The Nebula Framework: A Deep Gamification Framework for High-Quality Online Learning Experience

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Declaration

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This is to certify that this dissertation is based on the work of

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under my supervision. The thesis has been prepared according to the format stipulated and is of acceptable standard.

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Abstract

The trend towards online learning has become a pivotal part of modern education, but it comes with notable challenges, particularly in maintaining student motivation, engagement, retention, and performance over time. Traditional approaches, including attempts at integrating gamification, have been unable to fully unlock its potential to address these issues. In response to these challenges, this research introduces "Nebula," a deep gamification framework designed specifically to enhance the student experience on online learning platforms. Nebula shifts the focus from surface-level (shallow) gamification elements, like badges and leaderboards, to a more immersive and meaningful application of deep gamification principles. It aims to improve key educational outcomes such as engagement, consistency, retention, and performance.

The project's scope includes the development and iterative testing of the Nebula framework on a custom-built online learning platform, utilizing the design science research method. Each iteration incorporates feedback and insights, refining the framework to ensure its effectiveness in different learning contexts.

The findings from our study indicate that the integration of Nebula into online learning platforms results in significant improvements in student engagement, consistent participation, retention rates, and overall performance.

Furthermore, it highlights how deep gamification can lead to a more enriching and sustainable learning experience, thereby enhancing the overall quality of higher education. This research provides valuable implications for educators and platform developers, offering a new perspective on how online learning environments can be optimized through advanced gamification strategies.

Keywords: Gamification, eSports, Personalization, Technology Enhanced Learning, The Nebula Framework.

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Sincerely,

B.A.I.V.Harischandra
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A.W.A.V.H.Abeyvickrama

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List of Acronyms

A Answer

AI Artificial Intelligence

API Application Programming Interface

APM Agile Project Management

APM-G Agile Project Management Gamified

APM-NG Agile Project Management Non-gamified

COVID Coronavirus Disease

DOTA Defense of the Ancients

DSA Data Structures and Algorithms

DSA-G Data Structures and Algorithms Gamified

DSA-NG Data Structures and Algorithms Non-generation

DSRM Design Science Research Methodology

e-Learning Electronic Learning

ES Enrolled Students

F Factor

H1 Hypothesis 1

H2 Hypothesis 2

H3 Hypothesis 3

H4 Hypothesis 4

HD Highest Difficulty

ICT Information and Communication Technology

IT Information Technology

LD Lowest Design

LMS Learning Management System

MaxPR Maximum Public Rank

MaxPRA Maximum Public Rank Achieved

MCQ Multiple Choice Question

MinPR Minimum Maximum Public Rank

MinPRA Minimum Maximum Public Rank Achieved

MOOC Massive Open Online Course

N-Ach Need for Achievement

N-Affil Need for Affiliation

N-Pow Need for Power

PD Previous Development

R Range

RTS Real-Time Strategy

SCeLE Student Centered e-Learning Environment

UD Universal Design

UI User Interface

US United States

UX User Experience

VLE Virtual Learning Environment

Chapter 1

Introduction

1.1 Motivations

In recent years, online education has seen a surge in popularity as it provides learners with convenient and flexible learning options, thanks to technological advancements. However, the outbreak of the COVID-19 pandemic has had a severe impact on traditional in-person learning[1], making it impossible in many cases. As a result, many instructors have been motivated to create online courses, enabling education to continue even during a global crisis.

While online learning offers flexibility and convenience, one of the biggest challenges faced by online education platforms is keeping students engaged and motivated [2]. As students spend more time on a particular subject, their motivation to continue learning tends to decline, which can hinder the effectiveness of the learning experience. This lack of sustained motivation is a significant problem that needs to be addressed by educators and platform developers alike. Despite the initial enthusiasm students may have towards the course material, maintaining their motivation over time is crucial for a successful online learning experience.

Maintaining student motivation is essential for the success of online education. It is important to address this challenge in order to optimize the efficacy of online education and ensure that students remain enthusiastic throughout their learning journey. To combat this issue, it is necessary to explore innovative approaches that can reignite students' motivation and sustain their engagement throughout the online learning experience.

One such approach is the use of deep gamification, which has been shown to provide a more sustainable solution compared to traditional shallow gamification. Many e-learning platforms have employed shallow gamification techniques—such as points, badges, and leaderboards—to increase student engagement. While these methods can be effective in the short term, they often fail to maintain engagement over longer periods, as they only offer superficial rewards that do not influence the core learning process. Shallow gamification typically focuses on adding game-like elements without modifying the underlying learning structure, leading to diminishing returns on student motivation.

Deep gamification, on the other hand, introduces game mechanics that fundamentally alter the way students interact with the content. This method transforms learning activities by embedding game design principles directly into the curriculum, making the learning experience more immersive and engaging [3]. For example, Quest to Learn, a school in New York City, integrated game design into its curriculum, demonstrating how deep gamification can create a more interactive and rewarding learning environment. Unlike shallow gamification, which primarily requires programming and visual design skills, deep gamification involves rethinking the learning process itself, requiring more sophisticated game design techniques that can sustain student engagement over time [3].

Deep gamification is essential because it directly impacts the learning process by creating a sense of progression, challenge, and mastery, which are key factors in maintaining long-term motivation. By integrating game mechanics such as adaptive challenges, rewards tied to mastery, and social competition, students remain more engaged and motivated to continue learning. This approach offers a more comprehensive solution to the challenge of declining motivation in online education.

In this research, we aim to explore how deep gamification principles inspired by competitive video games like Defense of the Ancients 2 (DOTA 2) can be leveraged to enhance the online learning experience. DOTA 2, a popular multiplayer action Real-Time-Strategy (RTS) game with a complex ranking system and leaderboard, has created a highly engaging and competitive environment for its players. We will investigate whether a similar approach can be applied to online education to improve student engagement and motivation. Our goal is to develop a unique and immersive learning experience that fosters active and continuous engagement by incorporating game elements from successful games like DOTA 2.

1.2 Scope

The scope of this research study is to explore the effectiveness of a comprehensive gamification framework for e-learning materials and to gather user feedback on its implementation and effectiveness. Our primary focus is on student engagement and performance with the proposed framework. We will conduct the research with the consent of relevant authorities, and all subjects will be given a pre-test and a post-test to assess the validity of our hypotheses. In addition to this, we will provide a survey-based questionnaire to collect student perspectives on the future usage of the framework. Our goal is to develop a deeper understanding of the potential benefits of gamification in e-learning and to provide recommendations for future implementations.

Given the limited timeframe, this study will focus on applying the proposed gamification framework to a select few courses. We aim to include a range of course types, both technical and non-technical, to address the bias towards tech-related courses in previous studies on the effectiveness of gamification. Our primary goal is to create an independent artifact called the

"Nebula framework," which will serve as a set of guidelines for implementing gamification in e-learning. We will then seamlessly integrate these guidelines into an established online e-learning platform. It is important to note that the development of the platform itself is not within the scope of this research endeavor. Our focus is primarily on evaluating the effectiveness of the gamification framework and collecting user feedback to refine and improve it.

1.3 Research Problem

The main research question that this study aims to answer is: **"How does deep gamification impact the quality of higher education by enhancing students' engagement, consistency, retention, and performance?"** We believe that gamification has the potential to improve the online learning experience by incorporating game elements such as rewards, challenges, and a sense of progression, which can enhance student engagement and motivation. By exploring the impact of deep gamification on student performance and other key metrics, we hope to gain a better understanding of its potential benefits and limitations in the context of higher education. Ultimately, our goal is to provide recommendations for implementing effective gamification strategies in e-learning that can enhance student engagement and improve the overall quality of education.

1.4 Hypotheses

The hypotheses related to deep gamification and its effects on students' **engagement**, **consistency**, **retention**, and **performance** are as follows:

- **H1: Due to deep gamification, students' engagement with learning materials increases.**
- **H2: Due to deep gamification, students' consistency with the learning activities increases.**
- **H3: Due to deep gamification, students' retention with the learning platform increases.**
- **H4: Due to deep gamification, students' performance with respect to marks increases.**

1.5 Aims and Objectives

This study has three objectives:

1. Design and implement the Nebula framework.
2. Evaluate the impact of the Nebula framework on student motivation and engagement through qualitative and quantitative data collection and analysis.

3. Provide recommendations for educators, instructional designers, and online education platforms on integrating game elements to improve learning outcomes.

Chapter 2

Literature Review

2.1 Introduction

In recent years, the integration of gamification in e-learning has gained significant attention and recognition for its ability to enhance user engagement and motivation. This literature review explores the applications, impact, and challenges of gamification in education. It discusses the historical development, growing popularity, and market growth of gamification in e-learning, emphasizing its effectiveness in improving student performance.

2.2 Gamification in e-Learning and its Applications

Gamification in education began in the second half of the twentieth century when gaming concepts were used for educational purposes[4, 5]. Nick Pelling introduced the term "gamification in education" in 2002, marking a pivotal moment in the recognition and exploration of game elements in the educational domain[6].

Gamification is a trending area[7, 8, 9, 10], particularly in education. It is being recognized as a new and effective learning strategy[11], and its application across various sectors has rapidly expanded in recent years[12]. The term "gamification" has become a buzzword due to its widespread recognition and intrigue[13]. Gamified eLearning techniques are becoming increasingly popular due to their effectiveness in improving student engagement and performance[14, 15]. The gamification market estimates billions of U.S. dollars and is expected to generate revenue of over $24 million by 2024[16, 17]. Additionally, the use of educational technology during the pandemic has further accelerated market growth, with experts predicting a compound annual growth rate of 29% from 2021 to 2027[18].

E-learning has grown significantly during the COVID-19 pandemic[19], with over 1000 institutions offering options[20]. Gamification in e-learning is being integrated with other educational activities and can be used as a single-player learning strategy, highlighting the trend of integrating game-based learning[15, 16]. Successful implementation of e-learning requires technology awareness, motivation, and changing learners' behavior[20]. Factors that contribute to a successful e-learning platform include learners' characteristics such as computer and internet self-efficacy, attitude toward e-learning, and instructors' attributes. Institution and service quality, infrastructure and system quality, course and information quality, and extrinsic motivation also play an important role in the effectiveness of e-learning initiatives[20]. Students' achievement goals rank highest among course characteristics, while instructor expertise and support play a crucial role in facilitating both learning achievement and course satisfaction[21]. Students who prioritise gains in competencies tend to experience higher levels of achievement, while factors such as motivation, opportunities for self-regulated and collaborative learning, and the clarity of the course structure also contribute to learning achievement and satisfaction[21]. Gamification in e-learning requires strategies that capture learners' attention, challenge them, and engage and entertain them, while teaching them[14]. Implementing a point system can significantly enhance learner engagement, with 89% of respondents expressing increased engagement[22]. Gamification in e-learning offers the potential to create exciting, educational, and entertaining courses that keep learners motivated[14]. Continuous updates, evolving storylines, new features, and challenges can prevent user disinterest and provide an engaging learning experience[23].

Raharjo[24] investigates the impact of gamification on active learning in SCeLE Fasilkom, providing valuable insights into its effectiveness in improving student engagement and learning outcomes. Almotairi[12] showcases the development and deployment of a leaderboard plugin within the Moodle LMS, enhancing gamification elements and fostering competition and motivation among learners. Gamified frameworks in higher education aim to enhance student engagement and promote diverse learning methods, offering students the opportunity to explore and engage with different learning activities and approaches[25]. Alsubhi[15] proposes an engagement framework to enhance student engagement and performance in e-learning environments, contributing to the advancement of gamification in education. Gamification and engagement elements are widely used in e-learning websites, with the most commonly employed tools being highly effective, enhancing user engagement and promoting effective learning experiences[26].

2.3 Aspects and Impact of Gamification in e-Learning

Previous studies[27, 14, 12] provide evidence of the positive impact of gamification on student engagement in e-learning. Jun[28] and Huseman[16] explore the influence of gamification on students' study and learning engagement. Puig[29] and Rebelo[26] shed light on the evaluation of learner engagement and the use of gamification as an engagement tool in e-learning websites.

Gamification in e-learning is essential to maximize engagement and effectiveness and should be integrated into instructional design[14]. Gamification can be an effective strategy for enhancing learner motivation and engagement in educational settings[7].

Bhuasiri[20] provides insights into the key factors that contribute to the successful implementation of gamification in e-learning in developing countries. Alsubhi[15] examines the design and evaluation of an engagement framework for gamification in eLearning, providing valuable insights for researchers and practitioners. Gamification can be used to enhance learner motivation, participation, and engagement in online educational platforms, as demonstrated by Rebelo[26].

Previous studies[7, 10, 24, 30, 11, 12] contribute to the literature on gamification in e-learning platforms. They demonstrate the implementation and evaluation of gamified elements within Moodle to enhance student motivation, engagement, and performance. These findings contribute to the growing body of knowledge on utilizing gamification as a means to create more interactive and engaging online learning experiences. Previous studies[7, 31, 32, 33, 34] explore the relationship between gamification and student motivation and engagement. They investigate the effects of gamification on psychological need satisfaction, learning and behavior based on personality traits, and experimentation with gamified tools in educational contexts. These findings contribute to understanding how gamification can be leveraged to foster motivation and engagement in eLearning environments. Research papers[8, 25] explore the relationship between gamification and classroom engagement, exploring aspects such as class-related work and the use of a gamification and machine learning approach.

Students' expectations and experiences in e-learning are linked to learning achievements and course satisfaction[35]. Handayani[36] highlights the potential of eLearning as an effective solution for distance learning in a pandemic context. Gamified eLearning is beneficial for undergraduate students[19]. Gamification has the potential to be an effective educational approach, improving student response, engagement, and achievement in online learning[37].

Smiderle[32] investigates the influence of gamification on students' learning, engagement, and behavior, taking into account individual personality traits. Curriculum design is essential for promoting learning performance by creating engaging and creative elements that stimulate curiosity, competition, and motivation[20, 14]. Aguilos[19] highlights the implications of structural course design on classroom engagement, providing valuable insights for improving teaching and learning practices. Gamification elements in education have been shown to enhance student engagement and motivation, leading to improved learning outcomes[32, 14, 38]. This approach fosters human motivation, performance, and the quality of learning, and can benefit high-performing or competitive students[19]. Overall, gamification presents promising opportunities to enhance student engagement and motivation in e-learning environments[39, 40]. Gamification in eLearning offers benefits such as increased learner engagement, improved knowledge absorption and retention, friendly competition, and real-world application opportunities[14]. Kim[41] highlights a performance advantage of college students in a gamified cell biology class. These findings support the effectiveness of gamification in enhancing learning outcomes.

Gamification can be used to engage students and encourage their active involvement in the learning process, as suggested by Raharjo[24]. Gaming can be used to increase learning engagement and motivation among students, as evidenced by a growing body of research[42, 43, 38, 44]. Puig[29] introduces a novel approach to gamification in MOOCs and evaluates its effectiveness, contributing to the existing literature on gamification in MOOCs.

Student engagement is the amount of time and effort invested in their academic experiences[45, 46]. Gamification can have a positive impact on student engagement in online courses, providing valuable insights into the relationship between gamification and student engagement[12]. Student engagement is shaped by instructional delivery methods, student readiness, and their enthusiasm to actively participate in their studies[15]. Gamification can be used to motivate students and foster engagement in learning[23]. Gamification strategies, such as incorporating game elements and setting clear goals, have been found to enhance student engagement in learning environments. They foster creativity, competitiveness, and motivation, while also providing interactive and personalized learning opportunities[23, 16].

Intrinsic motivation can be measured using tools such as Hanus[8] providing insight into individual drive and interest. Gamification in a school district led to a 300% increase in student talk time, indicating the potential positive impact of gamification on student performance and engagement[47].

Measurement of student engagement and satisfaction can include class satisfaction, effort, learner empowerment, and social comparison, providing a comprehensive understanding of student satisfaction[8]. Gamification has a positive impact on learning outcomes, behavior patterns, and engagement levels, particularly in web-based programming learning environments[32]. Student engagement is measured using indices such as login frequency, activity completion rate, number of posts, and views to understand the level of engagement[12]. AI can be used to personalize game elements to align with learners' preferences, needs, and values[48].

Gamification can positively influence student learning engagement and interactivity with eLearning technologies, acting as a motivating force for sustained learning[24]. Harini[23] provides a comprehensive overview of game elements and the impact of gamification on learner engagement and motivation, including points, leaderboards, and badges. Nurhikmah[37] provides insight into the potential benefits and effectiveness of incorporating gamification elements in educational settings, providing insight into student interest, engagement, and achievement. Rebelo[26] explores the relationship between gamification tools and engagement in e-learning platforms, highlighting the potential of gamification strategies to enhance student engagement and participation. Legaki[49] demonstrates that blending traditional learning approaches with elements of play can lead to significant performance outcomes, with some students showing an increase of up to 89.45%.

Gamified experiences led to better scores in practical assignments and overall performance, accompanied by higher initial motivation[7]. Different game design elements had varying effects on motivation, with badges, leaderboards, and performance graphs enhancing competence satisfaction[31]. Gamified e-learning courses resulted in high satisfaction and engagement among students, with significant differences in online interaction frequency between above-average and below-average performing groups[10]. Gamification strategies were effective in increasing scores and reducing unwanted behaviors[50, 51, 32]. Gamification in learning management systems positively influenced active learning, student performance, and participation, with positive feedback on weekly reviews, badges, and leaderboards[24]. Gamification proved to be a valuable tool for enticing user uptake in educational systems and enhancing interactivity and engagement[24, 11]. Initial findings suggest that gamified online courses yield better results than traditional online courses, with gamification influencing study engagement through enjoyment and self-efficacy[12, 28]. Several research studies have examined the negative effects of gamification in educational settings. A study[8] found that students enrolled in a gamified course exhibited lower levels of motivation, satisfaction, final scores, and feelings of empowerment compared to students in a non-gamified class. Additionally, ranking mechanisms in gamification can have varying effects on women, and gamification was found to have detrimental effects on pleasure and motivation[52, 8, 53]. Additionally, no statistically significant differences in engagement were observed between the gamified and non-gamified groups[32], suggesting that gamification did not enhance student engagement as intended. These findings call for careful consideration when implementing such strategies[7].

2.4 Challenges and Issues in e-Learning

Domínguez[7] examines the practical implementation of gamification in educational settings, focusing on the design aspects and consequences of implementing it in an authentic educational environment. The perception of traditional schooling as ineffective and boring is a major challenge for students[9], leading to a decline in student engagement with lectures and seminars. Effective strategies are needed to enhance student involvement in educational settings[54, 55]. Online education presents challenges for student retention, with lower rates than face-to-face courses[10]. The COVID-19 pandemic caused a shift to online education, requiring swift and effective solutions[19]. Factors influencing student retention and engagement in MOOCs include limited social interaction, boredom, fatigue, lack of motivation, and time constraints[29]. VLEs can also contribute to student disengagement and reduced motivation, negatively impacting their learning experience[56]. Remote learning has introduced new teaching methods that can create distractions for students[16].

Gamification in eLearning has been criticized for its addictive nature and pattern-based methods, as well as its lack of in-depth research and iterative prototyping for system ideation[14, 57, 58, 59]. Additionally, gamified learning systems have limitations such as a lack of in-depth research and iterative prototyping[60], as well as underexplored user characteristics and preferences[61]. The novelty effect is another challenge, where user interest and engagement may diminish over time due to the game elements losing their initial appeal[62]. Gamified learning has shown promising results, but it may have limitations in certain contexts. For unmotivated or inattentive students, gamification may have little to no impact on their engagement and learning outcomes[19, 63, 46]. It also has potential distractions, limited long-term impact, bias, lack of relevance, and implementation challenges[16]. Not all students benefit directly from gamified approaches, and there may be individuals for whom gamification does not work effectively[64].

2.5 Psychological and Motivational Factors in Gamification

Dinia[14] explores the relationship between the brain's response and gamification in eLearning, shedding light on the neurological mechanisms underlying its effectiveness.

Gamification in eLearning has psychological effects, such as excitement and accomplishment[14]. The human brain's drive for challenge and completion[16] creates an ideal environment for effective learning through gamification, leveraging the brain's motivation and reward systems to enhance engagement and promote a sense of purpose and recognition.

2.6 Research Methods and Analysis in Gamification Studies

Previous studies[7, 21, 28, 23, 34, 26] provide insights into the effectiveness and impact of interventions and approaches in university courses. Hanus[8] and Raharjo[24] provide valuable insights into the impact of gamified interventions on gender-based samples, with Hanus[8] focusing on participants from a Midwestern university and Raharjo[24] examining the integration of a gamified platform with an online e-learning portal. Gamification has a positive impact on active learning in SCeLE Fasilkom at UI[24]. Puig[29] involved 66 students from six high schools.

Domínguez[7] had a small sample size of 45 students, Aguilos[19] had 19 undergraduate students, and Almotairi[12] used a quasi-experimental design with 48 female students in Saudi Arabia. Rebelo[26, 21] involved a large-scale sample of 2196 students from 29 universities in Austria, providing a comprehensive perspective on the topic.

Mixed methods approaches have been used in research studies to collect both quantitative and qualitative data. Examples include Domínguez[7], Raharjo[24], and Tsay[34], which combined quantitative data on student engagement and performance with qualitative insights on the impact of gamification on learner motivations. Comparative studies have been conducted to examine the effects of gamification in educational settings. Hanus[8] compared two courses with a gamified curriculum, and Smiderle[32] randomly assigned students to a gamified programming learning environment with ranking, points, and badges, allowing for a comparative analysis of the impact of gamification on student outcomes. Statistical analysis is essential for educational research to examine the effectiveness of interventions. In Smiderle[32], the Shapiro-Wilk test was used to verify the normality of the data, while in Poondej[10], a t-test was used to analyze the data. Alsadoon[11] and Almotairi[12] employed a quasi-experimental design with a blended learning approach and a t-test to assess the effect. These statistical methods enable researchers to draw meaningful conclusions from the collected data. Qualitative research methods have been used to gain insights into students' experiences and perceptions of gamified learning in studies like Aguilos[19] and Nurhikmah[37]. Bhuasiri[20], Paechter[21], Jun[28], and Sailer[31] used various data collection and analysis techniques to investigate the impact of gamification in education. Delphi, AHP, multiple regression, correlational, regression, and self-determination theory were used to analyze responses.

Studies testing the effects of gamification in education have focused on ICT courses, such as "Qualification for users of ICT"[7] and first-year programming courses[32]. Gamification's impact on active learning was examined in SCeLE and middle school computer courses[24]. However, this bias towards ICT courses raises concerns about the generalizability of the findings to other academic disciplines[12, 11]. The literature suggests that limited gamification elements, such as a leaderboard and badges, can restrict the potential impact and effectiveness of gamified interventions[8]. This highlights the need for comprehensive and diverse gamification strategies in educational settings.

2.7 Framework Comparison

Several key distinctions (Table 2.1) emerged when comparing gamification solutions proposed by other studies with the Nebula Framework Integrated Online Learning Platform.

Table 2.1: Framework Comparison

Features	**Gamification Solutions Proposed by Other Studies**	**Nebula Framework Integrated Online Learning Platform**	**Significance**
Downward Grading	No	Yes	Promotes student accountability by reducing grades for wrong answers.
Rating Recalibration	No	Yes	Dynamically adjusts scores to reflect current performance, ensuring fairness over time.
Seasonal Rating	No	Yes	Introduces periodic resets of ratings to encourage ongoing competition and motivation.
Hidden Rating System	No	Yes	Keeps student ratings concealed to reduce pressure and promote consistent performance.
Adaptive Difficulty Levels	No	Yes	Adjust the complexity of tasks based on a student's performance, ensuring the learning experience remains challenging but achievable.
Game Elements	Yes	Yes	Standard elements like badges, points, etc., used in both systems.
Leaderboard	Yes	Yes	Promotes competition but balanced by Nebula's other advanced features (powered by recalibration).

These comparisons highlight the comprehensive nature of the Nebula Framework, which not only includes commonly found gamification elements but also introduces innovative features like downward grading, rating recalibration, seasonal rating, and a hidden rating system.

2.8 Research Gap

When reviewing the previous literature, almost all the studies used shallow gamification. They implemented solutions using gamification artifacts and evaluated their effect on student engagement and performance. There is a clear gap when checking the effectiveness of deep gamification artifacts in e-learning. Several studies used gamification artifacts selectively without mentioning reasons for their justifications for using them. Most of the studies evaluated the usefulness of gamified systems concerning IT-based subjects. Several pivot studies mentioned issues of gamification. However, the sample size of those studies was considerably small. We can clearly define that there is a clear research gap in conducting research studies on applying and evaluating the effectiveness of using deep gamification artifacts in e-learning with a variety of subject domains and a considerably large sample.

2.9 Conclusion

This literature review has shed light on the diverse themes related to gamification in eLearning, presenting a comprehensive analysis of its applications, impact, and challenges. The review has highlighted the growing recognition of gamification as an effective learning strategy, with its widespread adoption and market expansion in recent years. Gamification has been shown to enhance student engagement, motivation, and performance in e-learning environments, offering opportunities for interactive and personalized learning experiences. Despite the positive impact of gamification, the review has also identified certain challenges and issues associated with its implementation. These include concerns about addiction tendencies, the need for more in-depth research, and the consideration of user preferences and characteristics. Such considerations call for careful and thoughtful integration of gamification elements into e-learning platforms to ensure their effectiveness and mitigate potential drawbacks.

Chapter 3

Methodology

3.1 Choosing a Methodology

Selecting an appropriate methodology is crucial for the successful development of a new framework. In this case, adopting the **Design Science Research Methodology (DSRM)** offers significant advantages. DSRM allows for iterative testing and refinement of the framework, incorporating feedback from each iteration to enhance its design and implementation. By following DSRM, we can systematically develop and evaluate the framework in multiple iterations, ensuring that it meets the requirements and expectations of its intended users. This iterative approach enables us to address any limitations or challenges encountered during the development process, leading to continuous improvement and ultimately resulting in a more effective and reliable artifact.

3.2 Design Science Research Method (DSRM)

The DSRM is a qualitative research approach focused on the design process and the artifact being developed. It aims to generate knowledge about both the methodology used to design the artifact and the artifact itself. DSRM is characterized by its iterative nature, consisting of six key activities (Figure 3.1) that guide the research process. Through these activities, researchers iteratively refine and improve the artifact while also gaining insights into the design process itself. This iterative approach allows for continual refinement based on feedback and evaluation, leading to the creation of effective and impactful artifacts.

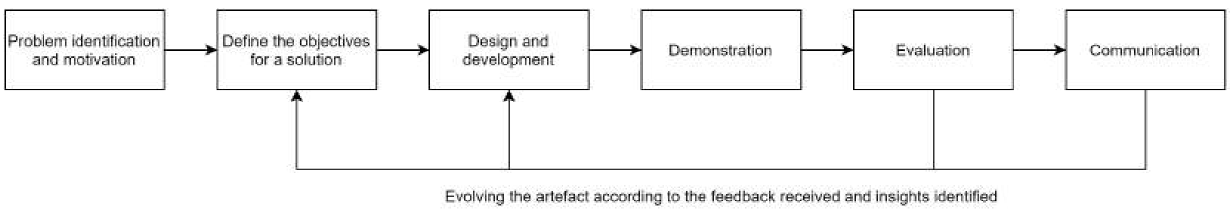

Figure 3.1: Main Activities Performed in DSRM

3.2.1 Main Activities Performed

Problem Identification and Motivation

In the Problem Identification and Motivation activity, researchers define the specific research problem and justify the value of finding a solution. This not only motivates the researcher but also helps the audience understand the depth of the problem and the importance of addressing it. Knowledge of the current state of the problem and its significance is crucial for this activity.

Define the Objectives for a Solution

Next, in the Define the Objectives for a Solution activity, researchers determine the objectives that the solution should achieve based on the problem definition and feasibility considerations. These objectives can be quantitative or qualitative and should logically stem from the problem specification.

Design and Development

The Design and Development activity involves creating the actual artifact, which could be any designed object embedding a research contribution. Researchers define the functionality and architecture of the artifact before proceeding to its creation.

Demonstration

During the Demonstration phase, the artifact is showcased in action to solve instances of the problem. This may involve experimentation, simulation, case studies, or other relevant activities to illustrate the artifact's utility.

Evaluation

The evaluation assesses how effectively the artifact addresses the problem by comparing its performance against the predefined objectives. Various evaluation methods may be employed, depending on the nature of the problem and the artifact.

Communication

In the Communication stage, researchers disseminate findings and insights to relevant stakeholders using appropriate communication channels. This ensures that the problem and the designed solution are effectively communicated and understood by the intended audience, which may include practitioners or other researchers.

3.2.2 Iteration 1 (2024-02-01 to 2024-02-29)

Activity 1: Problem Identification and Motivation

The motivation outlined in the introduction highlights the growing popularity of online education, particularly accelerated by technological advancements and the necessity brought on by the COVID-19 pandemic. Despite the benefits of online learning, sustaining student motivation over time presents a significant challenge. This lack of sustained motivation can hinder the effectiveness of the learning experience. To address this challenge, the introduction suggests exploring innovative approaches, such as incorporating gamification elements inspired by successful video games like Defense of the Ancients 2 (DOTA 2), to enhance student engagement and motivation in online education. The research aims to investigate whether leveraging gamification principles from games like DOTA 2 can create a more immersive and engaging online learning experience, ultimately optimizing the efficacy of online education.

The main research question of the study is **"How does deep gamification impact the quality of higher education by enhancing students' engagement, consistency, retention, and performance?"**. The hypotheses related to deep gamification and its effects on students' engagement, consistency, retention, and performance are as follows:

- **H1: Due to deep gamification, students' engagement with learning materials increases.**
- **H2: Due to deep gamification, students' consistency with the learning activities increases.**
- **H3: Due to deep gamification, students' retention with the learning platform increases.**
- **H4: Due to deep gamification, students' performance with respect to marks increases.**

Activity 2: Define the Objectives for a Solution

The objectives outlined in the introduction are:

1. Design and implement the Nebula framework.
2. Evaluate the impact of the Nebula framework on student motivation and engagement using both qualitative and quantitative data collection and analysis methods.
3. Provide recommendations for educators, instructional designers, and online education platforms on integrating game elements to enhance learning outcomes, based on the findings of the evaluation.

Activity 3: Design and Development

During the implementation phase, the team successfully developed and implemented the Nebula framework as outlined in the implementation section. Additionally, they created two online learning platforms and only one of them has been integrated with the Nebula framework (Figure 3.2). The implementation process involved rigorous testing and refinement to ensure seamless integration and optimal functionality. Through these efforts, the team has laid the foundation for deploying the Nebula framework in real-world educational settings.

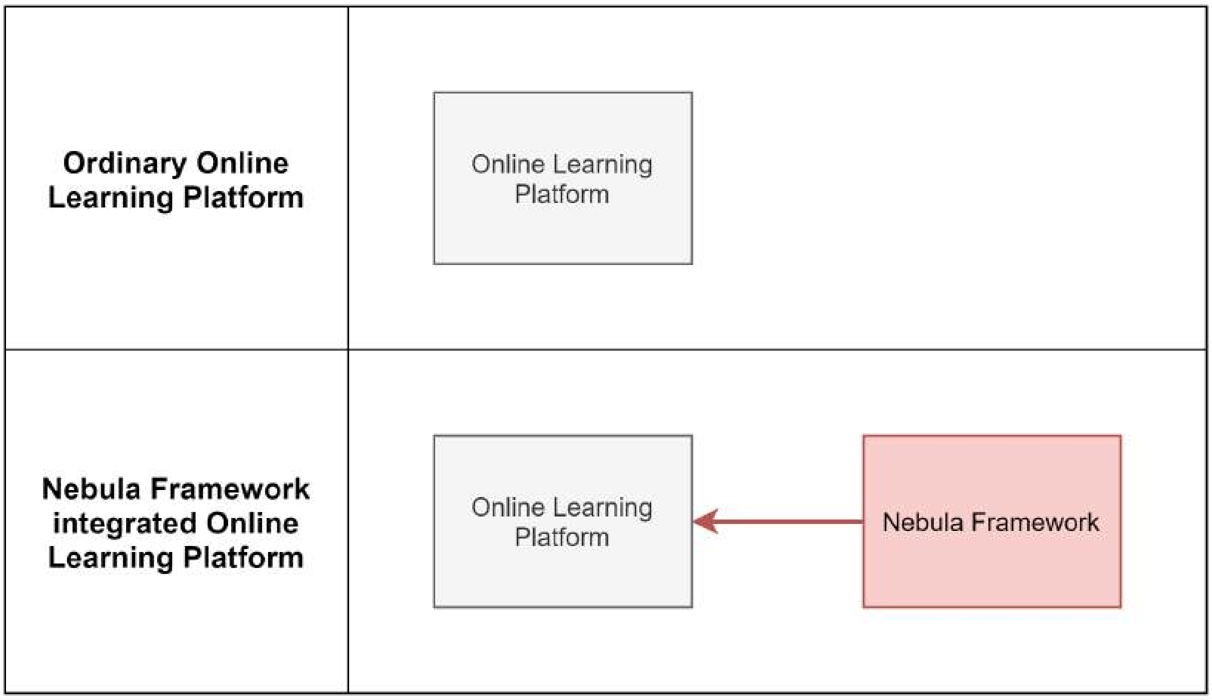

Figure 3.2: Setup of the Online Learning Platforms

For the study, two subjects were chosen to encompass both technical and non-technical aspects: **Data Structures and Algorithms (technical)** and **Agile Project Management (non-technical)**. During the course creation process, existing online course materials available on the internet were referenced extensively. Two variants of each course were developed: Variant 1, which remained non-gamified and retained the original course content, and Variant 2, which was gamified according to the guidelines outlined in the Nebula framework (Table 3.1). It's important to note that the core knowledge content of both variants remained unchanged. This approach allowed for a comparative analysis of the effectiveness of gamification in enhancing engagement and retention within the online learning environment while ensuring consistency in the delivery of course content.

Table 3.1: Course Setup Based on the Environment

Aspects	**Subject**	**Environment (Online Learning Platform)**	
		Ordinary	**Nebula Integrated**
Technical	Data Structures and Algorithms	DSA-NG (Variant 1)	DSA-G (Variant 2)
Non-technical	Agile Project Management	APM-NG (Variant 1)	APM-G (Variant 2)

To ensure the integrity of the research process, course videos were hosted on YouTube and privately shared exclusively with the research participants. This approach not only safeguards the confidentiality of the materials but also enables the researchers to verify the accuracy and reliability of the statistics obtained through YouTube analytics. Additionally, measures were taken to limit the possibility of students capturing screen images of the learning materials, thereby mitigating the risk of resource sharing between the two groups. These precautions were implemented to maintain the integrity of the study and prevent any potential biases or confounding variables that could affect the outcomes.

Activity 4: Demonstration

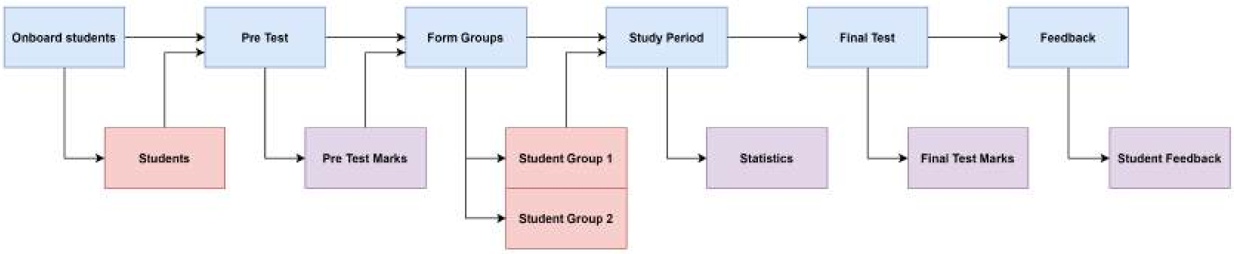

Figure 3.3: Steps of the Demonstration Phase

Fifty information systems undergraduates were onboarded to participate in the study, following a rigorous process that prioritized obtaining their consent (Appendix A). This ensured that all participants were fully informed about the nature of the research and willingly agreed to participate.

Before the commencement of the study (Figure 3.3), a comprehensive pre-test was arranged, consisting of 50 multiple-choice questions (MCQs) divided equally between Data Structures and Algorithms (DSA) and Agile Project Management (APM) prerequisites (Appendix D). This pre-test was conducted online and aimed to assess the participant's understanding of the fundamental concepts necessary to engage with the respective subjects effectively. By incorporating 25 MCQs for each subject area, the pre-test provided a balanced evaluation of the participant's readiness for the courses. The primary objective of the pre-test was to gauge the participants' current knowledge levels regarding the prerequisites essential for pursuing DSA and APM. The Data Structures and Algorithms (DSA) pre-test questions were designed to cover a wide range of identified prerequisites essential for mastering DSA concepts effectively. These prerequisites encompassed various key areas, including:

- **Syntax and Semantics**: Participants were assessed on their understanding of fundamental programming language components, such as variables, operators, control flow statements (loops, conditionals), and functions, which form the building blocks for algorithm implementation.
- **Data Types**: Proficiency in common data types like integers, floats, strings, boolean values, and arrays was evaluated to gauge participants' ability to manipulate and manage data efficiently within algorithmic contexts.
- **Object-oriented Programming Concepts**: While optional, familiarity with object-oriented programming principles such as classes, objects, and inheritance was included to assess participants' foundational knowledge, particularly relevant for object-oriented algorithm design paradigms.
- **Algebra**: Competency in basic arithmetic operations, equation manipulation, and solving for unknown variables were tested to ensure participants' readiness for understanding mathematical representations and operations inherent in algorithmic problem-solving.
- **Logic**: Participants' comprehension of logical operators like AND, OR, and NOT, along with their ability to construct logical statements, was evaluated, as these skills are crucial for effective algorithm design and decision-making processes.
- **Discrete Mathematics**: Familiarity with concepts such as sets, functions, relations, and basic graph theory was assessed to enhance participants' understanding and application of algorithms and data structures within discrete environments.
- **Proof Techniques**: Basic proficiency in mathematical proof techniques, including induction and contradiction, was included to assess participants' ability to analyze algorithm correctness and conduct algorithm analysis effectively.
- **Problem-solving Skills**: Participants' proficiency in breaking down complex problems into manageable steps, analyzing their components, and devising systematic approaches to problem-solving was evaluated, as these skills are foundational for DSA.
- **Algorithmic Thinking**: Understanding the concept of an algorithm as a sequential set of steps aimed at solving a problem was assessed to gauge participants' ability to design and analyze algorithms effectively.
- **Abstraction**: Participants' ability to identify essential aspects of a problem and abstract away irrelevant details to focus on the core solution was evaluated, as abstraction is crucial for designing efficient algorithms and data structures.

