communicated by:
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Prof Dr. Ulrik Schroeder

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Incentivizing Learning: The Role of Competitive Leaderboards in Education

Anreize zum Lernen: Die Rolle wettbewerbsorientierter Ranglisten in der Bildung

Master-Thesis
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presented by / von

Shah, Vinay
441918

Prof. Dr.-Ing. Ulrik Schroeder

Dr. rer. nat. Svenja Noichl

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Abstract

The integration of gamification elements in educational platforms has gained significant attention as a means to enhance motivation and engagement among learners. Leaderboards, as a key gamification feature, introduce a competitive aspect that encourages students to participate actively and track their progress. This thesis explores the development, implementation, and evaluation of a competitive leaderboard within the DiGaBo platform, an interactive digital gamebook system designed to make learning more engaging. The primary objective of this research is to assess the impact of the leaderboard on user motivation, engagement, and learning effectiveness.

A structured methodology was employed, beginning with an extensive literature review on gamification in education, followed by the design and implementation of a leaderboard in DiGaBo. A user evaluation study was conducted with eight participants from diverse academic and professional backgrounds, using two data collection methods: User Interaction Observation and Semi-Structured Interviews. Participants provided qualitative insights into the usability, competitiveness, fairness, and behavioral influence of the leaderboard.

The findings indicate that the leaderboard significantly enhanced user engagement, with most participants reporting increased motivation to check their rankings and improve their scores. The leaderboard transformed the platform from an individual learning experience to a more social and competitive environment, fostering a sense of community. While the majority of users appreciated the ranking system, some suggested implementing dynamic scoring to provide a more granular view of performance in specific gamebooks. Additionally, feedback highlighted the need for improved scoring notifications.

Overall, this study demonstrates that leaderboards can be a powerful tool for incentivizing learning when designed with user experience considerations in mind. The results contribute to the broader discourse on gamification in education, offering insights into best practices for leaderboard implementation to maximize motivation and engagement. Future research should explore long-term user engagement and the scalability of leaderboards across different educational contexts.

Chapter 1 Introduction

1.1 Background

In recent years, the integration of gamification into educational settings has received significant attention as a strategy to enhance student engagement and motivation. Gamification involves the application of game-design elements, such as point systems, badges, and leaderboards, to non-game settings, aiming to make learning experiences more interactive and enjoyable. Studies have demonstrated that gamification can positively influence students' learning outcomes by fostering increased engagement and motivation [SRM+20].

Introduction to DiGaBo and Leaderboards

At RWTH Aachen University, Digital Gamebook (DiGaBo) application is developed to provide an interactive platform where learners can engage with educational content in a game-like environment. DiGaBo offers a collection of interactive gamebooks that transform traditional educational content into immersive learning experiences, thereby gamifying the learning process. Although DiGaBo successfully incorporated various gamification elements, it lacked a competitive leaderboard feature.

Recognizing the potential of leaderboards to further enhance motivation and engagement, this thesis focuses on the design and implementation of a leaderboard functionality within DiGaBo. The primary objective is to assess the impact of this feature on student motivation and learning outcomes, thus contributing to a broader understanding of gamification in educational settings.

Leaderboards are a common gamification element that ranks users based on their performance, introducing a competitive aspect to the learning environment. Research indicates that leaderboards can serve as an efficient tool for fostering competition and cooperation among learners, helping them set specific goals, and increasing their motivation [PK21]. However, the effectiveness of leaderboards in educational settings depends on various factors, including their design, implementation, and the context in which they are used. For example, poorly designed leaderboards can discourage lower-ranked students, while well-designed ones can promote a healthy competitive spirit and improve learning outcomes [LLFS24].

The integration of a leaderboard into DiGaBo aims to motivate students to engage more frequently and deeply with the gamebooks, thus enhancing their learning experience. By providing real-time feedback on performance relative to peers, the leaderboard is expected to encourage students to revisit and master the content, fostering a cycle of continuous improvement. This approach aligns with the broader educational goal of utilizing gamification to create dynamic and effective learning environments that cater to diverse learning needs.

In summary, this thesis explores the development and implementation of a leaderboard feature within the DiGaBo application and evaluates its impact on student engagement and learning outcomes.

1.2 Problem Statement

Student participation and motivation have been recognized for a long time as crucial elements in the study of educational experiences. Despite the progress in digital learning tools, numerous students continue to encounter difficulties in consistent engagement and motivation during their learning experiences. Conventional teaching approaches are finding it increasingly challenging to maintain student motivation, particularly in settings where feedback is rare or lacks adequate personalization.

Although gamification elements such as badges and points have shown promise in enhancing engagement, stronger tools are still necessary to cultivate sustained motivation and enhance learning outcomes. Due to their ability to add a competitive aspect to the learning setting, leaderboards have emerged as one of the most captivating gamification strategies. Despite their common use in gaming environments, there is limited understanding of the role of leaderboards in educational contexts, especially concerning their impact on student motivation, engagement, and learning behaviors. Although DiGaBo effectively gamifies the learning experience, there is still significant potential for improvement, particularly in fully leveraging the motivational benefits of competition. The absence of a competitive leaderboard limits the application's ability to maximize student engagement and motivation. This presents an opportunity to explore how the introduction of a leaderboard can address these challenges by fostering a more competitive and motivating learning environment.

Need for a Leaderboard in DiGaBo

Thus, the problem addressed by this thesis is the need to explore and assess the potential of competitive leaderboards as an effective incentive mechanism in educational platforms like DiGaBo. Specifically, it aims to evaluate whether the introduction of a leaderboard can significantly enhance student motivation, improve engagement with educational content, and positively influence learning outcomes. Furthermore, it seeks to understand how competition, fairness, and usability of the leaderboard can impact user experience and learning behavior, ultimately informing best practices for the design and implementation of leaderboards in educational contexts.

1.3 Objectives

The main goal of this thesis is to explore and assess the impact of introducing a competitive leaderboard into the DiGaBo application on student engagement, motivation, and learning outcomes. The objectives of this research are as follows:

1. **Design & Implementation of the Leaderboard**: To design and implement a competitive leaderboard functionality within the DiGaBo application, integrating it seamlessly with the existing gamification elements. This includes determining the best design and mechanics to ensure fairness and enhance user experience.

2. **Evaluate the Impact on User Motivation**: To investigate how the introduction of the leaderboard influences user motivation and engagement with educational content. This involves assessing whether users are more motivated to participate actively in the gamebooks, complete tasks, and improve their performance as a result of the competitive nature of the leaderboard.

Goals of this thesis

3. **Analyze User Experience & Perceptions**: To evaluate the user's perceptions of the leaderboard, including its usability, fairness, and overall impact on their learning behavior. This will be achieved through user testing, interviews, and surveys to gather qualitative data on user satisfaction and experience.

4. **Provide Recommendations for Best Practices**: To provide recommendations on the design and implementation of leaderboards in educational settings, based on the findings of this research. This includes identifying key factors that contribute to the effectiveness of leaderboards and offering guidance on how to optimize their use to enhance student motivation and engagement in gamified learning environments.

1.3.1 Research Questions

This thesis aims to explore the impact of competitive leaderboards on student motivation and engagement within the DiGaBo application. The following research questions guide this investigation:

1. **How do competitive leaderboards affect user motivation and engagement in educational activities?**
   This question seeks to assess the overall impact of introducing a competitive leaderboard on user's motivation levels and their active participation in learning activities within the DiGaBo application. Understanding this relationship is crucial for designing features that effectively encourage active participation and sustained interest in learning activities.

What this study aims to find

2. **How do users perceive the use of leaderboards in the DiGaBo application?**
   This question aims to gather user feedback on the fairness, usability, and overall effectiveness of the leaderboard feature. By understanding user's perceptions, areas for improvement can be identified, ensuring that the leaderboard aligns with user expectations and contributes positively to the learning experience.

3. **How does the integration of a leaderboard into the DiGaBo app influence user interaction and learning effectiveness?**
   This question explores how the presence of a leaderboard affects user interactions within the app and its impact on learning outcomes, such as knowledge retention and application. Understanding these effects is essential for assessing the educational value of the leaderboard feature and its role in enhancing the overall learning experience.

1.4 Methodology

This thesis employs a methodical approach that comprises four essential stages, which are as follows:

1. **Research Based on Previous Work:** The study starts with a comprehensive literature analysis to grasp the impact of gamification, especially leaderboards, within educational environments. This encompasses:
   - Examining current research on the impact of competition in educational settings.
   - Analyzing studies about the impact of leaderboards on motivation and engagement psychologically.
   - Recognizing effective strategies and possible challenges in creating leaderboards.

