

Implementing a Gamified Learning System for Enhancing Student Engagement and Motivation Using Reward-Based Mechanisms and Machine Learning

Anand Sharma, Kunal Borage, Sujal Trivedi, Nikhil Neware, Professor Radhika Adki

Department of Artificial Intelligence and Data Science,
Progressive Education Society's Modern College of Engineering, Pune

Abstract- Student engagement would be one of the core elements that improve educational outcomes in the classroom. A gamification framework with machine learning would increase participation and personalize the experience of learning. The framework, through mechanics such as points, badges, leader boards, and challenges, encourages the participants to engage in the learning experience and enjoy it. However, machine learning facilitates adaptive learning by adapting the content based on the individual's performance metrics. Student sentiment analysis helps to identify which students are in need of support, and predictive analytics would be used for identifying the students that may require more support. Real-time analytics allows teachers to keep track of student progression as well as classroom trends in real time. The system was designed to improve engagement and increase efficiency in the learning process. It considers the fact that competition can get unhealthy at times as well.

Index Terms- Gamification, Education, Classroom Learning, Machine Learning, Engagement.

I. INTRODUCTION

Many students find traditional classroom education to be uninteresting and ineffective, which diminishes their enthusiasm and commitment. Educational institutions still struggle to keep students interested in the learning process, despite teachers' best efforts to use innovative teaching techniques. One of the most important challenges confronting educators is keeping students in class on a regular basis, as poor attendance is often linked to poor academic performance and a higher risk of dropping out.

Gamification has emerged as a fascinating area of research in recent years, offering fresh approaches to raising student engagement in the classroom. However, there are a lot of gamification-related subjects that still require investigation, particularly when it comes to the educational setting. It is possible to alter how students engage with the traditional learning framework by including game-based elements.

In order to make learning more dynamic and interesting, gamification entails incorporating game features like points, badges, leaderboards, challenges, and prizes into the classroom. Recent research has demonstrated that by addressing problems like stress, anxiety, and burnout, these strategies can enhance students' motivation, performance, and mental health. Gamification generates an engagement loop

that keeps students engaged and focused on their progress, going beyond a simple set of game elements.

The emergence of online education platforms such as Massive Open Online Courses (MOOCs) has led to the discovery of gamification as a useful method for improving student learning. It fosters the development of critical abilities like cooperation, communication, and problem-solving. Research indicates that gamification might enhance students' learning outcomes by providing incentives and an organized approach to learning abilities.

In order to make teaching more efficient and interesting, we suggest a system in this study that blends gamification with machine learning. We have added the following to this system:

- Measuring attendance and consistency in lectures by using a gamified framework to track student participation.
- Tracking and assessing each week's and month's overall performance of the students.
- Examining how much each student participates in the many gamified components of the system.
- Implementing a decision-making mechanism that is reward-based and uses machine learning to increase student engagement in the classroom.

This system attempts to change the traditional model of schooling by combining machine literacy and gamification

approaches to create more dynamic and engaging literacy terrain. This strategy may boost pupil participation and achievement, raise engagement, and provide educational institutions with a basis for learning issues to perfect.

II. METHODOLOGY

Gamification in education refers to incorporating game design elements into learning environments to increase student engagement, motivation, and participation. By introducing elements such as points, badges, leaderboards, and interactive challenges, students are encouraged to participate in their learning journey actively. A gamified learning system aims to create an immersive and dynamic educational experience that not only makes learning enjoyable but also fosters better retention of concepts. In this study, we designed a gamified learning system specifically for computer science students, where traditional lectures are augmented with game-based activities, virtual rewards, and machine learning algorithms to predict and enhance student performance. This system integrates educational tools like quizzes and memory games with a reward system, making the learning process competitive, interactive, and data-driven.

Applying Machine Learning technologies to interact more efficiently with users will help students develop their skills through multiple technologies. Use of the machine learning model Random-Forest will impact the user's progress. It will show the progress of the students in the leaderboard though Predictive analysis of the student day-to-day events or contributions students have implemented.