- **Calculus and Probability**: While not always required, familiarity with calculus and probability concepts was included, particularly for advanced courses covering algorithm analysis or specific data structures such as heaps and tries.
- **Computer Architecture**: Understanding basic concepts of computer architecture, including memory layout and operations, was assessed to provide insights into algorithm performance and optimization strategies.

The Agile Project Management (APM) pre-test questions were formulated to assess participants' understanding and proficiency in key areas essential for effective project management. These areas included:

- **Time Management Concepts**: Participants were evaluated on their proficiency in project scheduling, understanding milestones, recognizing task dependencies, and conducting critical path analysis. Mastery of these concepts ensures effective time management in project execution and adherence to stipulated timelines.
- **Cost Management Basics**: Familiarity with budgeting, resource allocation techniques, and cost estimation methodologies formed the basis of evaluation. Awareness of these basics enables project managers to optimize resource utilization, control project expenditures, and ensure project profitability.
- **Risk Management Awareness**: Participants' comprehension of risk management was assessed, including their ability to identify potential risks, assess their impact and probability, devise response plans, and implement mitigation strategies. Heightened risk management awareness enables project teams to anticipate and proactively address potential threats to project objectives.
- **Communication Skills**: Effective communication is crucial for project success, facilitating collaboration, alignment, and clarity among project teams and stakeholders. Participants were evaluated on their active listening skills, clear articulation of ideas, and adaptability to diverse communication styles, fostering a conducive project environment.
- **Team Collaboration**: Understanding the dynamics of teamwork, including aspects such as team formation, roles, and responsibilities, was assessed. Proficiency in conflict resolution techniques and appreciation of the value of teamwork empowers project teams to overcome challenges and achieve shared objectives efficiently.

Dividing the students into two groups based on their DSA and APM pre-test marks (Table 3.2) ensures that each group has a balanced distribution of skills and knowledge across both subjects. By aiming for roughly equal average marks in both DSA and APM pre-tests, we can create groups that are comparable in terms of their overall preparedness and proficiency in the subject areas. This approach helps to ensure that each group has a similar level of intelligence and skill set, which can contribute to fair and effective comparisons between the groups throughout the study.

Table 3.2: First Iteration Pre-test Marks

Student Group	**Pre-test Marks**	
	DSA (out of 25)	**APM (out of 25)**
Student Group 1	13.36	12.88
Student Group 2	13.32	12.84

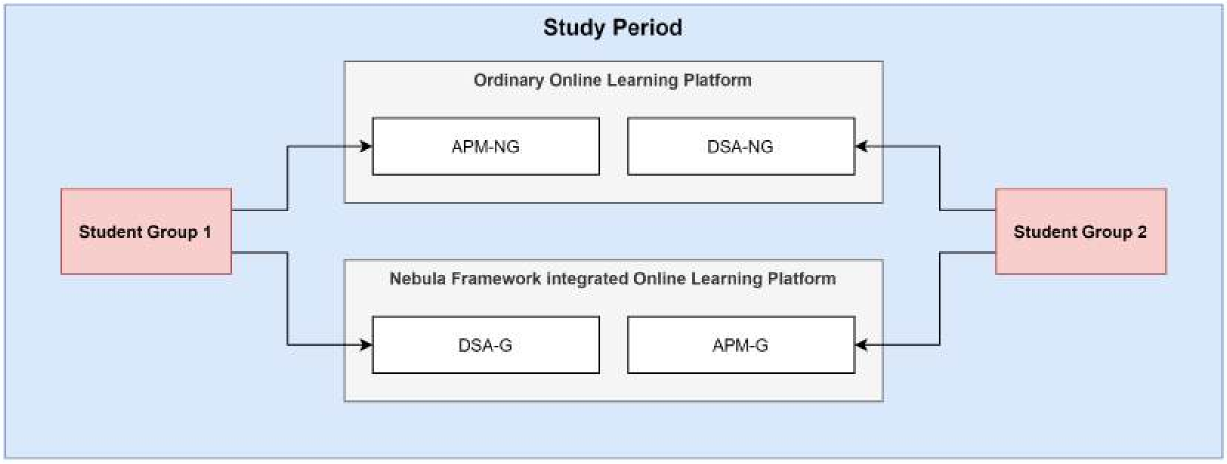

Figure 3.4: Granting Course Access for Student Groups

During the study period, Student Group 1 was granted access to the gamified version of the Data Structures and Algorithms (DSA-G) course and the non-gamified version of the Agile Project Management (APM-NG) course. On the other hand, Student Group 2 had access to the non-gamified version of the Data Structures and Algorithms (DSA-NG) course and the gamified version of the Agile Project Management (APM-G) course (Figure 3.4). The primary objectives of this setup were to ensure equivalency between the two groups and to examine the potential cross-effects of gamification across different subjects. Equivalency was implemented by ensuring that both groups had access to one gamified and one non-gamified course, albeit in different subject combinations. This approach aimed to balance any potential biases or variations resulting from the gamification aspect itself, allowing for a more accurate comparison between the effects of gamification across subjects. By examining the cross-effect, the study aimed to understand how the presence or absence of gamification in one subject influenced the students' experiences and outcomes in the other subject.

Both Student Group 1 and Student Group 2 were provided with a period of 27 days to refer to the respective courses assigned to them. This timeframe allowed ample opportunity for the students to engage with the course materials, complete assignments, and familiarize themselves with the content and structure of the courses. By allocating the same duration to both groups, the study aimed to ensure parity in terms of the time available for learning and engagement, thereby minimizing potential confounding variables related to time constraints.

The final test (Table 3.3) comprised 50 multiple-choice questions, with 25 questions based on Data Structures and Algorithms (DSA) and 25 questions based on Agile Project Management (APM) (Appendix E). The test was conducted online to facilitate easy access for the participants. The total participation in the final test was five individuals. Each participant was required to answer all 50 questions within the designated timeframe, allowing for a comprehensive assessment of their understanding of the course materials across both subjects.

Table 3.3: First Iteration Final-test Marks

Student Group	**No. of Participants**	**Final-test Marks**	
		DSA (out of 25)	**APM (out of 25)**
Student Group 1	2	11.5	15.5
Student Group 2	3	15	15.67

Feedback from Student Group 1 indicates a positive experience overall, with a quality of experience rating of 4.5 out of 5. The learning material was praised for its clarity, accessibility, and organization, with lessons presented in a logical order. Participants appreciated the abundance of questions accompanying each lesson, allowing them to track their progress effectively. The platform's provision of real-world examples and a focus on programming basics were cited as particularly beneficial aspects. Additionally, all respondents from this group expressed a willingness to recommend the platform to others as a learning tool.

In contrast, feedback from Student Group 2 reflects a slightly lower average quality of experience rating of 3.67 out of 5. While participants acknowledged the platform as a rich source of information with clear language understanding, they noted areas for improvement. Some respondents mentioned occasional difficulty in understanding context and suggested enhancements to the user interface to enhance engagement. Additionally, suggestions were made to introduce features such as peer review assignments or discussion forums to further enrich the learning experience. However, similar to Group 1, all participants in Group 2 expressed a willingness to recommend the platform to others for learning purposes.

Overall, both groups appreciated the structured content, accessibility of learning materials, and opportunities for self-assessment provided by the platform. However, there are areas where improvements could be made, such as enhancing contextual understanding, improving the user interface, and introducing additional interactive features for greater engagement and collaboration among learners.

Activity 5: Evaluation

It seems that due to the low participation in both course referrals during the study period and attendance at the final test, we are unable to draw conclusive findings regarding the hypotheses tested. The limited number of participants may not provide a representative sample to generalize the results or assess the effectiveness of the intervention accurately.

Activity 6: Communication

Identifying loopholes in the study design and Nebula framework components is crucial for refining the research methodology and platform functionalities. The feedback gathered from users and inspections following the first iteration has provided valuable insights into areas for improvement. By acknowledging these shortcomings and leveraging user feedback, we aim to enhance the quality and effectiveness of the second iteration.

1. **Selecting the control and experimental groups** presents a challenge when participants have busy schedules due to academic commitments. The engagement of previous users in the study might have been impacted by their academic workload, leading to potential biases in group assignments and participation rates.

2. The **onboarding process** is crucial for ensuring that participants are well-informed and prepared for their involvement in the study. However, in the first iteration, organizing multiple online meetings posed challenges as some users were unable to attend due to personal matters. This resulted in incomplete knowledge sharing, which could have affected participants' understanding of the research objectives, procedures, and expectations.

3. In the previous iteration, the **division between the control and experimental groups** across online learning platforms lacked clarity. Student Group 1 was granted access to DSA-G (gamified) and APM-NG (non-gamified), while Student Group 2 received access to DSA-NG (non-gamified) and APM-G (gamified). The intention was to assess the impact of gamified versus non-gamified courses on learning outcomes. However, this approach did not yield the expected results because both groups were exposed to gamified experiences, albeit in different subjects. Consequently, it became challenging to isolate the effects of gamification on learning outcomes as both groups had some exposure to gamified content

4. During the initial iteration, all participants belonged to the same university batch and were acquainted with one another. This familiarity facilitated communication about their experiences with the online learning platforms, leading to discussions about the changes implemented between the platforms. Over time, participants began **sharing both gamified and non-gamified resources** among themselves, blurring the distinction between the controlled and experimental groups. This exchange of resources compromised the integrity of the research study, as it became challenging to monitor and track changes between the two groups.

5. Addressing the lack of clarity and usability issues in certain gamified features of the user interfaces is crucial, as it may impact the effectiveness of the study. While the online learning platforms operate outside the direct scope of the Nebula framework, any **UI/UX-related issues** within these platforms could potentially influence the outcomes of the study. Therefore, by improving the UI/UX aspects of the platforms, we aim to mitigate any potential confounding factors that could affect the reliability and validity of the study results.

6. The observed behavior of some participants **completing quizzes without watching the accompanying video lessons** can potentially lead to a suboptimal learning experience and hinder the accuracy of data collection for the study.

7. The phenomenon of **question isolation**, where certain questions are not suggested to any students due to the difficulty level matching algorithm of the Nebula framework, poses a challenge to the comprehensive assessment of student's knowledge and skills.

3.2.3 Iteration 2 (2024-03-07 to 2024-04-04)

Activity 1: Problem Identification and Motivation

Continuing with the problem identification and motivation phase for iteration 2, we maintain our focus on addressing the challenges identified in the first iteration while striving to improve the effectiveness and reliability of our research framework.

Activity 2: Define the Objectives for a Solution

The objectives for the solution remain unchanged from the previous iteration.

Activity 3: Design and Development

In the second iteration, significant improvements were made to the user interface (UI) and user experience (UX) of the online learning platforms. Specifically, the following issues were addressed:

- **Navigation Bar Revamp**: The UI of the navigation bar was overhauled to enhance usability and clarity. Clearer navigation options and intuitive design elements were implemented to improve user interaction and facilitate smoother browsing through course content (Figure 3.5).

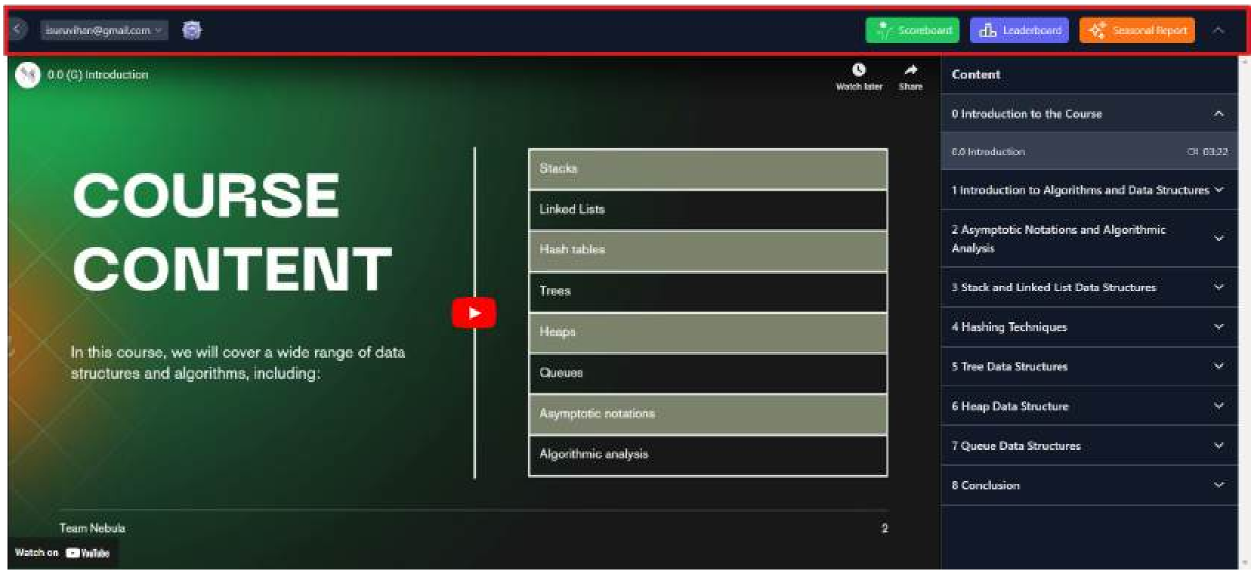

Figure 3.5: Navigation Bar Revamp

- **Leaderboard Component Redesign**: The UI of the leaderboard components underwent a redesign to enhance visual appeal and usability. A clearer presentation of student rankings and performance metrics was prioritized to provide users with a more engaging and informative experience (Figure 3.6).

Figure 3.6: Leaderboard Component Redesign

- **Introduction of New UI Component**: A new UI component was introduced to display student performance during the last season and recalibration results. This addition aims to provide users with valuable insights into their progress and achievements, fostering motivation and engagement with the learning platform (Figure 3.7).

Figure 3.7: Recalibration Results UI

In response to the observed issues with the content-unlocking process, a new algorithm has been implemented (Figure 3.8) to streamline the progression of students through course materials. Here's how it works:

- **Instructor-defined Sections**: The course instructor now can specify which sections of the course content are available for each relevant season. This allows for a more structured and organized approach to content delivery, ensuring that students are presented with materials in a logical sequence.

- **Sequential Progression**: Under the new algorithm, students are required to complete the quiz associated with each section before they can proceed to the next video. This sequential progression ensures that students engage with and demonstrate an understanding of the content before moving forward, promoting active learning and retention.

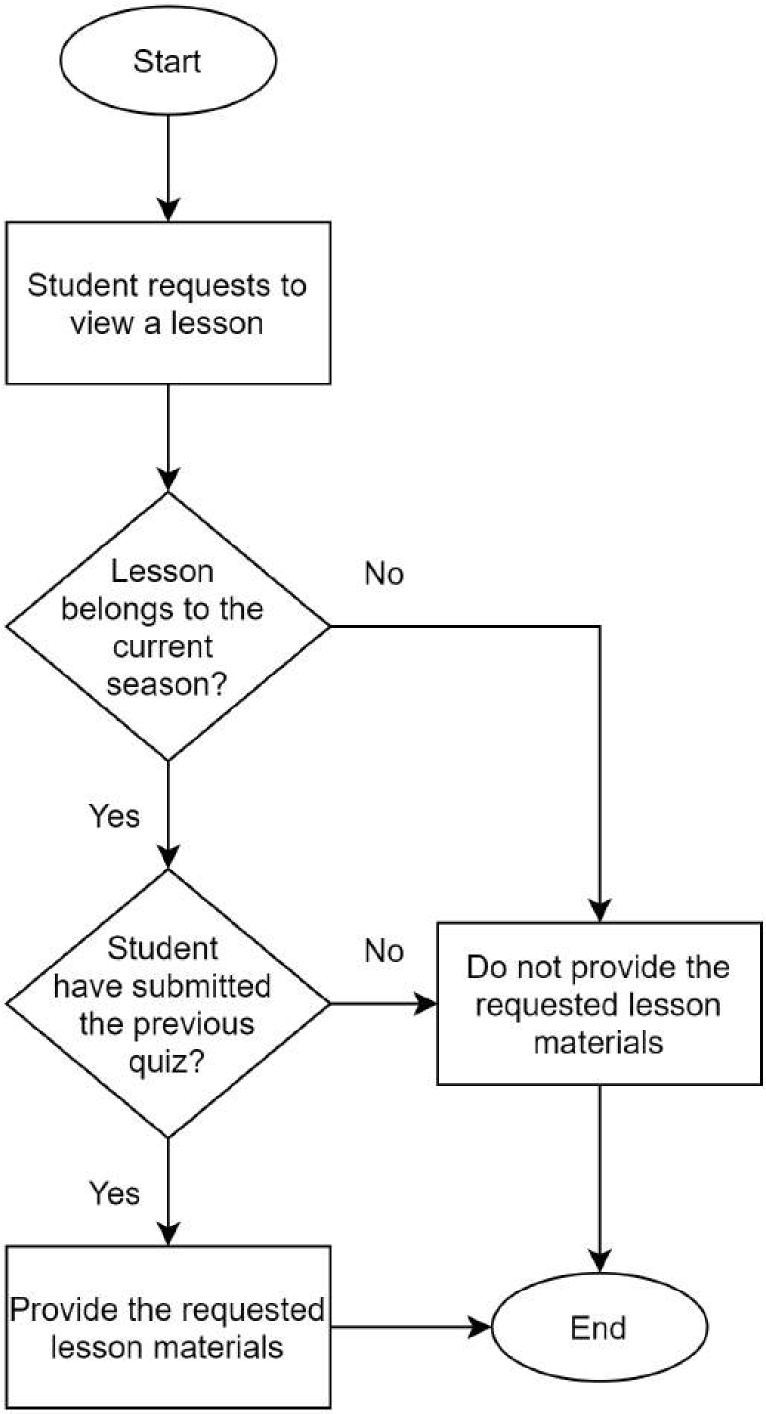

Figure 3.8: Content Unlocking Algorithm

To address the issue of question isolation in the quiz generation process, significant enhancements have been made to the Nebula framework's algorithm. Here's how it works now:

- **Improved Quiz Generation Algorithm:** The quiz generation algorithm has been revamped to ensure a more balanced selection of questions for each student. Instead of solely prioritizing questions that match the student's competence level, the algorithm now aims for a more comprehensive approach.
- **70-30 Rule:** Under the new algorithm, 70% of the questions in the quiz are selected based on their alignment with the student's competence level. These questions are tailored to challenge the student appropriately while ensuring that they are within the student's grasp. To prevent question isolation and ensure a diverse quiz experience, the remaining 30% of the quiz comprises questions that have received the minimum number of student attempts. This inclusion helps to address any gaps in coverage and ensures that all questions have the opportunity to be attempted by students (Figure 3.9).
- **Quality Assurance:** Even with the inclusion of underrepresented questions, the algorithm maintains a focus on quality by prioritizing questions with difficulty levels that align with the student's capabilities. This ensures that the quiz remains challenging yet fair, offering an optimal learning experience for each student.

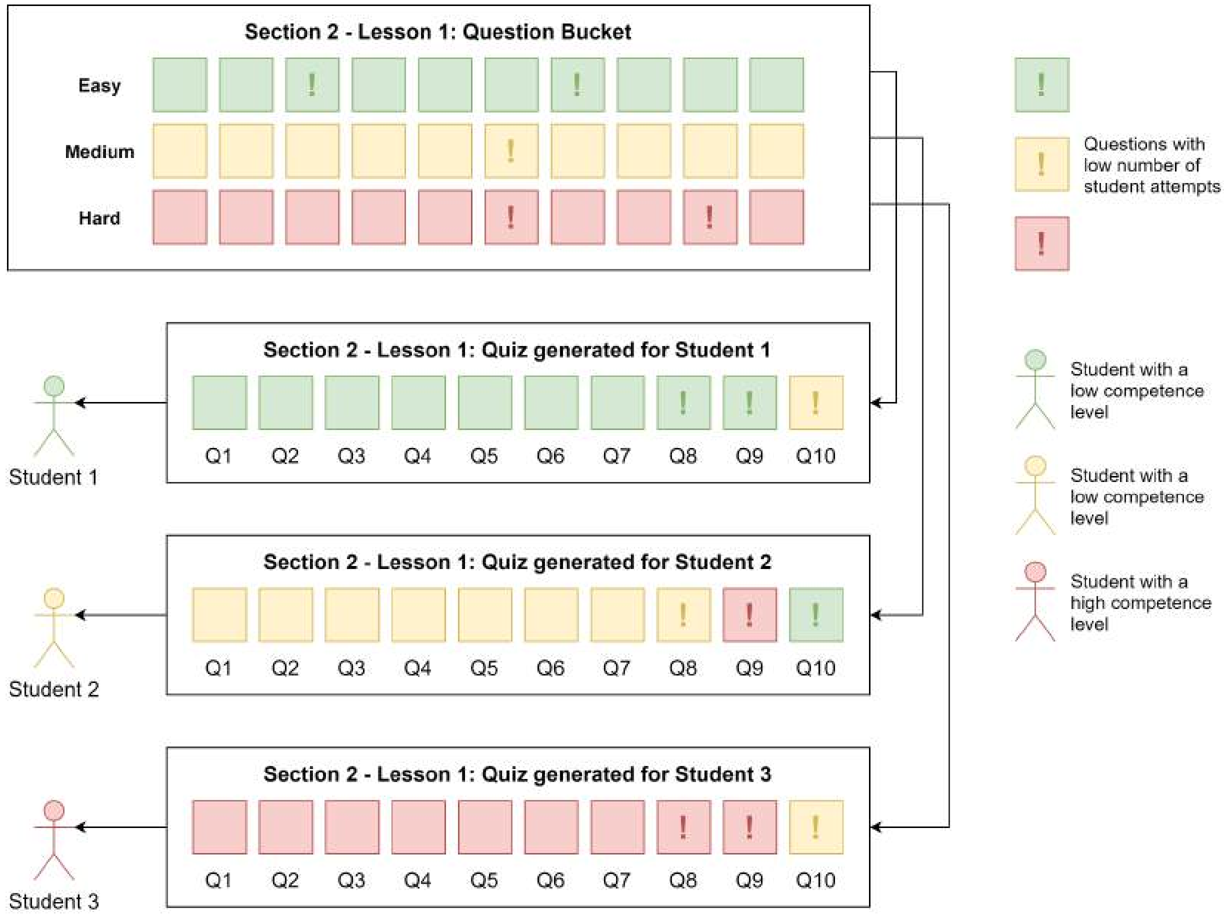

Figure 3.9: Quiz Generation According to the 70-30 Rule

Activity 4: Demonstration

The **onboarding process** was expanded to include 112 students (Table 3.4) selected from IT-related bachelor's degree programs across five universities in Sri Lanka.

Table 3.4: Onboarded Student Counts from Universities for the Second Iteration

University	Number of Students
A	59
B	33
C	13
D	4
E	3

For selecting candidates in the second iteration, the focus shifted from undergraduate students, who often have busy schedules due to academic commitments, to individuals who have applied to universities but have not yet been admitted. These individuals have more flexibility and time to engage with the research study. To streamline the onboarding process and ensure comprehensive knowledge sharing with the research participants, we have implemented several improvements. Recognizing the challenges faced during the first iteration, including scheduling conflicts and incomplete knowledge sharing, we have adopted a more accessible and efficient approach. Firstly, we have organized online meetings with the research participants to provide detailed information about the research objectives, methodology, and key activities such as the pre-test, study period, and final test. However, to accommodate participants' busy schedules and minimize disruptions, we have introduced flexible meeting timings and alternative communication channels. Instead of scheduling online meetings, we have created WhatsApp groups dedicated to the research study. These groups serve as a platform for continuous communication, allowing participants to access relevant information, and ask questions about the research study.

As in the first iteration, we arranged an online **pre-test** consisting of 50 multiple-choice questions (MCQs), with 25 questions focusing on Data Structures and Algorithms (DSA) prerequisites and 25 questions on Agile Project Management (APM) prerequisites.

To ensure fairness and comparability between the **controlled and experimental groups**, we divided the 112 students into two groups while adhering to the following criteria:

- **Community Cohesion**: We ensured that students from the same community or university were not split between the controlled and experimental groups. For example, if a student was selected for a bachelor's degree program in University A, they were assigned to either the controlled or experimental group, but not both. This approach aimed to maintain community cohesion within each group and minimize potential biases resulting from community-specific factors.
- **Balanced Pre-Test Marks**: We aimed to achieve balance in the average pre-test marks for both DSA and APM between the controlled and experimental groups. By distributing students based on their pre-test performance (Table 3.5), we sought to mitigate any initial differences in subject knowledge or aptitude that could influence the study outcomes. This balance ensured that both groups started the study period with comparable levels of proficiency in the prerequisite concepts for DSA and APM.

Table 3.5: Second Iteration Pre-test Marks

Student Group	**University**	**Pre-test Marks**	
		DSA (out of 25)	**APM (out of 25)**
Student Group 1 (53 students)	B	12.38	12.77
	C		
	D		
	E		
Student Group 2 (59 students)	A	13.44	14.03

To establish clear boundaries between the controlled and experimental groups and ensure distinct experiences for each, we have allocated the online learning platforms as follows:

- **Controlled Group (Student Group 1):**
  - Access to non-gamified courses only (DSA-NG and APM-NG).
  - Students in this group will exclusively engage with the non-gamified versions of the Data Structures and Algorithms (DSA-NG) and Agile Project Management (APM-NG) courses (Figure 3.10).
- **Experimental Group (Student Group 2):**
  - Access to gamified courses only (DSA-G and APM-G).
  - Students in this group will exclusively engage with the gamified versions of the Data Structures and Algorithms (DSA-G) and Agile Project Management (APM-G) courses (Figure 3.10).

By ensuring that each group has access to either gamified or non-gamified courses, we aim to examine the specific impact of gamification on learning outcomes while maintaining consistency within each group's learning environment. This clear division allows for a more controlled comparison between the two groups and enhances the validity of the study results.

To minimize information flow between the controlled and experimental groups and maintain the integrity of the study, we have taken several measures:

- **Diverse Audience Selection**: Instead of recruiting participants from a single university batch, we have chosen students from different universities and communities. This ensures that each group comprises individuals who are not familiar with each other and reduces the likelihood of information exchange between groups.
- **Community-based Group Allocation**: Students selected for a particular bachelor's degree program from a specific university are assigned to either the controlled or experimental group, ensuring that individuals from the same community are grouped. This further mitigates the potential for information sharing between the two groups.
- **Restricted Access**: Students in the controlled and experimental groups are provided access only to the designated online learning platforms corresponding to their group assignment (gamified or non-gamified courses). By restricting access to resources outside their designated group, we minimize the chance of cross-group information exchange.

During the **study period**, the control group (Student Group 1) will have access to the ordinary online learning platform, while the experimental group (Student Group 2) will utilize the Nebula framework integrated online learning platform (Figure 3.11). This division allows us to compare the outcomes between the traditional learning approach and the gamified learning experience facilitated by the Nebula framework. Each group will have the opportunity to engage with their respective platforms and complete the assigned coursework within the designated timeframe.

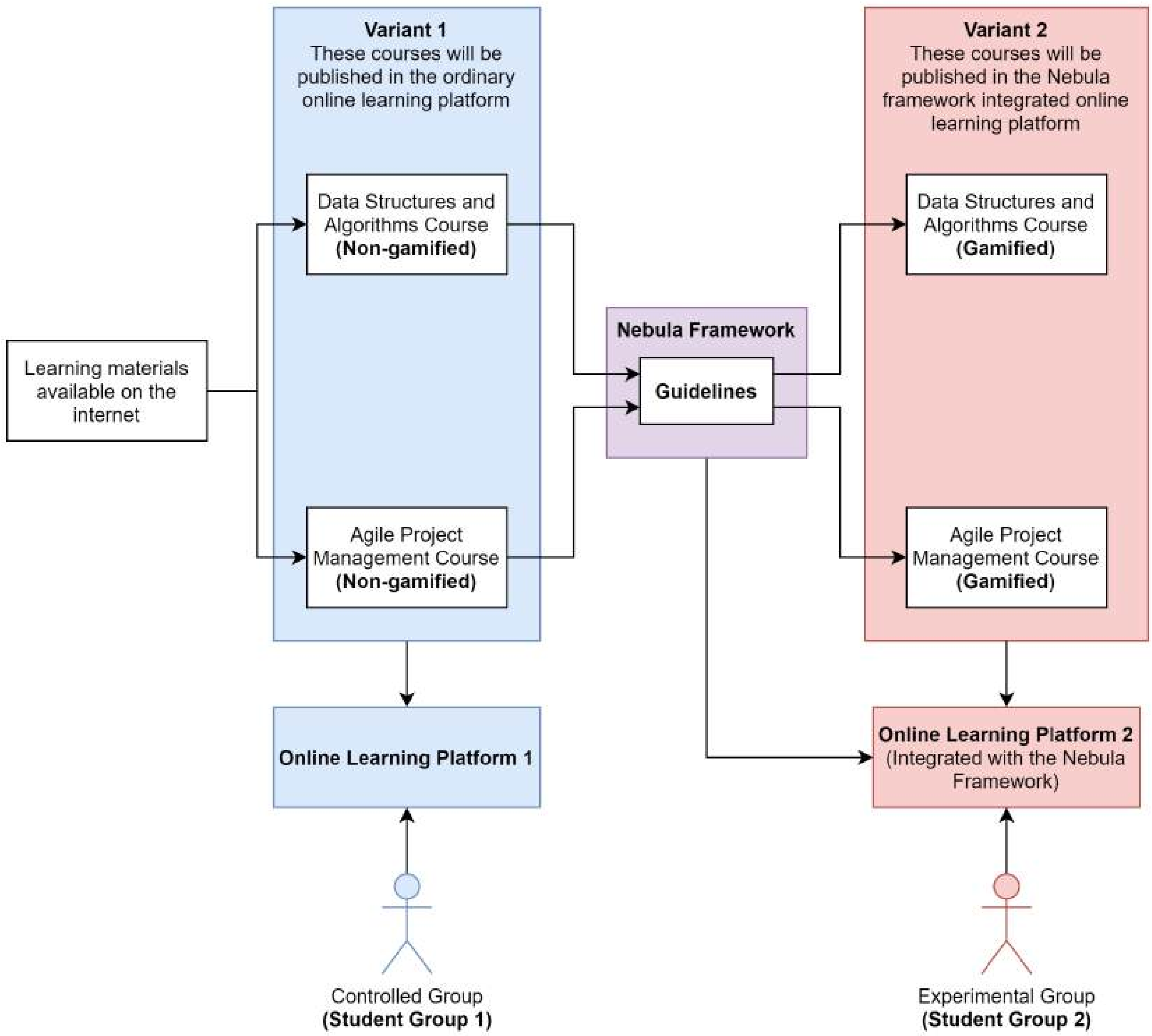

Figure 3.10: Allocation of Gamified and Non-gamified Courses

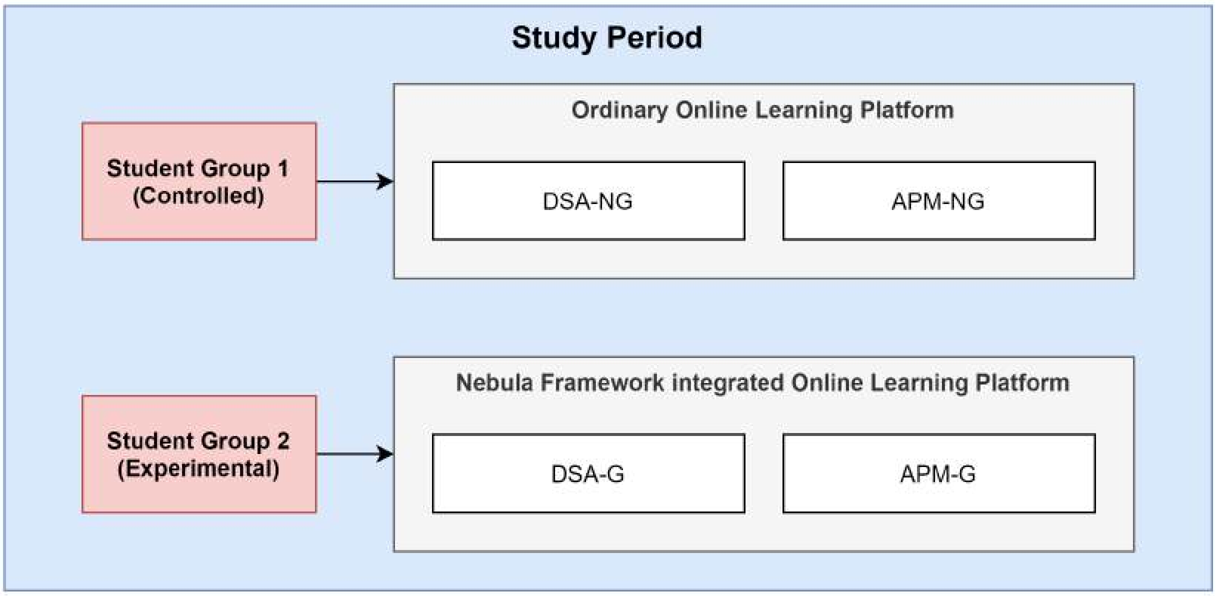

Figure 3.11: Allocation of Student Groups in Iteration 2

In Student Group 1, comprising 59 students, all of them successfully registered on the online learning platform. However, in Student Group 2, which consists of 53 students, only 38 of them completed the registration process on the online learning platform. Both Student Groups were provided with a period of 28 days to refer to the respective courses assigned to them. This timeframe allowed ample opportunity for the students to engage with the course materials, complete assignments, and familiarize themselves with the content and structure of the courses. By allocating the same duration to both groups, the study aimed to ensure parity in terms of the time available for learning and engagement, thereby minimizing potential confounding variables related to time constraints.

For the **final test**, the same assessment used in the first iteration will be administered to all participants. This test consists of 50 multiple-choice questions, divided equally between DSA and APM topics. The participants will have the opportunity to demonstrate their knowledge and understanding acquired during the study period. The total participation for this test is 32 students (Table 3.6).

Table 3.6: Second Iteration Final-test Marks

Student Group	**No. of participants**	**Final-test Marks**	
		DSA (out of 25)	**APM (out of 25)**
Student Group 1 (Controlled Group)	4 (out of 38)	10.25	11
Student Group 2 (Experimental Group)	28 (out of 59)	13.89	14.36

Feedback from Student Group 1 (Appendix B) indicates a positive experience with the online education platform. One participant rated their experience at 4 out of 5, highlighting the clear organization, easy handling, and provision of notes as reasons for their appreciation. They expressed willingness to recommend the platform to others. Despite encountering some challenges with understanding due to language barriers, they still regarded the program as a beneficial learning method. Notably, they found no aspects of the platform or courses particularly challenging or frustrating. The user interface received a high rating of 5 out of 5 for its ease of use.

Feedback from Student Group 2 (Appendix C), consisting of four respondents, suggests a generally positive experience with the online education platform. The average rating for the platform's experience stands at 3.75 out of 5. Participants appreciated the study materials' quality and usefulness, along with the platform's functions, despite encountering occasional issues such as website freezing during quizzes. They also expressed a desire for features like final rankings, test results, and a discussion page, suggesting ways to enhance user experience. Nonetheless, they affirmed their willingness to recommend the platform to others. The presence of rankings, leaderboard, and seasonal rankings contributed to enhancing motivation and engagement, with ratings ranging from 4 to 4.75 out of 5. The effectiveness of questions at the end of video lessons received a rating of 4 out of 5. Engagement and motivation were generally positive, although some found the limited period to complete a season challenging. Beneficial aspects highlighted included the leaderboard, progress feature, and quizzes, while challenges included occasional quiz freezing and some topics being difficult to grasp. Despite minor user interface issues such as website freezing and progress-saving problems, the overall presentation and accessibility of the interface were rated favorably at 4 out of 5.

Activity 5: Evaluation

Evaluation will be thoroughly examined in the Testing and Evaluation section of our report, where we'll delve into the outcomes and assess the effectiveness of the implemented strategies and methodologies.

Activity 6: Communication

Communication will be the focal point of our Discussions and Conclusions section, where we'll analyze the communication processes undertaken during the project and draw conclusions based on their effectiveness and impact.