   Findings from this stage lay the groundwork for creating a successful leaderboard system.

Implementation outline

2. **Designing & Implementation:** In this phase, the leaderboard functionality is envisioned and incorporated into the DiGaBo app. Essential stages in this procedure consist of:
   - Establishing the scoring system and ranking standards to guarantee fair competition.
   - Structuring the leaderboard to encourage competition while maintaining a supportive learning environment.

   The implementation uses the following technology stack:
   - **Frontend:** Angular for rendering the leaderboard interface.
   - **Backend:** Node.js for handling business logic and data processing.
   - **Database:** MongoDB for managing leaderboard rankings and user scores.
3. **Testing & User Evaluation:** To assess the functionality and effectiveness of the leaderboard, a comprehensive evaluation study is conducted, including both system testing and user feedback. This includes:
   - **Leaderboard Testing**: Evaluating the accuracy and functionality of the leaderboard, ensuring fair ranking and real-time updates.
   - **Participant Selection:** Selecting a user group to test the Leaderboard feature in the DiGaBo platform.
   - **Usability Testing:** Observing user interactions with the leaderboard to evaluate its functionality and ease of use.
   - **Interviews and Surveys:** Gathering qualitative feedback on user experiences, engagement levels, and perceived motivation.

   The collected data provides insights into the impact of the leaderboard on learning behavior.
4. **Documentation:** The final phase involves systematically documenting the research process, findings, and conclusions, including:

- Recording key design decisions and implementation challenges.
- Summarizing user feedback and evaluation results.
- Presenting recommendations for future improvements to the leaderboard system.
- Contributing to the broader discussion on gamification in education by sharing research insights.

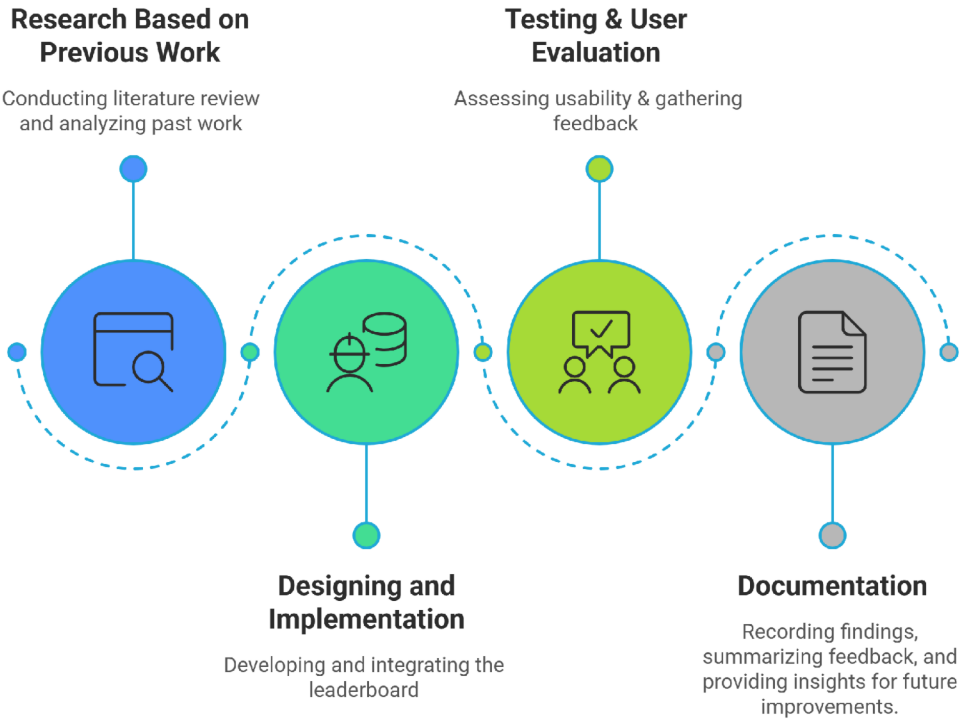

Figure 1.1: Methodology Steps

1.5 Thesis Structure

The structure of this thesis is organized into the following chapters:

1. **Introduction:** This chapter presents the research subject, offering a summary of the background and setting of gamification within the educational framework. It delineates the problem statement, research goals, and the research inquiries that direct the investigation.

2. **Literature Review:** This section provides an extensive examination of current literature concerning gamification, with particular emphasis on the application of leaderboards in educational environments. It analyzes different research on how competition and rankings affect student motivation, involvement, and educational results. The chapter additionally notes the shortcomings in existing research and emphasizes the importance of incorporating leaderboards within educational platforms such as DiGaBo.

Details about each chapter

3. **Implementation & Testing:** This chapter covers in depth the design and creation of the leaderboard feature on the DiGaBo platform. It addresses the technical details of setting up the leaderboard, encompassing the selected technology stack and the structure of the scoring and ranking mechanisms. The chapter additionally details the testing methods employed to verify the effectiveness and precision of the leaderboard function.

4. **User Evaluation & Results:** An in-depth examination of user responses, usability tests, and assessment outcomes to evaluate how the leaderboard contributes to increased engagement and motivation.

5. **Conclusion:** This final chapter summarizes the research findings, discusses implications, and suggests areas for future work.

To sum up, this chapter has presented the research subject, offering a comprehensive overview of the background and significance of gamification in learning settings. The chapter underscored the issue of student involvement and motivation in education, stressing the effectiveness of leaderboards as a strong gamification tool. It further established the research goals and detailed the approach for examining the effects of incorporating a leaderboard into the DiGaBo platform. The upcoming chapters will expand on this groundwork, concentrating on the design, execution, assessment, and outcomes of the leaderboard feature.

Chapter 2 Literature Review

2.1 Introduction to Gamification in Education

Gamification is the term used in education to describe the concept of introducing game-like aspects into the learning process, such as challenges, leaderboards, badges, and points. This method seeks to increase student motivation, make learning more interesting, and enhance learning results overall. It makes what may otherwise be a simple, typical educational experience more engaging and enjoyable [Moo20].

What does Gamification mean and it's general benefits

2.1.1 Historical Context and Evolution

Since the early 2010's, gamification has drawn a lot of interest and is currently seen as a trendy aspect in many domains, especially education. It is becoming more and more popular because people think it can increase motivation, encourage positive behavior, and foster better teamwork in a variety of contexts [DD16].
Platforms such as Duolingo have effectively applied gamification techniques in the educational field. By using features like leaderboards, progress monitoring, and badges to make language learning fun and efficient, Duolingo as a platform highlights the value of gamification in sustaining user engagement.

2.1.2 Key Principles of Gamification in Education

Effective gamification in education is built upon several core principles:

- **Progression & Mastery**: Learners advance through levels or stages, fostering a sense of achievement and mastery.
- **Instant Feedback**: Immediate feedback mechanisms allow students to adjust their learning strategies in real-time, enhancing the learning process.
- **Personalization**: Adaptive learning techniques tailor educational experiences to individual skill levels and learning paces.
- **Social Interaction**: Incorporating multiplayer elements, peer collaboration, and competitive leaderboards fosters a sense of community and engagement among learners [Moo20].

2.1.3 Applications of Gamification in Different Educational Contexts

Gamification has been applied across various educational domains:

- **K-12 Education**: Platforms like Prodigy Math Game utilize role-playing game mechanics to make learning mathematics engaging for younger students.

- **Higher Education**: Universities have integrated gamified elements into online courses, particularly in Massive Open Online Courses (MOOCs), to enhance student engagement and motivation.

- **Corporate Training**: Companies employ gamified training modules to improve employee knowledge retention and application, utilizing interactive scenarios and reward systems.

- **Special Education**: Gamification offers personalized and interactive learning experiences for students with disabilities, incorporating adaptive difficulty levels and real-time feedback to meet diverse learning needs [CIO+23].

2.1.4 Future Directions in Gamified Education

The future of gamification in education is poised to be influenced by emerging technologies:

- **Virtual Reality (VR) & Augmented Reality (AR)**: These technologies can create immersive learning environments, providing hands-on experiences in subjects like history and science.

- **Artificial Intelligence (AI)**: AI can offer personalized learning experiences, adapting content to individual learners' needs and enhancing engagement.