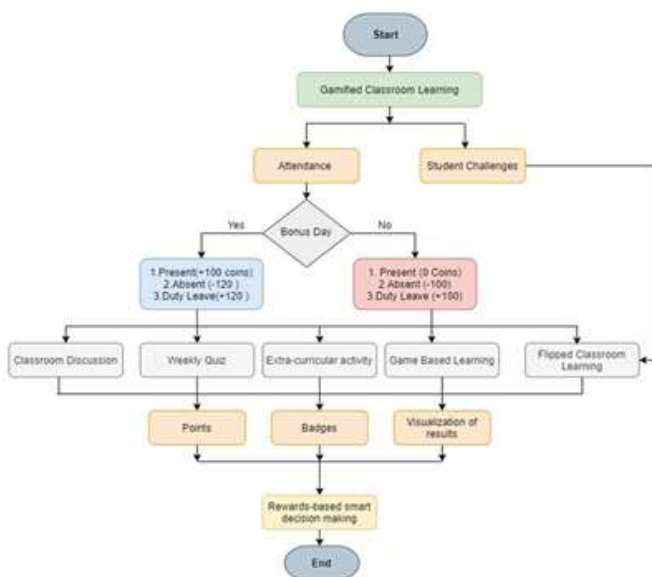


Fig. 1: Working Structure of the Gamification System Elements used in the Gamification Learning System is

Virtual Coin- Based Attendance: In the already established education system, it can be asserted that attendance is one of the most crucial policy variables showing how students would interact with their academics. Increase in the percentages of attendance will positively impact the literacy levels that are seen in the classroom environment.

Extra Lecture Attendance: Scholars will be provided with reward coins in return for their attendance in certain extra lectures, which will be added to their accounts.

- In the case of the supplementary lectures, when a student attends the class, he earns 100 coins that is, (+100)
- If the student is absent, then he loses 120 coins, i.e., (-120).

Coin-Based Classroom Discussion: Various uncertain events can be dealt with; there may be an immediate change too. This kind of terrain leads to interactive tutoring and engages scholars to suppose and explore the generalities that enhance speaking chops.

Weekly Online Quizzes: The daily online quiz can help the faculty to check the pupil's position of understanding of the conception tutored during the sessions. The quiz will be point-grounded and multiple options given to scholars.

- The top 5 scholars who would obtain the maximum right answers within the shortest period will be awarded double coins.
- The remaining scholars will be awarded coins based on the correctly answered questions.

Flipped Classroom Discussion: In classroom literacy, more emphasis is given to the completion of the class. The educator's emphasis lies in elucidating the concept without the involvement of students; thus, the entirety of the flipped classroom session will be based on active student engagement, participation, and meaningful discussions that can assist learners in constructing knowledge beyond conventional textbooks. The star performer badges will be awarded to the brightest scholars.

Participation in Extra Curricular Activities: This module is a great place for the students to gain a considerable amount of virtual currency, however, depending on the events or tasks hosted by the scholars.

- Whenever a student joins an international conference or event, 500 coins will be awarded.
- Engagement in national events will be costly at 300 coins.
- Involvement in inter-university events will attract 200 coins.
- Furthermore, engagement in or leading council or class events will attract 100 coins.
- The student's engagement in co-curricular activities is significantly crucial; however, the student has been

observed to be hesitant to express talents for fear of absences or demands on academic work.

Game-Based Learning Activities: It would be quite beneficial to include game-based literacy training. Such methods will be very helpful for playing the gamified approach to enhance the educational scenario. Provocation is considered as an inspiring method that suggests involving people so that they can participate in the gameplay activeness. Video games are observed to be an engaging form of learning, more so than other media types, according to research. Keyboard jumping and memory mystification can thus be used with regular curriculum programs and practices to increase the level of student's engagement.

III. LITERATURE SURVEY

The use of gamification in education has been studied extensively over the last few years, with various researchers highlighting its potential to enhance student motivation, engagement, and learning outcomes. The integration of game elements such as points, badges, leaderboards, and adaptive learning techniques into educational systems has been found to create dynamic and engaging learning environments. The following review synthesizes findings from key studies on gamification in education, focusing on the impact of game elements and how they influence learner engagement and academic performance.