Chapter 4

Implementation

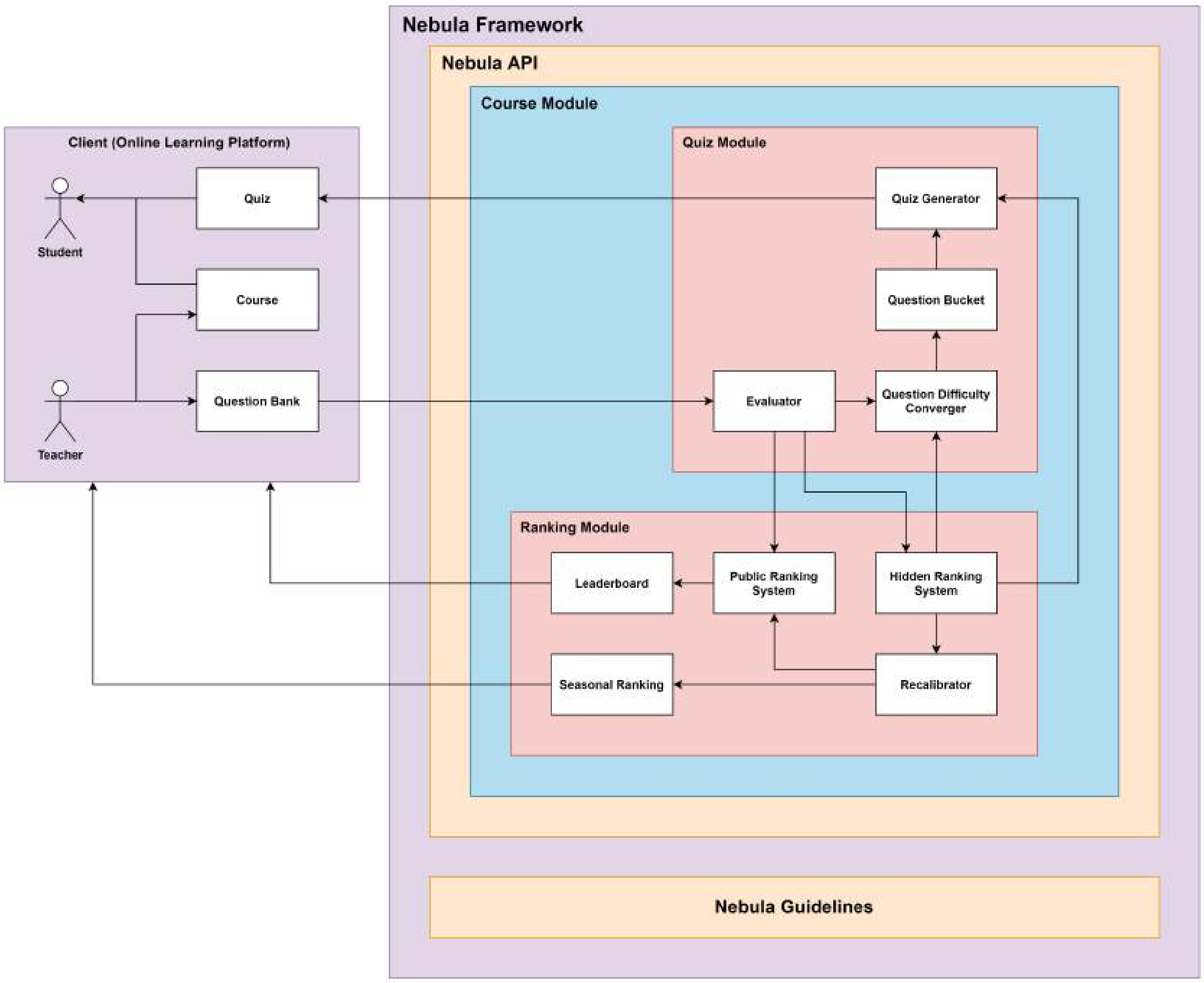

Figure 4.1: Boundaries of the Nebula Framework and Online Learning Platform

4.1 Online Learning Platform

The Nebula platform seamlessly integrates with an Online Learning Platform (Figure 4.1), facilitating a streamlined educational experience. Besides the integration, course instructors affiliated with the Online Learning Platform can publish their courses with a dedicated Question Bank tailored to each specific course (Figure 4.2) through the online learning platform.

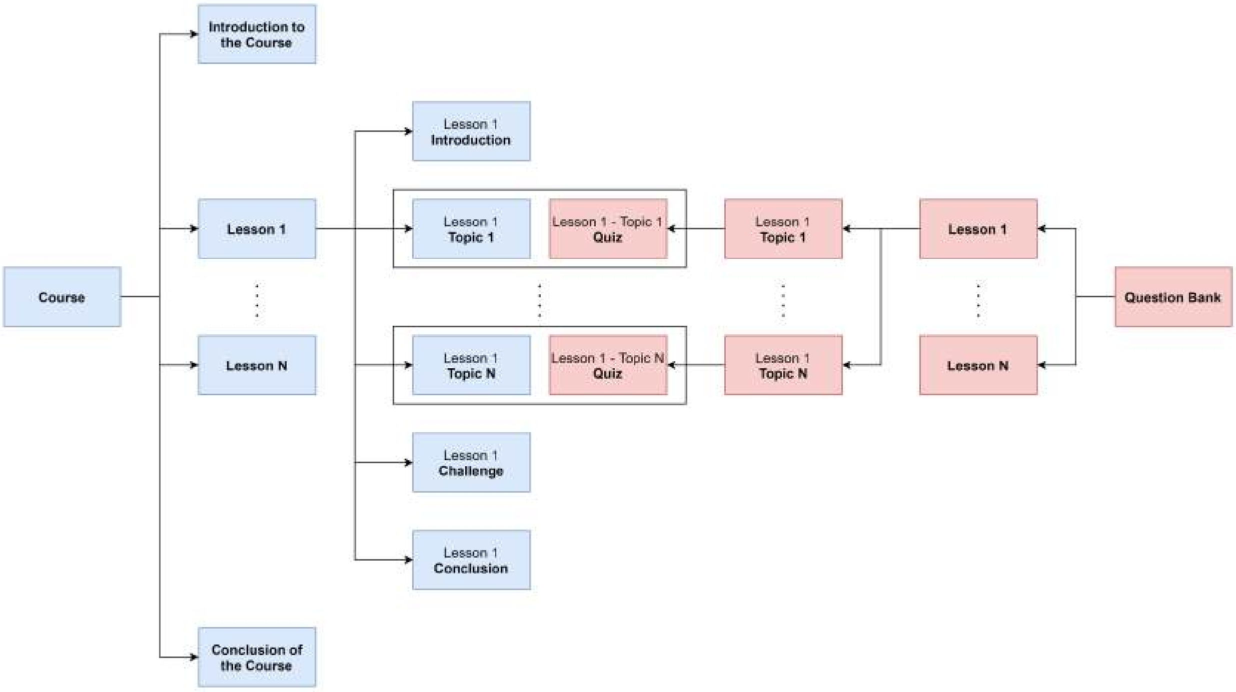

Figure 4.2: Structure of a Course and a Question Bank

4.1.1 Course

The Course is an external component supplied by instructors responsible for crafting eLearning courses. Instructors adhere to a prescribed structure provided by Nebula's recommended framework when creating courses. This structure, founded upon various guidelines detailed in subsequent sections, ensures coherence and effectiveness in course design, enhancing the overall learning experience for students.

Introduction to the Course

The Introduction to the Course section serves as a foundational element, commencing with an overview of the entire course. It unveils the comprehensive structure, outlining the roadmap of lessons and topics in sequential order. This initial exposition not only articulates the course's ultimate objective but also underscores its significance in the broader context of learning. Additionally, the Introduction encourages students by illustrating how the knowledge gained can be applied in real-world scenarios, fostering a practical understanding. Finally, it concludes with motivational words, wishing students good luck as they embark on their educational journey.

Lessons

In each lesson, the journey begins with an Introduction, setting the stage by outlining the lesson's scope and objectives while also situating students within the broader roadmap of the course. Emphasizing its pivotal role, this segment assures students of the support it offers in advancing towards the ultimate goal of the course while also extending words of encouragement for their endeavor.

Following the introduction, the lesson unfolds with a series of Topics, presenting core knowledge in both textual and video formats. Employing a narrative approach, these topics foster engagement through teacher-student dialogues and immersive perspectives, thereby establishing tangible connections to real-world applications. Multimedia artifacts such as tables, graphs, and images are extensively integrated to enhance content comprehension.

As students progress through the lesson, each topic is concluded by a corresponding Quiz designed to assess understanding and reinforce learning objectives. Detailed discussions regarding quizzes will be provided later.

Upon completing the last topic's quiz of a lesson, students are presented with a Challenge, a creative thinking problem that prompts them to apply acquired knowledge in novel scenarios. Encouraging open-ended exploration, these challenges foster independent thinking and problem-solving skills.

Concluding the lesson, a thoughtful Conclusion segment offers positive feedback and recognition of students' achievements, while also visualizing their progress within the course. Providing a clear segue, this segment directs students toward the next section of the course, instilling a sense of anticipation and continuity in their learning journey.

Conclusion of the Course

In the Conclusion of the Course section, students are warmly appreciated for their dedication and successful completion, marking a significant milestone in their educational journey. They are reminded of the valuable skills acquired throughout the course, empowering them with practical knowledge applicable to real-life scenarios. By illustrating the direct applications of their newfound expertise, students are encouraged to confidently utilize their skills beyond the classroom, bridging theory with real-world practice. Ultimately, this section reinforces their achievement of the course's ultimate goal, affirming their readiness to tackle challenges and contribute meaningfully in their chosen fields.

4.1.2 Question Bank

The Question Bank encompasses a comprehensive array of questions tailored to each lesson and topic within the course. These questions are categorized into three sub-levels of difficulty (Easy, Medium, and Hard) based on instructors' discernment. As students progress through the course and attempt quizzes following topic completion, the Nebula framework dynamically suggests a curated selection of questions from the extensive question bank. The methodology behind the framework's selection process will be discussed later.

4.2 The Nebula Framework

4.2.1 Guidelines

The Nebula Framework provides ten guidelines tailored to assist course module creators, serving as a valuable resource for instructors to craft course content. These guidelines ensure the creation of engaging and informative content and foster intrinsic motivation among students. By adhering to these guidelines, instructors can effectively structure their courses to inspire and captivate learners and enhance the educational experience.

1. Use both text and videos for teaching.
2. Explain the course's purpose and importance upfront.
3. Show how each section helps achieve the ultimate goal of the course.
4. Present content from the teacher's perspective.
5. Relate lessons to real-life situations.
6. Include pictures and videos to aid understanding.
7. Ask creative questions and explain the answers.
8. Give positive feedback at section completions.
9. Show students their progress to keep them motivated.
10. Ensure questions cover different levels of difficulties (thinking skills).

Underlying Theories

The guidelines within the Nebula Framework are grounded in five prominent theories of motivation: **Self-Determination Theory (SDT)** [65], **Daniel Pink's Theory of Motivation** [66], **McClelland's Human Motivation Theory** [67], **Flow Theory** [68], and **Motivation Crowding Theory** [69], **Bloom's Taxonomy** [70], a fundamental framework in educational psychology and instructional design. By integrating principles from these foundational theories and frameworks, the Nebula Framework provides instructors with a robust foundation to create course content that inspires and motivates learners effectively.

Self-Determination Theory (SDT), conceived by Edward L. Deci and Richard M. Ryan in the 1980s, delves into human motivation and personality development. SDT posits three fundamental psychological needs: **Autonomy**, **Competence**, and **Relatedness**.

- **Autonomy** involves the innate drive to control one's actions and decisions, rooted in feelings of freedom and independence.
- **Competence** entails the aspiration to master tasks and enhance skills, resulting in a sense of efficacy and self-assurance.
- **Relatedness** encompasses the yearning for meaningful social connections and a sense of belonging, nurturing feelings of camaraderie and support.

SDT asserts that when these needs are fulfilled, individuals are more inclined towards intrinsic motivation, wherein engagement in activities is driven by internal enjoyment and fulfillment rather than external rewards or pressures.

Daniel Pink's Theory of Motivation, as elucidated in his book "Drive: The Surprising Truth About What Motivates Us," posits that motivation is intricately linked to three core elements: **Autonomy**, **Mastery**, and **Purpose**.

- **Autonomy** reflects the desire for individuals to direct their own lives.
- **Mastery** entails the pursuit of improvement in areas of personal significance.
- **Purpose** involves working towards objectives greater than oneself.

Pink contends that when these three elements are present, individuals are more inclined towards intrinsic motivation and higher levels of engagement. Contrary to traditional carrot-and-stick approaches, which rely on extrinsic rewards and punishments, Pink's theory emphasizes the limitations of such methods, particularly in tasks requiring creativity and innovation. Instead, he advocates for fostering environments that nurture intrinsic motivation, creativity, and engagement within businesses and organizations.

McClelland's Human Motivation Theory, proposed by psychologist David McClelland, revolves around three core needs guiding human behavior: **Achievement**, **Affiliation**, and **Power**. According to this theory, individuals exhibit varying degrees of these needs, shaping their motivation and conduct across different contexts.

- **Achievement-oriented** individuals are driven by the pursuit of personal success and excellence in tasks.
- **Affiliation-motivated** individuals prioritize forming close relationships and fostering social connections.
- **Power-motivated** individuals seek to exert influence and control over others or situations.

This theory underscores the importance of recognizing these underlying needs to elucidate and forecast individual behavior within educational, occupational, and interpersonal realms.

Mihaly Csikszentmihalyi's Flow Theory posits that individuals reach their peak states of satisfaction and fulfillment when fully engrossed in an activity, characterized by deep concentration, complete engagement, and a sense of enjoyment. This **state of "flow"** emerges when the challenges of the task align harmoniously with the individual's skills, fostering a sensation of effortless action and intense focus. Flow experiences are linked to heightened productivity, creativity, and overall well-being. Within the flow state, time appears to stretch or contract, challenges feel manageable despite their difficulty, and individuals experience a blend of relaxation and intensity. Moreover, they become fully absorbed in the present moment, often losing awareness of their surroundings and sense of self. Five key factors contribute to the flow state: intrinsic reward in the task, clear goals and progress markers, immediate feedback, an appropriate challenge level matched to perceived skills, and unwavering focus on the present moment.

Motivation Crowding Theory posits that introducing external rewards or incentives for inherently motivated behaviors can potentially diminish intrinsic motivation, a phenomenon known as **"crowding out".** This theory suggests that offering extrinsic incentives for tasks driven by internal motivation may backfire, as the removal of incentives can lead to a subsequent decline in both motivation and performance. In essence, introducing external rewards may inadvertently undermine individuals' intrinsic drive, resulting in reduced enthusiasm and engagement with the activity once the external incentives are removed.

Bloom's Taxonomy, proposed by Benjamin Bloom, an educational psychologist at the University of Chicago in 1956, categorizes the outcomes and skills educators aim for in their students' learning journeys. Recently updated, it encompasses six levels of learning, offering a framework to structure learning outcomes, lessons, and assessments:

1. **Remembering**: Involves retrieving, recognizing, and recalling relevant knowledge from long-term memory.
2. **Understanding**: Requires constructing meaning from various sources through interpreting, exemplifying, summarizing, and explaining.
3. **Applying**: Involves executing or implementing learned procedures in practical contexts.
4. **Analysing**: This entails breaking down material into constituent parts and understanding their interrelationships.
5. **Evaluating**: Involves making judgments based on established criteria and standards.
6. **Creating**: Requires synthesizing elements to form new coherent structures or patterns.

This taxonomy operates hierarchically, meaning that attainment of higher-level skills is contingent upon mastery of foundational knowledge and skills at lower levels.

Guidelines Mapping with Underlying Theories

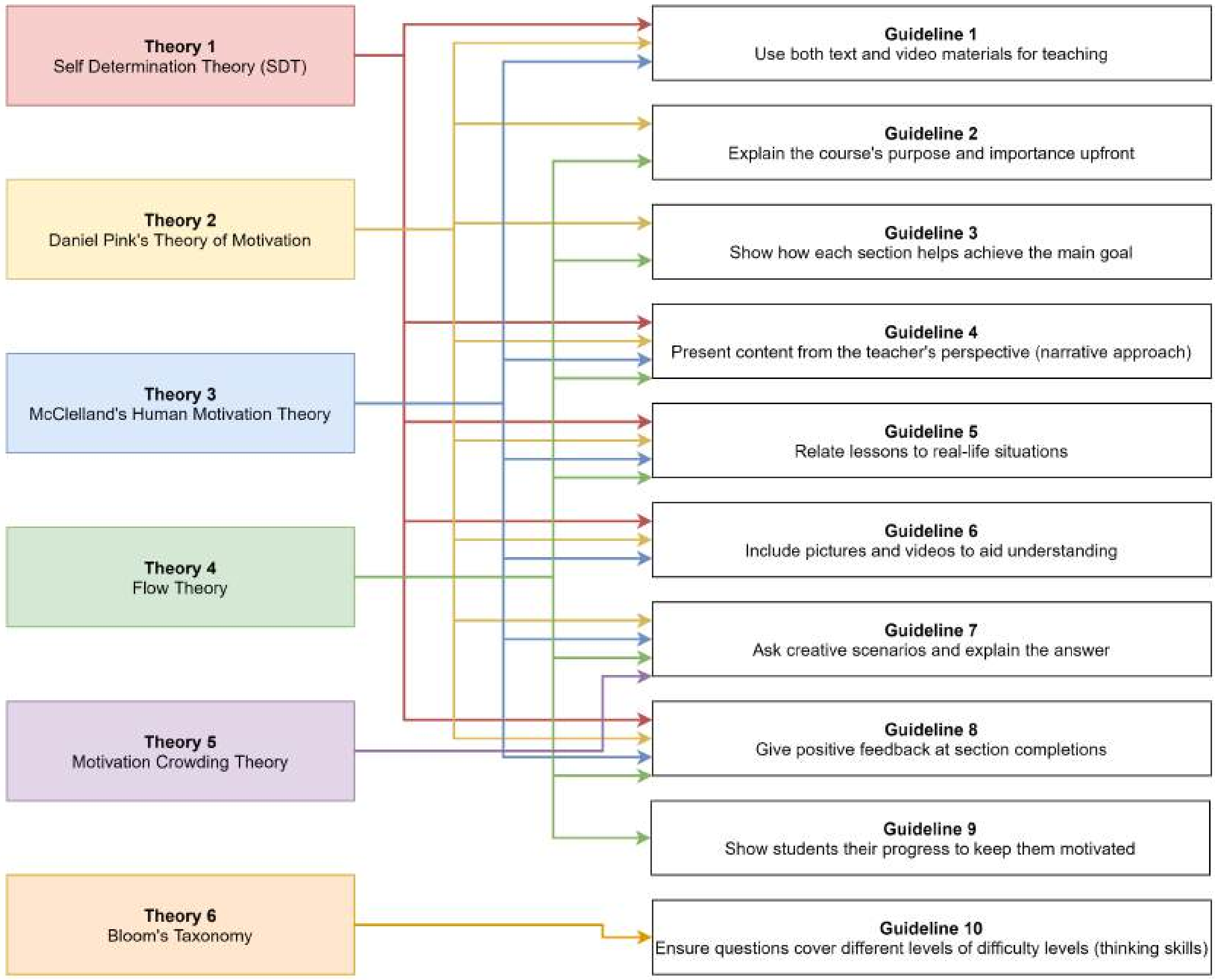

Figure 4.3: Guidelines Mapping with Underlying Theories

1. **Guideline 1: Use both text and video materials for teaching.**
    - **Self-Determination Theory**: This guideline aligns with the principles of Self-Determination Theory (SDT) by offering autonomy through material choice, and catering to individual learning preferences. Text materials support competence by allowing careful consideration, while videos engage visual and auditory learners. Both formats contribute to relatedness, connecting students through written discussions or visual interactions. The choice between text and video accommodates diverse learning styles, enhancing motivation and fostering a more personalized and engaging educational experience (Figure 4.3).

- **Daniel Pink's Theory of Motivation**: The recommendation to provide course materials in both text-based and video-based formats aligns with Daniel Pink's motivation theory, emphasizing autonomy, mastery, and purpose. Students can choose their preferred medium, fostering a more engaging and motivating learning experience. The implementation includes regular feedback and adjustments to optimize the balance between text and video content, creating a student-centric environment that promotes academic success (Figure 4.3).

- **McClelland's Theory of Motivation**: Presenting course materials in both text-based and video-based formats addresses the three primary needs highlighted by McClelland's Theory of Motivation—achievement, affiliation, and power. For the need for achievement (N-Ach), text-based materials suit those who prefer in-depth reading, while video content appeals to visual learners seeking diverse perspectives. Catering to the need for affiliation (N-Affil), text-based materials encourage personal reflection, while video content, especially collaborative discussions, fosters a sense of community. Addressing the need for power (N-Pow), text-based resources empower learners to take control, and video content, such as tutorials or expert interviews, provides authoritative insights (Figure 4.3).

2. **Guideline 2: Explain the course's purpose and importance upfront.**

   - **Daniel Pink's Theory of Motivation**: The guideline advising educators to explicitly state the ultimate objective of an online course and emphasize its significance from the beginning aligns with Daniel Pink's motivation theory, particularly the principle of purpose. By clarifying the broader goals and real-world applications, students gain a clear sense of why the course is valuable, addressing their need for meaningful objectives. Implementation includes a video introduction, a written overview, alignment with personal goals, and regular reinforcement to sustain motivation throughout the course (Figure 4.3).

   - **Flow Theory**: In the context of creating online courses, the guideline of clearly stating the course's ultimate objective and significance aligns with the Flow Theory. This guideline helps engage learners by providing a clear sense of purpose and relevance. Flow theory emphasizes that individuals are more likely to experience a state of flow when engaged in meaningful activities that balance challenge and skill. Articulating course objectives and significance contributes to this balance, fostering intrinsic motivation and creating an optimal learning environment. Practical implementation involves incorporating challenging yet achievable activities, providing regular feedback, and fostering a supportive online learning community (Figure 4.3).

3. **Guideline 3: Show how each section helps achieve the main goal.**
   - **Daniel Pink's Theory of Motivation**: The guideline recommends elucidating the connection between each lesson and the ultimate course goal at the beginning of each section in online courses, aligning with Daniel Pink's motivation theory, particularly the principle of purpose. By clearly demonstrating how individual lessons contribute to the broader objective, educators provide students with a sense of direction and purpose in their learning journey. Implementation involves starting lessons with relevant overviews, using visual aids, incorporating real-world examples, and including interactive activities to reinforce the connection between lessons and the course's ultimate goal (Figure 4.3).
   - **Flow Theory**: The guideline of explaining how each section supports the ultimate course goal in online learning aligns with Flow Theory. This practice provides a structured and purposeful learning experience, connecting each lesson to the overarching objective. By maintaining a balance between challenge and skill, enhancing intrinsic motivation, and establishing a clear feedback loop, this guideline promotes a more engaging and effective learning environment, fostering the conditions for flow (Figure 4.3).
4. **Guideline 4: Present content from the teacher's perspective (narrative approach).**
   - **Self-Determination Theory**: Constructing online course content with a narrative approach, including teacher-student dialogues and a first-person perspective, aligns with the principles of the Self-Determination Theory. This approach promotes autonomy by allowing students to engage deeply with real-world scenarios, supports competence through practical applications, fosters relatedness through personal perspectives, provides choice and variety, enhances motivation, encourages intrinsic motivation, and allows for personalization of the learning experience. Overall, it creates a more engaging and relatable learning environment that caters to individual learning styles and motivations (Figure 4.3).
   - **Daniel Pink's Theory of Motivation**: The guideline advises constructing online course content with a narrative approach, incorporating teacher-student dialogues and providing a first-person perspective. This approach aligns with Daniel Pink's motivation theory by promoting autonomy, purpose, and mastery. The narrative structure allows for a more personalized learning experience, enhancing student engagement and understanding. Implementation involves scenario-based learning, dialogue simulations, first-person perspectives, and storytelling videos to create a compelling and relatable educational experience (Figure 4.3).

- **McClelland's Theory of Motivation**: Constructing online course content with a narrative approach, teacher-student dialogues, and a first-person perspective aligns with McClelland's Theory of Motivation. This approach addresses the need for affiliation (N-Affil) by creating a sense of community through storytelling and the need for achievement (N-Ach) by providing real-world context and inspiring students to set and pursue their academic goals. In summary, incorporating these elements enhances engagement and relevance, catering to students' motivational needs in online learning (Figure 4.3).
- **Flow Theory**: Constructing online course content with a narrative approach, teacher-student dialogues, and a first-person perspective aligns with Flow Theory by enhancing engagement, providing clear goals and feedback, promoting immersion, balancing challenge and skill, and triggering intrinsic motivation. This narrative approach contributes to creating an optimal learning environment conducive to the flow state (Figure 4.3).

5. **Guideline 5: Relate lessons to real-life situations.**
   - **Self-Determination Theory**: Connecting course content to practical scenarios aligns with the Self-Determination Theory, promoting autonomy, enhancing competence, fostering relatedness, and cultivating intrinsic motivation. By showing the real-world relevance of learning, this guideline provides students with a more engaging and purposeful learning experience (Figure 4.3).
   - **Daniel Pink's Theory of Motivation**: Integrating practical scenarios that demonstrate real-world applications of course content in online courses aligns with Daniel Pink's motivation theory, addressing the need for purpose and mastery. Using case studies, simulations, and project-based assessments makes learning more relevant and applicable, enhancing student motivation and engagement (Figure 4.3).
   - **McClelland's Theory of Motivation**: Establishing real-world connections in online courses, particularly by applying content to practical scenarios, aligns with McClelland's Theory of Motivation, specifically addressing the need for achievement (N-Ach). By providing tangible contexts for learning and opportunities for problem-solving and application, this approach fosters a sense of accomplishment and motivates students to engage with course content (Figure 4.3).
   - **Flow Theory**: Establishing real-world connections in online courses by applying content to practical scenarios aligns with Flow Theory. This guideline enhances relevance, increases intrinsic motivation, and contributes to a dynamic and engaging learning environment conducive to the flow state (Figure 4.3).

6. **Guideline 6: Include pictures and videos to aid understanding.**
    - **Self-Determination Theory**: Integrating multimedia artifacts, like images, extensively in online courses aligns with Self-Determination Theory by supporting autonomy, enhancing competence, fostering relatedness, and promoting intrinsic motivation. Visual engagement accommodates diverse learning styles, clarifies complex concepts, connects abstract ideas to real-world examples, and provides choice and variety in learning modalities. Incorporating multimedia elements creates a more engaging and personalized learning experience (Figure 4.3).
    - **Daniel Pink's Theory of Motivation**: Advising the extensive integration of multimedia artifacts, such as images, into online course materials aligns with Daniel Pink's motivation theory by addressing the principles of mastery and autonomy. Multimedia elements visually stimulate learning, making complex concepts more understandable, and providing students with the autonomy to choose their preferred mode of engagement. Using infographics, video tutorials, and interactive images enhances content comprehension and creates a visually engaging and personalized learning experience (Figure 4.3).
    - **McClelland's Theory of Motivation**: Integrating multimedia artifacts, particularly images, in online courses aligns with McClelland's Theory of Motivation by enhancing comprehension and engagement through visual learning. For individuals with a high need for power, multimedia artifacts convey authority and impact, providing visual demonstrations that contribute to a dynamic and motivating online learning experience. The strategic use of images caters to the diverse motivational needs of learners (Figure 4.3).
7. **Guideline 7: Ask creative scenarios and explain the answers.**
    - **Daniel Pink's Theory of Motivation**: The guideline suggests incorporating creative thinking problems with explanations in each section of online courses to enhance student motivation and engagement. This aligns with Daniel Pink's motivation theory by addressing the principles of mastery, autonomy, and purpose. Creative problems encourage students to apply their knowledge, providing autonomy in their approach, and demonstrating real-world relevance, fostering a sense of purpose in learning. Implementation involves scenario-based problems, detailed explanations, collaborative problem-solving, and integration with real-world examples to create a fulfilling and motivating learning experience (Figure 4.3).
    - **Motivation Crowding Theory**: Providing extrinsic incentives for accomplishing certain intrinsically motivating tasks can undermine intrinsic motivation, leading to a drop in both motivation and performance once the incentive is removed (Motivation crowding out) (Figure 4.3).

- **McClelland's Theory of Motivation**: Including creative thinking problems with explanations in online courses aligns with McClelland's Theory of Motivation by catering to the need for achievement. This approach provides challenging tasks, stimulates goal orientation, and offers feedback for a sense of accomplishment. Additionally, it addresses the need for power by empowering learners to showcase their problem-solving expertise, fostering a sense of authority and recognition (Figure 4.3).
- **Flow Theory**: Including creative thinking problems with explanations in each section of an online course aligns with Flow Theory. This guideline promotes a balance between challenge and skill, encourages active engagement, fosters intrinsic motivation, provides immediate feedback, and enhances the overall learning experience. These elements contribute to creating an optimal environment for the flow state in online learning (Figure 4.3).

8. **Guideline 8: Give positive feedback at section completions.**
   - **Self-Determination Theory**: Providing positive and encouraging feedback upon the completion of a section in online courses aligns with Self-Determination Theory. This guideline supports autonomy by recognizing progress, enhancing competence by reinforcing skills, fostering relatedness through positive connections with instructors, and motivating students through positive reinforcement, contributing to intrinsic motivation and meaningful learning experiences (Figure 4.3).
   - **Daniel Pink's Theory of Motivation**: The guideline recommends providing positive and encouraging feedback upon the completion of each section in online courses to enhance student motivation and engagement. Personalized feedback acknowledges efforts, reinforces progress, and connects completion to a sense of accomplishment and larger educational goals, aligning with the principles of autonomy, mastery, and purpose (Figure 4.3).
   - **McClelland's Theory of Motivation**: Offering positive feedback upon section completion aligns with McClelland's Theory of Motivation by recognizing learners' success, motivating further efforts, and fostering positive social connections and instructor-student relationships, addressing the needs for achievement and affiliation (Figure 4.3).
   - **Flow Theory**: Offering positive feedback upon section completion aligns with Flow Theory by fostering a sense of accomplishment, maintaining motivation, providing a clear feedback loop, enhancing intrinsic motivation, and promoting a positive learning environment conducive to the flow state in online learning (Figure 4.3).

9. **Guideline 9: Show students their progress to keep them motivated.**
   - **Flow Theory**: Visualizing a student's progress throughout an online course aligns with Flow Theory by providing clear goals, facilitating feedback, maintaining the balance between challenge and skill, enhancing intrinsic motivation, and contributing to a positive learning experience. This approach creates an environment conducive to the flow state of online learning (Figure 4.3).
10. **Guideline 10: Ensure questions cover different levels of difficulty (thinking skills).**
    - **Easy (Knowledge and Comprehension)**: Test basic knowledge and understanding by mainly focusing on recall and comprehension. Questions should include definitions, facts, examples, and summarizations (Figure 4.3).
    - **Medium (Application and Analysis)**: Challenge students to apply and analyze information by requiring them to apply concepts to real-world scenarios and analyze causes, steps, or differences between concepts. Distractors should reflect common misconceptions related to the topic (Figure 4.3).
    - **Hard (Synthesis and Evaluation)**: Require synthesis and evaluation by involving higher-order thinking skills such as evaluating, synthesizing, and justifying. Questions should prompt students to create new solutions, hypotheses, or arguments while evaluating strengths and weaknesses or the effectiveness of strategies. Distractors should reflect plausible but incorrect choices, mirroring real-world problem-solving situations (Figure 4.3).

4.2.2 Nebula API (Application Program Interface)

The Nebula API serves as the central component of the Nebula framework, facilitating the rapid development and integration of gamification elements aimed at enhancing both engagement and retention within educational contexts. This API comprises three major components (Figure 4.4).

1. Course Module
2. Quiz Module
3. Ranking Module

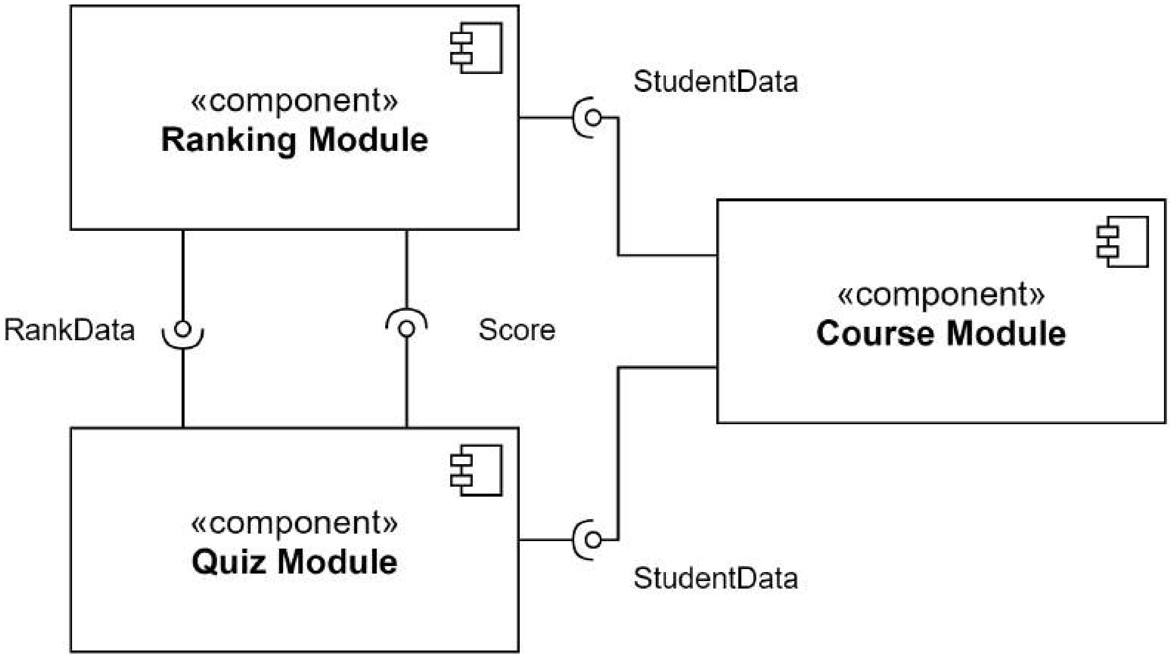

Figure 4.4: Main Components of the Nebula API

Course Module

The course module functions as a composite component within the system, amalgamating both the Quiz and Rank modules to deliver comprehensive functionality across the platform.

Quiz Module

The Quiz module encompasses three primary processes.

1. Quiz Generation Process
2. Evaluator Process
3. Question Difficulty Converging Process

The **quiz generation process** (Figure 4.5) initiates with the course instructor compiling a collection of **3n** questions, comprising **3 sets of n easy, medium, and hard questions** respectively. This assortment serves as the basis for creating a quiz containing n questions. The question selection process for a quiz involves two stages:

1. Initially, a portion of the questions, specifically **30%**, is chosen based on the **number of attempts** each question has received, prioritizing those requiring more attention or clarification.
2. Subsequently, the rest of the **70%** of questions are selected, considering both their **difficulty level** and the **performance history** of the user requesting the quiz, typically a student.

In the context of student question selection, questions are allocated based on the student's percentile rank. This rank is determined by sorting all students' ranks and assigning questions according to the following scheme:

- If the percentile rank is between **0 and 33 (percentile 1)**, there is a high likelihood of receiving **easy** questions.
- If the percentile rank is between **33 and 66 (percentile 2)**, there is a high likelihood of receiving **medium-difficulty** questions.
- If the percentile rank is between **66 and 100 (percentile 3)**, there is a high likelihood of receiving **hard** questions.

Ultimately, the generated quiz is dispatched to the user for completion.

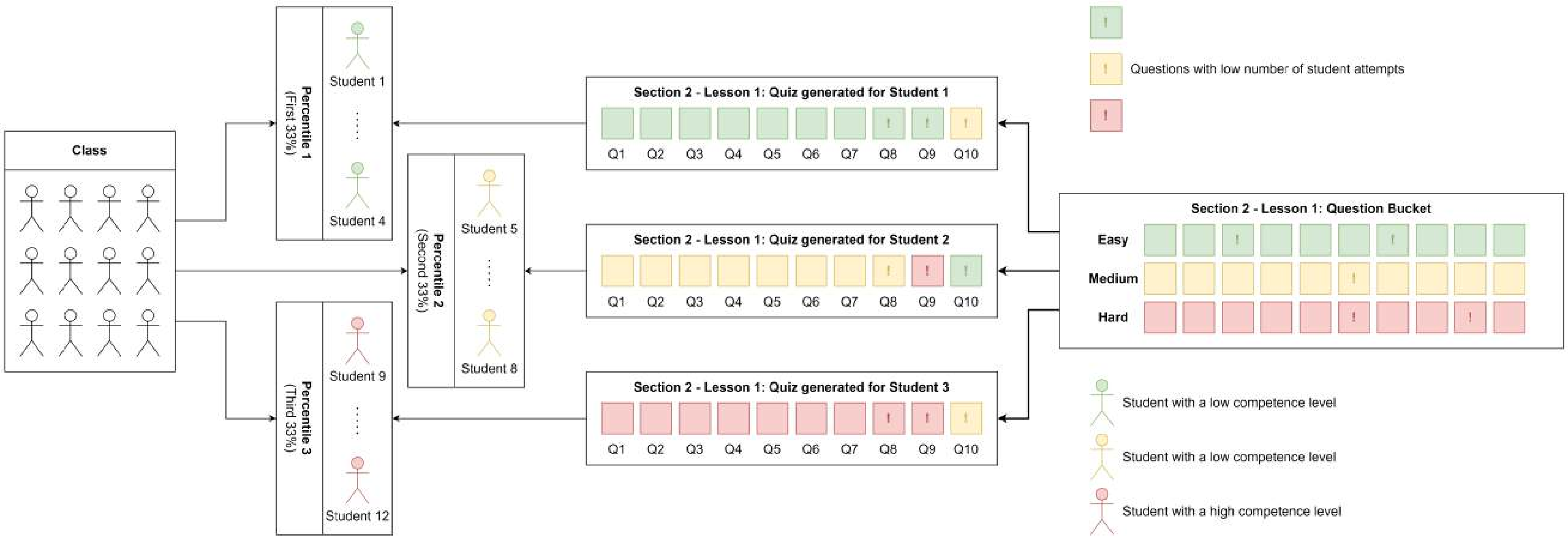

Figure 4.5: Quiz Generation Process

The **evaluation process** commences with the receipt of a completed quiz from the user, initiating a two-part evaluation procedure.

- **Calculating the Hidden Rank**
  - In the evaluation process, the hidden rank is calculated based on the correctness of the answers of the user (student). This mechanism introduces a dynamic element by attributing negative marks for incorrect answers, discouraging guesswork, and incentivizing accuracy. Marks for correct answers are determined by the difficulty level of the questions. **Easy questions** earn students **5 marks**, **medium questions** yield **10 marks**, and **hard questions** result in **15 marks**, ensuring appropriate rewards for mastery across different difficulty levels. In the hidden rank calculation, deductions for incorrect answers vary based on question difficulty. For **easy questions**, a substantial deduction of **15 marks** is applied, while **medium-difficulty questions** incur a moderate deduction of **10 marks**. **Hard questions** have a minimal deduction of only **5 marks**. This approach acknowledges the challenge of harder questions and provides a balanced deduction structure that reflects their difficulty level (Figure 4.6).
- **Calculating the Public Rank**
  - In the calculation of the public rank, marks are awarded only for correct answers, without any deduction for incorrect ones. Each **correct answer** carries a default weight of **10 marks**. Unlike the hidden rank, the public rank does not consider the difficulty level of the questions. Therefore, the public rank provides an accurate reflection of a student's question-answering accuracy based solely on the number of correct responses. For example, if a student answers 3 out of 5 questions correctly, they would receive a total score of 30 marks in the public rank assessment. This contrasts with the hidden rank system, where the outcome may vary based on the difficulty level of the questions answered correctly (Figure 4.6).