While gamification presents numerous benefits, it's essential to consider potential challenges. Overemphasis on competitive elements may lead to stress or a focus on extrinsic rewards. Therefore, designing balanced gamified systems that promote both engagement and well-being is crucial for the future of education [DD16].

2.2 Impact on User Motivation and Engagement

Gamification in education has been extensively studied for its potential to enhance student motivation and engagement. By integrating game-like elements into learning environments, educators aim to create more interactive and enjoyable experiences that can lead to improved educational outcomes.

2.2.1 Enhancing Motivation through Gamification

Research indicates that gamified learning interventions can significantly boost students' intrinsic motivation. A study examining the effects of gamification on undergraduate students found that incorporating game elements such as points, badges, and leaderboards increased students' enthusiasm and commitment to their studies. The interactive nature of gamification fosters a sense of achievement and progress, which can be particularly motivating for learners [SRM+20].

Advantages of Gamification

Moreover, gamification has been shown to reduce student demotivation. By leveraging gamified platforms, educators can create engaging learning experiences that counteract feelings of boredom and disengagement. This approach not only enhances motivation but also promotes positive learning behaviors [GLAGRL23].

2.2.2 Boosting Engagement through Game Elements

The incorporation of game elements in educational settings has a profound impact on student engagement. Studies have demonstrated that gamification influences students' study engagement through the indirect effects of enjoyment and self-efficacy. When learners find the activities enjoyable and believe in their capabilities to succeed, their engagement levels increase [CL22].

Additionally, gamification has been linked to improved academic performance. Research suggests that the positive impact of gamification on students' achievement is consistent across various factors, including geographical regions, education levels, learning environments, subjects, and game elements. This indicates that gamification can be a versatile tool in enhancing educational outcomes [ZSLF24].

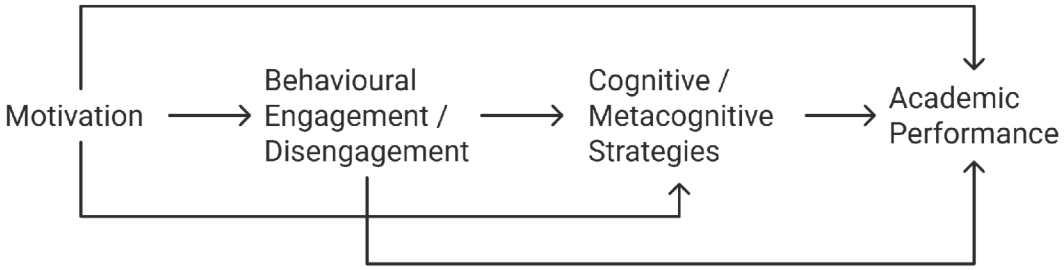

Figure 2.1: Conceptual Model [GLAGRL23]

Figure 2.1 emphasizes the role of gamification in boosting student engagement through various game elements, which significantly enhance motivation and academic performance. By integrating game mechanics into the learning process, such as rewards, challenges, and interactive tasks, students experience increased intrinsic and extrinsic motivation. This heightened motivation leads to greater behavioral engagement, which is crucial for effective learning. The model illustrates that when students are actively engaged through gamified platforms, they are more likely to employ cognitive and meta-cognitive strategies, ultimately improving their academic outcomes.

However, it also highlights the potential negative impact of behavioral disengagement, which can arise when motivation is low, underscoring the importance of maintaining engagement through gamification.

2.3 Leaderboards as a Gamification Element

Leaderboards are a prominent feature in gamified educational environments, designed to enhance motivation and engagement by introducing a competitive element among learners. By displaying participants' rankings based on their performance, leaderboards aim to foster a sense of achievement and encourage continuous improvement.

2.3.1 Psychological Effects of Rankings and Leaderboards

The integration of rankings and leaderboards into educational environments aims to enhance motivation and engagement by introducing competitive elements. However, their psychological impact on students is multifaceted, encompassing both positive and negative dimensions.

Positive Psychological Effects:

- **Enhanced Motivation & Engagement**: Leaderboards can stimulate a competitive spirit among students, fostering increased motivation to excel academically. The visibility of one's progress relative to peers serves as an extrinsic motivator, encouraging learners to invest more effort in their studies. A systematic review indicates that leaderboards can positively influence students' learning motivation, engagement, and performance [LLFS24].

- **Immediate Performance Feedback**: By providing real-time updates on academic standing, leaderboards offer immediate feedback, enabling students to assess their performance and make necessary adjustments. This prompt feedback loop can enhance self-regulated learning and personal accountability [Clu23b].

- **Goal Setting & Achievement**: The structured nature of leaderboards assists students in setting clear, measurable goals. Achieving higher rankings can serve as a tangible reward, reinforcing positive behaviors and promoting a sense of accomplishment [PK21].

Negative Psychological Effects:

- **Increased Anxiety & Stress**: The competitive atmosphere fostered by leaderboards may lead to heightened anxiety, particularly among students who consistently find themselves lower in the rankings. This stress can detract from the learning experience and potentially discourage participation [Jen18].

- **Diminished Intrinsic Motivation**: An overemphasis on extrinsic rewards, such as leaderboard positions, might undermine intrinsic motivation. Students may become more focused on outperforming peers than on the inherent value of learning, which can negatively impact long-term educational outcomes [PML+16].

- **Risk of Negative Self-Perception**: Lower-ranked students might develop feelings of inadequacy or reduced self-esteem, which can adversely affect their academic self-concept and overall mental health. This negative self-perception may lead to disengagement and decreased effort.

Moderating Factors:

- **Leaderboard Design & Implementation**: The psychological impact of leaderboards is significantly influenced by their design. Features such as anonymity, multiple performance metrics, and regular updates can mitigate negative effects and enhance positive outcomes. Thoughtful implementation that considers the diverse needs of students is crucial [PK21].

- **Individual Differences**: Students' personal characteristics, including their resilience, competitiveness, and prior academic experiences, play a role in how they perceive and are affected by rankings. Tailoring approaches to accommodate these differences can help in maximizing benefits and minimizing harm [Jen18].

2.3.2 Design Considerations for Effective Leaderboards

To maximize the benefits of leaderboards in educational contexts, the following design principles can be considered:

Brief Overview of design principles for Leaderboards

- **Anonymity & Privacy Considerations**:
  - **Protecting Student Identities**: Utilizing anonymous identifiers or pseudonyms can alleviate anxiety associated with public rankings. This practice ensures that students are motivated by self-improvement rather than fear of judgment, creating a safer learning environment [KK24].
  - **Controlled Visibility**: Allowing students to opt into public leaderboards or providing private performance dashboards can give learners control over their data. Respecting privacy preferences enhances comfort and engagement.
- **Clarity & Relevance of Metrics**:
  - **Alignment with Learning Objectives**: Leaderboards should reflect metrics that are directly tied to the desired learning outcomes. This ensures that students focus on activities that promote meaningful learning rather than superficial achievements. For instance, incorporating metrics that assess both the quality and quantity of contributions can provide a more comprehensive evaluation of student performance [LLFS24].

    - **Transparency in Scoring**: Clearly defined criteria for how points are awarded and displayed can help students understand what is expected and how to succeed. Transparency reduces confusion and builds trust in the system, motivating students to engage with the content.

- **Immediate Performance Insights**: Providing real-time updates on leaderboard standings can help students monitor their progress and make timely adjustments to their learning strategies. Immediate feedback reinforces learning and keeps students engaged [Zid24].

- **Inclusivity & Positive Reinforcement**: Designing leaderboards that celebrate personal progress and effort, rather than just top performance, can motivate all learners.

    - **Multiple Avenues for Success**: Designing leaderboards that recognize various forms of achievement can cater to diverse student strengths. For example, separate leaderboards for different skill sets or collaborative efforts can encourage participation from all students, not just the top performers [LLFS24].

    - **Emphasis on Personal Progress**: Highlighting individual improvement over time, rather than solely ranking students against each other, can foster a growth mindset. This approach encourages students to focus on their personal development and reduces negative competition.

- **Soliciting Student Feedback**: Regularly gathering input from students about their experiences with leaderboards can inform necessary adjustments. This participatory approach ensures that the tool remains effective and responsive to student needs.

In conclusion, leaderboards can be a valuable tool in educational settings, fostering motivation, engagement, and a sense of accomplishment when designed thoughtfully. However, their impact varies depending on individual student differences and the overall learning context. To maximize their benefits while mitigating potential drawbacks, educators/developers should prioritize factors such as anonymity, diverse performance metrics, regular updates, and inclusivity. By carefully integrating leaderboards into the learning experience, an environment can be created that encourages both competition and personal growth, ultimately enhancing student motivation and educational outcomes.