Gamification and Learning Outcomes

Minzi Li, Siyu Ma, and Yuyang Shi conducted a comprehensive analysis of AI-driven gamification in education, with a particular focus on classroom engagement and learning outcomes [1]. Their findings show that gamification significantly improves learning outcomes, with a large effect size of 0.822, suggesting a substantial positive impact. However, they emphasize that the effectiveness of gamification is influenced by various factors, including the type of users (students), the educational discipline, the design principles employed, the duration of the gamified experience, and the learning environment. These insights highlight the importance of a carefully designed gamification strategy that considers the context and characteristics of the learners.

Gabriela Kiryakov, Nadezhda Angelova, and Lina Yordanova explored the role of gamification in enhancing student engagement and motivation by incorporating game elements such as points, badges, and leaderboards [8]. According to their research, effective gamification requires a deep understanding of learner characteristics and well-defined learning objectives. By aligning game mechanics with educational goals, instructors can create a more immersive learning environment where students are motivated to participate and achieve learning milestones [8]. They argue that gamification, when used correctly, leads to higher levels

of intrinsic motivation, making the learning process more enjoyable and productive.

Impact on Essential Skills and Active Learning

The research focused on how gamification affects active learning in higher education. Their research, published in the International Journal of Quality and Service Sciences, underscores the role of gamification in enhancing essential skills such as teamwork, self-directed learning, and problem-solving. [9] The study highlights that integrating game-based techniques into higher education does not compromise academic achievement but instead creates a more engaging and satisfactory learning experience. Gamification fosters an environment where students are motivated to collaborate, take ownership of their learning, and develop skills that are critical for long-term success[6]. The authors also emphasize that gamification helps maintain student motivation over time, suggesting that it contributes to sustained engagement in academic activities.

Motivation, Engagement, and Comparative Learning Environments

César Morillas Barrio, Mario Muñoz Organero, and Joaquín Sánchez Soriano [8] explored the potential of gamification to improve the benefits of student response systems (SRS) in an educational setting. Their experimental study shows that the use of gamification techniques, particularly those that promote competition and comparison leads to increased learner motivation and engagement. By establishing a comparative learning environment—where students are encouraged to compete with each other— gamification boosts academic performance and fosters a more active learning atmosphere.[5] The study also highlights how gamification can create a more stimulating and dynamic environment for students, encouraging them to take active role in their learning.

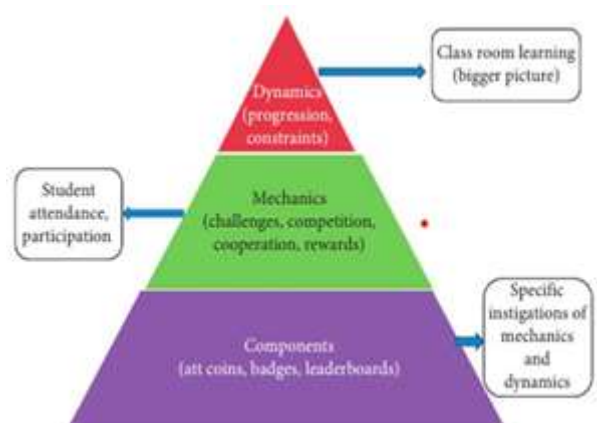


Fig. 2: Element Pyramid of classroom Learning

Core Game Elements in Education

Across these studies, several core game elements are repeatedly identified as essential for the successful implementation of gamification in educational settings. These include:

- **Points:** Providing immediate feedback on student performance and progress, points serve as a motivational tool to encourage continuous participation in learning activities.
- **Badges:** Awarded for achieving specific milestones or demonstrating mastery of a particular skill, badges act as both a reward and a visual marker of progress.
- **Leaderboards:** Ranking systems that promote healthy competition among students, motivating them to strive for higher performance and active participation.
- **Levels and Progression Systems:** These elements allow students to see their advancement over time, providing a sense of accomplishment and encouraging them to push toward completing their educational goals.