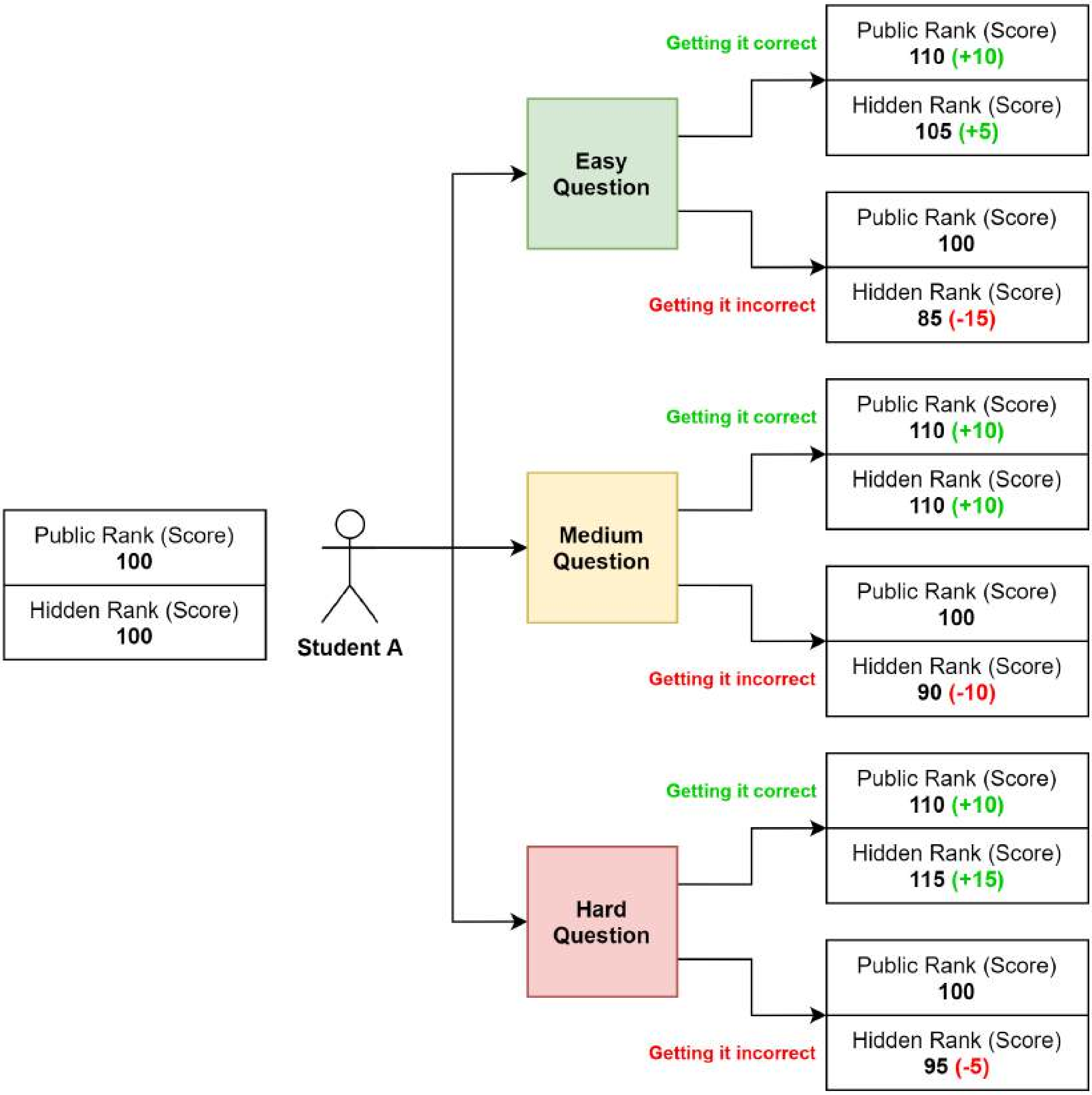

Figure 4.6: Calculating the Public Rank and Hidden Rank

The initial difficulty of questions is determined by dividing the scale of **0 to 1500** into three percentiles (Figure 4.7), representing **easy**, **medium**, and **hard** ranges. The midpoints of these percentiles serve as the initial difficulty levels for easy, medium, and hard questions. This approach ensures that questions are categorized into appropriate difficulty levels based on their position within the overall difficulty scale.

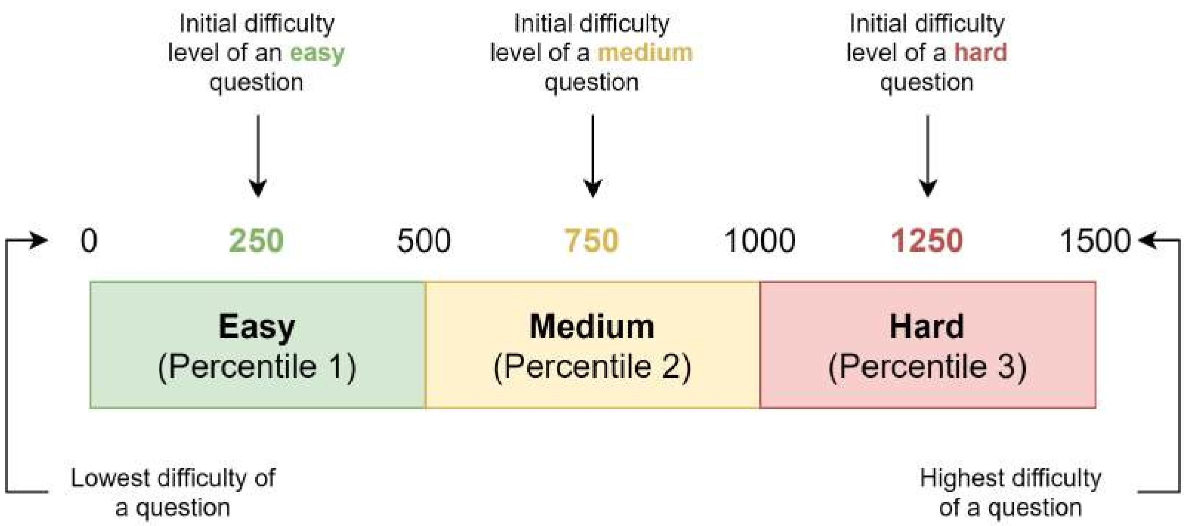

Figure 4.7: Difficulty Range of Questions

Converging the difficulty of a question involves adjusting its difficulty level based on the student's response while ensuring it remains within the defined range. Here's how it works:

- **Correct Answer**: If the student answers the question correctly, the difficulty of that question should be decreased. This adjustment reflects that the question may have been too easy for the student.
- **Incorrect Answer**: Conversely, if the student answers the question incorrectly, the difficulty of that question should be increased. This adjustment indicates that the question may have been too difficult for the student.
- **Range Limitation**: However, the difficulty of a question should not exceed the defined range, which in this case is between 0 and 1500. This constraint ensures that the difficulty remains within acceptable bounds.
- **Maximum Attempts**: Each question has a maximum number of attempts equal to the number of enrolled students in the course. This ensures that every student has the opportunity to attempt the question at least once, while also preventing excessive repetition of the same question for any individual student.

Suppose a question is initially categorized as easy by the instructor, resulting in an initial difficulty of 250. If there are 50 enrolled students for the course, the question's difficulty convergence will be based on two worst-case scenarios:

- In **Scenario 1**, where all 50 students correctly answer the question, the difficulty should converge from 250 to 0 (Figure 4.8).
- Conversely, in **Scenario 2**, where all 50 students answer the question incorrectly, the difficulty should converge from 250 to 1500 (Figure 4.8).

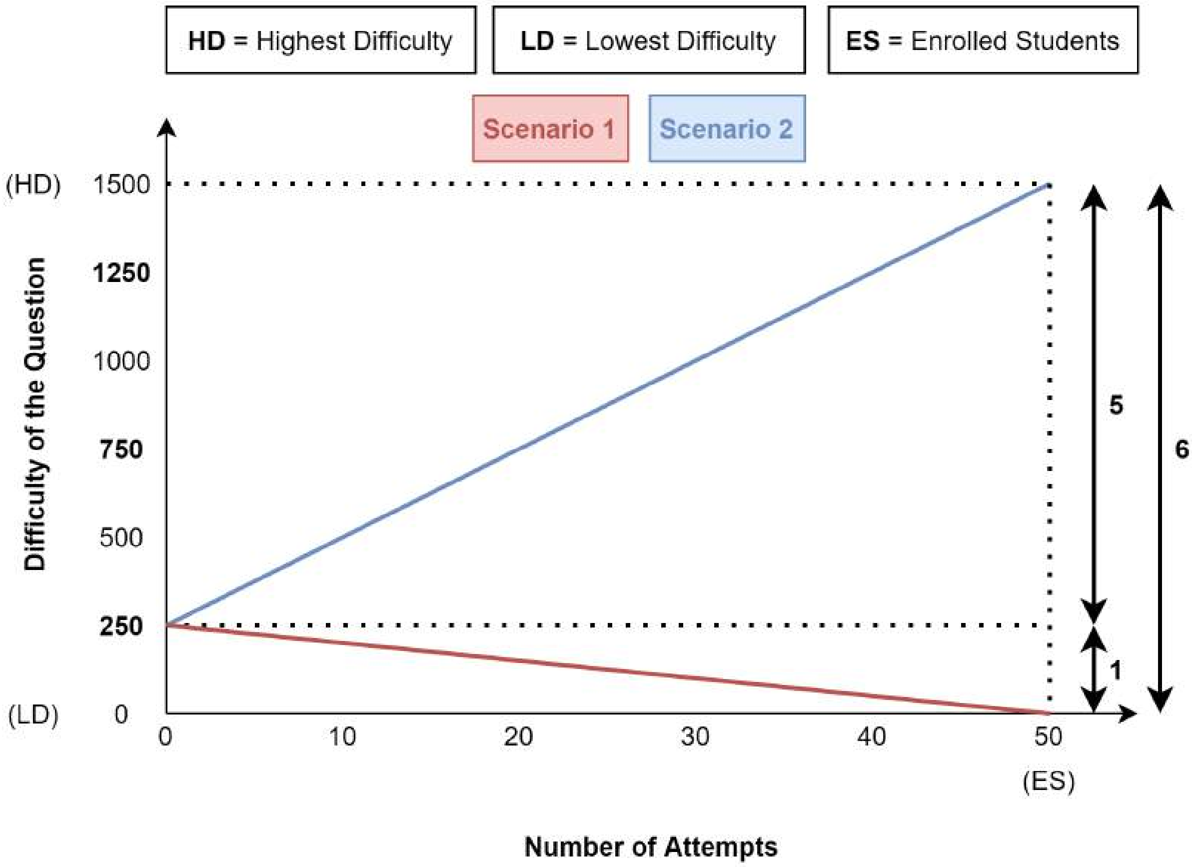

Figure 4.8: Worst-case Scenarios for an Easy Question

In Scenario 1, where all 50 students correctly answer the question, the difficulty of the question should decrease by 250 points, which is equivalent to $1500*(1/6)$. This convergence of decreasing 250 points should occur within 50 attempts, resulting in a decrease of 5 points for each attempt $(250/50 = 5)$. To calculate the number of points that need to be decreased in each attempt, we can use the formula $1500*(1/6)*(1/50)$, where HD represents the highest difficulty (1500), LD represents the lowest difficulty (0), and ES represents the number of enrolled students (50). Thus, the formula to calculate the updated difficulty (UD) of a question based on the previous difficulty (PD) and the number of points that need to be decreased in an attempt if a student answered the question correctly is:

$$UD = PD - [(HD - LD) * (1/6) * (1/ES)]$$

In Scenario 2, where all 50 students incorrectly answer the question, the difficulty of the question should increase by 1250 points, which is $1500*(5/6)$. This convergence of increasing 1250 points should occur within 50 attempts, resulting in an increase of 25 points for each attempt ($1250/50 = 25$). To calculate the number of points that need to be increased in each attempt, we can use the formula $1500*(5/6)*(1/50)$, where HD represents the highest difficulty (1500), LD represents the lowest difficulty (0), and ES represents the number of enrolled students (50). Thus, the formula to calculate the updated difficulty (UD) of a question based on the previous difficulty (PD) and the number of points that need to be increased in an attempt if a student answered the question incorrectly is:

$$UD = PD + [(HD - LD) * (5/6) * (1/ES)]$$

For a medium-difficulty question (Figure 4.9), the formulas to calculate the updated difficulty of the question after an attempt are as follows:

- If the answer is correct: $UD = PD - [(HD - LD) * (3/6) * (1/ES)]$
- If the answer is incorrect: $UD = PD + [(HD - LD) * (3/6) * (1/ES)]$

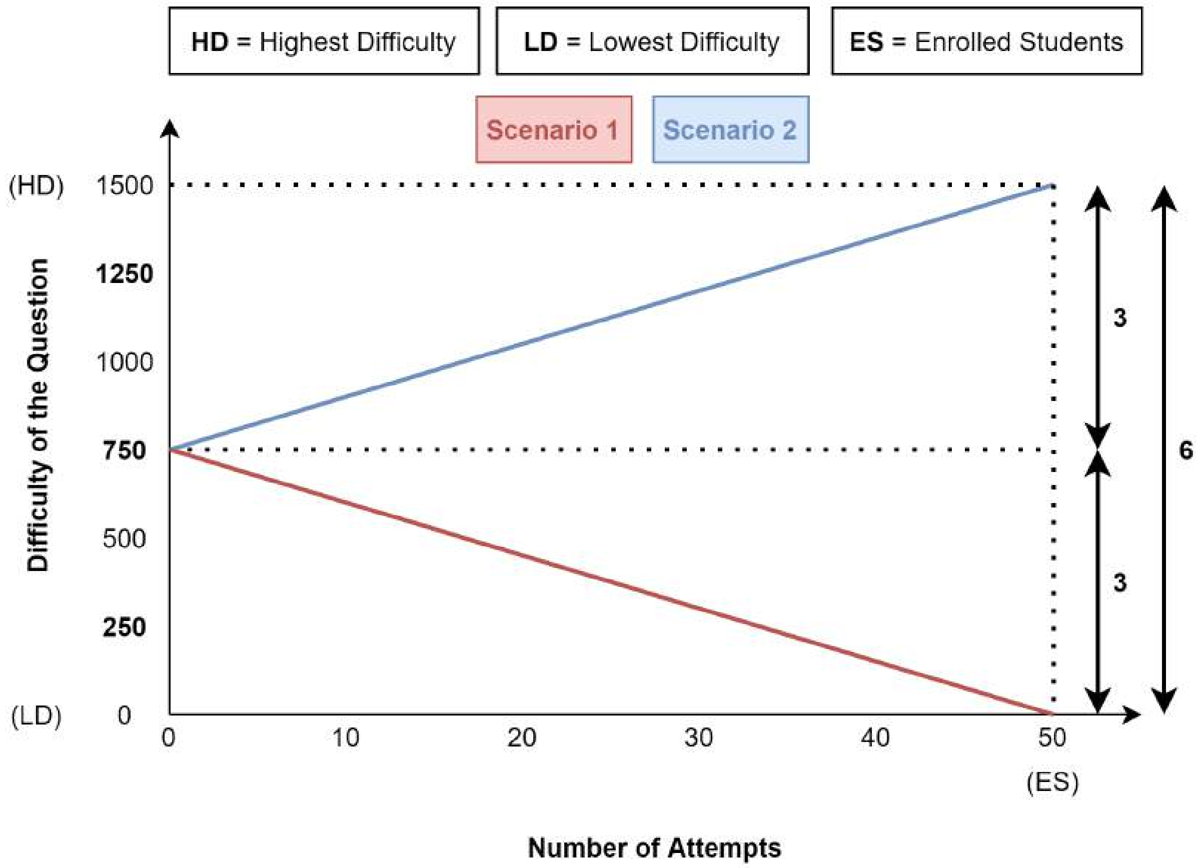

Figure 4.9: Worst-case Scenarios for a Medium Question

For a hard question (Figure 4.10), the formulas to calculate the updated difficulty of the question after an attempt are as follows:

- If the answer is correct: $UD = PD - [(HD - LD) * (5/6) * (1/ES)]$
- If the answer is incorrect: $UD = PD + [(HD - LD) * (1/6) * (1/ES)]$

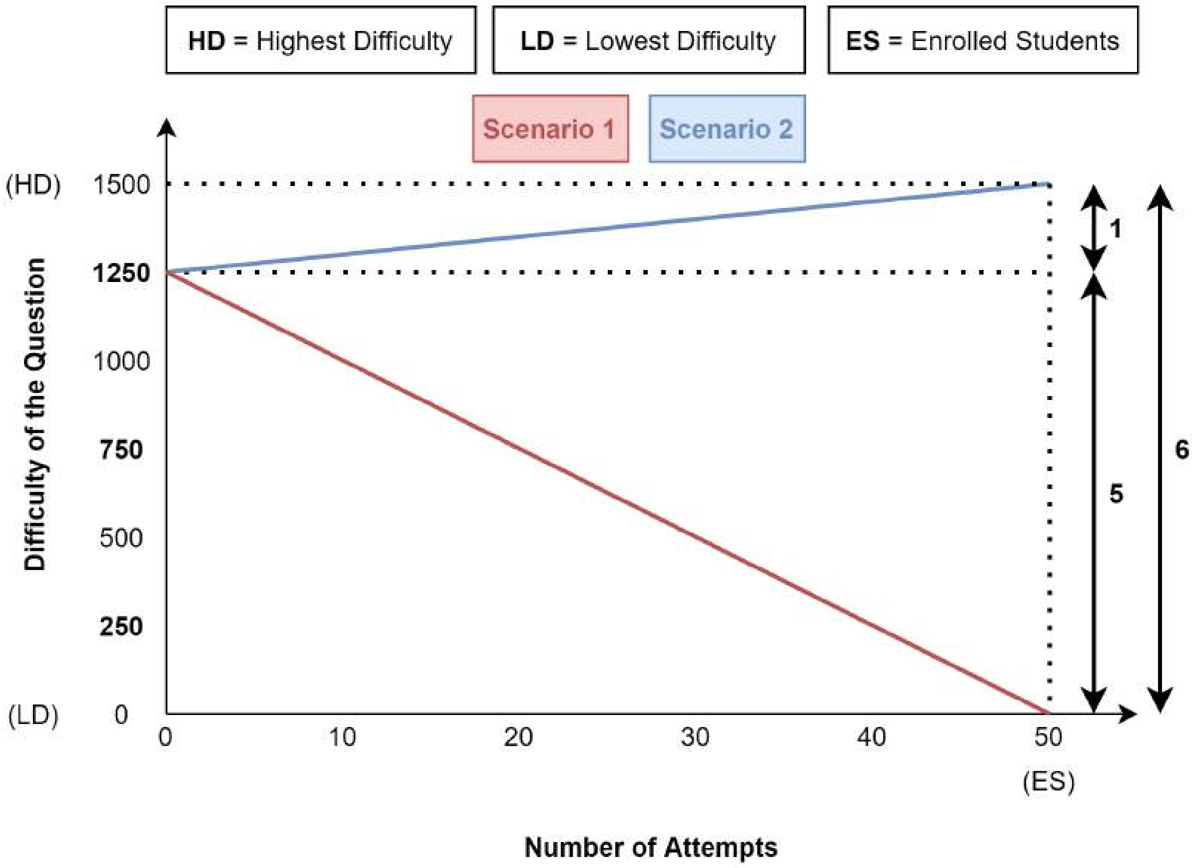

Figure 4.10: Worst-case Scenarios for a Hard Question

Based on the scenarios described, we can create a common formula to calculate the updated difficulty (UD) of a question after a student attempt:

$$UD = PD - A * [(HD - LD) * (F/6) * (1/ES)]$$

If the answer is correct, $A = +1$. If the answer is incorrect, $A = -1$. The factor F can be derived from Table 4.1.

Table 4.1: Deciding the Factor (F)

Answer (A)	**Initial Difficulty Level of the Question**	**Factor (F)**
Correct (+1)	Easy (250)	1
	Medium (750)	3
	Hard (1250)	5
Incorrect (-1)	Easy (250)	5
	Medium (750)	3
	Hard (1250)	1

The formula we derived is robust enough to handle both the worst-case scenarios and the normal-case scenarios. In real-world scenarios, it's common for students to provide a mix of correct and incorrect answers during their attempts. The formula adjusts the difficulty of the question accordingly after each attempt, ensuring that it converges towards an appropriate level based on the student's performance over time.

Ranking Module

The Ranking module encompasses two primary processes:

1. Leaderboard Generation Process
2. Recalibration Process

The **leaderboard generation process** in Nebula is pivotal for fostering a competitive atmosphere among students, thereby promoting extrinsic motivation and incentivizing performance improvement. The leaderboard showcases students' ranks based on their current public ranking, which reflects their accuracy in quizzes. By providing a visual representation of student standings, the leaderboard stimulates healthy competition and encourages individuals to strive for higher ranks. This process not only adds an element of excitement to the learning environment but also instills a sense of achievement as students work towards improving their positions on the leaderboard. Overall, the leaderboard generation process serves as a powerful tool for driving engagement and enhancing student performance within the educational platform.

The **recalibration process** in Nebula introduces the concept of seasonal ranking, which ensures the sustainability of a competitive environment over time. To implement this process, tutors divide their course content into discrete sections known as **"seasons"** (Figure 4.11). After each season, students who have actively participated in the course by submitting at least one quiz undergo a recalibration of their rank. During this recalibration process, students' ranks are reevaluated based on their hidden rank, which considers factors such as question difficulty and answer accuracy. The newly assigned ranks take effect at the beginning of the subsequent season, allowing students to continuously strive for improvement and maintain their competitive edge within the educational platform.

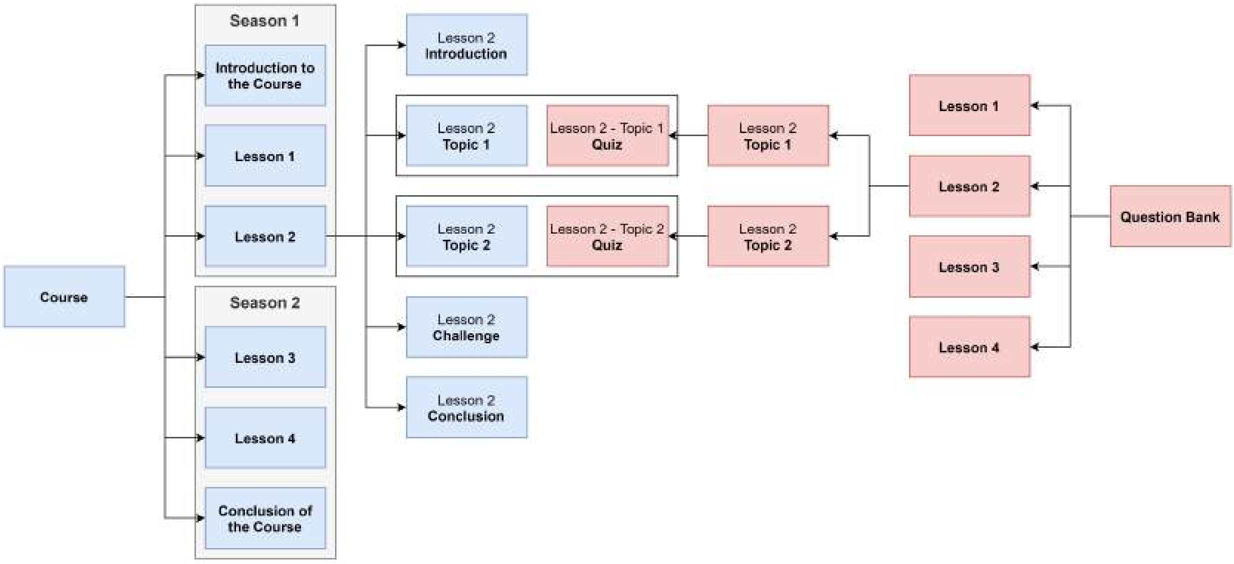

Figure 4.11: Dividing a Course Into Multiple Seasons

The recalibration process aims to enhance the accuracy of students' rank positions by considering their hidden ranks. This adjustment involves transforming rank positions into a standard normal distribution, which spans the range between the minimum and maximum public rank scores. After the course, this distribution range is **recalibrated** to match the minimum and maximum possible public rank scores for the entire course. To execute this process, the distribution range is divided into segments, with the specific number determined by the number of enrolled students. If the student count exceeds 50, the number of segments is set to $6 * n + 1$, where n is equal to 2; otherwise, it is set to $6 * n + 1$. For instance, with 60 students, there would be 13 ranges ($n = 2$). Next, the student count is assigned to these ranges to conform to a bell curve distribution. For example, with 60 students, the distribution might appear as follows: $[1, 2, 3, 4, 6, 8, 12, 8, 6, 4, 3, 2, 1]$. This distribution ensures that approximately 68% of students fall within the first 2 ranges from the middle to both ends, while 95% will fall within the first 4 ranges. This approach aligns student rankings with the Empirical rule (68, 95, 99.7), facilitating a more accurate representation of their performance within the educational platform.

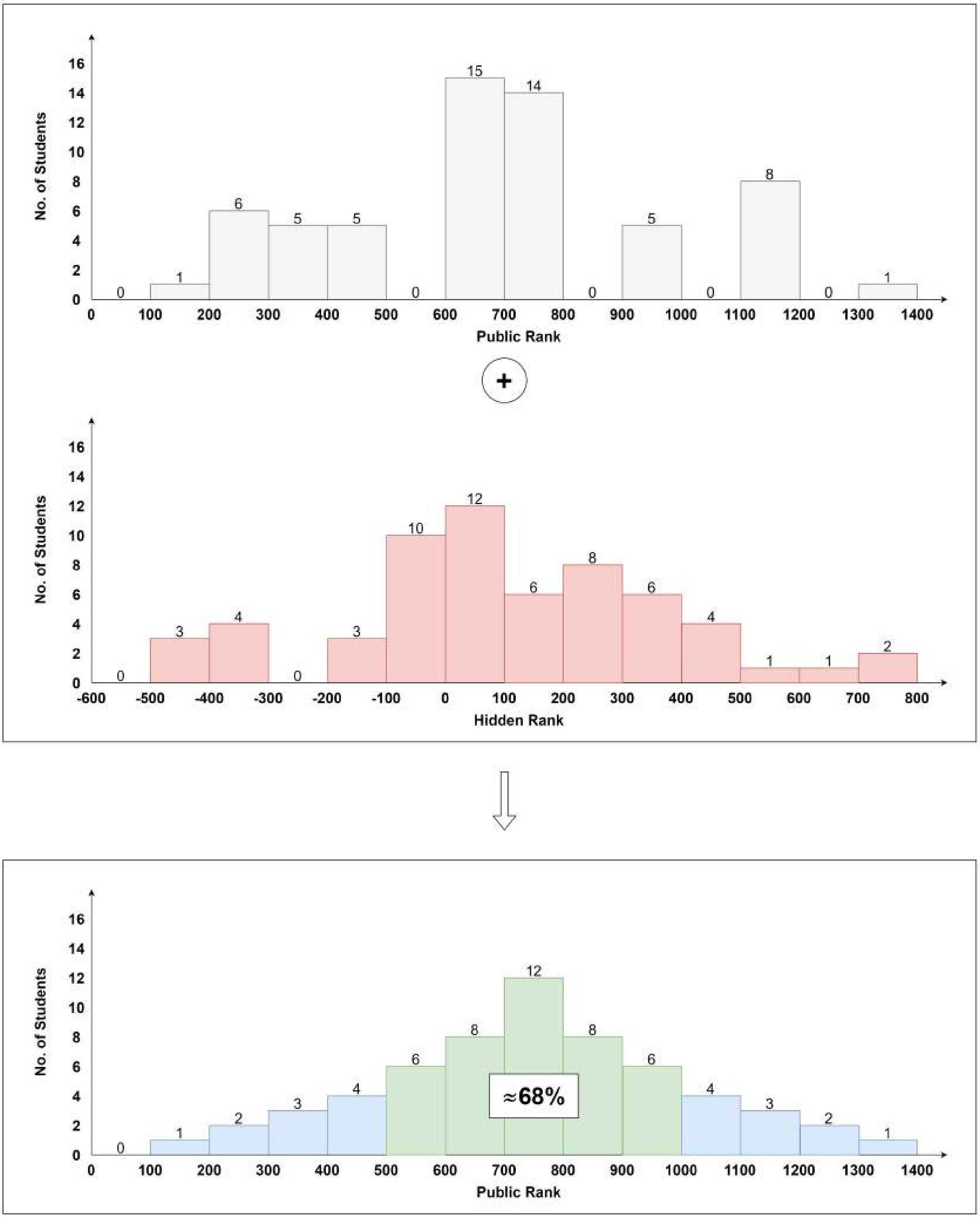

Figure 4.12: Distribution of the Public Ranks Before and After Recalibration

The **Empirical Rule** provides valuable insights into the distribution of values within a dataset, emphasizing the concentration of data points around the mean. This rule states that approximately 68% of values fall within one standard deviation of the mean (Figure 4.12), about 95% fall within two standard deviations, and nearly all—about 99.7%—fall within three standard deviations. In the context of Nebula's recalibration process, the determination of rank ranges is crucial for accurately reflecting student performance.

- At the **end of a season**, the range of values is calculated based on the maximum (MaxPRA) and minimum (MinPRA) public ranks achieved by students, divided by the number of ranges (R).

$$(MaxPRA - MinPRA)/R$$

- At the **end of the course**, the range of values is calculated based on the maximum (MaxPR) and minimum public (MinPR) ranks that can achieved by students, divided by the number of ranges (R).

$$(MaxPR - MinPR)/R$$

Once the rank ranges are established, the generation of scores follows a standardized procedure. For example, with a predefined set of student range values (e.g., [1, 2, 3, 4, 6, 8, 12, 8, 6, 4, 3, 2, 1]) and a specified range of values (e.g., 100-1400) divided into 13 ranges, the interval for each range is computed. Subsequently, random public ranks are generated within each range, ensuring representation across the entire distribution. After generating public ranks for each range, they are sorted in ascending order, along with students based on their hidden ranks. Finally, the newly generated public ranks are assigned to each student who actively participated in the season, aligning with their respective hidden ranks. By adhering to these standardized procedures, Nebula maintains a continuous competitive environment throughout the course, ensuring that students' true performance is accurately reflected by their hidden ranks. This approach fosters motivation and engagement while providing a fair and transparent assessment of student achievements within the educational platform.

Chapter 5

Results and Evaluation

5.1 Onboarding

Table 5.1: Second Iteration Student Onboarding Statistics

Student Group	**No. of Students Signed-up for the Research**	**No. of Students Created Accounts (Registered) in the Online Learning Platform**
Student Group 1 (Controlled)	59	59 (100%)
Student Group 2 (Experimental)	53	38 (71.69%)

During the onboarding process, all 59 students in the gamified group successfully signed up for the study, resulting in a 100% joining rate. Conversely, in the non-gamified group, out of the initial 53 students who completed the pre-test, only 38 proceeded to register on the platform, indicating a joining rate of 71.69% (Table 5.1).

While this discrepancy in participation rates between the two groups is notable, it's important to recognize that factors influencing students' decisions to register may extend beyond the scope of this research study. Various personal, logistical, or circumstantial reasons could contribute to students opting out of platform registration despite initially engaging with the pre-test.

Given the primary focus of this study on evaluating the impact of gamification elements on student motivation and engagement, the analysis and interpretations will primarily consider the number of participants who successfully signed up for the platform. This approach ensures a more accurate assessment of the effects of gamification on learning outcomes while acknowledging the complexities surrounding student participation in online learning environments.

5.2 Results

5.2.1 Video Views

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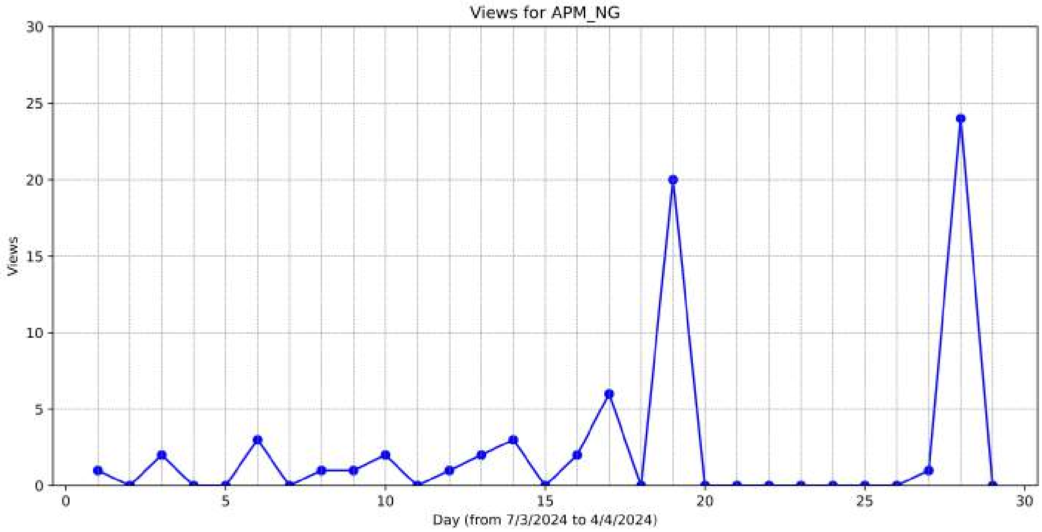
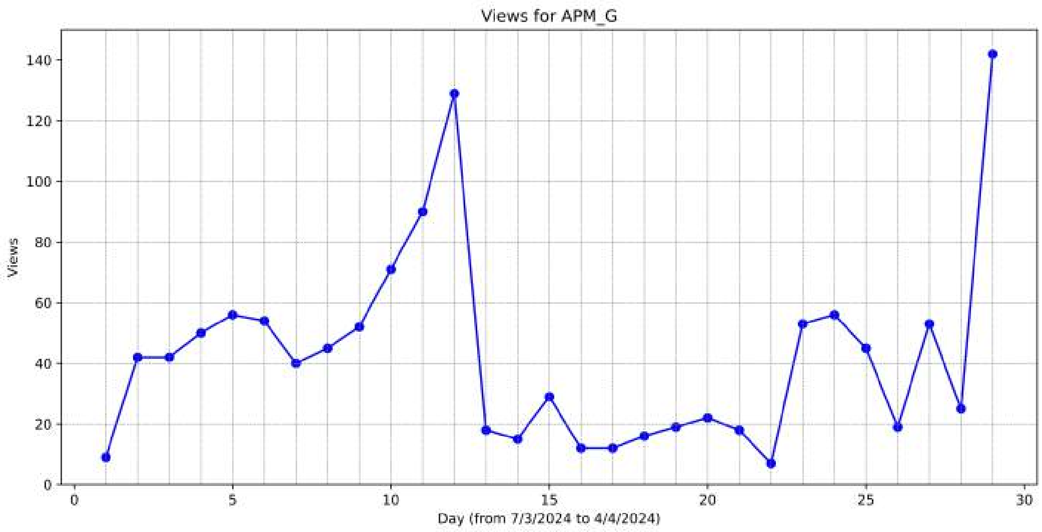


Day	Views
1	1
2	0
3	2
4	0
5	0
6	3
7	0
8	1
9	1
10	2
11	0
12	1
13	2
14	3
15	0
16	2
17	6
18	0
19	20
20	0
21	0
22	0
23	0
24	0
25	0
26	0
27	1
28	24
29	0

Figure 5.1: Views for APM-NG

In the non-gamified course, which included 38 students, video views remained consistently low throughout the study period. While there were occasional spikes in views, such as on days 19 and 28, with 20 and 24 views respectively, these peaks accounted for a minority (¡50%) of the total student population. On average, less than 10% of students engaged with the video content daily, and most days saw views remaining under 5 per day (Figure 5.1).

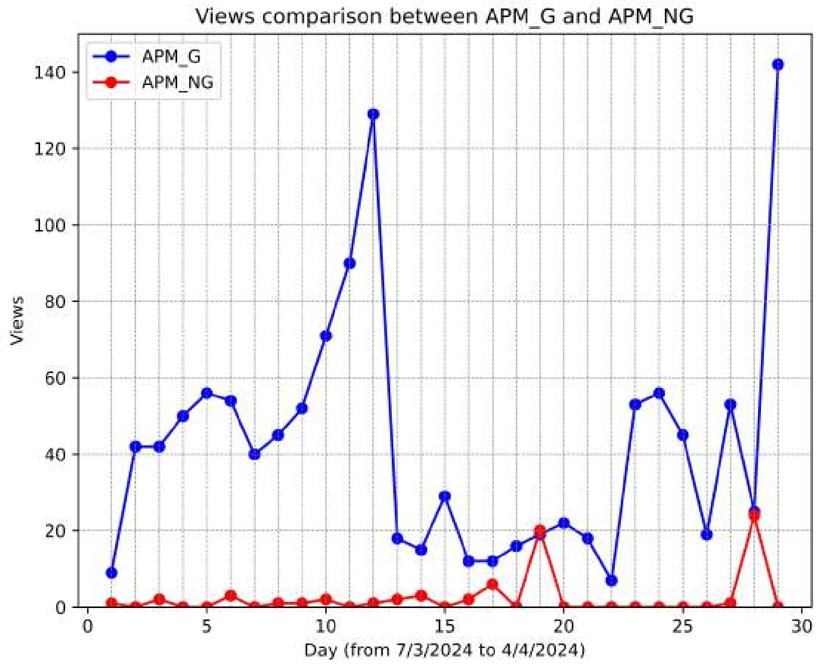


Day	Views
1	9
2	42
3	42
4	50
5	56
6	54
7	40
8	45
9	52
10	71
11	90
12	129
13	18
14	15
15	29
16	12
17	12
18	16
19	19
20	22
21	18
22	7
23	53
24	56
25	45
26	19
27	53
28	25
29	142

Figure 5.2: Views for APM-G

In contrast, the gamified version exhibited significantly higher levels of engagement. With an average of 42.7 views per day and an average student engagement rate of approximately 72%, the gamified approach proved to be more effective in capturing student interest.