2.4 Review of Leaderboard Implementation in Educational Platforms

The integration of leaderboards into educational platforms has been explored through various case studies, highlighting their impact on student engagement, motivation, and learning outcomes. These studies provide insights into effective design and implementation strategies.

LanguageGuru: This platform introduced a global leaderboard showcasing points earned by learners during language practice sessions. The competitive element fostered by the leaderboard led to increased engagement, with users participating in friendly competition that encouraged consistent practice and improved language proficiency [Clu23a].

Language Learning Platforms

Duolingo: Duolingo, a widely-used language learning application, has effectively incorporated leaderboards to boost user engagement and retention. The platform features competitive elements such as leagues, where users are ranked based on the experience points they accumulate weekly. This system fosters a sense of competition and motivation among learners, encouraging consistent practice and progression through various league levels, from Bronze to Diamond. The introduction of these gamified elements has significantly increased user activity and sustained interest in language learning [Eug24].

Higher Education Environments

Gamified Learning Modules: A quasi-experimental study examined the effects of incorporating leaderboards into online formative assessments within higher education. The findings indicated that leaderboards positively influenced learner achievement and motivation, suggesting that gamification elements can enhance the educational experience when thoughtfully integrated [COK+24].

Social E-Learning Platforms

FullBrain Platform: FullBrain, a social e-learning platform, integrated a leaderboard module to enhance user experience. Analysis revealed that 97% of user activity was directed toward the top four positions on the leaderboard, indicating a high level of engagement driven by competitive elements. This case underscores the potential of leaderboards to motivate learners through social comparison and recognition [BCF+22].

Gamified AI Education

Maestro Platform: Designed to teach AI robustness, Maestro incorporated a leaderboard as a central gamification feature. Assessment of the platform's impact showed that the leaderboard effectively contributed to increased student engagement and learning. Students reported heightened motivation and a sense of achievement, highlighting the role of competitive elements in complex subject matter education [GXL+23].

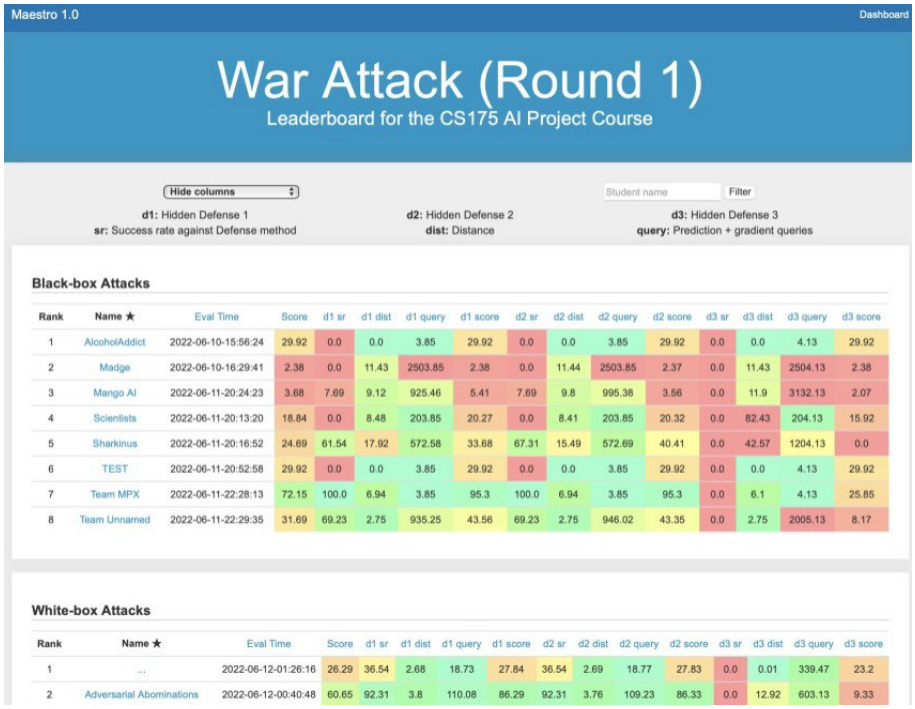

Figure 2.2: Maestro Leaderboard Example [GXL+23]

Anonymous Real-Time Leaderboards: Research into educational competitions utilizing anonymous and real-time leaderboards demonstrated that such designs could provide immediate feedback and maintain participant motivation. The anonymity aspect helped reduce anxiety associated with public rankings, fostering a more inclusive competitive environment [KK24].

Educational Competitions

2.5 Gaps in Current Research

While gamification, particularly the use of leaderboards, has garnered attention in educational research, several critical areas remain under-explored. Addressing these gaps is essential for a comprehensive understanding of the implications of leaderboards in educational settings.

Much of the existing research focuses on short-term outcomes or snapshots of user engagement with gamified systems. There is limited research on the long-term effects of leaderboards on student motivation, academic performance, and overall learning retention. Longitudinal studies are needed to evaluate whether the initial positive effects of competition and ranking lead to sustained improvements or potential negative outcomes such as burnout or disengagement [LLFS24].

Lack of Longitudinal Studies

The majority of studies on gamification and leaderboards are conducted in Western educational settings. However, educational practices, student motivation, and competitive behavior can vary significantly across cultures. There is a lack of research exploring how leaderboards function in non-Western contexts or in diverse cultural settings. Understanding these variations could offer insights into how leaderboards might be adapted for different user populations, providing a more global perspective on the issue [Guh17].

Contextual and Cultural Variability

Psychological Effects in Diverse Student Populations

While some studies have explored the psychological effects of leaderboards on students, the research tends to focus on specific student groups, such as high achievers or university students. There is limited research on how leaderboards impact diverse groups, including students with learning difficulties, under-performing students, or those from disadvantaged backgrounds. Further investigation is needed to explore whether leaderboards have different psychological effects depending on the user's educational background, learning style, or personal traits [ACK+23].

Personalization of Leaderboards

Although leaderboards are commonly used in gamified systems, there is insufficient research on how to personalize leaderboards to maximize their effectiveness. Studies suggest that personalization—such as adapting the leaderboard based on individual progress or creating smaller, peer-level competitions—could potentially reduce feelings of discouragement among lower-ranking students and increase overall engagement. However, practical strategies for implementing personalized leaderboards remain under-explored [PK21].

Negative Impacts on Collaboration and Social Learning

Most studies emphasize the benefits of competition in gamified learning environments, but there is limited discussion on the potential drawbacks, particularly regarding collaborative learning. Leaderboards, by nature, can foster individualistic behavior, possibly undermining opportunities for students to work together and learn from one another. Future research should investigate how to balance competition and collaboration within leaderboards, ensuring that the competitive aspect does not diminish the potential for co-operative learning [ACK+23].

Integration with Broader Educational Frameworks

Gamified systems, including leaderboards, are often studied in isolation from broader educational frameworks, such as curriculum design, pedagogy, and assessment strategies. More research is needed to explore how leaderboards can be integrated seamlessly with traditional educational models, enhancing both the learning experience and the assessment of academic achievement. Understanding how leaderboards can align with learning objectives and academic standards is crucial for their effective implementation [LLFS24].

Scalability of Leaderboard Systems

While some studies focus on the effectiveness of leaderboards in small-scale educational settings, fewer studies address their scalability in large, diverse classrooms or across entire educational institutions. Research is needed on how leaderboard systems can be scaled without losing their motivational power or overwhelming students with excessive competition. This includes investigating how leaderboards can be implemented in massive open online courses (MOOCs) or other large educational platforms [PK21].

Data Privacy and Ethical Concerns

As leaderboards typically involve the collection and display of student data, concerns related to privacy and data ethics remain largely under-explored in existing literature. Research is needed to address how leaderboard systems can be designed to respect student privacy, ensure ethical use of data, and prevent potential misuse or harm. Understanding these concerns is essential to creating a trustworthy gamified learning environment [MRG+22].

2.6 Synthesis of Literature

The literature review highlights the significant role of gamification in education, particularly the use of competitive leaderboards to enhance student motivation and engagement. Research indicates that well-designed gamified elements can positively

influence learning behaviors by fostering competition, goal-setting, and a sense of achievement. However, the effectiveness of leaderboards depends on multiple factors, including design considerations, user perception, and contextual variables.