Summary of Key Findings

From these studies, several key findings can be drawn:

- **Enhanced Learning Outcomes:** Gamification, particularly when combined with AI and machine learning, significantly enhances student engagement and academic performance [1]. The context, including the subject matter and learning environment, plays a critical role in determining the effectiveness of the gamified system.
- **Increased Motivation and Engagement:** Game elements such as points, badges, and leaderboards are critical in driving learner engagement and motivation [8]. The alignment of these elements with clear learning objectives is essential for successful implementation.
- **Development of Essential Skills:** Gamification fosters the development of key skills, including teamwork, self-learning, and problem-solving, without compromising academic [5]. This makes gamified environments particularly effective for higher education settings, where active learning is emphasized.
- **Promoting Competition:** Gamification can enhance student motivation by creating a competitive learning environment, where learners are encouraged to outperform their peers through mechanisms like leaderboards [3]. This comparative aspect of gamification further boosts engagement and performance.

IV. IMPLEMENTATION

The essence of the application strategy centers on establishing a collaborative and educational atmosphere that facilitates games and machine learning algorithms. In particular, the implementation of random forest techniques aims to enhance student involvement by fostering collaborative learning.

Feedback based on rewards, along with predictive analytics, offers a tailored educational experience. The

Gamified Learning Management System (LMS) serves as the cornerstone of this gamified educational framework. This system is categorized into three primary segments: administrators, educators, and learners.

Below is a succinct description of each one and the role they play:

Admin Panel

- User Management
- Course Management
- System Monitoring
- Table and Rewards Rankings
- Exams and Assessment Control

Faculty Panel

- Set Up Course
- Tracking Student Performance
- Attendance and Rewards

Panel of Students

- Coin-Based Attendance
- Participation in Quizzes and Assessments
- Redeem Rewards
- Interact with other students

Random Forest Algorithm

Random Forest algorithm plays an important role in the decision making. Random Forest is a learning technique that creates multiple decision trees during training and a separate format for division of labour. The key features of Random Forest suitable for this situation are -

- **Ensemble Learning:** Random Forest is a collection of decision trees. which make predictions together using averages (in regression work) or majority vote (In classification tasks), combining decisions from multiple trees reduces overlap. This algorithm helps in reducing the error and generating accurate output.
- **Bootstrapping and Clustering:** Random Forest uses a bootstrapping method. By randomizing multiple subsets of data. (with randomization) to train each decision tree. The final prediction depends entirely on the tree. This results in stronger and more accurate predictions.

The formula used to calculate the Gini impurity of each node in the Random Forest is:

$$G_{ini} = 1 - \sum (p_i^2)$$

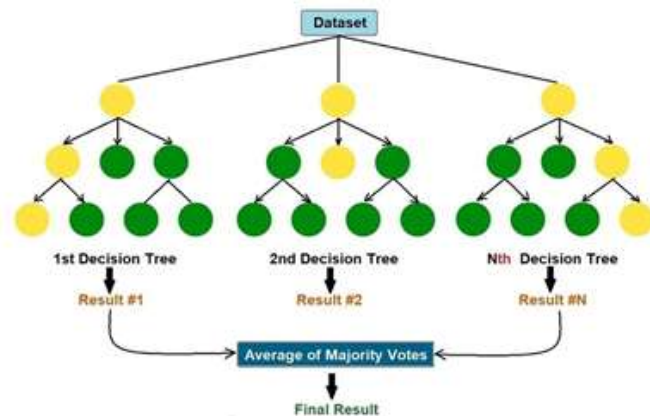


Fig 3. Random Forest Working Algorithm.

V. RESULT ANALYSIS

The system is tested using data including student activities such as attendance records, test scores, and game learning results collected over a semester. The data is split into training (70%) and testing (30%) for evaluation. The random forest algorithm consistently outperforms other algorithms such as logistic regression and SVM with a classification accuracy of 94%. The results showed that students who participated in the game experience experienced significant improvements in engagement and academic performance compared to students in the academic environment. The system has the ability to predict student performance, allowing teachers to adjust the difficulty of tests and provide individual rewards based on students' individual needs. understanding.