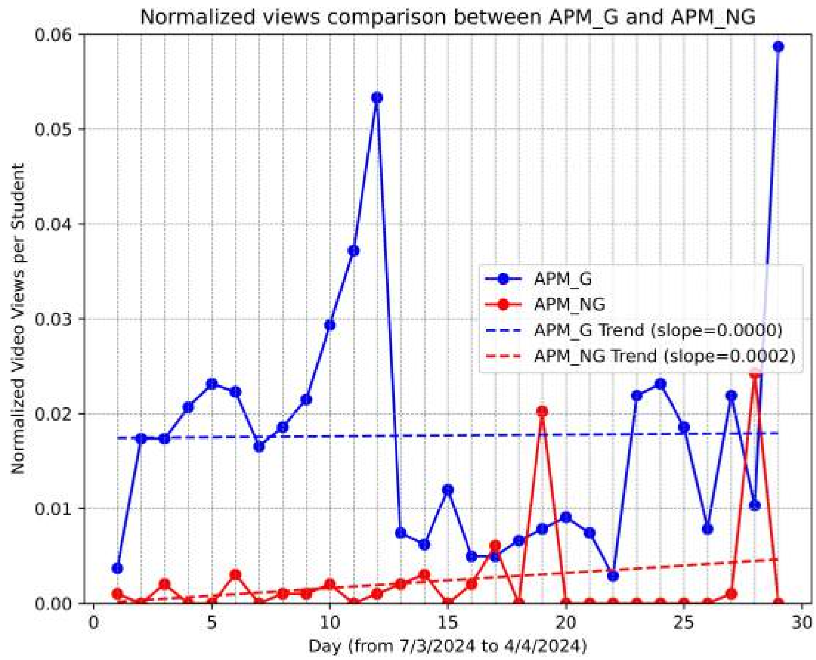
Noticeable peaks in video views were observed on day 2 and day 29, corresponding to the day before the conclusion of season 1 and season 2, respectively. Moreover, there was a steady increase in video views from the commencement to the culmination of each season. The range of video views varied from a minimum of 7 to a maximum of 142 throughout the duration of the study (Figure 5.2).



Day	APM_G	APM_NG
1	9	1
2	42	0
3	42	2
4	50	0
5	56	0
6	54	3
7	40	0
8	45	1
9	52	1
10	71	2
11	90	0
12	129	1
13	18	2
14	15	3
15	29	0
16	12	2
17	12	6
18	16	0
19	19	20
20	22	0
21	18	0
22	7	0
23	53	0
24	56	0
25	45	0
26	19	0
27	53	1
28	25	24
29	142	0

Figure 5.3: Views Comparison Between APM-G and APM-NG

Since the number of students differs between the controlled group (non-gamified) and experimental group (gamified), it's essential to normalize the data in figure 5.3 before comparison. Normalization was performed by dividing each data point (number of video views for a course on a particular day) by the number of students in the respective group (controlled or experimental).

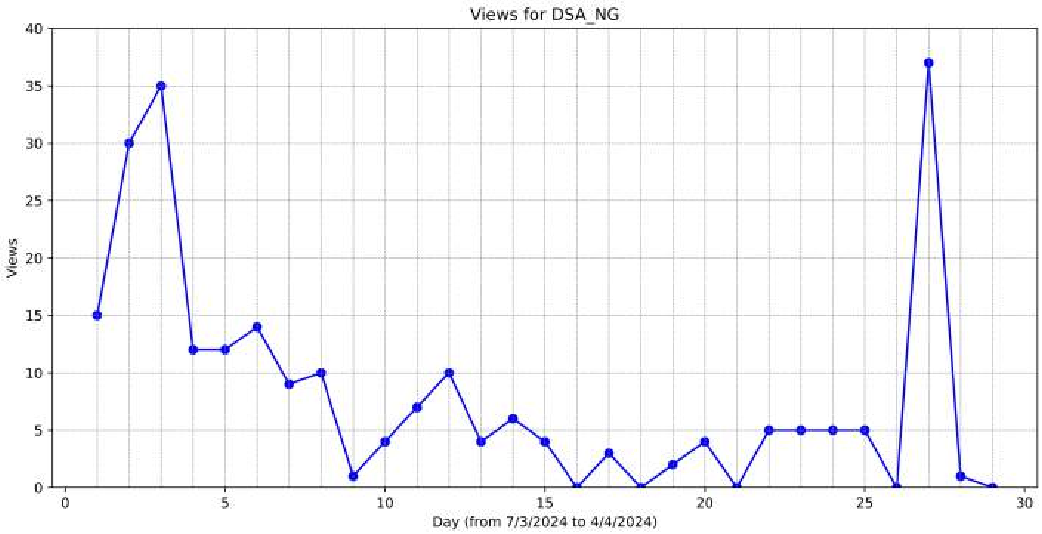


Day	APM_G	APM_NG
1	0.00372	0.00101
2	0.01736	0.0
3	0.01736	0.00202
4	0.02067	0.0
5	0.02315	0.0
6	0.02232	0.00304
7	0.01654	0.0
8	0.0186	0.00101
9	0.0215	0.00101
10	0.02935	0.00202
11	0.03721	0.0
12	0.05333	0.00101
13	0.00744	0.00202
14	0.0062	0.00304
15	0.01199	0.0
16	0.00496	0.00202
17	0.00496	0.00607
18	0.00661	0.0
19	0.00785	0.02024
20	0.00909	0.0
21	0.00744	0.0
22	0.00289	0.0
23	0.02191	0.0
24	0.02315	0.0
25	0.0186	0.0
26	0.00785	0.0
27	0.02191	0.00101
28	0.01033	0.02429
29	0.0587	0.0

Figure 5.4: Views Comparison Between APM-G and APM-NG (Normalized)

When comparing the gamified and non-gamified courses in Figure 5.4, the normalized graph illustrates a clear disparity in engagement patterns. The trendline for the gamified course demonstrates a notably higher average compared to its non-gamified counterpart. Particularly noteworthy are the distinct peaks around day 13 and day 29 in the gamified course, signifying increased levels of engagement during these intervals. Conversely, the non-gamified course lacks such pronounced peaks, particularly towards the conclusion of the second season.

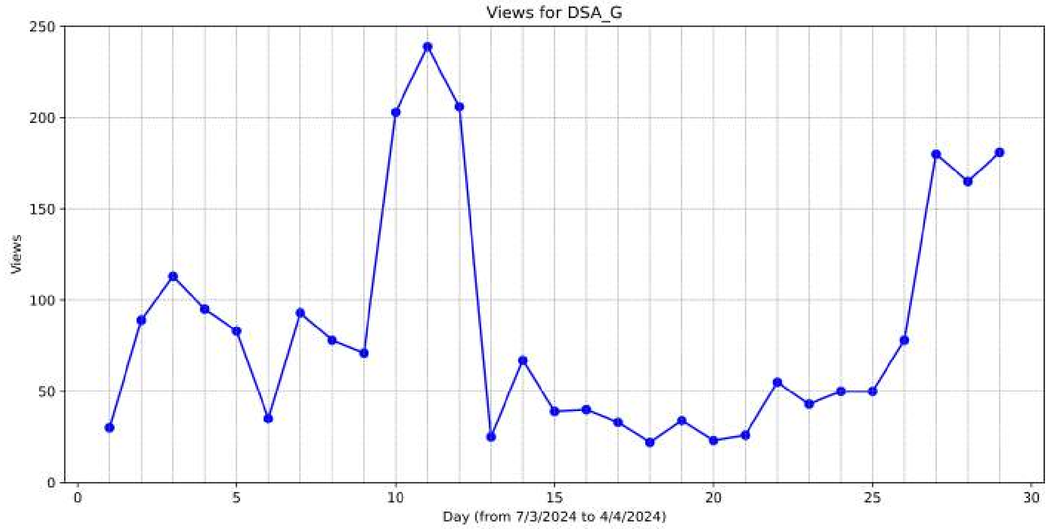
Data Structures and Algorithms



Day	Views
1	15
2	30
3	35
4	12
5	12
6	14
7	9
8	10
9	1
10	4
11	7
12	10
13	4
14	6
15	4
16	0
17	3
18	0
19	2
20	4
21	0
22	5
23	5
24	5
25	5
26	0
27	37
28	1
29	0

Figure 5.5: Views for DSA-NG

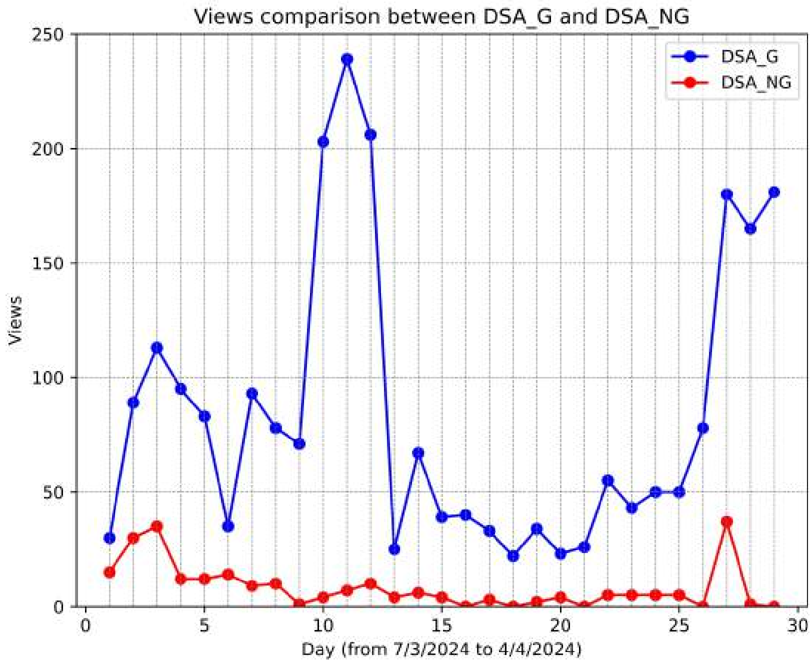
In the non-gamified course, there were significant peaks in video views on the 2nd and 28th days, reaching 35 and 37 views respectively. However, from day 8 to day 27, views remained consistently low, often hovering around zero. The spike in views on the 28th day coincided with the end of the study period (Figure 5.5).



Day	Views
1	30
2	89
3	113
4	95
5	83
6	35
7	93
8	78
9	71
10	203
11	239
12	206
13	25
14	67
15	39
16	40
17	33
18	22
19	34
20	23
21	26
22	55
23	43
24	50
25	50
26	78
27	180
28	165
29	181

Figure 5.6: Views for DSA-G

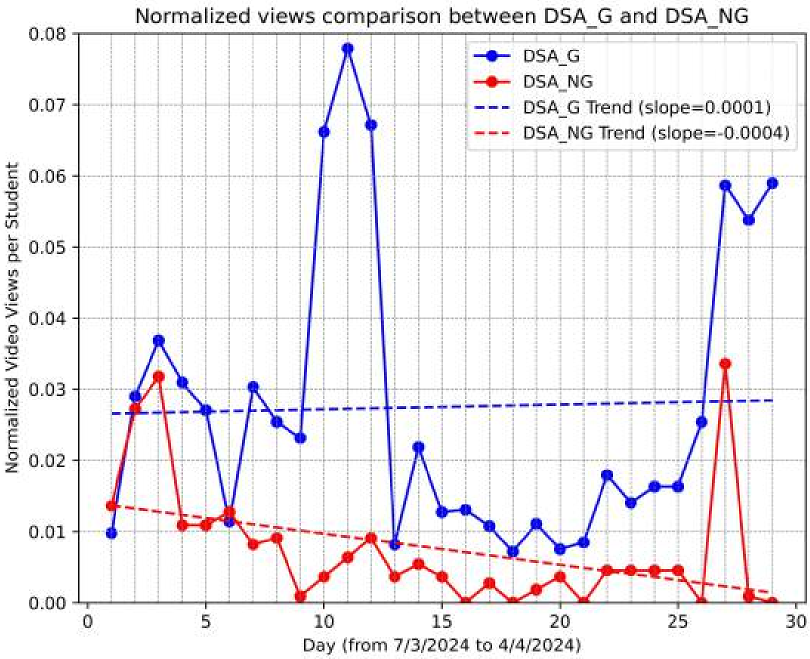
Conversely, in the gamified DSA course, there was a notable spike in views around days 10 to 12, surpassing 200 views just before the first season ended. However, this interest was not sustained, as views sharply declined to 26 by day 13. Another spike occurred on days 27 to 29, nearing 200 views again, towards the end of the second season. The average number of video views per day was 84.3 (Figure 5.6).



Day	DSA_G	DSA_NG
1	30	15
2	89	30
3	113	35
4	95	12
5	83	12
6	35	14
7	93	9
8	78	10
9	71	1
10	203	4
11	239	7
12	206	10
13	25	4
14	67	6
15	39	4
16	40	0
17	33	3
18	22	0
19	34	2
20	23	4
21	26	0
22	55	5
23	43	5
24	50	5
25	50	5
26	78	0
27	180	37
28	165	1
29	181	0

Figure 5.7: Views Comparison Between DSA-G and DSA-NG

Since the number of students differs between the controlled group (non-gamified) and experimental group (gamified), it's essential to normalize the data in figure 5.7 before comparison. Normalization was performed by dividing each data point (number of video views for a course on a particular day) by the number of students in the respective group (controlled or experimental).

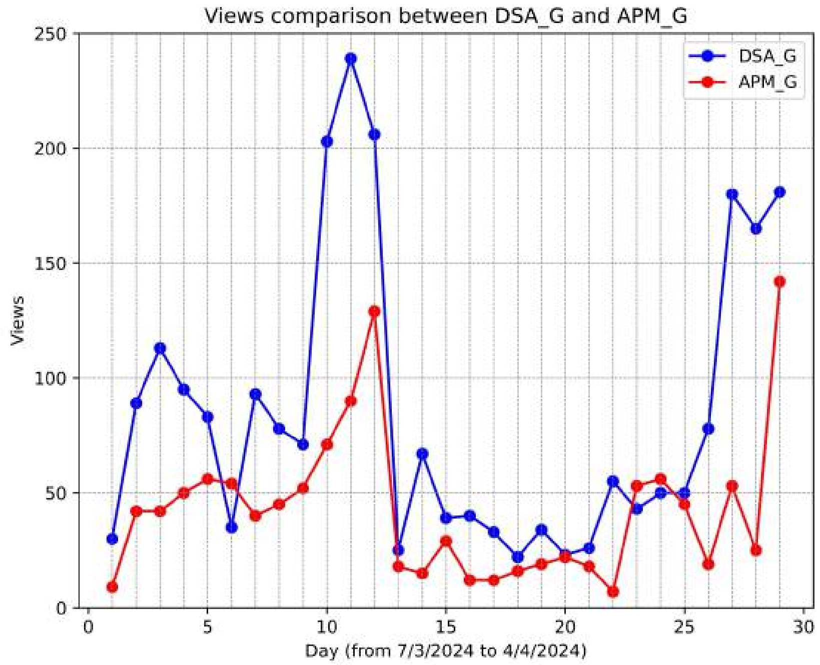


Day	DSA_G	DSA_NG
1	0.00978	0.01361
2	0.02901	0.02722
3	0.03683	0.03176
4	0.03096	0.01089
5	0.02705	0.01089
6	0.01141	0.0127
7	0.03031	0.00817
8	0.02542	0.00907
9	0.02314	0.00091
10	0.06617	0.00363
11	0.0779	0.00635
12	0.06714	0.00907
13	0.00815	0.00363
14	0.02184	0.00544
15	0.01271	0.00363
16	0.01304	0.0
17	0.01076	0.00272
18	0.00717	0.0
19	0.01108	0.00181
20	0.0075	0.00363
21	0.00847	0.0
22	0.01793	0.00454
23	0.01402	0.00454
24	0.0163	0.00454
25	0.0163	0.00454
26	0.02542	0.0
27	0.05867	0.03358
28	0.05378	0.00091
29	0.059	0.0

Figure 5.8: Views Comparison Between DSA-G and DSA-NG (Normalized)

Comparing the gamified and non-gamified courses, the gamified environment exhibited significant spikes around day 12 and day 27, coinciding with the end of season 1 and season 2 respectively. The trend line for the gamified course showed a slight increase in views over time, with a positive slope of +0.0001. In contrast, the non-gamified course maintained relatively stable views with minor fluctuations, indicating a slight decrease in views over time with a negative slope of -0.0004. Overall, the gamified DSA course generally demonstrated higher normalized views per student compared to the non-gamified counterpart (Figure 5.8).

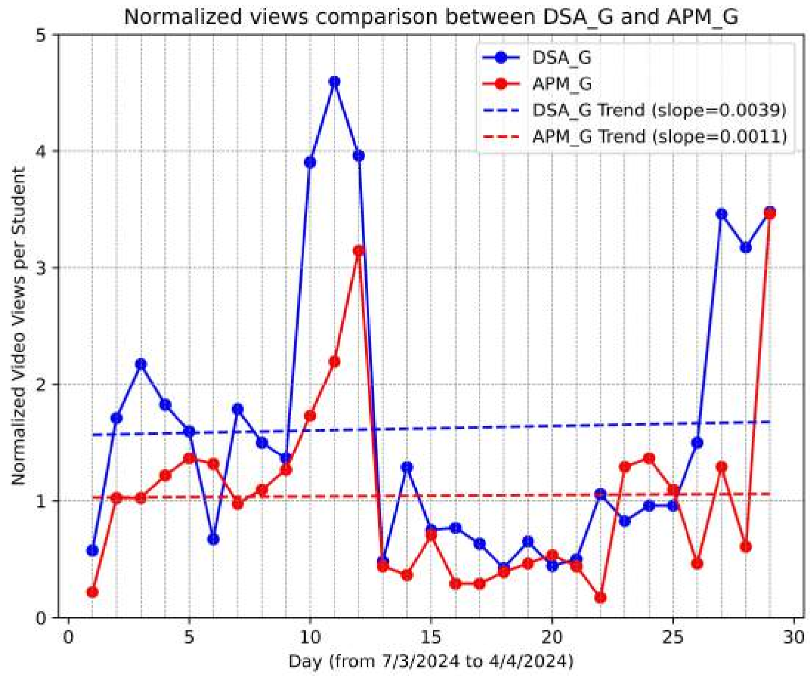
Gamified Videos



Day	DSA_G	APM_G
1	30	9
2	89	42
3	113	42
4	95	50
5	83	56
6	35	54
7	93	40
8	78	45
9	71	52
10	203	71
11	239	90
12	206	129
13	25	18
14	67	15
15	39	29
16	40	12
17	33	12
18	22	16
19	34	19
20	23	22
21	26	18
22	55	7
23	43	53
24	50	56
25	50	45
26	78	19
27	180	53
28	165	25
29	181	142

Figure 5.9: Views Comparison Between DSA-G and APM-G

Since the number of videos is different in DSA-G and APM-G, data in figure 5.9 should be normalized before comparing them. Normalization has been done by dividing each data point (number of video views for a course on a particular day) by the total number of video counts in the relevant course (DSA-G / APM-G).

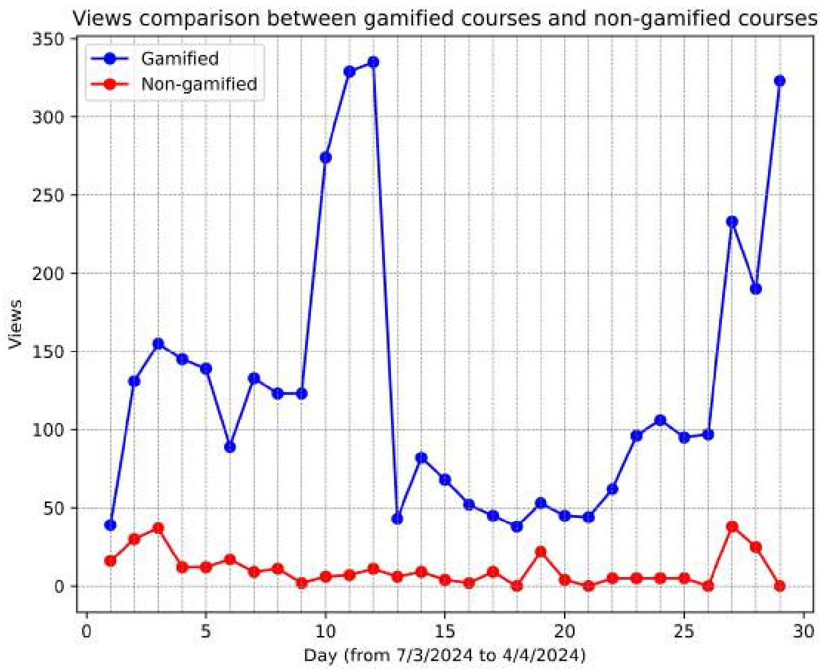


Day	DSA_G	APM_G
1	0.57692	0.21951
2	1.71154	1.02439
3	2.17308	1.02439
4	1.82692	1.21951
5	1.59615	1.36585
6	0.67308	1.31707
7	1.78846	0.97561
8	1.5	1.09756
9	1.36538	1.26829
10	3.90385	1.73171
11	4.59615	2.19512
12	3.96154	3.14634
13	0.48077	0.43902
14	1.28846	0.36585
15	0.75	0.70732
16	0.76923	0.29268
17	0.63462	0.29268
18	0.42308	0.39024
19	0.65385	0.46341
20	0.44231	0.53659
21	0.5	0.43902
22	1.05769	0.17073
23	0.82692	1.29268
24	0.96154	1.36585
25	0.96154	1.09756
26	1.5	0.46341
27	3.46154	1.29268
28	3.17308	0.60976
29	3.48077	3.46341

Figure 5.10: Views Comparison Between DSA-G and APM-G (Normalized)

The DSA gamified line exhibits significant fluctuations, with notable peaks on days 11, 27, and 29. Its trend line indicates a positive slope of +0.0039, suggesting a gradual increase in views over time. On the other hand, the APM gamified line remains relatively stable but demonstrates an upward trend towards the end of the period. The trend line for APM gamified indicates a positive slope of +0.0011, indicating a slight increase in views over time. While DSA gamified generally has higher normalized views per student, APM gamified shows a promising growth in interest towards the conclusion of the study period (Figure 5.10).

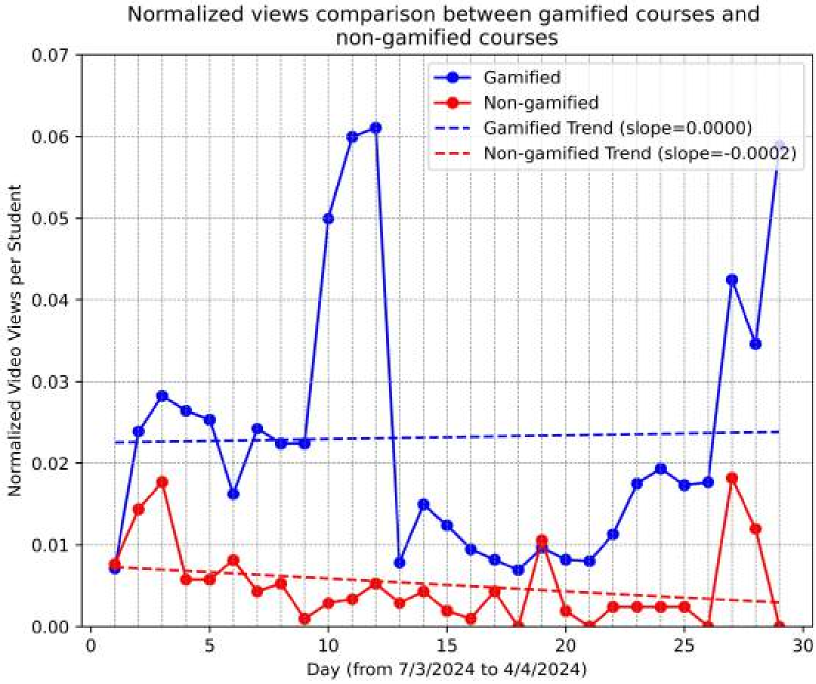
Gamified and Non-gamified Videos



Day	Gamified	Non-gamified
1	39	16
2	131	30
3	155	37
4	145	12
5	139	12
6	89	17
7	133	9
8	123	11
9	123	2
10	274	6
11	329	7
12	335	11
13	43	6
14	82	9
15	68	4
16	52	2
17	45	9
18	38	0
19	53	22
20	45	4
21	44	0
22	62	5
23	96	5
24	106	5
25	95	5
26	97	0
27	233	38
28	190	25
29	323	0

Figure 5.11: Views Comparison Between Gamified Courses and Non-gamified Courses

Since the number of videos regarding gamified and non-gamified courses and the number of enrolled students are different (Student Group 1 and Student Group 2), data in figure 5.11 should be normalized before comparing them. Normalization has been done by dividing each data point (number of video views for courses on a particular day) by the multiplication of the total number of video counts in the relevant courses and the number of enrolled students in the relevant student group (Student Group 1 or Student Group 2).



Day	Gamified	Non-gamified
1	0.00711	0.00766
2	0.02387	0.01435
3	0.02825	0.0177
4	0.02643	0.00574
5	0.02533	0.00574
6	0.01622	0.00813
7	0.02424	0.00431
8	0.02242	0.00526
9	0.02242	0.00096
10	0.04994	0.00287
11	0.05996	0.00335
12	0.06105	0.00526
13	0.00784	0.00287
14	0.01494	0.00431
15	0.01239	0.00191
16	0.00948	0.00096
17	0.0082	0.00431
18	0.00693	0.0
19	0.00966	0.01053
20	0.0082	0.00191
21	0.00802	0.0
22	0.0113	0.00239
23	0.0175	0.00239
24	0.01932	0.00239
25	0.01731	0.00239
26	0.01768	0.0
27	0.04246	0.01818
28	0.03463	0.01196
29	0.05887	0.0

Figure 5.12: Views Comparison Between Gamified Courses and Non-gamified Courses (Normalized)

When comparing gamified and non-gamified views, the gamified line displays more pronounced fluctuations, with significant peaks around days 10, 15, and near day 30. In contrast, the non-gamified line maintains a relatively stable trajectory throughout the study period but consistently records lower views compared to the gamified line. This suggests that gamified courses tend to attract more views and are potentially more engaging or appealing to viewers. Additionally, when examining the normalized views, it becomes evident that gamified courses consistently yield higher views per student compared to non-gamified courses (Figure 5.12).

5.2.2 Watch Time

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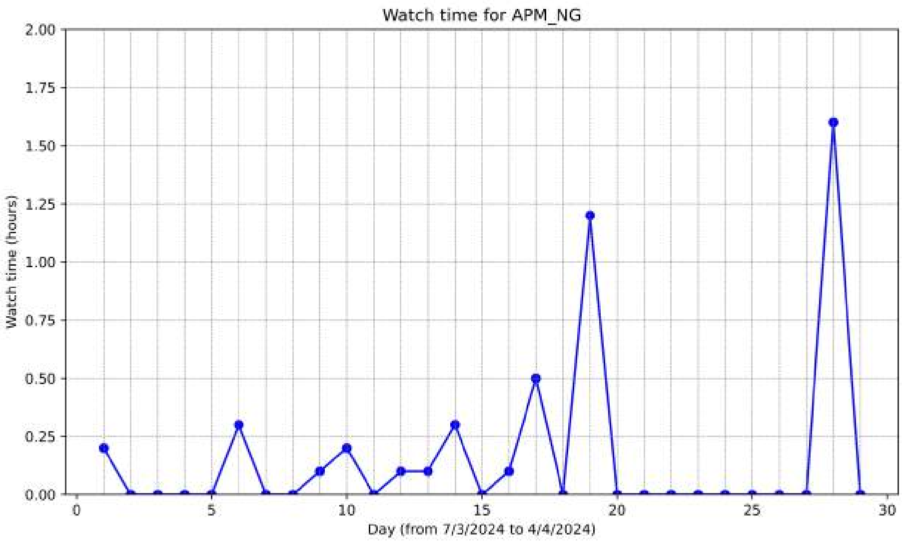
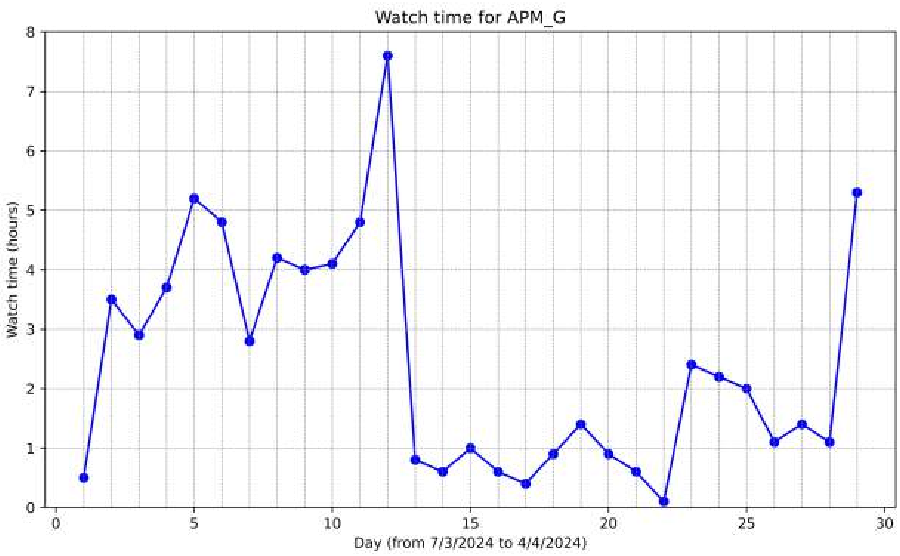


Day	Watch time (hours)
1	0.2
2	0.0
3	0.0
4	0.0
5	0.0
6	0.3
7	0.0
8	0.0
9	0.1
10	0.2
11	0.0
12	0.1
13	0.1
14	0.3
15	0.0
16	0.1
17	0.5
18	0.0
19	1.2
20	0.0
21	0.0
22	0.0
23	0.0
24	0.0
25	0.0
26	0.0
27	0.0
28	1.6
29	0.0

Figure 5.13: Watch Time for APM-NG

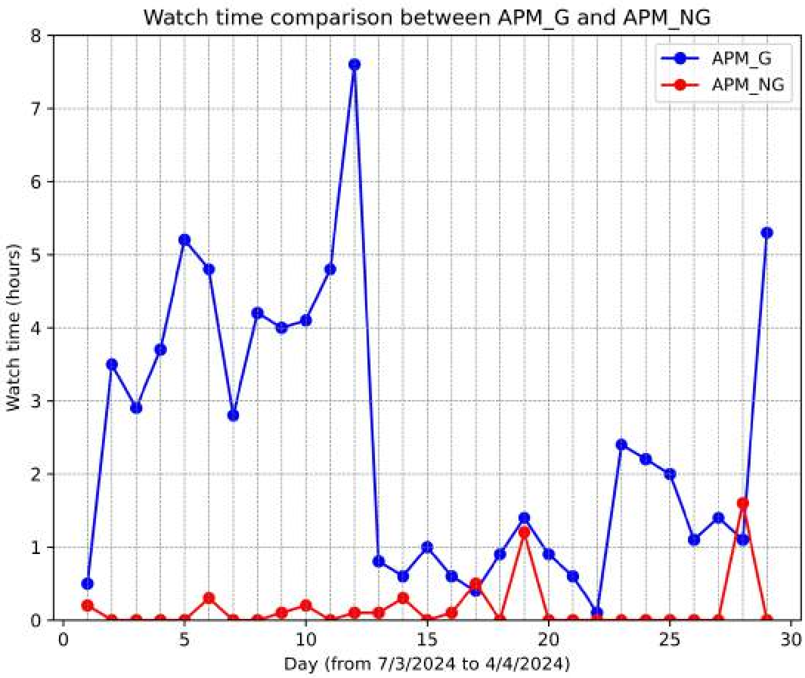
The watch time for the non-gamified course exhibits a variable trend, characterized by several peaks and troughs throughout the study period. Notably, there are three prominent peaks around days 10, 15, and just before day 30, indicating higher engagement on these specific days. Conversely, there are also days with zero watch time, suggesting periods of disengagement. On average, the watch time is less than one hour per day (0.16 hours), with the highest watch time recorded at 1.6 hours per day (Figure 5.13).



Day	Watch time (hours)
1	0.5
2	3.5
3	2.9
4	3.7
5	5.2
6	4.8
7	2.8
8	4.2
9	4.0
10	4.1
11	4.8
12	7.6
13	0.8
14	0.6
15	1.0
16	0.6
17	0.4
18	0.9
19	1.4
20	0.9
21	0.6
22	0.1
23	2.4
24	2.2
25	2.0
26	1.1
27	1.4
28	1.1
29	5.3

Figure 5.14: Watch Time for APM-G

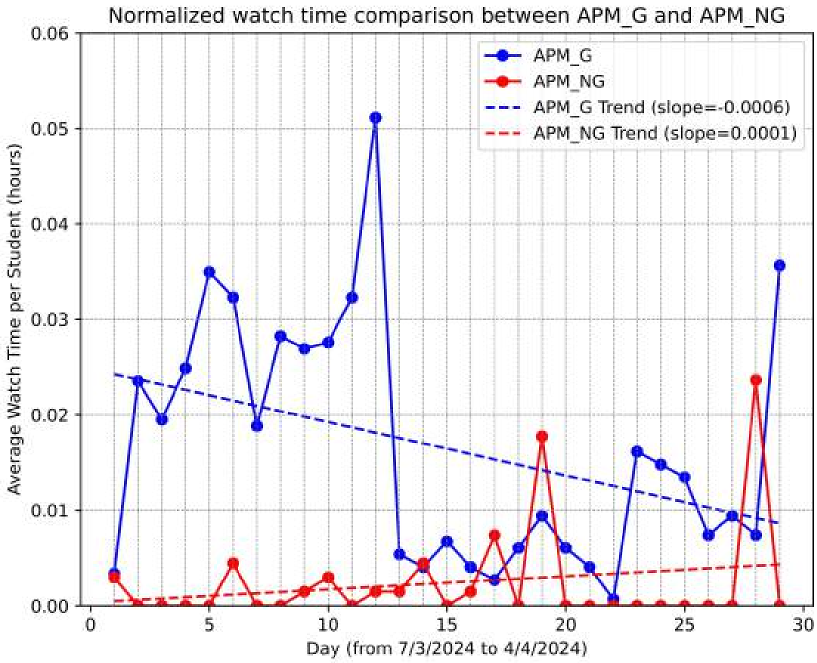
Similarly, the watch time for the gamified course displays a variable trend, with peaks and troughs observed throughout the study period. The highest peak of watch time surpasses 7 hours on day 10, indicating substantial engagement on that particular day. However, there are significant drops in watch time around days 15 and between days 20 and 25, suggesting periods of reduced engagement. On average, the watch time is 2.44 hours per day (Figure 5.14).



Day	APM_G	APM_NG
1	0.5	0.2
2	3.5	0.0
3	2.9	0.0
4	3.7	0.0
5	5.2	0.0
6	4.8	0.3
7	2.8	0.0
8	4.2	0.0
9	4.0	0.1
10	4.1	0.2
11	4.8	0.0
12	7.6	0.1
13	0.8	0.1
14	0.6	0.3
15	1.0	0.0
16	0.6	0.1
17	0.4	0.5
18	0.9	0.0
19	1.4	1.2
20	0.9	0.0
21	0.6	0.0
22	0.1	0.0
23	2.4	0.0
24	2.2	0.0
25	2.0	0.0
26	1.1	0.0
27	1.4	0.0
28	1.1	1.6
29	5.3	0.0

Figure 5.15: Watch Time Comparison Between APM-G and APM-NG

Since the number of students differs between the controlled group (non-gamified) and experimental group (gamified), it's essential to normalize the data in figure 5.15 before comparison. Normalization was performed by dividing each data point (total hours of watch time for a course on a particular day) by the number of students in the respective group (controlled or experimental).