Research Insights and Implications

Existing studies demonstrate that leaderboards can drive engagement in various educational contexts, from language learning platforms to higher education environments. Nonetheless, certain gaps remain in current research, particularly regarding the long-term impact of leaderboards, their effects on different user populations, and their integration within broader educational frameworks. Additionally, concerns regarding potential negative effects, such as increased anxiety or reduced intrinsic motivation, highlight the need for thoughtful implementation.

By addressing these gaps, this thesis aims to contribute to the ongoing discourse on gamification in education. The subsequent chapters will focus on the design, implementation, and evaluation of a competitive leaderboard within the DiGaBo application, assessing its impact on student motivation, engagement, and learning effectiveness.

Chapter 3 Implementation & Testing

The successful integration of gamification elements, such as leaderboards, requires a well-planned and systematic implementation approach. This chapter outlines the technical details of how the competitive leaderboard was designed, developed, and integrated into the DiGaBo platform. The implementation process involved careful consideration of user engagement strategies, real-time scoring mechanisms, and a structured ranking system to ensure an intuitive and rewarding experience for learners.

To validate the effectiveness of the leaderboard, rigorous testing was conducted to assess both functionality and user experience. This included evaluating the accuracy of score calculations, the responsiveness of the ranking system, and the visibility of scoring-related notifications. The testing phase also focused on identifying potential usability challenges and ensuring that the leaderboard effectively motivates users to engage with the platform. The chapter is structured as follows: first, the core architecture and system components of the leaderboard are discussed, followed by an explanation of how scores are assigned and updated dynamically. Next, the testing methodology is presented, detailing the procedures used to evaluate system performance, user interactions, and feedback mechanisms. The findings from these tests provide insights into system reliability and areas for potential improvement, laying the foundation for future enhancements.

Overview of the chapter

By detailing the implementation and testing processes, this chapter aims to demonstrate the technical feasibility of incorporating a competitive leaderboard into educational platforms and highlight key design considerations necessary for maximizing user engagement and learning effectiveness.

3.1 Overview of DiGaBo

Developed by RWTH Aachen University, DiGaBo (Digital Gamebook) is a novel educational platform that uses interactive, game-like aspects to improve learning experiences. By converting traditional course material into interactive activities, it empowers educators to produce engaging digital gamebooks that boost user motivation and engagement.

Key Features:

- **Interactive Learning:** Educators can craft course materials as interactive activities, allowing students to navigate through content in a dynamic, non-linear fashion.

- **Game-Like Elements:** In order to enhance the learning process and accommodate different learning styles, the platform allows the addition of a variety of interactive features like multiple-choice questions, number scale ratings, matching pairs, sorting tasks, and many more.
- **Customization and Flexibility:** Educators have the flexibility to design gamebooks tailored to specific course objectives, with customizable templates and content modules that can be adapted to various educational contexts. Educators can in-fact create their own unique templates that suite their individual requirement to make the learning experience more dynamic.

3.2 Technology Stack

The DiGaBo application code base is designed into 3 major components which are the `"digabo-ui"`, `"digabo-editor"` and the `"digabo-backend"`. The following is the technology stack for the DiGaBo application:

Overview of the Tech-stack used

- **Frontend Development:** The frontend is built using *HTML*, which forms the foundation of the structure, and *Angular.js* for dynamic and interactive elements. Angular.js helps in developing single-page applications, offering features like two-way data binding, modularity, and a structured way to build large-scale applications.
- **Backend Development:** The backend is built with *Node.js*, utilizing its non-blocking, event-driven architecture to manage concurrent requests efficiently. *JavaScript*, the language used for both frontend and backend, allows for a uniform development experience across both layers of the application.
- **Database:** *MongoDB*, a NoSQL database, is used to store and manage the application data. MongoDB is ideal for handling large amounts of unstructured or semi-structured data, providing flexibility in the storage and querying of leaderboard data. It supports JSON-like documents which align well with the dynamic nature of the application.
- **API Design:** *RESTful APIs* are implemented to facilitate communication between the frontend, the editor and backend. This ensures a smooth interaction between the different layers and supports scalability for future features.
- **Containerization:** The application is containerized using *Docker*, ensuring consistency across different environments by packaging the application along with its dependencies. This allows for easy deployment, scalability, and efficient management of microservices.
- **Version Control:** *Git* is used for version control, enabling efficient collaboration and code management.

3.3 Leaderboard Design & Development

This section focuses on the implementation of the leaderboard system into the DiGaBo platform on the basis of frontend and backend aspects.

3.3.1 Frontend Development

UI design choices

User Interface (UI) Design: The goal was to design an engaging and intuitive leaderboard interface that effectively showcases rankings while maintaining clarity and accessibility for all users. To enhance visual appeal and user experience, color coding and icons were incorporated, ensuring that rankings are easily distinguishable at a glance. A key design element was the implementation of a gold, silver, and bronze ranking system for the top three users. This approach serves a dual purpose: first, it acts as a form of recognition and appreciation for the top performers, celebrating their achievements and reinforcing their sense of accomplishment. Second, it serves as a motivational tool for other users, encouraging them to strive for higher rankings by creating a clear visual distinction between different performance levels.

```
IF loadingLeaderboard IS TRUE:
    DISPLAY "Loading Leaderboard..."
ELSE:
    DISPLAY "Leaderboard" AS HEADER

    CREATE TABLE "Leaderboard":
        HEADER ROW:
            COLUMN 1: "Rank"
            COLUMN 2: "Name"
            COLUMN 3: "Email"
            COLUMN 4: "Score"

        FOR EACH user IN leaderboard, index i:
            IF user.name IS EQUAL TO loggedInUserId:
                APPLY highlight-row STYLE TO ROW
            ELSE IF i IS EVEN:
                APPLY even-row STYLE TO ROW

            INSERT ROW:
                COLUMN 1:
                    SET rank-badge CLASS
                    IF user.rank IS 1: APPLY gold CLASS
                    ELSE IF user.rank IS 2: APPLY silver CLASS
                    ELSE IF user.rank IS 3: APPLY bronze CLASS
                    DISPLAY user.rank

                COLUMN 2: DISPLAY user.name
                COLUMN 3: DISPLAY user.email
                COLUMN 4: DISPLAY user.score
```

Listing 3.1: Top 3 users' Ranking Scheme

The pseudo-code 3.1 displays the mechanism used to implement the ranking scheme for the top three users. Since the data displayed on a leaderboard significantly influences user motivation, careful thought was given to selecting the most relevant and impactful information. After evaluating multiple options, it was determined that a clean, minimalistic design would be the most effective in catering to a broad audience across different age groups. By avoiding unnecessary complexity and keeping the leaderboard simple yet informative, users can easily track their progress without feeling overwhelmed. The combination of a structured ranking system, clear visual distinctions, and a user-friendly design fosters a competitive yet inclusive environment that encourages continuous engagement and improvement. Figure 3.1 shows the user interface of the implemented leaderboard.

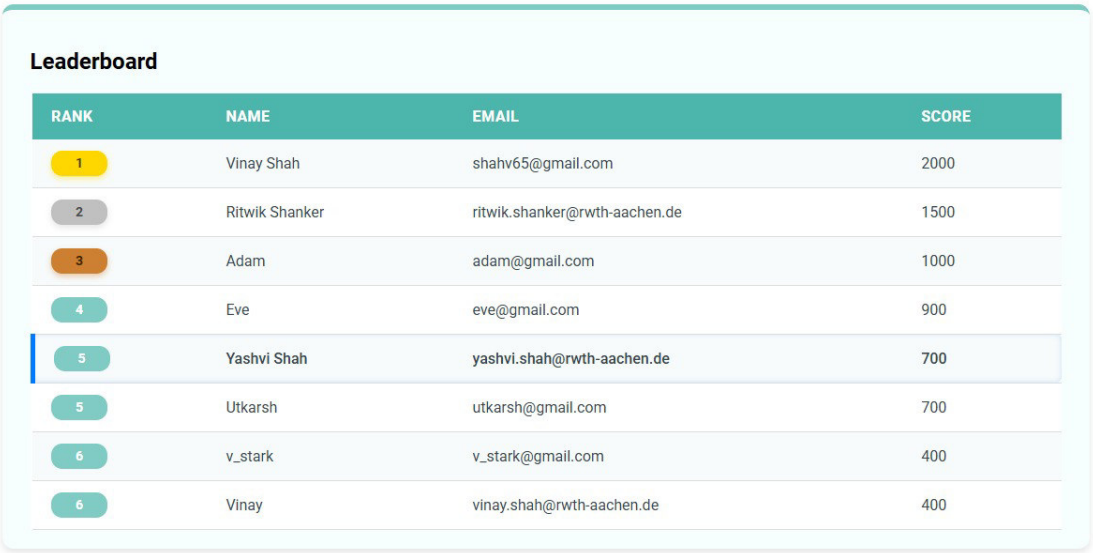

Figure 3.1: UI of the implemented leaderboard

User Experience (UX) Considerations:

- **Instant Gratification**: When a user finishes playing a gamebook and clicks the *End* button, an immediate feedback mechanism is triggered. If the user is playing the gamebook for the first time, they are rewarded with points corresponding to the gamebook. Additionally, an alert is generated to provide instant gratification, reinforcing a sense of achievement and motivation for continued engagement. Figure 3.2 demonstrates the implemented method for instant gratification in the DiGaBo platform.

