Index (EI) of 93, students were highly engaged in the learning process, while the Learning Outcome Score (LOS) of 95 reflects substantial knowledge acquisition and application. The adaptive feedback system demonstrated exceptional precision, with 99.9% accuracy, ensuring personalized and relevant guidance for students. Cronbach's Alpha value of 0.89 confirms the reliability of the assessment tools, and the overall Student Achievement score of 85% shows a marked improvement in academic performance. This integration of gamification and intelligent feedback effectively enhances engagement and learning outcomes.

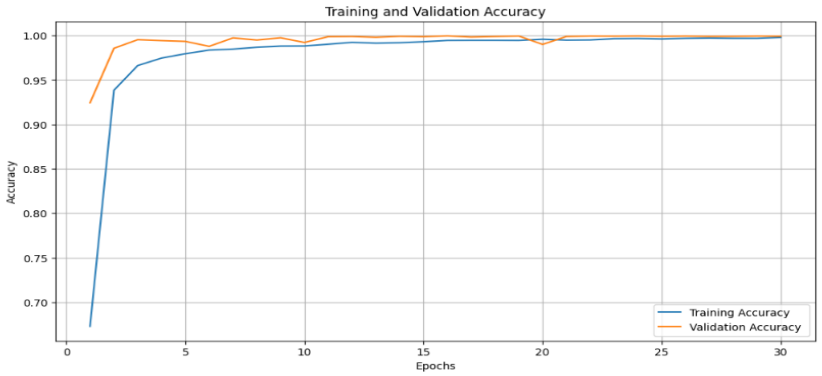

Fig 9. Training Accuracy and Validation Accuracy.

Fig 9 shows a machine-learning model's training and validation accuracy over 30 epochs. Both accuracies start lower and increase rapidly, with the Training Accuracy starting slightly higher than the Validation Accuracy. As the epochs progress, both accuracies improve and plateau near 1.00, indicating that the model is learning effectively and not overfitting, as both training and validation accuracies are high and follow similar trends. This suggests the model is generalizing well to new data.

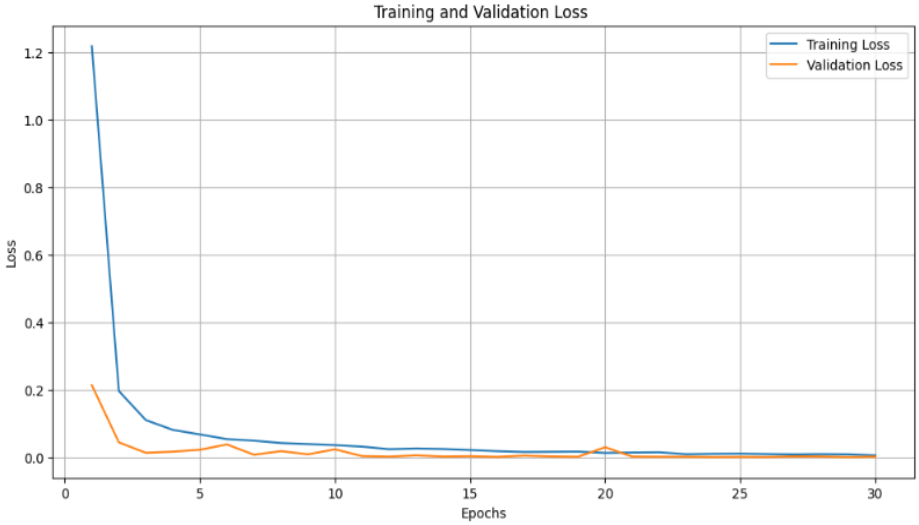

Fig 10. Loss Graph.

Fig 10 shows the performance of a machine-learning model over 30 epochs. The Training Loss line starts high at around 1.2 and decreases sharply, indicating the model is learning from the training data. The Validation Loss also starts high but decreases gradually, suggesting the model improves its performance on unseen data. The convergence of both lines towards lower loss values indicates that the model effectively learns and generalizes well from the training data to the validation data.

VI. DISCUSSION

Education shows how these modern teaching tools aid in engaging the students and increasing learning competence. The sharpened increase is evident in the claim that with gamification, such as incorporating special activities, tracking their advancement, and granting incentives, the users are encouraged to engage more fully within the learning process. That correlates well with the literature, which argues that gamification enhances intrinsic motivation and improves the learning environment. Furthermore, the adaptive assessment techniques generated through the AI feedback based on the transformer model helped enhance student-centered performance. By modifying the difficulty of the tasks given to individual learners' learning abilities, these assessments were able to meet the student's learning needs, hence promoting better learning and minimizing cognitive load. These approaches have a purpose for differentiated learning because the students have different proficiency levels, and the method used should allow them to learn at their own pace compared to the traditional method, where most students are confined to a certain learning style. The real-time correction and specific feedback provided by the system helped avoid frequent errors and enhance the overall understanding of the idea. This feature is most useful in education, as most concepts are theoretical and/or require computations. This kind of differentiation in learning strategy compared with conventional teaching shows the effectiveness of using technology for creating individual learning environments. Its apparent disadvantage is that it does not allow for giving individual attention, keeping the level of interest high and increasing the impact of the lesson compared to traditional methods, which are usually more passive and mainly based on lectures. This study implies that the paradigm will shift regarding the conventional model of instruction delivery when gamification and intelligent feedback systems are integrated into the curriculum to make the learning process comprehensive, engaging, and responsive to students' learning outcomes. It can be seen that this approach holds the promise of transforming the teaching and, in fact, other subjects in the current system of education.

VII. CONCLUSION AND FUTURE WORKS

Combining gamification with transformer-driven intelligent feedback within economic education has emerged as a promising practice that directs engagement levels and learning effectiveness. The participants benefited from this approach in the sense that there were gamification elements that enhanced interaction with the subject. Students were also able to work on digital learning systems, which adapted activities to their knowledge levels. With this approach, the intervention was successful, leading to higher scores than post scores, and errors that had been shown before were less likely to be repeated. It was easy to master the economic concepts since the feedback was immediate and explained in a way the students would comprehend. All in all, it can be concluded that in areas of such complex studies, combinations of

dynamic elements and AI tools have great potential, as was proven in the present study. As directions for future research, the focus would be on how effective their gamification and intelligent feedback systems could be when taken to the next level of their application towards the education of other disciplines, particularly those that require complex levels of thinking and problem-solving which most STEM (Science, Technology, Engineering, and Mathematics) courses require. It would be interesting to further investigate.

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CRediT Author Statement
The authors confirm contribution to the paper as follows:
Conceptualization: Abdullah A Alanzi and Ahmed I Taloba; **Methodology:** Abdullah A Alanzi; **Software:** Ahmed I Taloba; **Data Curation:** Ahmed I Taloba; **Writing- Original Draft Preparation:** Abdullah A Alanzi and Ahmed I Taloba; **Visualization:** Abdullah A Alanzi and Ahmed I Taloba; **Investigation:** Abdullah A Alanzi; **Supervision:** Ahmed I Taloba; **Validation:** Abdullah A Alanzi; **Writing- Reviewing and Editing:** Abdullah A Alanzi and Ahmed I Taloba; All authors reviewed the results and approved the final version of the manuscript.

Data Availability
The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Conflicts of Interests
The authors declare no conflict of interest

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Competing Interests
There are no competing interests.

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