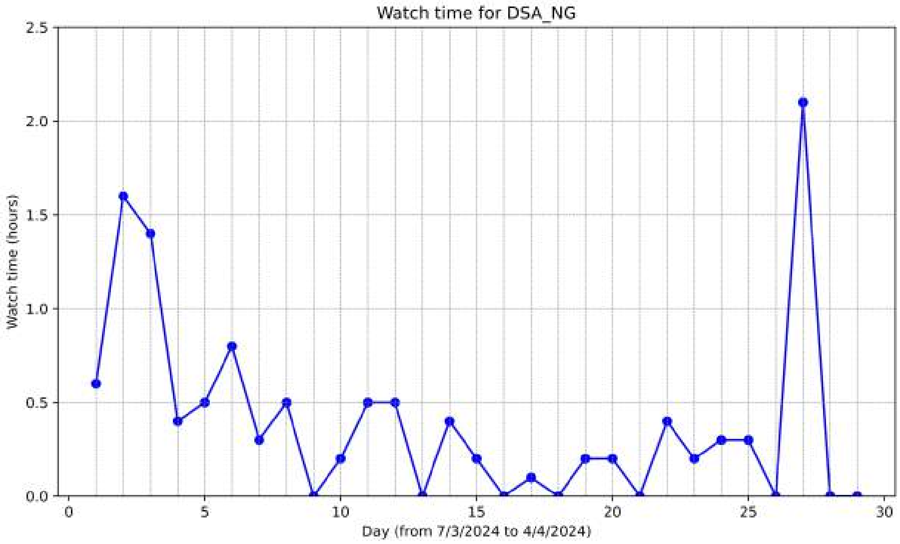


Day	APM_G	APM_NG
1	0.00336	0.00296
2	0.02354	0.0
3	0.0195	0.0
4	0.02489	0.0
5	0.03497	0.0
6	0.03228	0.00444
7	0.01883	0.0
8	0.02825	0.0
9	0.0269	0.00148
10	0.02758	0.00296
11	0.03228	0.0
12	0.05112	0.00148
13	0.00538	0.00148
14	0.00404	0.00444
15	0.00673	0.0
16	0.00404	0.00148
17	0.00269	0.00739
18	0.00605	0.0
19	0.00942	0.01774
20	0.00605	0.0
21	0.00404	0.0
22	0.00067	0.0
23	0.01614	0.0
24	0.0148	0.0
25	0.01345	0.0
26	0.0074	0.0
27	0.00942	0.0
28	0.0074	0.02365
29	0.03565	0.0

Figure 5.16: Watch Time Comparison Between APM-G and APM-NG (Normalized)

When comparing the watch time between the gamified and non-gamified courses, both exhibit variable trends with several peaks and troughs. The gamified course generally boasts higher watch times (2.44 hours) compared to the non-gamified course (0.16 hours). Peaks in watch time for the gamified course occur around days 9 and 19, indicating increased engagement on these specific days. However, there are also significant drops in watch time on certain days, suggesting periods of disengagement. In contrast, the non-gamified course demonstrates a more consistent watch time with less variation. The trend line for the gamified course shows a general upward direction, indicating an increase in average watch time per student over the 30 days, albeit with significant fluctuations. Conversely, the trend line for the non-gamified course appears more stable and consistent, with less variation in watch time, albeit at a lower average compared to the gamified course (Figure 5.16).

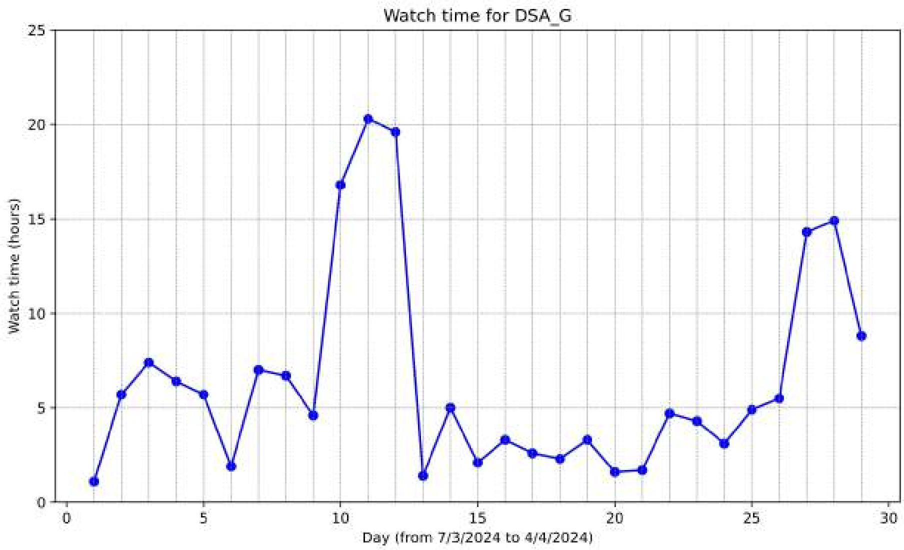
Data Structures and Algorithms



Day	Watch time (hours)
1	0.6
2	1.6
3	1.4
4	0.4
5	0.5
6	0.8
7	0.3
8	0.5
9	0.0
10	0.2
11	0.5
12	0.5
13	0.0
14	0.4
15	0.2
16	0.0
17	0.1
18	0.0
19	0.2
20	0.2
21	0.0
22	0.4
23	0.2
24	0.3
25	0.3
26	0.0
27	2.1
28	0.0
29	0.0

Figure 5.17: Watch Time for DSA-NG

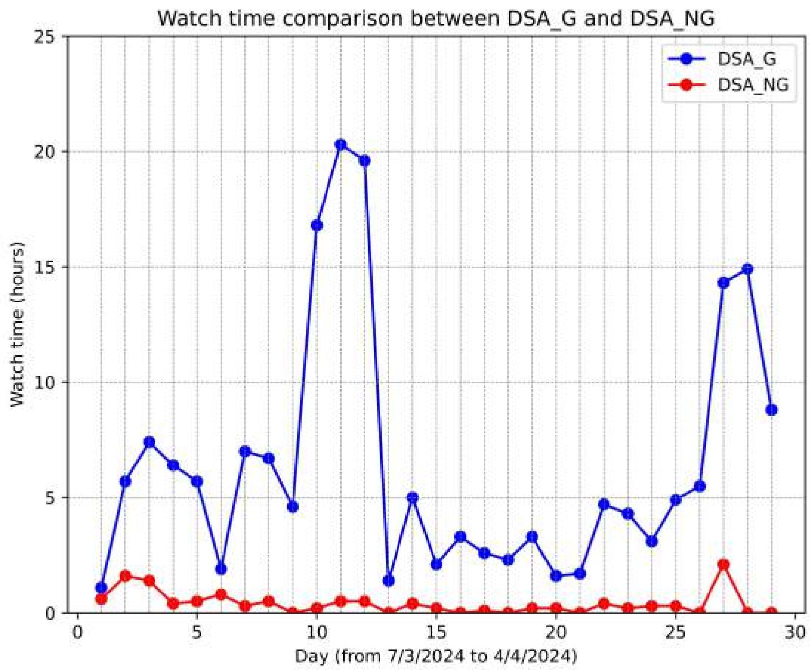
The watch time for the non-gamified course exhibits a variable trend, characterized by several peaks and troughs throughout the study period. The highest peak of watch time is observed on day 29, exceeding two hours, suggesting increased engagement on this specific day. However, there are also several days with low watch time, indicating periods of disengagement. On average, the watch time is less than an hour per day, considering the range of the y-axis (Figure 5.17).



Day	Watch time (hours)
1	1.1
2	5.7
3	7.4
4	6.4
5	5.7
6	1.9
7	7.0
8	6.7
9	4.6
10	16.8
11	20.3
12	19.6
13	1.4
14	5.0
15	2.1
16	3.3
17	2.6
18	2.3
19	3.3
20	1.6
21	1.7
22	4.7
23	4.3
24	3.1
25	4.9
26	5.5
27	14.3
28	14.9
29	8.8

Figure 5.18: Watch Time for DSA-G

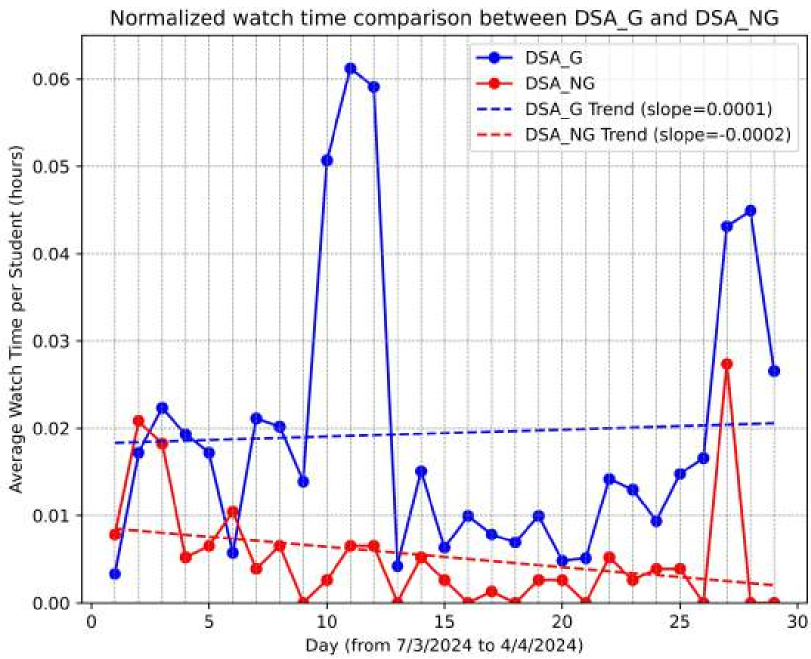
Similarly, the watch time for the gamified course displays a variable trend with peaks and troughs observed throughout the study period. The highest peak of watch time occurs on day 10, nearing 25 hours, indicating substantial engagement on that particular day. However, there are also several days with low watch time, suggesting periods of reduced engagement. On average, the watch time is higher than the non-gamified version (6.44 hours), considering the range of the y-axis (Figure 5.18).



Day	DSA_G	DSA_NG
1	1.1	0.6
2	5.7	1.6
3	7.4	1.4
4	6.4	0.4
5	5.7	0.5
6	1.9	0.8
7	7.0	0.3
8	6.7	0.5
9	4.6	0.0
10	16.8	0.2
11	20.3	0.5
12	19.6	0.5
13	1.4	0.0
14	5.0	0.4
15	2.1	0.2
16	3.3	0.0
17	2.6	0.1
18	2.3	0.0
19	3.3	0.2
20	1.6	0.2
21	1.7	0.0
22	4.7	0.4
23	4.3	0.2
24	3.1	0.3
25	4.9	0.3
26	5.5	0.0
27	14.3	2.1
28	14.9	0.0
29	8.8	0.0

Figure 5.19: Watch Time Comparison Between DSA-G and DSA-NG

Since the number of students differs between the controlled group (non-gamified) and experimental group (gamified), it's essential to normalize the data in figure 5.19 before comparison. Normalization was performed by dividing each data point (total hours of watch time for a course on a particular day) by the number of students in the respective group (controlled or experimental).

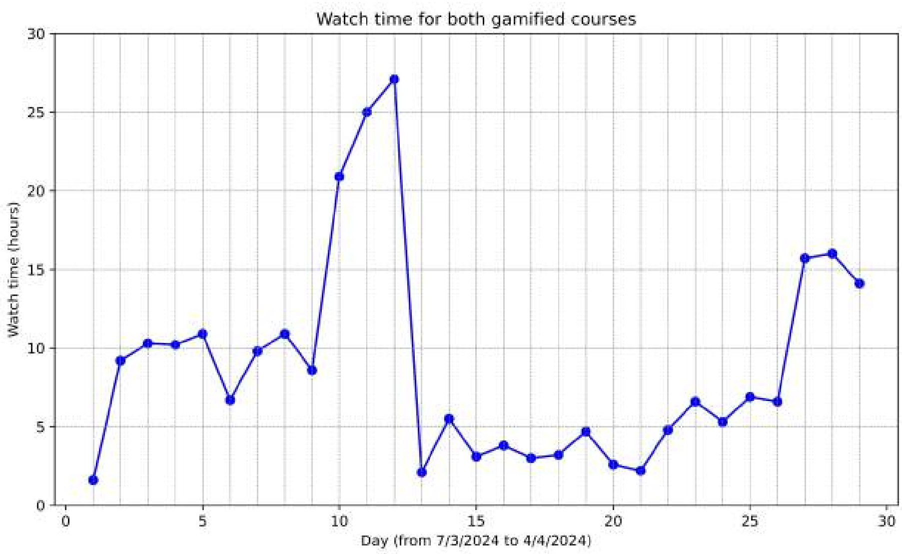


Day	DSA_G	DSA_NG
1	0.00332	0.00782
2	0.01719	0.02084
3	0.02232	0.01824
4	0.0193	0.00521
5	0.01719	0.00651
6	0.00573	0.01042
7	0.02111	0.00391
8	0.02021	0.00651
9	0.01387	0.0
10	0.05067	0.00261
11	0.06122	0.00651
12	0.05911	0.00651
13	0.00422	0.0
14	0.01508	0.00521
15	0.00633	0.00261
16	0.00995	0.0
17	0.00784	0.0013
18	0.00694	0.0
19	0.00995	0.00261
20	0.00483	0.00261
21	0.00513	0.0
22	0.01417	0.00521
23	0.01297	0.00261
24	0.00935	0.00391
25	0.01478	0.00391
26	0.01659	0.0
27	0.04313	0.02736
28	0.04494	0.0
29	0.02654	0.0

Figure 5.20: Watch Time Comparison Between DSA-G and DSA-NG (Normalized)

When comparing the watch time between the gamified and non-gamified courses, both exhibit variable trends with several peaks and troughs. However, the gamified course generally boasts higher watch times compared to the non-gamified course. Peaks in watch time for the gamified course occur around days 9 and 19, suggesting increased engagement during these periods. Additionally, when examining the normalized watch time, it's evident that the gamified DSA course consistently achieves higher watch times per student compared to the non-gamified course (Figure 5.20).

Gamified Videos

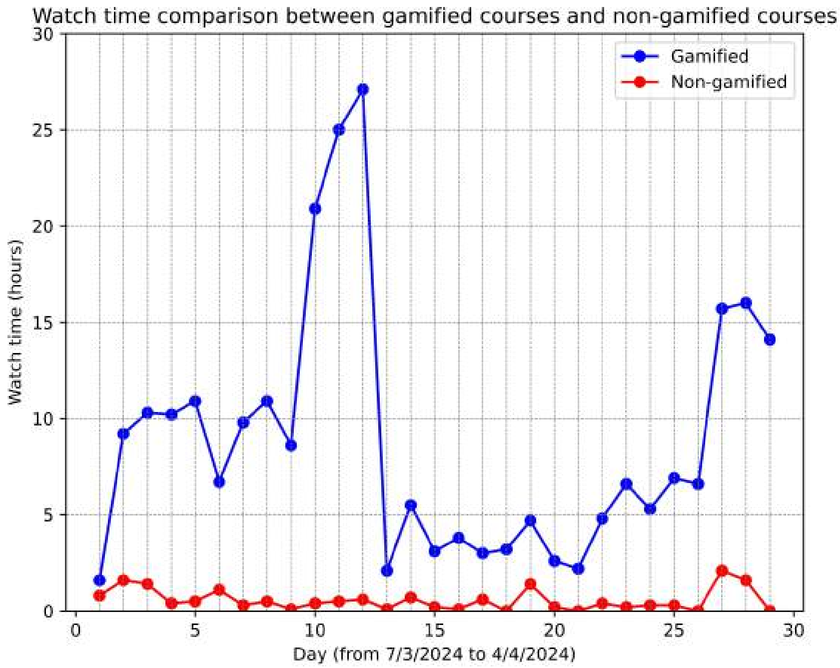


Day	Watch time (hours)
1	1.6
2	9.2
3	10.3
4	10.2
5	10.9
6	6.7
7	9.8
8	10.9
9	8.6
10	20.9
11	25.0
12	27.1
13	2.1
14	5.5
15	3.1
16	3.8
17	3.0
18	3.2
19	4.7
20	2.6
21	2.2
22	4.8
23	6.6
24	5.3
25	6.9
26	6.6
27	15.7
28	16.0
29	14.1

Figure 5.21: Watch Time For Both Gamified Courses

The watch time for gamified courses fluctuates significantly, starting at a low point and peaking dramatically on day 12 with over 25 hours of watch time before dropping sharply. After day 12, watch time remains relatively low with slight increases and decreases until rising again towards the end of the period. The significant peak on day 12 indicates a period of high user engagement or interest, while the lowest watch time occurs on day 1, suggesting a period of low user engagement or interest (Figure 5.21).

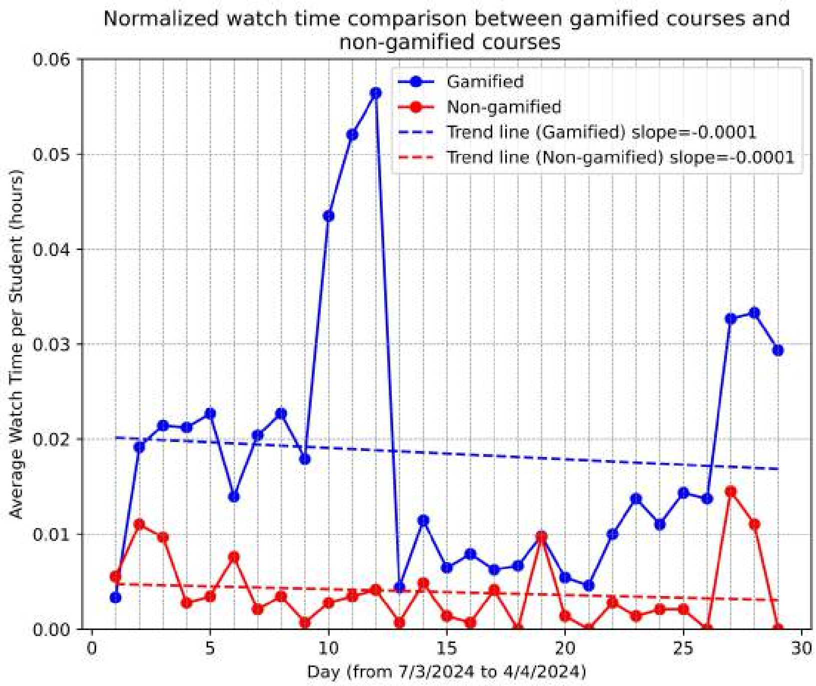
Gamified and Non-gamified Videos



Day	Gamified	Non-gamified
1	1.6	0.8
2	9.2	1.6
3	10.3	1.4
4	10.2	0.4
5	10.9	0.5
6	6.7	1.1
7	9.8	0.3
8	10.9	0.5
9	8.6	0.1
10	20.9	0.4
11	25.0	0.5
12	27.1	0.6
13	2.1	0.1
14	5.5	0.7
15	3.1	0.2
16	3.8	0.1
17	3.0	0.6
18	3.2	0.0
19	4.7	1.4
20	2.6	0.2
21	2.2	0.0
22	4.8	0.4
23	6.6	0.2
24	5.3	0.3
25	6.9	0.3
26	6.6	0.0
27	15.7	2.1
28	16.0	1.6
29	14.1	0.0

Figure 5.22: Watch Time Comparison Between Gamified and Non-gamified Courses

Since the total duration of videos regarding gamified and non-gamified courses and the number of enrolled students are different (Student Group 1 and Student Group 2), data in figure 5.22 should be normalized before comparing them. Normalization has been done by dividing each data point (total hours of watch time for a course on a particular day) by the multiplication of the total duration of videos in the relevant courses and the number of enrolled students in the relevant student group (Student Group 1 or Student Group 2).



Day	Gamified	Non-gamified
1	0.00333	0.00553
2	0.01916	0.01105
3	0.02145	0.00967
4	0.02124	0.00276
5	0.0227	0.00345
6	0.01395	0.0076
7	0.02041	0.00207
8	0.0227	0.00345
9	0.01791	0.00069
10	0.04352	0.00276
11	0.05206	0.00345
12	0.05643	0.00414
13	0.00437	0.00069
14	0.01145	0.00483
15	0.00645	0.00138
16	0.00791	0.00069
17	0.00625	0.00414
18	0.00666	0.0
19	0.00979	0.00967
20	0.00541	0.00138
21	0.00458	0.0
22	0.00999	0.00276
23	0.01374	0.00138
24	0.01104	0.00207
25	0.01437	0.00207
26	0.01374	0.0
27	0.03269	0.0145
28	0.03332	0.01105
29	0.02936	0.0

Figure 5.23: Watch Time Comparison Between Gamified and Non-gamified Courses (Normalized)

Comparing gamified and non-gamified courses, gamified courses exhibit more variability in watch time with higher peaks, particularly notable on day 12 where watch time exceeds 0.05 minutes. Despite fluctuations, there is an overall increasing trend in watch time for gamified courses, indicated by the positive slope of the trend line. Conversely, watch time remains relatively stable and lower for non-gamified courses throughout the period, with no significant peaks or troughs. The trend line for non-gamified courses indicates a slight increase in watch time but not as pronounced as in gamified courses (Figure 5.23).

5.2.3 Quiz Submission

Agile Project Management

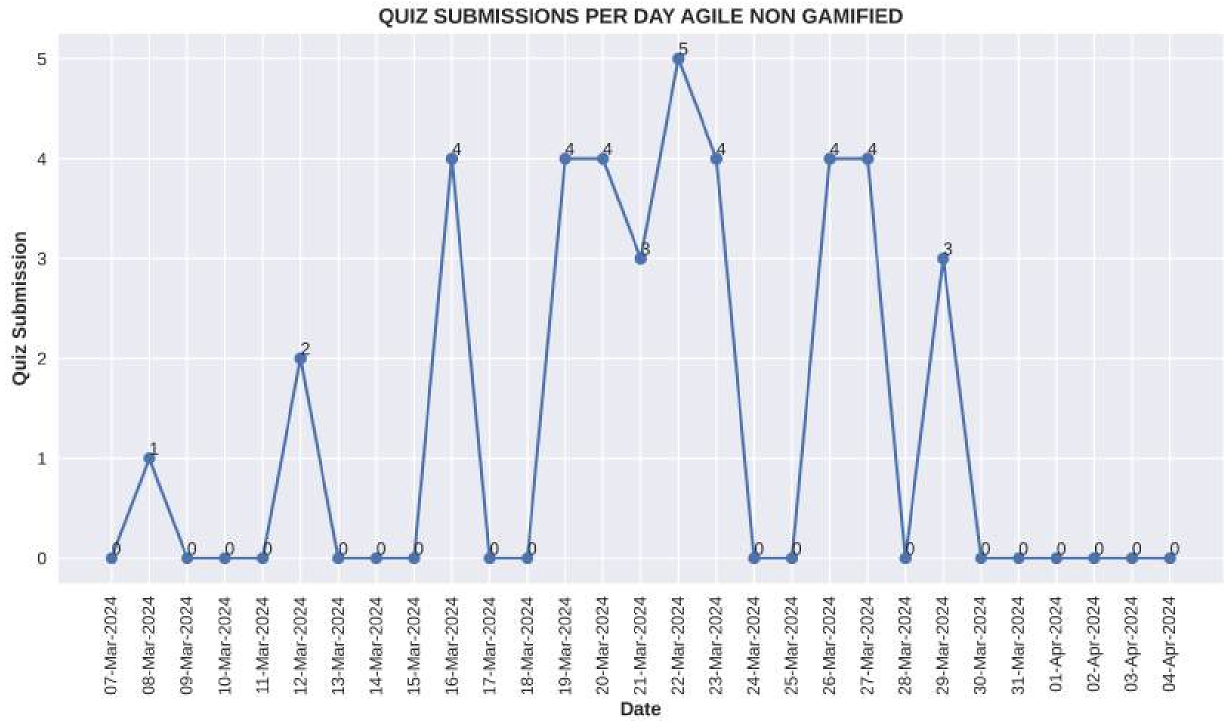


Figure 5.24: Number of Quiz Submissions Per Day for APM-NG

The data illustrates the variability in the number of submissions, characterized by peaks on certain days and no submissions on others. Notably, a prominent peak occurred on March 22nd, where the submission count reached 5, accompanied by 6 secondary peaks with 4 submissions each on March 16th, 19th, 20th, 23rd, 26th, and 27th. Conversely, the lowest submission count hit zero multiple times throughout the observed period. A discernible pattern emerges where after reaching a peak, there is a sharp decline to zero or near-zero submissions before another increase (Figure 5.24).

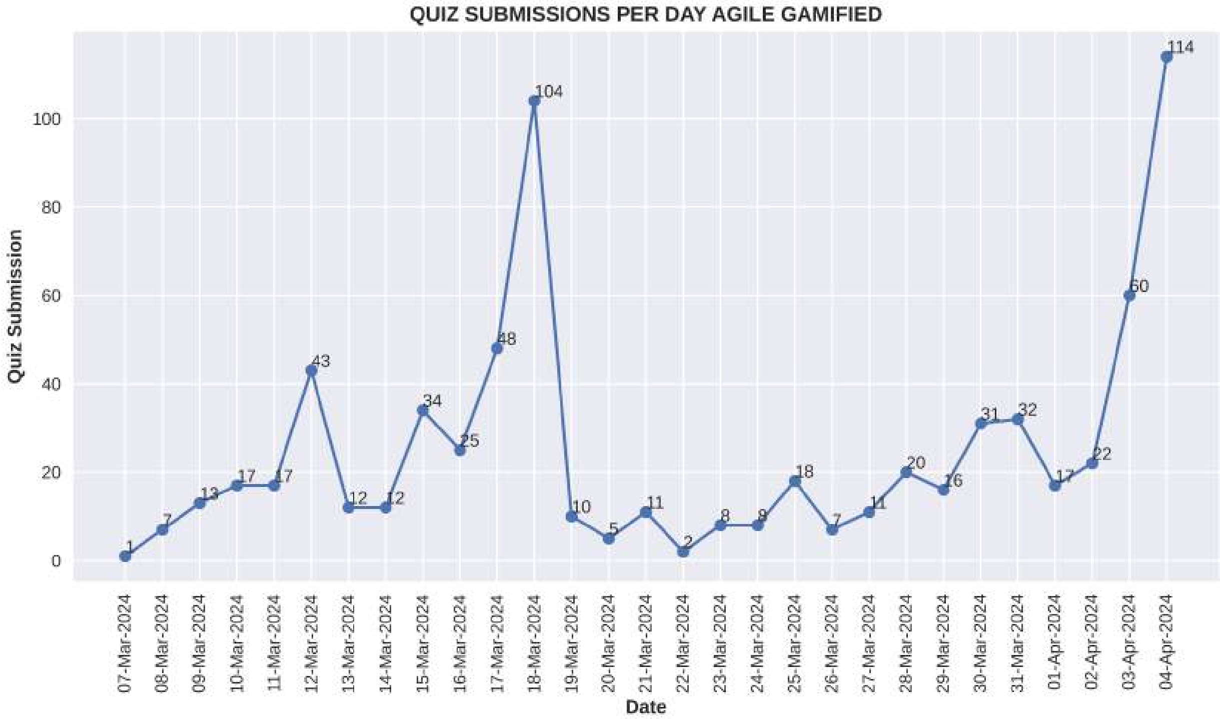


Figure 5.25: Number of Quiz Submissions Per Day for APM-G

The data depicts variability in daily submissions, highlighted by two prominent peaks on March 18th, 2022, and April 4th, 2022, reaching 104 and 114 submissions, respectively. Additionally, there's a general increase in submissions towards the end of each season, with season 1 ending on March 18th and season 2 on April 4th. Periods of low submission numbers, notably between March 20th and March 31st, where numbers range mostly between approximately 5 to 32, suggest a period of less activity or engagement (Figure 5.25).

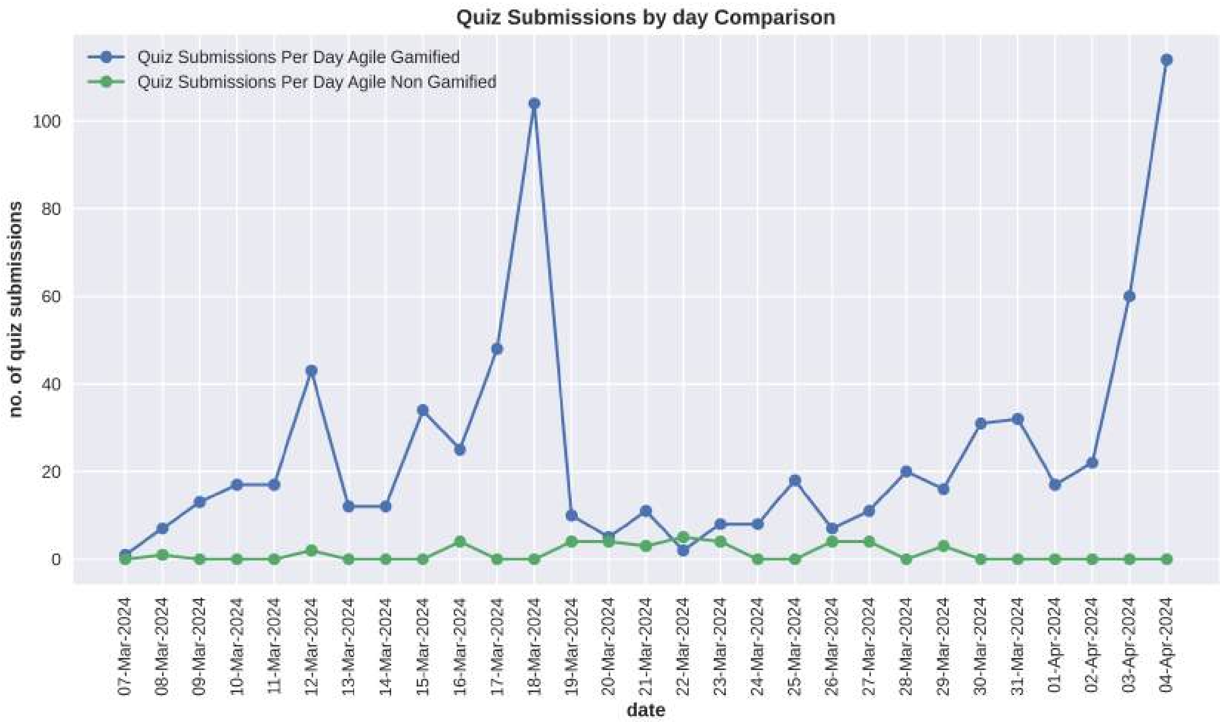


Figure 5.26: Quiz Submissions Comparison Between APM-G and APM-NG

In comparing APM-NG and APM-G quiz submissions, both exhibit a low starting point in March, but AMP-G submissions notably surge around March 18th, peaking with over 100 submissions. Following this peak, APM-G submissions stabilize, consistently surpassing APM-NG submissions until late March. Additionally, there's a noticeable increase in APM-G submissions from late March to early April, while APM-NG submissions remain consistently low. Throughout the period, APM-NG submissions maintain a consistently low level, suggesting that without gamification, engagement levels may be lower (Figure 5.26).

Data Structures and Algorithms

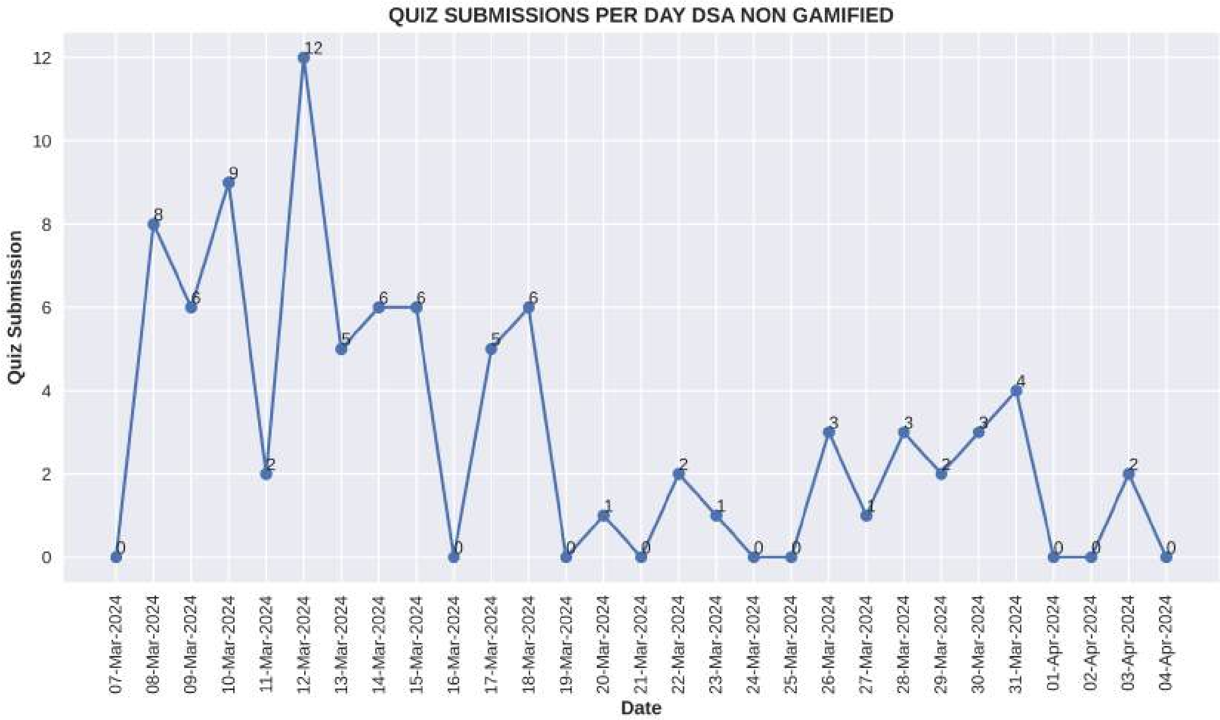


Figure 5.27: Number of Quiz Submissions Per Day for DSA-NG

Submissions peaked at 12 on April 12th, 2022, followed by significant fluctuations, with noticeable drops on April 11th and April 16th. An overall declining trend in the number of submissions after the initial peak stabilizes around 3 submissions per day towards the end of the observed period. This suggests that the non-gamified DSA group might have specific days with increased engagement or deadlines leading to higher submission rates, while there are also periods of low engagement where no quizzes are submitted (Figure 5.27).

Figure 5.28: Number of Quiz Submissions Per Day for DSA-G

A significant spike in submissions occurred on March 18th, with 147 submissions, an outlier compared to other days where submissions ranged from 9 to 37. After this peak, there was a sharp decline, reaching the lowest point of 7 submissions on March 24th. However, starting from this low point, there was another increase in quiz submissions, reaching up to 117 by the end of the observed period. This suggests that the gamified DSA group might have specific days with increased engagement or deadlines leading to higher submission rates, while there are also periods of low engagement where fewer quizzes are submitted (Figure 5.28).

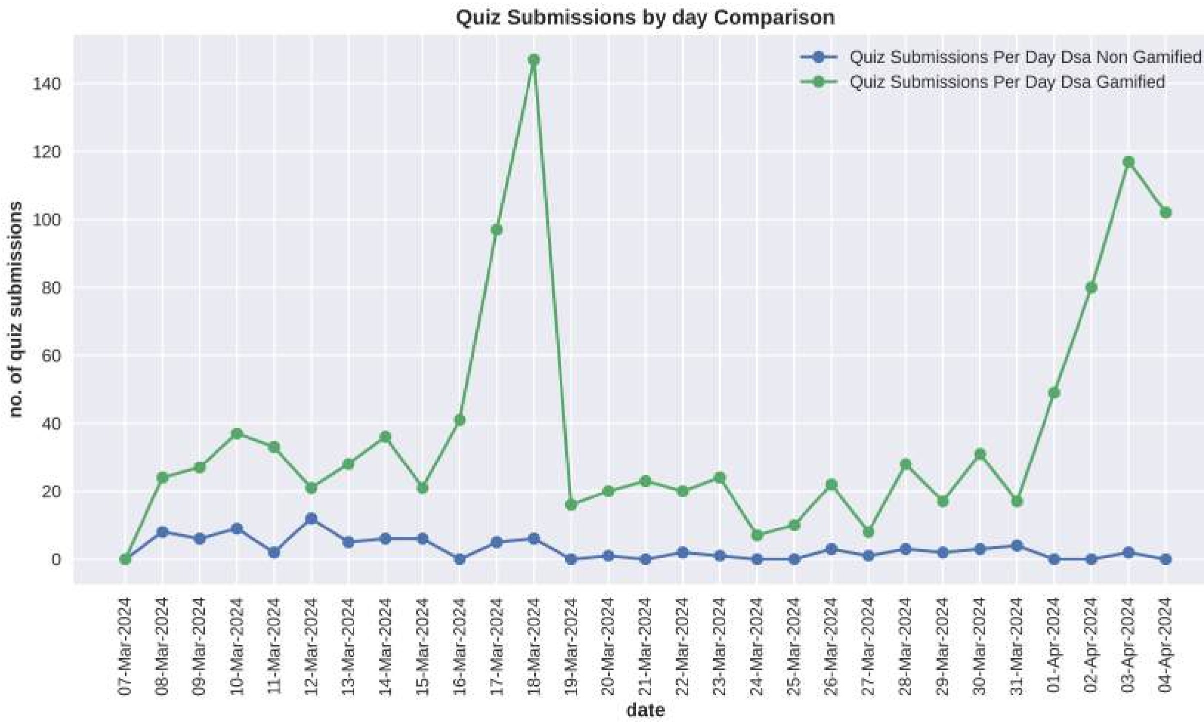
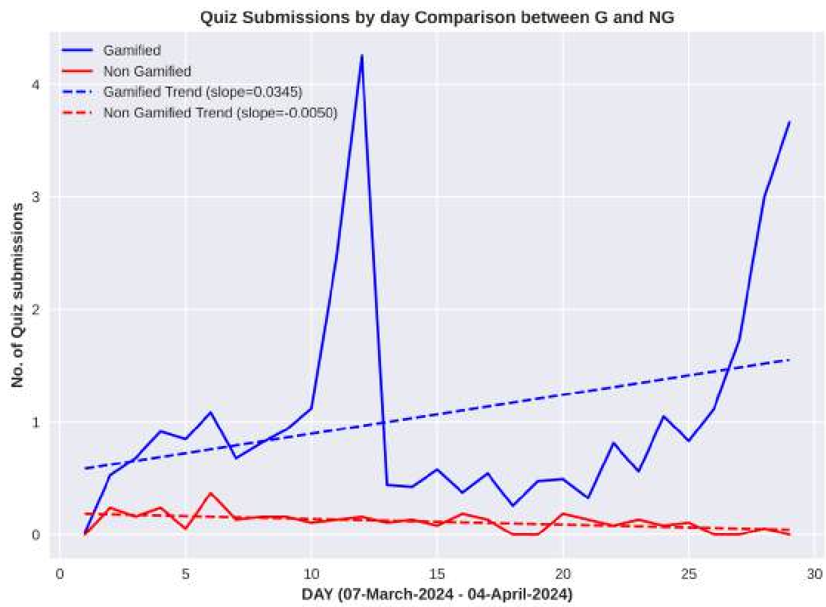


Figure 5.29: Quiz Submissions Comparison Between DSA-G and DSA-NG

Comparing DSA non-gamified and gamified quiz submissions, both exhibit a low starting point in March, yet gamified submissions notably surge around March 18th, peaking with over 140 submissions. Following this peak, gamified submissions stabilize, consistently surpassing non-gamified submissions until late March, indicating that gamification may lead to a more consistent level of engagement over time. Additionally, there's another noticeable increase in gamified submissions from late March to early April, while non-gamified submissions remain consistently low. Throughout the period, non-gamified submissions maintained a consistently low level, highlighting that without gamification, the level of engagement may be lower (Figure 5.29).