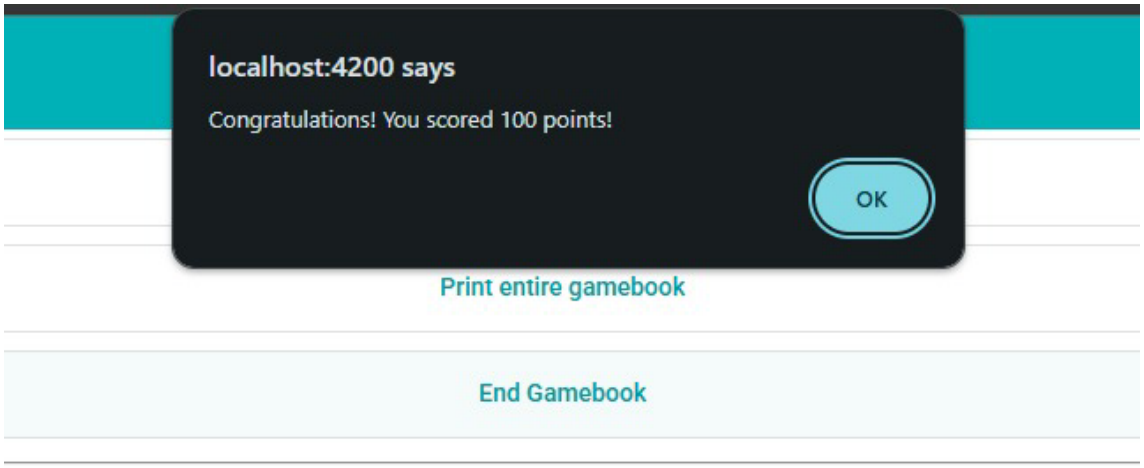

Figure 3.2: Instant Gratification Example

- **Instant Updates**: Ensuring that users receive real-time feedback immediately after completing a gamebook, allowing them to see their updated ranking and performance metrics without delay. This instant reinforcement not only enhances motivation but also encourages continuous engagement by providing users with a clear sense of progress and achievement. By eliminating waiting times, players can quickly assess their standing, reflect on their performance, and set new goals for improvement, fostering a dynamic and responsive learning experience.

- **Personalization**: As seen in the pseudo-code above the leaderboard is designed to offer a tailored experience by highlighting the user's position when they are logged in. This ensures that each user can quickly and easily identify their standing relative to others, providing a sense of personal progress and achievement. By visually distinguishing the user's rank—such as through color coding or bold formatting—the leaderboard enhances engagement and encourages self-improvement. This personalized approach fosters a more immersive experience, making users more invested in tracking their progress, setting goals, and striving for better performance in future gamebook sessions.

3.3.2 Backend Development

Scoring Mechanism: There were three approaches that were considered to define the scoring for a particular gamebook.

Approaches to Scoring Mechanism

The first approach was to score based on a **weighted mechanism** where the score that the user got would be directly proportional to the extent till where the user has played the gamebook and the size of the gamebook. As each gamebook will be of different sizes in terms of the pages it has and the activities involved in the gamebook.

The second approach was **editor-based method** where the opportunity to give a score for a gamebook was provided to the creator of the gamebook. While the gamebook is being created by the editor, they would be prompted to decide a score that best justifies the difficulty and learning for a particular gamebook.
The third approach was a **direct scoring method** where the score was allotted to a user based on the fact whether they completed playing a gamebook or not. In this method, a constant score for each gamebook is pre-defined and it is awarded to the user at the end of a gamebook. After a lot of consideration on which scoring mechanism to employ, it was decided that the direct scoring method should be used as it provided two major benefits, first was it encourages the user to finish the entire gamebook to be allotted the score for that gamebook and the second reason was that it's comparatively easier to implement.

Effective gamebook design for utilizing the leaderboard

Gamebook Design Principle: The direct scoring method comes with certain drawbacks which is that it focuses on the aspect that the user reaches the end of a gamebook but it does not focus on the aspect that the user provided correct answers or not. This can lead to a problem where users are inputting wrong answers just to reach the end of the gamebook to score the points. Keeping this problem in mind, some gamebook design principle should be inculcated while creating gamebooks for successful implementation and utilization of the leaderboard. The gamebook should be designed in such a way that if the user selects a wrong answer they are redirected to either the start of the gamebook or back to the question they got wrong. This helps maintain the credibility and functionality of this method intact as the users are redirected to try the gamebook again till they get the answers right.

Ranking Algorithm:

- **Aggregation Logic**: The aggregation logic is a simple calculation of the total score the user has achieved in the multiple gamebooks they have played. This process basically involves the score of a gamebook being added to the 'score' attribute of a user which has the total score the user has gained so far by playing multiple gamebooks.
- **Tie-Breaking Rules**: As the direct scoring method is employed to score the users, it is very much possible that more often than not there will be a tie of scores between two or more users. In this scenario it is important to define some tie-breaking rules as this can become a tricky aspect if multiple users have the same score but they aren't given their deserved ranking. To handle this scenario fairly, all the users with the same score are given the same rank. This ensures that all the users are treated equally and the tie-breaking scenario is handled correctly.

```
FUNCTION getLeaderboard():
    users = FETCH all users SORTED by score in descending order

    leaderboard = EMPTY LIST
    // Initialize rank tracking variables
    currentRank = 0
    previousScore = NULL

    FOR EACH user IN users:
        // If the user's score is different from the previous one, update the rank
        IF user.score IS NOT EQUAL TO previousScore:
            currentRank = currentRank + 1

        ADD { rank: currentRank, name: user.name, email: user.email, score: user.score } TO leaderboard
        // Store the user's score as the last seen score
        previousScore = user.score

    RETURN leaderboard

END FUNCTION
```

Listing 3.2: Tie-Breaking Mechanism

The tie-breaking rule in the pseudo-code 3.2 ensures that users with the same score receive the same rank, and the next unique score is assigned the correct rank without skipping positions. When iterating through the sorted list of users, the function checks if the current user's score is the same as the previous score. If the score matches, the user retains the same rank as the previous user, ensuring that users with identical scores are ranked equally. However, if the score is different, the function increments the rank, moving to the next available position. This prevents incorrect ranking gaps and ensures fairness.

Data Management: The database structure already existed for the users and the gamebooks in the DiGaBo application so the database design consisted of modifying the original structure of the gamebooks and the users to accompany the 'score' attribute. This was needed to be done to implement the leaderboard successfully and it was also important to not modify any other aspect of the database to alter the functionality of the application in a negative way. Another important aspect was to keep a track of the gamebooks already played by the user as this was crucial to the functionality of the leaderboard. A similar aspect already existed in the previous data structure but for some reason the code was not functioning correctly. For this reason a new list-type structure was added to keep check of the previously played gamebooks.