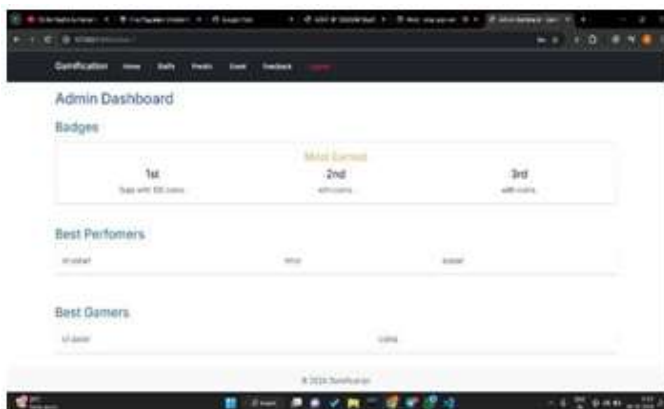


Fig 4: Implementation of Admin Page

While staff can easily identify students who are falling behind and engage them early, high achievers are increasingly finding it difficult to engage them. understanding. The analysis showed that attendance data had the highest predictor. This is based on test scores and participation in game-based learning.



Fig. 5: Implementation of Staff Page.

This suggests that regular absences play a significant role in students' overall learning. Participation in exams and games can facilitate learning. A key advantage of using random forest in this framework is its ability to provide insights into the importance of features. The analysis showed that the attendance report had the highest predictive value. Followed by test scores and participation in game-based learning activities. This indicates that regular attendance plays an important role in students' overall academic performance. While active participation in quizzes and games serves as a learning reinforcement mechanism.

V. CONCLUSION

This study has shown how using gamification in education can make learning more interesting, especially by increasing student motivation, involvement, and participation. By adding game-like elements to educational activities, such as friendly competition and personalized rewards, gamification can turn learning into a more fun and interactive experience. This, in turn, helps motivate students to complete their tasks better and learn important skills.

Our findings show that giving feedback is a key part of making gamification work well. General feedback (that isn't specific to the student) was helpful in getting more students involved. However, personalized feedback (which included details like the number of times a student used the system) had mixed results. This means that how personalization is done really matters. Future research should explore if giving even more specific feedback (like on individual answers or learning materials) could increase engagement without any negative effects.

One important finding is that the level of challenge matters a lot. Students who got perfect scores often lost interest and stopped playing. This shows that tasks need to be challenging enough to keep students engaged but not so hard that they give up. Future research could look into creating learning

systems that change the difficulty level based on each student's progress to keep them interested.

Even though the results are promising, our study did have some limitations. For example, the sample size was small, and participation was voluntary without any rewards, which could have affected the results. These limitations highlight the need for more field studies to find better ways to get students involved in gamified learning environments. While it's easier to keep students engaged once they start using the system, the real challenge is getting them to try it in the first place.

In summary, this research shows that gamification can make learning more engaging and rewarding. However, for gamification to work well in education, it's important to create systems that meet the needs of different students, provide useful feedback, and keep tasks balanced in terms of difficulty. Future studies should focus on improving gamification practices and finding solutions that work in different educational settings. As technology and gamification continue to grow, there are many exciting opportunities to improve learning experiences in today's digital world

Future Scope

The future of gamified learning offers many exciting possibilities. One important area is making learning more personalized by using advanced technology like AI and machine learning. Future studies can focus on customizing learning experiences based on each student's progress and learning style. These technologies can create challenges that fit individual needs, provide adaptive learning paths, and give personalized feedback, making sure students stay motivated and engaged. AI can also help by adjusting tasks in real-time as students learn, giving immediate feedback and creating a more effective learning experience.

Another key area for the future is addressing the gap between developed and developing countries in using gamified learning. This difference often happens because of unequal access to technology and resources. Researchers should explore ways to create affordable and scalable gamification solutions that can be used in less developed regions. This will help make modern learning tools accessible to everyone, no matter where they live. Additionally, understanding cultural differences is crucial because gamification may not work the same way everywhere. Future research should look into developing strategies that fit different cultural attitudes towards things like competition, collaboration, and rewards, so gamification can be effective worldwide.

Finally, it's important to study the long-term effects of gamified learning. While we know it helps boost student engagement and performance in the short term, we still don't fully understand how it affects learning in the long run. Future research should focus on long-term studies to see how

gamification impacts things like knowledge retention, skill development, and overall academic success over time. This will give a clearer picture of its benefits and any challenges it might bring to education in the long run.

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