Gamified and Non-gamified Videos

Since the number of students differs between the controlled group (non-gamified) and experimental group (gamified), it's essential to normalize the data before comparison. Normalization was performed by dividing each data point (number of quiz submissions for a course on a particular day) by the number of students in the respective group (controlled or experimental).



Day	Gamified	Non Gamified
1	0.01695	0.0
2	0.52542	0.23684
3	0.67797	0.15789
4	0.91525	0.23684
5	0.84746	0.05263
6	1.08475	0.36842
7	0.67797	0.13158
8	0.81356	0.15789
9	0.9322	0.15789
10	1.11864	0.10526
11	2.45763	0.13158
12	4.25424	0.15789
13	0.44068	0.10526
14	0.42373	0.13158
15	0.57627	0.07895
16	0.37288	0.18421
17	0.54237	0.13158
18	0.25424	0.0
19	0.47458	0.0
20	0.49153	0.18421
21	0.32203	0.13158
22	0.81356	0.07895
23	0.55932	0.13158
24	1.05085	0.07895
25	0.83051	0.10526
26	1.11864	0.0
27	1.72881	0.0
28	3.0	0.05263
29	3.66102	0.0

Figure 5.30: Quiz Submissions Comparison Between Gamified and Non-gamified Courses (Normalized)

During the observed period, gamified submissions exhibited notable fluctuations, peaking on the second day and showing another uptick towards the end. This trend contrasted with the relatively stable non-gamified submissions, which experienced minor fluctuations but lacked significant peaks. Gamified submissions spiked notably on the second day, surpassing three submissions before sharply declining and stabilizing to around one submission per day. The trend line for gamified submissions indicated a positive slope of +0.0345, suggesting an overall increasing trend. In contrast, non-gamified submissions remained steady, with a slight downward trend indicated by a slope of -0.0050. The comparison between the two indicates that gamification fosters higher engagement levels, leading to increased submission rates, albeit with more variability from day to day compared to non-gamified approaches (Figure 5.30).

5.2.4 Course Completion Rate Analysis

Table 5.2: Course Completion Statistics

Course	**No. of Students Registered to the Platform**	**No. of Students Completed the Course**
APM-G	59 (out of 59)	23 (38.99%)
DSA-G		29 (49.15%)
APM-NG	38 (out of 53)	1 (2.63%)
DSA-NG		1 (2.63%)

In the APM-G course, out of the 59 students registered to the platform, 23 completed the study, representing a completion rate of 38.98%. Conversely, in the non-gamified version of the course (APM-NG), only 1 out of 38 registered students completed the study, resulting in a completion rate of 2.63%.

The DSA-G witnessed significantly higher completion rates compared to its non-gamified counterpart (DSA-NG). Out of the 59 students registered to the platform, 29 completed the study, representing a completion rate of 49.15% in the DSA-G course. Conversely, in the DSA-NG course, only 1 out of 38 registered students completed the study, resulting in a completion rate of 2.63%.

Overall, the gamified versions of both the APM and DSA courses demonstrate significantly higher completion rates compared to their non-gamified counterparts. This suggests the potential effectiveness of gamification in enhancing student engagement and motivation toward course completion (Table 5.2).

5.2.5 Drop-off Rate Analysis

Table 5.3: Drop-off Statistics

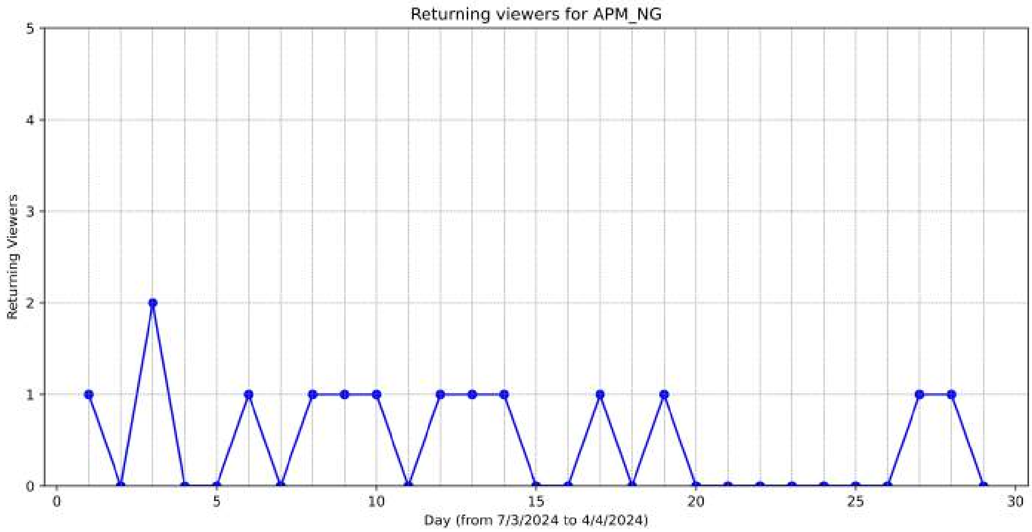
Course	**No. of Students Registered to the Platform**	**No. of Students Dropped-off Before Completing the Course**
APM-G	59 (out of 59)	36 (61.01%)
DSA-G		30 (50.85%)
APM-NG	38 (out of 53)	37 (97.36%)
DSA-NG		37 (97.36%)

The analysis of drop-off rates across course modules underscores significant disparities, revealing the impact of gamification on student retention. In the Agile Project Management course, 36 out of 59 students dropped off from the gamified version, resulting in a 61.01% drop-off rate. Conversely, the non-gamified counterpart experienced a staggering drop-off rate, with 37 out of 38 registered students discontinuing the course, totaling 97.36%. This substantial difference highlights the potential of gamification in mitigating drop-off rates.

Similarly, in the Data Structure and Algorithms (DSA) course, the gamified iteration saw 30 out of 59 registered students dropping off, leading to a 50.85% drop-off rate. Conversely, the non-gamified DSA course displayed a comparable drop-off rate, with 37 out of 38 students discontinuing, also resulting in a 97.36% rate (Table 5.3).

5.2.6 Returning Viewers

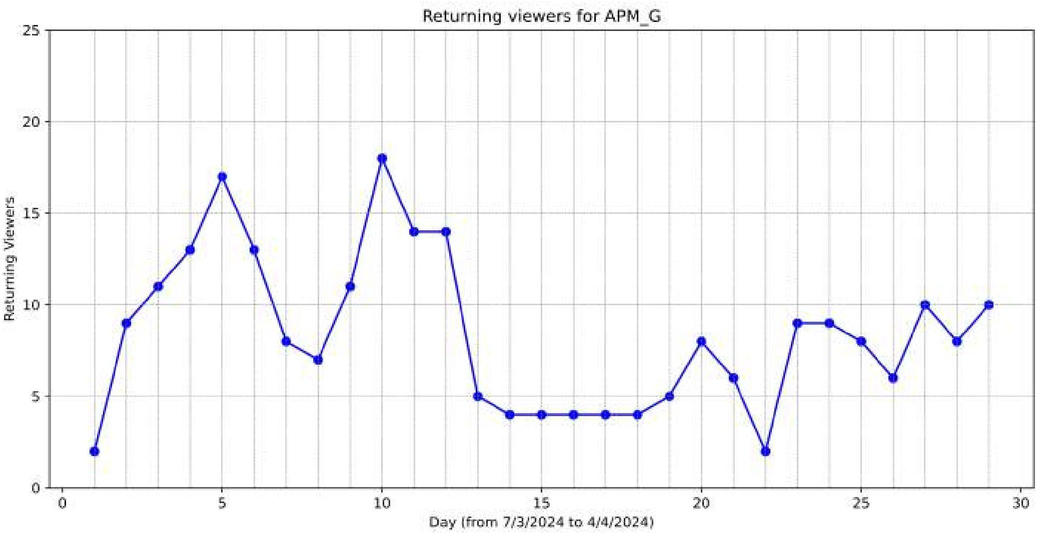
Agile Project Management



Day	Views
1	1
2	0
3	2
4	0
5	0
6	1
7	0
8	1
9	1
10	1
11	0
12	1
13	1
14	1
15	0
16	0
17	1
18	0
19	1
20	0
21	0
22	0
23	0
24	0
25	0
26	0
27	1
28	1
29	0

Figure 5.31: Returning Viewers for APM-NG

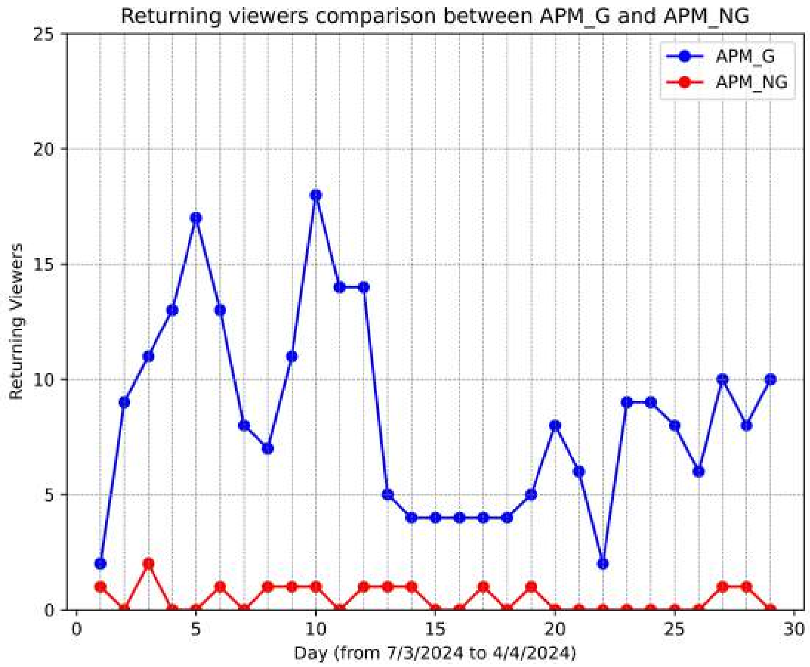
The graph representing returning viewers for the non-gamified version of the e-learning platform displays significant fluctuations, marked by peaks on days 2, 9, and 16. The highest number of returning viewers, four, occurred on day 2. However, there are also numerous days with zero returning viewers, indicating periods of low engagement within the non-gamified platform (Figure 5.31).



Day	Views
1	2
2	9
3	11
4	13
5	17
6	13
7	8
8	7
9	11
10	18
11	14
12	14
13	5
14	4
15	4
16	4
17	4
18	4
19	5
20	8
21	6
22	2
23	9
24	9
25	8
26	6
27	10
28	8
29	10

Figure 5.32: Returning Viewers for APM-G

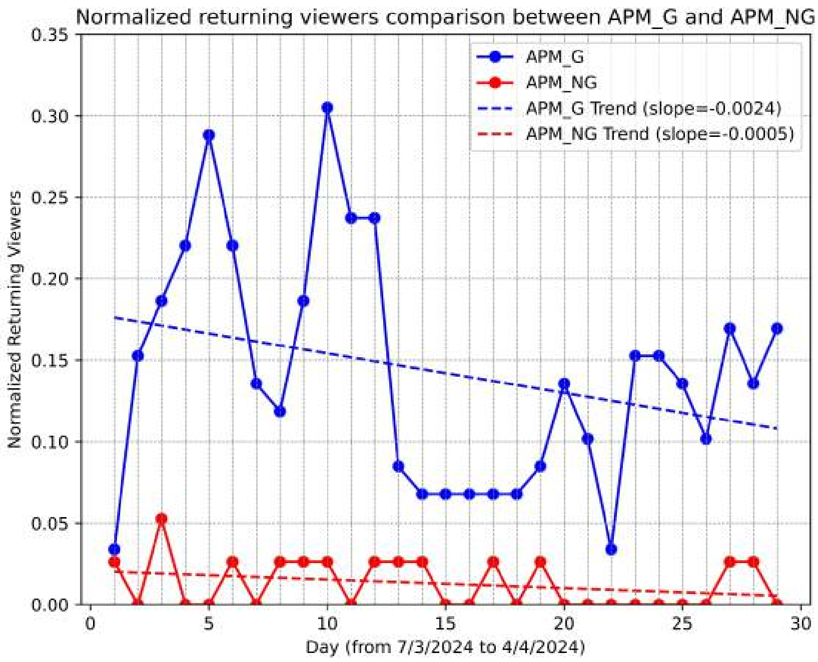
Conversely, the gamified version demonstrates a varying number of returning viewers, ranging from 2 to 18 per day, with an average of approximately 8.27 returning viewers daily. The highest number of returning viewers is observed on days 5 and 10 (Figure 5.32).



Day	APM_G	APM_NG
1	2	1
2	9	0
3	11	2
4	13	0
5	17	0
6	13	1
7	8	0
8	7	1
9	11	1
10	18	1
11	14	0
12	14	1
13	5	1
14	4	1
15	4	0
16	4	0
17	4	1
18	4	0
19	5	1
20	8	0
21	6	0
22	2	0
23	9	0
24	9	0
25	8	0
26	6	0
27	10	1
28	8	1
29	10	0

Figure 5.33: Returning Viewers Comparison Between APM-G and APM-NG

Since the number of students differs between the controlled group (non-gamified) and experimental group (gamified), it's essential to normalize the data in figure 5.33 before comparison. Normalization was performed by dividing each data point (number of returning viewers for a course on a particular day) by the number of students in the respective group (controlled or experimental).

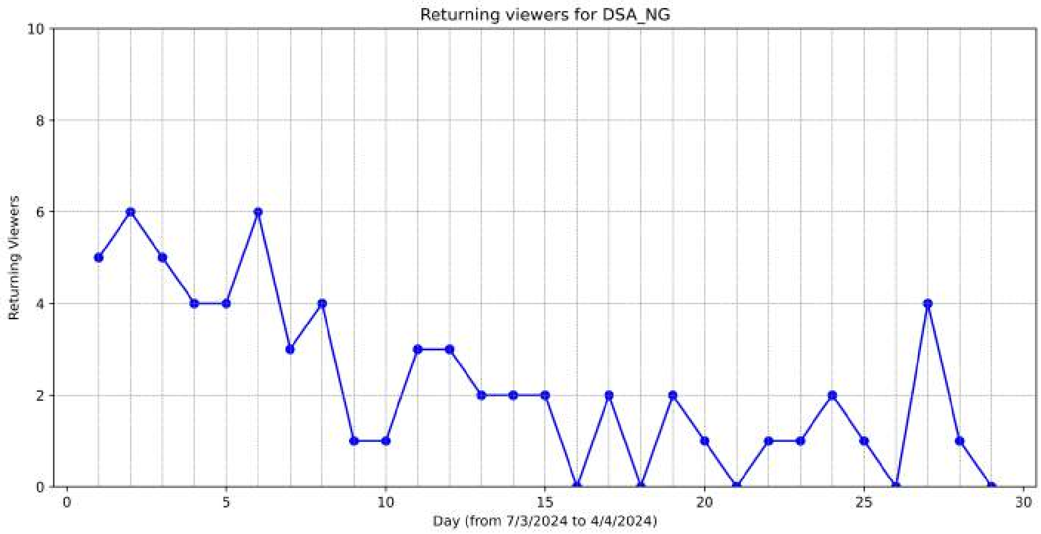


Day	APM_G	APM_NG
1	0.0339	0.02632
2	0.15254	0.0
3	0.18644	0.05263
4	0.22034	0.0
5	0.28814	0.0
6	0.22034	0.02632
7	0.13559	0.0
8	0.11864	0.02632
9	0.18644	0.02632
10	0.30508	0.02632
11	0.23729	0.0
12	0.23729	0.02632
13	0.08475	0.02632
14	0.0678	0.02632
15	0.0678	0.0
16	0.0678	0.0
17	0.0678	0.02632
18	0.0678	0.0
19	0.08475	0.02632
20	0.13559	0.0
21	0.10169	0.0
22	0.0339	0.0
23	0.15254	0.0
24	0.15254	0.0
25	0.13559	0.0
26	0.10169	0.0
27	0.16949	0.02632
28	0.13559	0.02632
29	0.16949	0.0

Figure 5.34: Returning Viewers Comparison Between APM-G and APM-NG (Normalized)

The analysis of return views for both the gamified and non-gamified versions of the course indicates differences in engagement trends. While the gamified version experiences a steeper decline in return views, other metrics suggest the effectiveness of gamification. Despite the sharper decline in return views for the APM-G compared to the APM-NG, APM-G demonstrates greater variability with peaks around days 5 and 10, suggesting higher engagement levels during these periods. Additionally, the average return views per day are higher in the gamified version, with an average of approximately 8.27 viewers compared to APM-NG. Thus, despite the steeper decline, the gamified version offers a more engaging learning experience, as indicated by higher average return views (Figure 5.34).

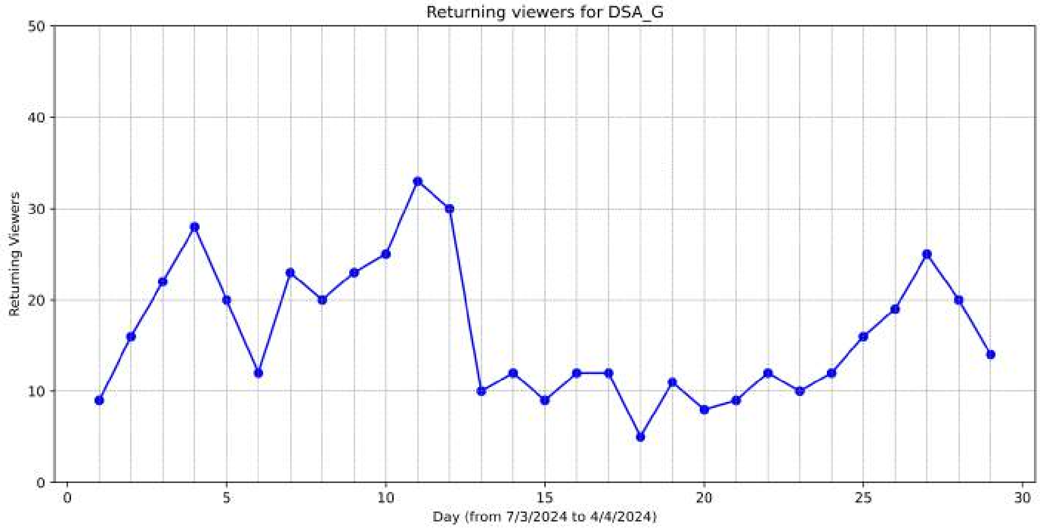
Data Structures and Algorithms



Day	Views
1	5
2	6
3	5
4	4
5	4
6	6
7	3
8	4
9	1
10	1
11	3
12	3
13	2
14	2
15	2
16	0
17	2
18	0
19	2
20	1
21	0
22	1
23	1
24	2
25	1
26	0
27	4
28	1
29	0

Figure 5.35: Returning Viewers for DSA-NG

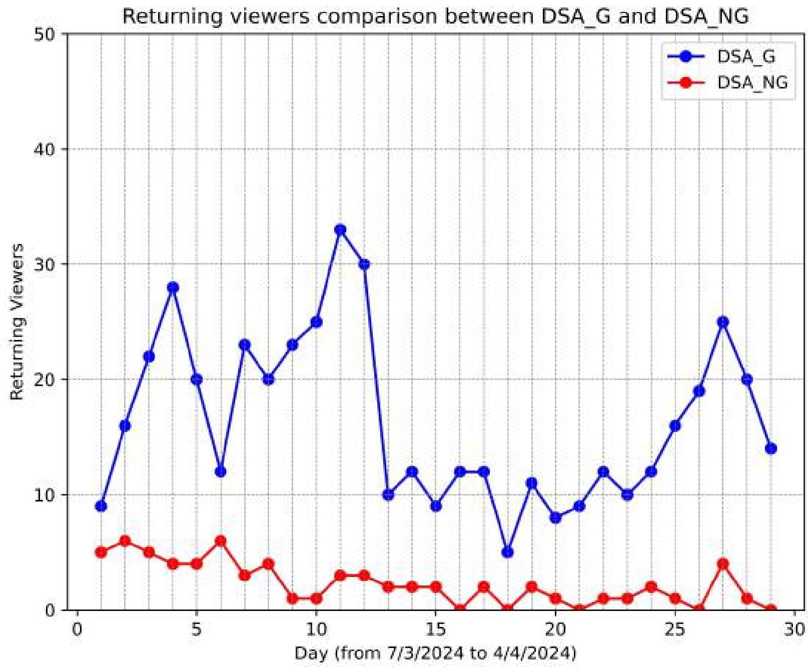
In the non-gamified environment, returning viewership displays noticeable fluctuations, characterized by a general downward trend interspersed with intermittent peaks. The highest engagement, observed on day 2 and day 6, saw 6 returning viewers. However, there were also periods of low engagement, with some days registering no returning viewers. This trend indicates a gradual decrease in returning viewers over time (Figure 5.35).



Day	Views
1	9
2	16
3	22
4	28
5	20
6	12
7	23
8	20
9	23
10	25
11	33
12	30
13	10
14	12
15	9
16	12
17	12
18	5
19	11
20	8
21	9
22	12
23	10
24	12
25	16
26	19
27	25
28	20
29	14

Figure 5.36: Returning Viewers for DSA-G

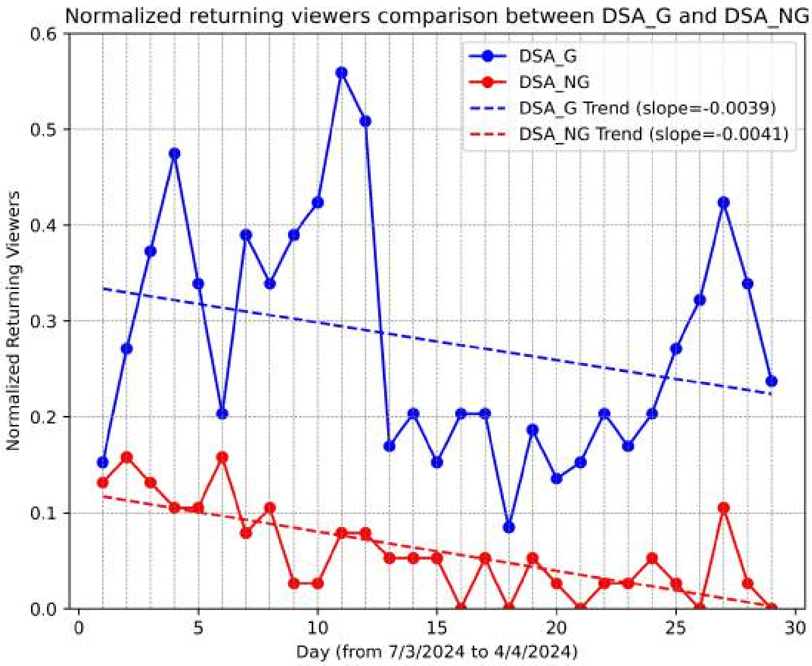
Conversely, within the gamified environment, returning viewership displays a fluctuating pattern with a general upward trend, punctuated by some dips. The highest engagement occurred on day 11, attracting 33 returning viewers, while the lowest engagement, on day 18, saw 5 returning viewers. This suggests an overall increase in returning viewers over time, albeit with fluctuations (Figure 5.36).



Day	DSA_G	DSA_NG
1	9	5
2	16	6
3	22	5
4	28	4
5	20	4
6	12	6
7	23	3
8	20	4
9	23	1
10	25	1
11	33	3
12	30	3
13	10	2
14	12	2
15	9	2
16	12	0
17	12	2
18	5	0
19	11	2
20	8	1
21	9	0
22	12	1
23	10	1
24	12	2
25	16	1
26	19	0
27	25	4
28	20	1
29	14	0

Figure 5.37: Returning Viewers Comparison Between DSA-G and DSA-NG

Since the number of students differs between the controlled group (non-gamified) and experimental group (gamified), it's essential to normalize the data in figure 5.37 before comparison. Normalization was performed by dividing each data point (number of returning viewers for a course on a particular day) by the number of students in the respective group (controlled or experimental).

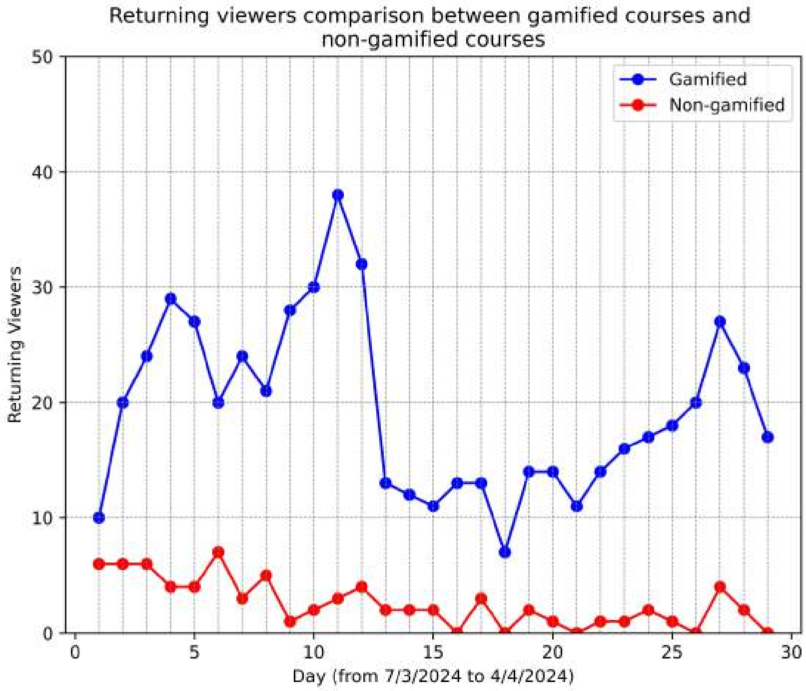


Day	DSA_G	DSA_NG
1	0.15254	0.13158
2	0.27119	0.15789
3	0.37288	0.13158
4	0.47458	0.10526
5	0.33898	0.10526
6	0.20339	0.15789
7	0.38983	0.07895
8	0.33898	0.10526
9	0.38983	0.02632
10	0.42373	0.02632
11	0.55932	0.07895
12	0.50847	0.07895
13	0.16949	0.05263
14	0.20339	0.05263
15	0.15254	0.05263
16	0.20339	0.0
17	0.20339	0.05263
18	0.08475	0.0
19	0.18644	0.05263
20	0.13559	0.02632
21	0.15254	0.0
22	0.20339	0.02632
23	0.16949	0.02632
24	0.20339	0.05263
25	0.27119	0.02632
26	0.32203	0.0
27	0.42373	0.10526
28	0.33898	0.02632
29	0.23729	0.0

Figure 5.38: Returning Viewers Comparison Between DSA-G and DSA-NG (Normalized)

The returning visits for both DSA-G and DSA-NG exhibit a declining trend over the observed period. The trend lines for both versions indicate negative slopes, with DSA G showing a slope of -0.0039 and DSA NG showing a slightly steeper slope of -0.0041, suggesting a gradual decrease in returning visits for both. However, there is notable variability in the data, particularly in DSA-G, where higher peaks indicate more returning viewers compared to DSA-NG. Despite this variability, both versions experience a decline over time. In comparing the two versions, it becomes evident that while the gamified version (DSA-G) had higher peaks of returning viewers, it also exhibited a decline over time, mirroring the trend observed in the non-gamified version (DSA-NG) (Figure 5.38).

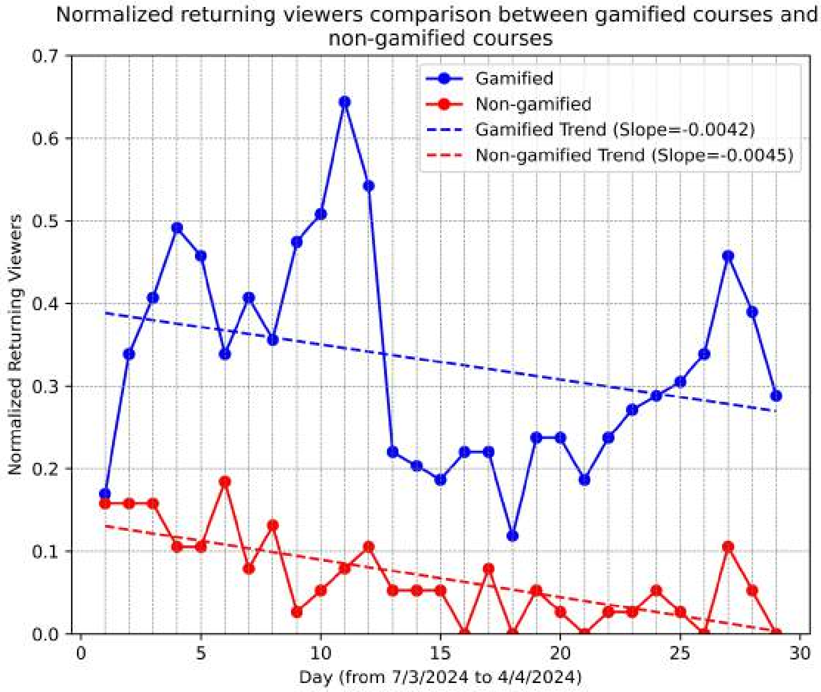
Gamified and Non-gamified Videos



Day	Gamified	Non-gamified
1	10	6
2	20	6
3	24	6
4	29	4
5	27	4
6	20	7
7	24	3
8	21	5
9	28	1
10	30	2
11	38	3
12	32	4
13	13	2
14	12	2
15	11	2
16	13	0
17	13	3
18	7	0
19	14	2
20	14	1
21	11	0
22	14	1
23	16	1
24	17	2
25	18	1
26	20	0
27	27	4
28	23	2
29	17	0

Figure 5.39: Returning Viewers Comparison Between Gamified and Non-gamified Courses

Since the enrolled students are different in the control (Student Group 1) and experiment group (Student Group 2), data in figure 5.39 should be normalized before comparing them. Normalization has been done by dividing each data point (number of returning viewers on a particular day) by the number of enrolled students in the relevant student group (Student Group 1 or Student Group 2).



Day	Gamified	Non-gamified
1	0.16949	0.15789
2	0.33898	0.15789
3	0.40678	0.15789
4	0.49153	0.10526
5	0.45763	0.10526
6	0.33898	0.18421
7	0.40678	0.07895
8	0.35593	0.13158
9	0.47458	0.02632
10	0.50847	0.05263
11	0.64407	0.07895
12	0.54237	0.10526
13	0.22034	0.05263
14	0.20339	0.05263
15	0.18644	0.05263
16	0.22034	0.0
17	0.22034	0.07895
18	0.11864	0.0
19	0.23729	0.05263
20	0.23729	0.02632
21	0.18644	0.0
22	0.23729	0.02632
23	0.27119	0.02632
24	0.28814	0.05263
25	0.30508	0.02632
26	0.33898	0.0
27	0.45763	0.10526
28	0.38983	0.05263
29	0.28814	0.0

Figure 5.40: Returning Viewers Comparison Between Gamified and Non-gamified Courses (Normalized)

Both courses exhibit a declining trend in returning viewership over the observed period, with the gamified course showing a slope of -0.0042 and the non-gamified course demonstrating a slightly steeper decline at -0.0045. Despite variability in engagement, evidenced by higher peaks in the gamified course data, both environments experienced fluctuations in returning viewership. While the gamified version displayed higher peaks of returning viewers, it also showed a decline over time, similar to the non-gamified version (Figure 5.40).

5.2.7 Final Test Evaluation

To assess the effectiveness of gamification in improving test scores, we aim to conduct a **t-test** to compare the mean scores of two groups: one from a gamified test and another from a non-gamified test. By performing a t-test, we can determine if there is a statistically significant difference between the average test scores of students in these two groups.

- **Comparison of Means**: The t-test is a suitable statistical method for comparing the means of two groups. It will enable us to ascertain whether the average test scores of students who took the gamified test differ significantly from those who took the non-gamified test.
- **Statistical Inference**: Through the t-test, we can make informed statistical inferences about the broader population based on the sample data. If a significant difference is found between the two groups, it suggests that this difference likely extends to the population from which the samples were drawn.

- **Quantitative Assessment**: The t-test offers a quantitative measure of the disparity between the two groups. The t-statistic provides insight into the magnitude of the difference relative to the variability within each group, aiding in the interpretation of the results.

Defining Hypotheses

- **Null Hypothesis:** There is no significant difference between the mean scores of the gamified and non-gamified tests.
- **Alternative Hypothesis:** There is a significant difference between the mean scores of the gamified and non-gamified tests.

Significance Level

The significance level is the probability threshold used to determine whether to reject the null hypothesis in hypothesis testing. It represents the maximum acceptable probability of rejecting the null hypothesis when it is true.

The significance level of 0.05 is a commonly used convention in many scientific fields, including statistics.

- **Tradition and Common Practice**: Over the years, the significance level of 0.05 has become a widely accepted standard in scientific research. It's a balance between being stringent enough to avoid too many false positives (Type I errors) and still being sensitive enough to detect meaningful differences.
- **Risk of Type I Error**: A significance level of 0.05 means that there's a 5% chance of erroneously rejecting the null hypothesis when it's true. This level of risk is considered acceptable in many contexts.
- **Interpretability**: A significance level of 0.05 is often seen as easy to interpret. If the p-value is less than 0.05, it's commonly interpreted as "statistically significant," indicating that the observed results are unlikely to have occurred by chance alone.
- **Consistency**: Using a standard significance level across studies helps ensure consistency and comparability of results. Researchers can more easily interpret findings and compare them with other studies if they use a common threshold.

Given the significance of our analysis, we are selecting a significance level of 0.05. This choice indicates that we are willing to accept a 5% probability of incorrectly rejecting the null hypothesis, thus providing a balance between the risk of Type I and Type II errors in our statistical inference.

Calculation

Table 5.4: Second Iteration Final Test Marks

Group	Final Test Marks
Student Group 1 (Control)	46
	38
	70
	16
Student Group 2 (Experiment)	80
	74
	66
	72
	76
	68
	64
	72
	60
	58
	66
	62
	58
	60
	54
	66
	60
	60
	52
	54
	44
	46
	36
	44
	32
	38
	30
	30

To calculate the weighted average post-test scores (Table 5.4) for both student groups, we consider the participation rates in the final test. From Student Group 1, 4 out of 38 students participated, while from Student Group 2, 28 out of 59 students took the final test. For those who did not participate, we assume their final test score to be 0. This approach allows us to incorporate the performance of all students, adjusting for the discrepancy in attendance between the initial group size and the number of students who attended the final test.

$$T - statistic : 4.2593184453567074$$

$$P - value : 4.822114377064576e - 05$$

With a t-statistic of 4.259 and a p-value of 4.822e-05, we reject the null hypothesis ($significancelevel > P - value$), indicating a significant difference between the mean scores of the two groups. This suggests that there is a statistically significant distinction in the average test scores between students who took the gamified test and those who took the non-gamified test.

5.3 Data Analysis

5.3.1 Hypothesis 1

Due to deep gamification, students' engagement with learning materials increases.

The comparison between the gamified and non-gamified versions of the Agile Project Management (APM) course reveals a stark contrast in student engagement levels. The non-gamified course consistently maintained low video views (Section 5.2.1), often with fewer than five views per day. In contrast, the gamified version demonstrated significantly higher engagement, averaging 42.7 views per day with an approximate student engagement rate of 72%. Notable spikes in video views coincided with the conclusion of each season, indicating heightened interest and engagement during these periods. Similarly, in the Data Structure and Algorithms (DSA) course, the gamified version outperformed its non-gamified counterpart in terms of video views, particularly evident around the end of each season. These findings suggest that deep gamification effectively enhances student engagement by attracting more views and sustaining interest over time.

Moreover, the analysis of time spent on videos (Section 5.2.2) reinforces the idea that deep gamification fosters increased engagement with learning materials. Both in the APM and DSA courses, gamified versions exhibited higher average watch times compared to non-gamified ones. Despite fluctuations, the trend lines for gamified courses generally displayed an upward trajectory, indicating a gradual increase in average watch time per student throughout the study period. Conversely, non-gamified courses exhibited more variable trends with lower average watch times, suggesting less sustained engagement.

In summary, the comparison between gamified and non-gamified courses underscores the efficacy of deep gamification in enhancing student engagement with learning materials.

5.3.2 Hypothesis 2

Due to deep gamification, students' consistency with the learning activities increases.

The analysis of return visits (Section 5.2.6) reveals intriguing patterns between gamified and non-gamified versions across both Agile Project Management (APM) and Data Structure and Algorithms (DSA) courses. In the non-gamified versions, fluctuations are evident, with intermittent peaks but also days of zero returning viewers, indicating periods of low engagement. Conversely, the gamified versions demonstrate more consistent engagement, with higher average return views per day and notable peaks, particularly around days 5 and 10 in the APM course and day 11 in the DSA course. Despite a steeper decline in return views in the gamified versions over time, the variability suggests higher engagement levels overall, supporting the hypothesis that deep gamification increases students' consistency with learning activities.

Analysis of quiz submissions (Section 5.2.3) indicates distinct differences between gamified and non-gamified versions. In both APM and DSA courses, gamified submissions show surges, notably around March 18th, with subsequent stabilization at higher levels compared to non-gamified submissions. Non-gamified submissions exhibit lower and more sporadic engagement, with no significant peaks observed. The trend lines for both types of submissions further support this observation, with gamified submissions showing an increasing trend and non-gamified submissions remaining relatively stable or declining slightly. This suggests that deep gamification indeed enhances submission consistency, aligning with the hypothesis.