3.4 Data Flow Between Gamebooks and Leaderboard

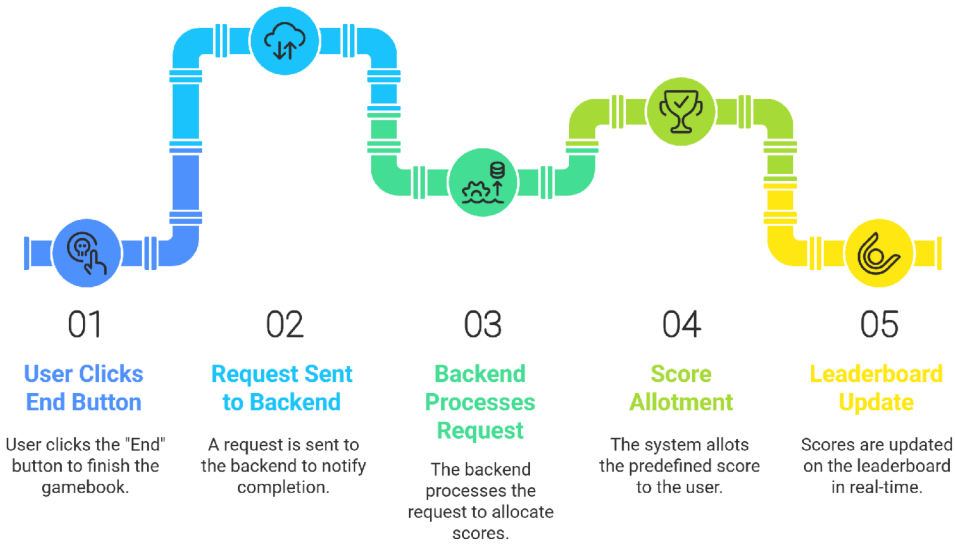

Figure 3.3: Dataflow Process from Gamebook to Leaderboard

When a user clicks the "End" button to conclude their interaction with a gamebook, the following sequence of actions takes place, as depicted in the figure 3.3. Both user interaction and backend operations are used in this procedure to make sure that the user's session is appropriately ended and that their performance is documented.

When the user selects the "End" button, indicating that their interaction with the gamebook is over, the process starts. A request is sent to the backend server as a result of this action. This request serves to inform the backend that the user has completed the gamebook and that the system should take the appropriate action to close the session. After receiving the request, the backend processes the data and assigns the user a score. After the score is allotted to the user, it is then used to update the leaderboard in real-time. The real-time update ensures that the leaderboard immediately reflects the user's latest score, maintaining an up-to-date and accurate representation of user standings. This process ensures that users receive immediate feedback on their performance and that the competitive aspects of the gamebook are maintained through timely leaderboard updates.

stages of score updation

3.5 Testing

Testing ensures that the leaderboard operates as expected, providing accurate rankings, real-time updates, and a smooth user experience. The testing process for the leaderboard involved manual testing.

3.5.1 Test Cases Defined for Leaderboard Functionality

Test cases focused on core leaderboard functionalities such as:

- Correct calculation of scores and rankings.
- Handling of tie-breaking scenarios.
- Data consistency between frontend and backend.
- Proper API responses for user actions. (e.g., submitting a score)
- Real-time updates for leaderboard positions.
- Prevention of score tampering by multiple API calls.

3.5.2 Manual Testing Approach

- **Feature Validation**: Each implemented feature was manually tested to ensure it functions correctly as intended. This involved verifying that core leaderboard operations—such as score submission, ranking updates, and data retrieval—work as expected. The testing process included checking whether user scores were correctly recorded, rankings were updated dynamically, and all expected interactions between the frontend and backend operated smoothly. Any discrepancies or unexpected behaviors were addressed through iterative debugging and refinement.
- **UI/UX Testing**: The user interface was evaluated to ensure that it was both visually appealing and functionally intuitive. This involved testing for consistency in design elements and smooth user interactions. Attention was given to ensuring that leaderboard updates appeared in real-time without requiring excessive manual refreshes. Additionally, user flows were examined to confirm that navigating to the leaderboard was intuitive, with clear indications of user standings and score changes.
- **Edge Case Testing**: Various edge cases were considered to evaluate the robustness of the leaderboard system. This included:
  - Handling of Ties: Ensuring that users with the same score were ranked the same to signify unbiased ranking. Also, the ranking was in order if such a scenario should arise when there are multiple pairs of users with same score.
  - Incorrect or Multiple Score Submissions: Measures were implemented to prevent duplicate or erroneous entries from affecting the ranking calculations. Measures were also taken to ensure that a single user is awarded points only once for a particular gamebook.

- Avoiding Self-Scoring: In a scenario when the user themselves have created the gamebook, they should not be awarded the points for playing that gamebook.

3.6 Challenges & Solutions

Throughout the implementation phase there were multiple roadblocks encountered. Below is a brief description of the challenges faced and the employed solutions for them.

Problems encountered during implementation & their resolutions

Issues with Initial Setup: The provided DiGaBo application had few errors in the Docker files and the docker-compose configuration, which was causing unexpected behavior from the application and was also causing deployment failures. Also, the docker-compose file took too long to setup the entire application which made it infeasible to use every time. Another major challenge was that the docker-compose file required the application to be manually restarted after every code change, making it impractical for long-term use. **Solution:** First approach in solving this challenge was to try and debug the Docker configurations.Even after multiple attempts for some reason the problem still remained. The next best alternative was to run only the database via the docker container and later starting the individual components manually. This solution helped reduce the start-up time significantly and it also helped to carry out the implementation smoothly.

Complexity of the Application Structure: The DiGaBo application codebase is quite extensive and comprises three major components: `"digabo-backend"`, `"digabo-ui"`, and `"digabo-editor"`. Each of these components contains multiple packages, and the complexity of the application's structure made it challenging to understand how the different parts interacted with one another.

Solution: Conducted a thorough code analysis, traced API flows, and documented key functionalities to streamline development and debugging.

Multiple API Calls: In a particular scenario in a session when a user plays a gamebook for the first time, the score that the user gets is updated once. After this if the user plays another gamebook for the first time in the same session, then the score gets updated not once but twice. This happens in a fashion where for the n^{th} new gamebook played the system makes 'n' API calls. This was happening due to the internal structuring of the API calls when the user clicks the 'End' button. This was not a problem before but due to the addition of the scoring mechanism for the leaderboard it became a huge problem as it was directly causing incorrect score calculation.

Solution: Tried to identify the root cause in the application's logic and tried to fix the multiple API calls. This approach didn't work and the problem behind multiple API calls seems more deep than before. Next approach was to handle the multiple API calls in the backend. This was done using a timer method in the backend. In this approach, only a single API call will be handled within a specific time-window and all the other API calls are returned without updating the score. The time-window was set to three seconds as this duration was sufficient for all the redundant API calls. This method successfully updates the user score only once ensuring accurate leaderboard updates.

Chapter 4 User Evaluation & Results

This chapter covers the User Evaluation & Results of the DiGaBo platform, focusing on the integration of the leaderboard feature. The evaluation aims to assess user engagement, motivation, and the overall impact of the leaderboard on the learning experience. The methodology encompasses participant selection, data collection methods, interview design and assessing the evaluation results.

4.1 Details about the User Evaluation

Selection Criteria: To capture a wide range of perspectives, diversity was considered during selection. The participants varied in age, academic background, and familiarity with digital learning tools, allowing for a more comprehensive evaluation of the platform. This ensured that there was a mix of participants who were unique to one another to provide meaningful feedback regarding its features, usability, and overall impact on learning.

Demographics: A total of **8 individuals** took part in the study, representing a broad spectrum of users. The participants' ages ranged from 18 to 35 years, ensuring insights from both younger and older learners. Their academic backgrounds were diverse, including undergraduate students, graduate students, and early-career professionals from various disciplines. This mix provided a well-rounded understanding of how different educational backgrounds influence engagement with the platform.

User Evaluation Method: There were primarily two approaches considered for conducting the user evaluation, each differing significantly in its methodology and the type of feedback obtained. The first approach involved using a structured questionnaire to gather feedback about the leaderboard, while the second approach relied on conducting in-person interviews with users to capture both visual and verbal feedback.

While questionnaires are useful for obtaining structured responses and quantifiable data, they present challenges when the sample size is limited. With only 8 participants, it becomes difficult to extract high-quality quantitative insights due to the small dataset. Statistical analysis is less reliable with such a small number of responses, making it hard to derive meaningful patterns or generalizable conclusions. Additionally, participants may provide surface-level responses without elaborating on their experiences, which limits the depth of the insights gathered.