Regarding module completion rates (Section 5.2.4), they significantly favor the gamified versions in both APM and DSA courses. In the gamified APM course, completion rates stand at 38.99%, compared to a mere 2.63% in the non-gamified version. Similarly, in the gamified DSA course, completion rates reach 49.15%, while the non-gamified version lags far behind at 2.63%. These stark differences underscore the effectiveness of deep gamification in motivating students to complete course modules. Higher completion rates in the gamified versions suggest that deep gamification indeed fosters increased consistency in student engagement with learning activities, supporting the hypothesis.

Overall, the analysis across various metrics consistently supports Hypothesis 2, indicating that deep gamification positively influences students' consistency with learning activities by enhancing engagement, submission rates, and module completion rates.

5.3.3 Hypothesis 3

Due to deep gamification, students' retention with the learning platform increases.

The stark contrast in drop-off rates (Section 5.2.5) between gamified and non-gamified versions of the Agile Project Management (APM) and Data Structure and Algorithms (DSA) courses underscores the significant impact of gamification on student retention. In the APM course, the gamified version exhibited a drop-off rate of 61.01%, notably lower than the staggering 97.36% drop-off rate in the non-gamified counterpart. Similarly, in the DSA course, the gamified iteration displayed a drop-off rate of 50.85%, contrasting sharply with the 97.36% drop-off rate observed in the non-gamified environment. These data points highlight the effectiveness of deep gamification in mitigating dropout rates and promoting sustained student engagement with the course content.

Furthermore, the analysis of return visits (Section 5.2.6) reinforces the notion that deep gamification enhances student retention within the learning platform. Despite fluctuations in returning viewership over time, the gamified versions of both APM and DSA courses consistently attracted higher average return views per day compared to their non-gamified counterparts. In the APM course, despite experiencing a steeper decline in return views, the gamified environment maintained higher average return views, indicating a more engaging learning experience. Similarly, in the DSA course, the gamified environment exhibited a fluctuating pattern of returning viewership with an overall upward trend, suggesting increased student retention over time.

Overall, data obtained from the study strongly supports Hypothesis 3, indicating that deep gamification contributes to increased student retention within the learning platform.

5.3.4 Hypothesis 4

Due to deep gamification, students' performance with respect to marks increases.

The results of the t-test (Section 5.2.7) provide statistical evidence supporting the fourth hypothesis that deep gamification positively impacts students' performance, as measured by their test scores. Here's how the results of the t-test support Hypothesis 4:

- **T-statistic**: The calculated t-statistic is 4.259. This value indicates the magnitude of the difference between the mean scores of the gamified and non-gamified tests relative to the variability within the groups. A higher absolute t-statistic suggests a more significant difference between the two groups.

- **P-value**: The p-value associated with the t-test is 4.822×10^{-5}, which is extremely small. This indicates that the probability of observing such extreme differences in test scores between the gamified and non-gamified groups by random chance alone is very low. In statistical terms, it's significantly lower than the commonly used significance level of 0.05.

- **Rejecting the Null Hypothesis**: With such a small p-value, we reject the null hypothesis, which states that there is no significant difference between the mean scores of the gamified and non-gamified tests. Instead, we accept the alternative hypothesis, which suggests that there is indeed a significant difference between the mean scores.

- **Direction of the Difference**: Since the mean scores of the gamified test group are significantly higher than those of the non-gamified test group, this supports the notion that deep gamification leads to improved student performance.

- **Practical Significance**: While statistical significance is crucial, it's also essential to consider practical significance. In this case, the t-test results not only indicate a statistically significant difference but also suggest a meaningful improvement in student performance due to deep gamification, given the magnitude of the t-statistic.

Overall, the results of the t-test provide strong support for Hypothesis 4, indicating that deep gamification positively influences students' performance concerning marks. These findings have practical implications for educators and curriculum developers, suggesting that implementing deep gamification strategies could lead to improved learning outcomes.

Chapter 6

Discussion and Conclusion

6.1 Discussion

The results of our study support all four hypotheses, indicating that deep gamification enhances the quality of higher education by improving students' engagement, consistency, retention, and performance. This finding contributes significantly to the existing body of knowledge in the field, as it provides empirical evidence of the effectiveness of deep gamification in online learning environments. By demonstrating the positive impact of deep gamification on various aspects of student learning, our study reinforces the importance of incorporating gamified elements into educational platforms.

Comparing our findings with previous research, we note several distinctions that highlight the novelty and significance of our study. Unlike previous studies that predominantly focused on shallow gamification, we utilized deep gamification strategies, which involve more immersive and meaningful game elements. Additionally, our research made iterative refinements to the Nebula framework, integrating clear justifications for the components and architecture. Moreover, while many studies evaluated gamified systems in IT-based subjects, our research evaluated the Nebula framework's performance across both technical and non-technical courses, broadening the scope of the investigation.

Despite the strengths of our study, we acknowledge certain limitations that may have influenced our results. The sample size, comprising approximately 100 individuals, could be considered relatively small, potentially limiting the generalizability of our findings. Future research endeavors could aim to increase the sample size to enhance the robustness of conclusions drawn from similar studies.

The practical implications of our findings are significant, as they suggest that integrating the Nebula framework into existing and newly developed online learning platforms can lead to improved student outcomes. Content creators can also benefit from the insights provided by the Nebula guidelines when designing course content, ensuring that gamified elements are strategically incorporated to enhance student engagement and learning experiences. Overall, our study underscores the potential of deep gamification in revolutionizing online education and opens avenues for further investigation into its applications and efficacy in real-world settings.

6.2 Conclusion

In conclusion, our research aimed to investigate the impact of deep gamification on the quality of higher education, specifically focusing on enhancing students' engagement, consistency, retention, and performance. We formulated four hypotheses to guide our study, and through the design and implementation of the Nebula framework, we sought to test these hypotheses rigorously. Utilizing the Design Science Research Methodology (DSRM), we developed and integrated the Nebula framework into custom online learning platforms. By comparing the learning experiences of students using the Nebula-integrated platform with those using a conventional online learning platform, we were able to evaluate the efficacy of deep gamification in achieving our research objectives. Our findings unequivocally support the hypotheses formulated. Students engaging with the Nebula-integrated platform exhibited higher levels of engagement with learning materials, demonstrated greater consistency in their learning activities, displayed improved retention within the learning platform, and achieved better performance in terms of marks. These results underscore the transformative potential of deep gamification in enhancing the quality of higher education. By providing educators and curriculum developers with a versatile framework for gamifying online learning experiences, the Nebula framework offers a promising avenue for fostering more engaging, consistent, and effective learning environments. Moving forward, further refinement and expansion of the Nebula framework, as well as continued research into the intersection of gamification and education, will be essential. By leveraging innovative technologies and pedagogical insights, we can continue to push the boundaries of online education and empower learners to succeed in an increasingly digital and dynamic world.

6.3 Future Work

These insights aim to further enhance the effectiveness and functionality of the Nebula framework:

1. **Nebula Guidelines Enhancement**: Continuously refine and expand the Nebula guidelines based on additional underlying theories and empirical research. Incorporate feedback from educators and students to ensure that the guidelines remain relevant and effective in guiding course development and implementation.

2. **Dynamic Quiz Generation Process**: Implement a dynamic quiz generation process that adapts to students' proficiency levels and learning progress. Explore algorithms that personalize quiz content based on individual learning needs and performance.

3. **Hidden Rank Calculation**: Develop a formula to calculate a hidden rank that accurately reflects students' true competence levels. Incorporate various performance metrics and learning analytics data to derive a comprehensive assessment of students' knowledge and skills.

4. **Difficulty Range of Questions**: Refine the framework to allow users to define the difficulty range of questions dynamically. Provide flexibility for educators to customize quiz difficulty levels based on course objectives, student demographics, and learning outcomes.

5. **Difficulty Convergence Formula**: Explore and implement an improved formula to converge the difficulty of quiz questions dynamically. Utilize advanced algorithms and machine learning techniques to adjust question difficulty based on students' responses and performance.

6. **Recalibration Process Automation**: Develop an algorithm to automate the recalibration process.

7. **Integration of Artificial Intelligence**: Investigate ways to incorporate artificial intelligence (AI) technologies into the Nebula framework. Explore AI-driven features such as personalized recommendations, adaptive learning pathways, and intelligent feedback mechanisms enhance student engagement and learning outcomes.

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Appendices

Appendix A

Consent Form

Consent Form for Research Participation

Dear Participant,

We invite you to take part in a research study conducted by Team Nebula from University of Colombo School of Computing. The purpose of this study is to compare the learning experiences of university students on an online education platform.

Introduction:
Before you decide to participate, it is important for you to understand the purpose and procedures of the study. You are encouraged to ask any questions you may have about the study.

Study Description:
You will be asked to participate in an online education platform, which includes two courses: Data Structures and Algorithms (DSA) and Agile Project Management. At the end of your participation, we will evaluate your experience.

Participation:
Your participation will involve accessing the online platform, completing the assigned courses, and potentially responding to surveys or interviews about your experiences.

Confidentiality:
Your personal information, such as your name and email address, will be kept confidential and will not be shared with anyone outside of the research team. Your responses will be anonymized.

Voluntary Participation:
Participation in this study is completely voluntary. You may choose to withdraw from the study at any time without any consequences.

Risks and Benefits:
There are no foreseeable risks associated with this research. The potential benefits of participating include understanding concepts of your some of the subjects in the university. It will be an added advantage when you're facing your exams.

Contact Information:
If you have any questions or concerns about the research or your participation, please contact nebula team.

Harsha - 071-1425085

Consent:
By completing the following questionnaire, you agree to participate in this research study.

* Indicates required question

1. Email *

2. **First name** (Ex: John) *

3. **Last name** (Ex: Doe) *

4. **Gmail Address** (Ex: johndoe@gmail.com) *

5. **Have you participated in online education platforms before?** *

Mark only one oval.

- Yes
- No

6. **How often do you typically engage in online learning activities (e.g., online courses, webinars)?** *

Mark only one oval.

- Frequently
- Occasionally
- Rarely
- Never

7. **Are you comfortable using online learning platforms?** *

Mark only one oval.

- Very comfortable
- Somewhat comfortable
- Neutral
- Somewhat uncomfortable
- Very uncomfortable

8. **WhatsApp Contact Number** *

9. **Please indicate your agreement with the following statement: "I consent to participate in this research and agree to use the provided online education platform for the study."** *

Mark only one oval.

- Agree
- Disagree

10. **Do you have any comments, questions, or concerns related to your participation in this study? (Optional)**

Appendix B

Feedback Form (Control Group)

Nebula Research Study: Feedback Form

Dear Participant,

We extend our heartfelt gratitude for your active participation in the Nebula Platform Research study. Your invaluable contributions have significantly enriched our research endeavors thus far.

As we reach the culmination of this study, we are eager to gather your candid feedback on the course materials you encountered during the study period and your experience with the features available on the Nebula Platform.

Rest assured, we prioritize your privacy throughout our research process. None of your personal information will be retained or shared with any third parties, organizations, or institutes, and it will not be disclosed in any research publications.

We kindly ask you to provide your honest feedback using the form provided. Your insights are instrumental in helping us enhance the Nebula Platform for future users.

* Indicates required question

1. Email *

Overall Experience

2. Rate your experience on the Nebula platform *

Mark only one oval.

	1	2	3	4	5	
Very	◯	◯	◯	◯	◯	Excellent

3. Mention your reasons for the above rating?

4. Would you recommend the Nebula platform to others as a way of learning? *

Mark only one oval.

- Yes
- No
- Maybe

Engagement and Motivation

5. Rate your overall experience with course engagement and motivation *

Mark only one oval.

	1	2	3	4	5	
Very	◯	◯	◯	◯	◯	Excellent

6. How effective were the questions provided at the end of each video lesson in assessing your understanding of the course material? *

Mark only one oval.

	1	2	3	4	5	
Not	◯	◯	◯	◯	◯	Very Effective

7. How would you rate the difficulty level of the questions you received after each video lesson? *

Mark only one oval.

	1	2	3	4	5	
Very	◯	◯	◯	◯	◯	Very Difficult

8. Your comments on your engagement and motivation throughout the course on the platform.

Please provide any comments, feedback, or insights regarding your level of engagement and motivation during the course. This could include factors that positively influenced your engagement, challenges you faced, or suggestions for improvement.

Strengths and Areas for Improvement

9. What aspects of the platform/courses did you find most beneficial/enjoyable? Mention at least three. *

10. What aspects of the platform/courses did you found challenging or frustrating? Mention at least three. *

User Interface

11. How would you rate the user interface of the platform? *

Mark only one oval.

	1	2	3	4	5	
Very	◯	◯	◯	◯	◯	Excellent

12. Mention your reasons for the above rating?

Include any positive aspects of the User Interface and the User Experience of the Nebula platform or any improvements you suggest

____

____

____

13. Is there any additional feedback or insights you would like to share regarding your experience with the platform/course?

____

____

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____

Appendix C

Feedback Form (Experiment Group)

Nebula Research Study: Feedback Form

Dear Participant,

We extend our heartfelt gratitude for your active participation in the Nebula Platform Research study. Your invaluable contributions have significantly enriched our research endeavors thus far.

As we reach the culmination of this study, we are eager to gather your candid feedback on the course materials you encountered during the study period and your experience with the features available on the Nebula Platform.

Rest assured, we prioritize your privacy throughout our research process. None of your personal information will be retained or shared with any third parties, organizations, or institutes, and it will not be disclosed in any research publications.

We kindly ask you to provide your honest feedback using the form provided. Your insights are instrumental in helping us enhance the Nebula Platform for future users.

* Indicates required question

1. Email *

Overall Experience

2. Rate your experience on the Nebula platform *

Mark only one oval.

	1	2	3	4	5	
Very	◯	◯	◯	◯	◯	Excellent

3. Mention your reasons for the above rating?

____

____

____

____

____

4. Would you recommend the Nebula platform to others as a way of learning? *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe

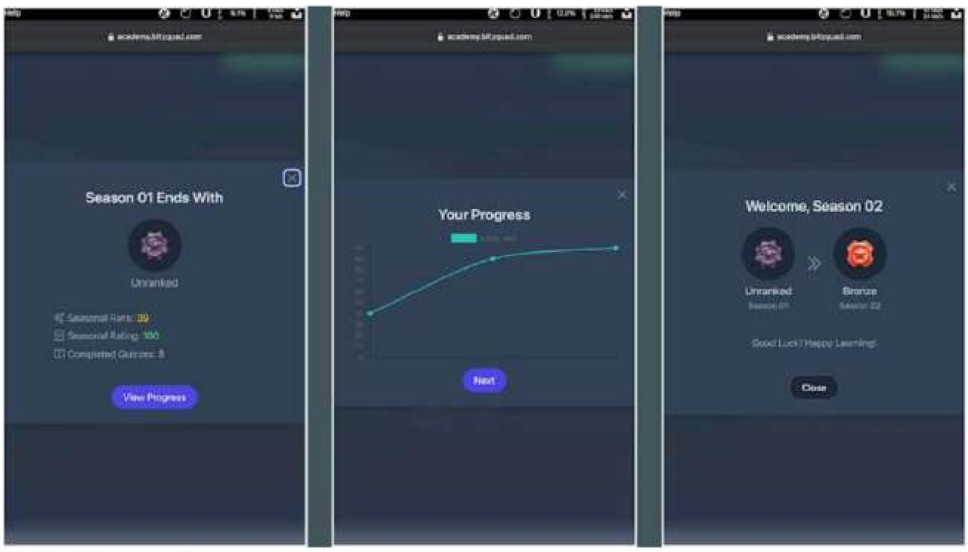
Engagement and Motivation

5. Rate your overall experience with course engagement and motivation *

Mark only one oval.

	1	2	3	4	5	
Very	◯	◯	◯	◯	◯	Excellent

6. Did the presence of **rankings** enhance your motivation and engagement with the course content? *



Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

7. Did the presence of a **leaderboard** enhance your motivation and engagement with the course content? *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

8. Did the presence of **Seasons** enhance your motivation and engagement with the course content? *

Mark only one oval.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

9. How effective were the questions provided at the end of each video lesson in assessing your understanding of the course material? *

Mark only one oval.

	1	2	3	4	5	
Not	◯	◯	◯	◯	◯	Very Effective

10. How would you rate the difficulty level of the questions you received after each video lesson? *

Mark only one oval.

	1	2	3	4	5	
Very	◯	◯	◯	◯	◯	Very Difficult

11. Your comments on your engagement and motivation throughout the course on the platform.

Please provide any comments, feedback, or insights regarding your level of engagement and motivation during the course. This could include factors that positively influenced your engagement, challenges you faced, or suggestions for improvement.

Strengths and Areas for Improvement

12. What aspects of the platform/courses did you find most beneficial/enjoyable? Mention at least three. *

13. What aspects of the platform/courses did you found challenging or frustrating? Mention at least three. *

User Interface

14. How would you rate the user interface of the platform? *

Mark only one oval.

	1	2	3	4	5	
Very	◯	◯	◯	◯	◯	Excellent

15. Mention your reasons for the above rating?

Include any positive aspects of the User Interface and the User Experience of the Nebula platform or any improvements you suggest

General Comments

16. Is there any additional feedback or insights you would like to share regarding your experience with the platform/course?

Appendix D

Pre-test Questions

1. What is the primary purpose of variables in programming?

   a) To execute control flow statements
   b) To define functions
   c) To create graphical user interfaces
   d) To store and manipulate data

2. In programming, which of the following statements is used to execute a block of code repeatedly as long as a specified condition is true?

   a) switch statement
   b) break statement
   c) if statement
   d) for loop

3. Consider the following code snippet in a programming language:

```
x = 5
y = 3
result = x++ - --y + x-- * y++
```

   What is the final value of the variable result after executing this code?

   a) 25
   b) 20
   c) 23
   d) 16

4. In programming languages that support pointers, what does the "dereference" operation do?

   a) Access the value stored at a memory address
   b) Access the memory address of a variable
   c) Create a new variable in memory
   d) Increment the value of a variable

5. How are elements typically accessed in an array in most programming languages?

a) By using the "access" function
b) By specifying the position with an index
c) By using a loop
d) By using the "element" keyword

6. Which data type is used to represent true or false values in programming?

a) Boolean
b) String
c) Integer
d) Float

7. In object-oriented programming, what is a class?

a) A blueprint for creating objects
b) A collection of functions
c) A variable with a predefined value
d) A specific instance of an object

8. In the context of object-oriented programming, what is the significance of the term "polymorphism"?

a) It refers to the ability of an object to take on multiple forms based on its attributes
b) It represents the process of converting a class into an object
c) It describes the concept of encapsulation within a class hierarchy
d) It denotes the process of dynamically allocating memory for objects during runtime

9. What is the correct first step in solving the equation **$2x + 5 = 11$** for x?

a) Multiply both sides by 5
b) Divide both sides by 2
c) Subtract 5 from both sides
d) Add 5 to both sides

10. Evaluate the expression **$3(4 + 2) - 7$**

a) 19
b) 13
c) 11
d) 15

11. Solve for x in the equation: **$4(2x - 3) + 7 = 5x + 1$**

a) $x = 2$
b) $x = 3$
c) $x = -1$
d) $x = 1$

12. Simplify the expression **$(2x^2 - 5x + 3) / (x - 1) + (x^2 + 2x - 8) / (x + 2)$**

a) $(2x^2 + 3x - 5) / (x + 2)$
b) $(x (3x^2 - 17) + 14) / (x - 1) (x + 2)$
c) $(4x^2 - 3x + 5) / (2x + 1)$
d) $(3x^2 - 9) / (x - 1)$

13. Which of the following represents the logical expression "NOT P AND Q," where P and Q are boolean variables?

a) NOT P OR Q
b) P AND NOT Q
c) Q AND NOT P
d) P OR NOT Q

14. What is the result of the logical expression "(P OR Q) AND NOT Q" when P is true and Q is false?

a) False
b) Cannot be determined
c) Depends on the values of P and Q
d) True

15. Consider the logical expression "P AND (Q OR NOT P)." What is the simplified form of this expression?

a) P AND Q
b) (NOT P OR Q) AND (P OR NOT Q)
c) P AND (NOT Q AND P)
d) (NOT P AND Q) OR (P AND NOT Q)

16. Construct a logical expression using P, Q, and R such that it represents the statement "Either (P AND Q) OR (NOT R) is true, but not both."

a) (P AND Q) XOR (NOT R)
b) (P AND Q) XNOR R
c) (P AND Q) XOR R
d) (P AND Q) OR (R AND NOT P)

17. In mathematics, what is a function?

a) A set of integers
b) A relation between sets where each input has multiple outputs
c) A one-to-one mapping between elements of two sets
d) A set of ordered pairs where each input has exactly one output

18. In a simple undirected graph, what is the maximum number of edges that can be present with n vertices?

a) n(n - 1) / 2
b) 2n
c) n
d) n - 1

19. Consider a set A with n elements. How many subsets does the power set of A have?

a) n!
b) 2^n
c) n^2
d) 2n

20. **Let f: A → B** be a function. If A has m elements and B has n elements, what is the maximum number of elements in the Cartesian product **A × B**?

a) m! + n!
b) m + n
c) mn
d) m^n

21. What is the primary benefit of breaking down a complex problem into smaller steps?

a) It makes the problem look simpler on paper
b) It allows for easier memorization of each step
c) It facilitates a more manageable and systematic approach to problem-solving
d) It speeds up the solution process

22. What is the primary goal of abstraction in problem-solving?

a) To avoid solving the problem
b) To emphasize irrelevant details
c) To simplify and focus on the essential aspects of the problem
d) To complicate the problem

23. Why is it important to identify and ignore irrelevant details when practicing abstraction?

a) Irrelevant details can lead to incorrect solutions
b) Irrelevant details make the problem more interesting
c) Ignoring irrelevant details is a time-consuming process
d) Irrelevant details are crucial for a comprehensive solution

24. In the context of abstraction, what is the concept of "information hiding" aimed at achieving?

a) Exposing all details to ensure a comprehensive understanding
b) Focusing solely on irrelevant details for a holistic approach
c) Minimizing the use of abstraction for clarity
d) Concealing essential details to simplify problem-solving

25. In a computer's memory, what is the purpose of memory addresses?

a) To locate specific locations in memory for data storage/retrieval
b) To control the execution of programs
c) To identify the type of data stored
d) To store data values

26. How does effective team collaboration benefit a project?

a) Reduces project costs
b) Improves decision-making
c) Delays project deadlines
d) Increases project scope

27. In a cross-functional team:

a) Members work remotely
b) Members have the same skills and expertise
c) Members have similar personalities
d) Members belong to different departments or specialties

28. A team faces a conflict regarding the best approach for a project. What could be the best initial step to resolve this conflict?

a) Seek mediation from an external consultant
b) Encourage open dialogue and brainstorming within the team
c) Assign a team leader to make the final decision
d) Let team members settle the conflict themselves

29. Which communication channel allows immediate interaction among team members?

a) Emails
b) Phone calls
c) Video conferences
d) Instant messaging

30. What is the primary purpose of a status report in project communication?

a) Resolve team conflicts
b) Review project milestones
c) Share project updates with stakeholders
d) Document team meeting minutes

31. In a multicultural project team, what should be the primary focus of communication to ensure effectiveness?

a) Rely more on written communication
b) Use formal language in all communications
c) Tailor communication styles to accommodate cultural differences
d) Avoid discussing sensitive topics

32. What is the first step in the risk management process?

a) Risk analysis
b) Risk monitoring
c) Risk response planning
d) Risk identification

33. Which risk response strategy involves sharing the risk with a third party?

a) Transference
b) Mitigation
c) Avoidance
d) Acceptance

34. A project manager identifies a potential risk of resource scarcity due to external market fluctuations. What is the most appropriate risk response?

a) Mitigate the risk by hiring additional resources immediately
b) Accept the risk and proceed with the project
c) Transfer the risk by outsourcing some project tasks
d) Avoid the risk by changing project scope

35. Which process ensures that project deliverables meet quality standards?

a) Quality control
b) Quality assurance
c) Quality monitoring
d) Quality planning

36. What tool is commonly used to visually represent the sequence of tasks in a project?

a) Histogram
b) Gantt chart
c) Pareto chart
d) Scatter plot

37. What does the Critical Path in project management signify?

a) The fastest completion path in the project
b) The most crucial tasks in the project
c) The path with the least dependencies
d) The longest path in the project schedule

38. In a project where unexpected delays occur, what could be the most effective time management strategy?

a) Reduce project scope to meet deadlines
b) Implement overtime for the team to catch up
c) Re-evaluate the project schedule and adjust timelines realistically
d) Reallocate resources from other projects to compensate for delays

39. What is the primary purpose of conducting team-building activities in a project?

a) Reduce team efficiency
b) Improve team morale and cooperation
c) Extend project timelines
d) Increase project costs

40. How does diversity within a team contribute to better problem-solving?

a) By hindering communication
b) By limiting perspectives
c) By creating conflicts
d) By bringing varied perspectives and approaches

41. In a team where members have different working styles and preferences, what could be a strategy to ensure effective collaboration?

a) Assign tasks based on individual preferences
b) Standardize one working style for all team members
c) Establish rigid protocols to streamline working styles
d) Encourage understanding and flexibility in accommodating diverse working styles

42. What communication skill emphasizes the ability to listen and understand others' viewpoints?

a) Speaking clearly
b) Active listening
c) Effective presentation
d) Writing concisely

43. Which communication barrier occurs when information is altered or changed as it is transmitted?

a) Semantic barriers
b) Distortion
c) Noise
d) Filtering

44. When dealing with a conflict arising from misinterpretation of written communication, what could be a suitable resolution approach?

a) Ignore the issue if it doesn't affect the project directly
b) Reprimand the individual responsible for the misinterpretation
c) Publicly highlight the misinterpretation to prevent future mistakes
d) Address the issue privately with the concerned parties, seeking clarification

45. Which risk response involves reducing the probability or impact of a risk to an acceptable threshold?

a) Transference
b) Mitigation
c) Acceptance
d) Avoidance

46. What document outlines the project's quality objectives, standards, and processes?

a) Quality report
b) Quality plan
c) Quality checklist
d) Quality metrics

47. What is the primary purpose of a project schedule?

a) To conduct risk analysis
b) To track project costs
c) To plan project activities and deadlines
d) To allocate resources

48. How does effective conflict resolution contribute to team collaboration?

a) It suppresses opinions to maintain harmony
b) It escalates conflicts to higher authorities
c) It encourages healthy debates and discussions
d) It avoids conflicts altogether

49. In a project team with members from different time zones, what communication strategy would be most effective?

a) Restrict communication to specific time slots convenient for everyone
b) Conduct regular face-to-face meetings despite time differences
c) Require all team members to adjust their work hours to a common time zone
d) Use asynchronous communication methods like emails or project management tools

50. A critical supplier faces financial instability. What is the most appropriate risk response strategy?

a) Accept the risk and find alternative suppliers if needed
b) Transfer the risk by purchasing insurance for the supplier
c) Mitigate the risk by reducing reliance on the supplier
d) Avoid the risk by terminating the contract immediately

Appendix E

Final Test Questions

1. What is the time complexity of an algorithm with the following loop:

```
for i in range(n):
for j in range(i):
print(i, j)
```

   a) O(n)
   b) O(n^2)
   c) O(logn)
   d) O(nlogn)

2. What is the time complexity of an algorithm that divides the problem into two subproblems of size n/2 each and combines their solutions in O(n) time?

   a) O(n^2)
   b) O(n)
   c) O(logn)
   d) O(nlogn)

3. Which algorithm uses the divide and conquer strategy to find the maximum subarray sum?

   a) Quick Sort
   b) Binary Search
   c) Merge Sort
   d) None

4. Which of the following operations on a stack has a time complexity of O(1)?

a) Push
b) Peek
c) Size
d) Pop

5. What is the time complexity to insert an element at the end of a singly linked list with n elements?

a) O(logn)
b) O(1)
c) O(n)
d) O(n^2)

6. Which operation on a linked list requires traversing the entire list?

a) Insertion at the head
b) Deletion from the end
c) Insertion at the end
d) Deletion from the head

7. Which type of linked list allows traversal in both forward and backward directions?

a) Circular linked list
b) Singly linked list
c) Doubly linked list
d) None

8. Which hashing technique resolves collisions by chaining?

a) Linear Probing
b) Separate Chaining
c) Quadratic Probing
d) Double Hashing

9. What is the space complexity of a hash table with n key-value pairs?

a) O(nlogn)
b) O(n)
c) O(1)
d) O(logn)

10. In which tree traversal do you visit the root node after visiting its left and right subtrees?

a) Level order
b) Inorder
c) Postorder
d) Preorder

11. What is the maximum number of nodes at height h in a binary tree?

a) h^2
b) 2h
c) 2^h
d) hlogh

12. A full binary tree with height h has how many leaf nodes?

a) 2^h
b) 2^(h-1)
c) h
d) 2h

13. In a perfect binary tree with height h, how many total nodes are there?

a) 2^h
b) 2h
c) h^2
d) 2^(h+1) - 1

14. In a complete binary tree of height h, what is the minimum number of nodes possible?

a) h^2
b) 2h
c) 2^h
d) 2^(h-1)

15. Which property guarantees that the height difference between the left and right subtrees of any node in a binary tree is at most 1?

a) Red-Black property
b) B-tree property
c) AVL property
d) Binary Heap property

16. Which operation on a binary search tree has a time complexity of O(logn) in the average case?

a) Traversal
b) Search
c) Insertion
d) Deletion

17. In an AVL tree, what is the maximum height difference allowed between the left and right subtrees of any node?

a) 1
b) 3
c) 2
d) 4

18. Which heap operation ensures that the maximum (or minimum) element can be efficiently retrieved?

a) Insert
b) Delete
c) Decrease-Key (or Increase-Key)
d) Extract-Max (or Extract-Min)

19. Which operation in Fibonacci Heap has a time complexity of O(1)?

a) Extract-Min
b) Insert
c) Decrease-Key
d) Delete

20. What is the time complexity of the Decrease-Key operation in Fibonacci Heap?

a) O(1)
b) O(logn)
c) O(n)
d) O(loglogn)

21. Which operation in a queue follows the First-In-First-Out (FIFO) principle?

a) Peek
b) Enqueue
c) Size
d) Dequeue

22. Which type of queue allows elements to be added and removed from both ends?

a) Linear Queue
b) Priority Queue
c) Double Ended Queue (Deque)
d) Circular Queue

23. In a circular queue implementation using an array of size n, what is the maximum number of elements that can be stored without overflow?

a) n+1
b) n
c) 2n
d) n-1

24. Which element will be removed first from a priority queue based on the highest priority?

a) The element inserted first
b) The element with the lowest value
c) The element with the highest value
d) The element inserted last

25. Which operation allows adding an element to the front of a double-ended queue?

a) Dequeue
b) Front-Enqueue
c) Rear-Enqueue
d) Enqueue

26. *Which event is specifically dedicated to reflecting on what worked, what didn't, and how to improve in the next sprint?*

a) Sprint Planning
b) Sprint Review
c) Daily Scrum
d) Sprint Retrospective

27. *What is the primary objective of Agile project management?*

a) Maximizing documentation
b) Adapting to change
c) Following a strict plan
d) Minimizing collaboration

28. *Which Agile framework is characterized by its focus on continuous improvement, flexibility, and self-organization?*

a) Lean
b) Waterfall
c) Six Sigma
d) Scrum

29. *What are the key characteristics of a VUCA environment, and how do they impact Agile project management strategies?*

a) Volatility, Uncertainty, Complexity, Ambiguity; they necessitate frequent adaptation and flexibility
b) Transparency, Collaboration, Documentation, Control; they emphasize control and hierarchy
c) Change, Innovation, Progress, Creativity; they encourage experimentation and risk-taking
d) Stability, Predictability, Clarity, Order; they require strict adherence to plans and timelines

30. *How do the three pillars of Scrum contribute to the success of Agile projects, and what role does each pillar play?*

a) Transparency ensures accountability, Inspection facilitates feedback, and Adaptation fosters innovation
b) Transparency enables monitoring, Inspection validates performance, and Adaptation drives change
c) Transparency enhances visibility, Inspection verifies progress, and Adaptation encourages flexibility
d) Transparency promotes open communication, Inspection ensures quality, and Adaptation enables continuous improvement

31. *How does backlog refinement contribute to the effectiveness of Agile project management, and what activities are typically involved in this process?*

a) It facilitates collaboration between the Scrum Master and Product Owner; activities include daily stand-ups and sprint reviews
b) It helps maintain a prioritized list of work items; activities include adding, removing, and estimating backlog items
c) It ensures alignment with stakeholder expectations; activities include backlog grooming, backlog refinement, and sprint planning
d) It ensures that all items are completed within a sprint; activities include prioritization, estimation, and clarification

32. *What techniques can optimize Kanban boards in Agile project management?*

a) Implementing automation tools and enforcing strict policies
b) Integrating with other project management tools and customizing board layouts
c) Implementing agile metrics and conducting regular retrospectives
d) Regular board reviews and process refinement

33. *What techniques ensure effective backlog grooming in Agile projects?*

a) Creating acceptance criteria, conducting impact mapping, and involving stakeholders
b) Story mapping, user story splitting, and backlog grooming sessions
c) Using MoSCoW prioritization, conducting value stream mapping, and maintaining a balanced mix
d) Conducting risk assessments, estimating backlog items using poker planning, and maintaining a balanced mix

34. *How can the Daily Scrum meeting be optimized for team communication and collaboration?*

a) Timeboxing, focusing on the three questions, and standing up

b) Conducting the meeting asynchronously, using collaboration tools, and focusing on impediment removal

c) Conducting the meeting in a designated space, using visual aids, and encouraging participation

d) Rotating the facilitator, conducting the meeting at the same time and place, and using a round-robin format

35. *What organizational impacts may arise from adopting an Agile mindset?*

a) Increased collaboration, faster decision-making, and improved customer satisfaction

b) Reduced project risk, improved product quality, and higher team morale

c) Changes in roles and responsibilities, shifts in organizational culture, and adjustments to governance structures

d) Resistance to change, confusion about new processes, and challenges in scaling Agile practices

36. *How can the traits of an effective Product Owner contribute to the success of a Scrum team?*

a) Collaboration, empathy, and negotiation

b) Leadership, vision, and strategic thinking

c) Technical expertise, domain knowledge, and communication skills

d) Stakeholder management, prioritization, and decision-making

37. *What is the role of the Development Team in Scrum?*

a) To prioritize the items in the product backlog

b) To create and deliver increments of potentially shippable product functionality

c) To resolve conflicts between the Scrum Master and Product Owner

d) To facilitate the Scrum events

38. *What is one of the core values of Scrum that emphasizes the importance of delivering valuable software frequently?*

a) Inspection

b) Customer collaboration

c) Adaptation

d) Transparency

39. *Which role in Scrum is responsible for maximizing the value of the product and the work of the Development Team?*

a) Development Team

b) Project Manager

c) Product Owner

d) Scrum Master

40. *What is the primary goal of implementing Kanban in Agile project management?*

a) Maximizing work in progress

b) Minimizing team collaboration

c) Eliminating change requests

d) Visualizing workflow and optimizing throughput

41. *What key principles distinguish Scrum from other Agile methodologies?*

a) Timeboxing and iterative development

b) Lean thinking and value stream mapping

c) Continuous flow and visual management

d) Empirical process control and self-organization

42. *How does the Scrum Master facilitate the resolution of conflicts within the team?*

a) By escalating conflicts to higher management levels for resolution, ensuring that they do not disrupt the team's progress.

b) By coaching team members on conflict resolution techniques and facilitating open discussions to address underlying issues.

c) By assigning blame and reprimanding team members for their role in conflicts, establishing consequences for future behavior.

d) By making unilateral decisions to resolve conflicts quickly and maintain project momentum.

43. *What strategies can a Product Owner use to prioritize backlog items effectively?*

a) By considering the value of each item to the customer, the effort required for implementation, and the dependencies between items.

b) By randomly selecting items from the backlog for implementation, allowing the team to focus on a diverse range of tasks.

c) By delegating the task of prioritization to the Development Team, who are responsible for delivering the product increment.

d) By prioritizing items based on personal preferences and opinions, ensuring that their vision for the product is reflected in the backlog.

44. *How does the Sprint Review meeting contribute to stakeholder engagement and product development?*

a) By providing stakeholders with an opportunity to provide feedback on the product increment and suggest changes or improvements.

b) By planning the work to be done in the upcoming sprint, including selecting backlog items and estimating the effort required for implementation.

c) By conducting a retrospective on the sprint and discussing what went well, what didn't, and how the team can improve in the next sprint.

d) By reviewing the team's performance during the sprint and identifying areas for improvement in their processes or practices.

45. *What is the purpose of velocity and burndown charts in Scrum?*

a) To assign tasks to team members and monitor their progress throughout the sprint

b) To record the time spent by each team member on different tasks and activities

c) To visualize the flow of work on the team's Kanban board and identify bottlenecks

d) To track the team's progress and forecast the likelihood of completing the work in the sprint

46. *What is the purpose of the Product Backlog in Scrum?*

a) To schedule meetings and events for the Scrum team

b) To document all the tasks completed during the sprint

c) To prioritize the work that needs to be done in the project

d) To track the time spent on each task by team members

47. *What is the primary difference between Agile and Waterfall project management methodologies?*

a) Agile emphasizes iterative development and flexibility, while Waterfall follows a sequential approach with fixed phases.

b) Agile relies on rigid timelines and milestones, while Waterfall allows for continuous feedback and adjustments.

c) Agile focuses on documentation and strict adherence to plans, while Waterfall prioritizes adaptability and customer collaboration.

d) Agile promotes individual tasks over team collaboration, while Waterfall encourages collective decision-making.

48. *What are the three pillars of Scrum?*

a) Collaboration, Communication, and Documentation

b) Transparency, Inspection, and Adaptation

c) Planning, Execution, and Monitoring

d) Customer satisfaction, Quality, and Continuous improvement

49. *What is the Agile Manifesto?*

a) A formal document outlining project requirements and specifications

b) A software tool used for Agile project tracking and management

c) A set of principles and values that guide Agile project management practices

d) A project management framework focused on hierarchical structures and rigid planning

50. *Who is responsible for ensuring that the Scrum team understands and follows the Scrum framework?*

a) Product Owner

b) Development Team

c) Stakeholders

d) Scrum Master