On the other hand, in-person interviews offer a more qualitative and nuanced understanding of user experiences. They allow for real-time interaction, where participants can elaborate on their thoughts, clarify their opinions, and express emotions that may not be captured through a questionnaire. Observing users'

reactions while they interact with the leaderboard provides valuable insights into usability issues, engagement levels, and any frustrations they may experience. Furthermore, interviewers can ask follow-up questions based on user responses, leading to a more in-depth exploration of user behavior, preferences, and pain points. Another key advantage of in-person interviews is the ability to gather implicit feedback through non-verbal cues such as facial expressions, tone of voice, and body language. These subtle indicators can reveal insights that participants might not explicitly articulate in a written survey. For instance, hesitation, confusion, or excitement while navigating the leaderboard can highlight design flaws or particularly engaging features that might not have been evident through a questionnaire.

Reasoning for selecting in-person interviews method

Overall, while questionnaires provide structured and easily analyzable data, in-person interviews offer richer, more contextual feedback that is particularly beneficial when working with a small number of participants. The qualitative insights obtained from interviews can help refine and improve the leaderboard more effectively by addressing specific user concerns and enhancing the overall user experience. Due to these compelling reasons, **in-person interviews were used as the evaluation method** for understanding the impact of leaderboard in the DiGaBo platform.

4.2 Data Collection Methods

There are multiple approaches available for collecting qualitative data from users, each offering unique advantages in capturing their experiences and perspectives. This section outlines the specific methods utilized in this study to gather user feedback regarding their interaction with the leaderboard. To ensure a comprehensive understanding, a combination of two primary methods was employed. These methods were integrated during the interview process, allowing for a more holistic analysis of user responses. By combining different qualitative techniques, the study aimed to capture both the subjective experiences of users and the contextual factors influencing their engagement with the leaderboard. This approach not only enhanced the depth of insights but also provided a balanced perspective on the leaderboard's usability, effectiveness, and areas for improvement.

4.2.1 User Interaction Observation

Purpose: The primary goal of this approach was to gain detailed insights into how users engage with the leaderboard feature in real-time.By observing participants as they interacted with the platform, the aim was to understand their navigation patterns, any specific aspect they liked/disliked most, and any challenges they encountered during the process. This method allowed to directly observe user behavior, which provided valuable context for understanding the impact of leaderboard's design and functionality.

Method: Participants were observed while they interacted with the leaderboard and the DiGaBo platform. Several key aspects were focused on during the observation:

- **Navigation Patterns**: Understanding how users moved through the leaderboard interface, understanding how the points table worked and navigation to the leaderboard page.

- **Feature Utilization**: Analyzing which features of the leaderboard users liked/disliked the most. This included checking their own ranking and viewing others' scores.
- **Challenges Encountered**: Identifying any usability issues or obstacles that participants faced while using the leaderboard. This could involve confusing navigation, unclear instructions, or technical issues affecting their ability to interact with the leaderboard effectively.

4.2.2 Semi-Structured Interviews

Purpose: The primary objective of conducting semi-structured interviews was to gain deeper insights into users' perceptions, experiences, and attitudes toward the leaderboard feature. While quantitative data from questionnaires can provide useful statistical insights, these interviews enable a richer, more nuanced understanding of users' motivations, frustrations, and overall experiences. By allowing participants to elaborate on their thoughts, identifying patterns, gathering qualitative feedback, and uncovering potential areas for improvement that might not have been evident through other evaluation methods is possible.
Method: The interviews followed a semi-structured format, meaning that a predefined set of guiding questions was used to ensure consistency across sessions while allowing flexibility for deeper exploration of specific topics. This approach ensured that core aspects of leaderboard usability and engagement were covered while also permitting participants to introduce emergent themes that were particularly relevant to their experiences. Key aspects of the method included:

- **Guiding Questions**: The interviews were structured around a flexible interview question set that included questions about users' experiences with the leaderboard, their motivations for engaging with it, the perceived fairness of the ranking system, and any difficulties they encountered.
- **Adaptive Flow**: Depending on participants' responses, follow-up questions were posed to probe further into specific aspects. If a user mentioned an issue with leaderboard visibility, for example, additional questions explored how this impacted their engagement and whether they had suggestions for improvement.
- **Encouraging Open Responses**: Participants were encouraged to share their thoughts freely rather than being confined to predetermined response options. This approach facilitated more genuine feedback and provided insight into user behavior that might not have been anticipated during the design phase.

Duration: Each interview lasted approximately 10 to 15 minutes. This time-frame was sufficient to cover key topics in depth while maintaining participant engagement. The length allowed interviewers to explore various aspects of user experience without causing fatigue, ensuring that responses remained detailed and thoughtful.
Employing semi-structured interviews, enabled to gather qualitative data that complemented the results obtained from the User Interaction Observation. The flexibility of this approach allowed for a comprehensive understanding of users' interactions with the leaderboard, ultimately informing future refinements to improve user experience.

Additionally, users were asked to perform specific tasks during the interview to further assess the impact of the leaderboard. For instance, participants were instructed to play a gamebook, check their position on the leaderboard, then either replay the same gamebook or try a different one before checking the leaderboard again. This **task-based approach** helped gather observational data on how users interact with the leaderboard in real-time and how their performance influences their engagement with the platform. By integrating direct user interaction into the interview process, the study was able to capture more detailed and actionable feedback regarding the effectiveness of the leaderboard feature.

4.3 Interview Design

The interview questions were carefully structured around key themes to evaluate the effectiveness of the leaderboard and its impact on user engagement. Each theme was designed to explore specific aspects of user experience, motivation, and behavior, ensuring a comprehensive assessment of how the leaderboard influences learning. By addressing multiple dimensions, the interview aimed to uncover both positive and negative perceptions, providing valuable insights for future improvements. Below are the categories in which the interview questions were divided into to understand the impact of the leaderboard feature:

- **Usability & Design**: The overall usability and visual design of the leaderboard play a crucial role in its effectiveness. A poorly designed leaderboard might confuse users or fail to provide a clear representation of rankings and progress.

  Example Question: *"How would you rate the ease of use and design of the leaderboard feature?"*

  This question was intended to assess whether users found the interface intuitive, visually appealing, and easy to navigate. Feedback from this theme could help refine the user interface to enhance clarity and functionality.

- **Competitiveness**: One of the primary goals of a leaderboard is to introduce an element of competition among users. However, competition can have both positive and negative effects. Some users may find it motivating, while others might experience stress or disengagement.

  Example Question: *"What are your thoughts on the competitive aspect introduced by the leaderboard?"*

  This question sought to understand whether users enjoyed the competitive nature of the leaderboard or if it had unintended consequences, such as discouraging those who fell behind.

- **Fairness & Accessibility**: A well-designed leaderboard should provide a fair ranking system that ensures all users, regardless of skill level or prior experience, have an equal opportunity to succeed. This aspect of fairness and accessibility was explored to determine whether any inherent biases existed in the ranking mechanism.

  Example Question: *"Do you find the ranking system fair and accessible to all users?"*

By asking this, the study aimed to uncover whether users believed the leaderboard adequately reflected their efforts and abilities, and whether any design improvements were necessary to promote inclusivity.

Explanation of various criterion for interview questions

- **Engagement & Motivation**: The leaderboard is intended to encourage user participation and sustained engagement with the learning content. To assess this, participants were asked about the motivational effects of the leaderboard, particularly whether it incentivized them to interact more actively with the platform.

  Example Question: *"How has the leaderboard influenced your motivation to engage with the course content?"*

  This question aimed to explore whether users felt encouraged to put in more effort, complete more tasks, or engage in healthy competition due to the presence of the leaderboard.

- **Behavioral Impact**: The introduction of a leaderboard may influence how users approach their learning activities, either positively by encouraging them to stay on track or negatively by shifting their focus toward ranking rather than learning outcomes.

  Example Question: *"Has the presence of the leaderboard altered the way you approach the learning activities?"*

  This question was designed to analyze whether users changed their learning strategies, or engagement patterns due to the leaderboard, providing insights into its broader impact on learning behavior.

- **Task-Based Interaction**: To further assess user behavior and motivation, participants were also asked to perform a specific task as part of the interview process. They were instructed to play a gamebook and check their position on the leaderboard, followed by playing the same or a different gamebook to observe how their ranking changed.

  This task-based approach provided valuable real-time insights into how users interacted with the leaderboard and whether it influenced their decision-making and engagement. By analyzing how users responded to changes in their rankings, the study aimed to better understand the role of the leaderboard in shaping user behavior.

  By structuring the interview around these core themes, the study aimed to gather in-depth qualitative insights that could inform future improvements to the leaderboard and ensure its alignment with user needs and educational goals.

4.4 Results

The results from the study are based on data collected from **8 participants** through two key methods: **User Interaction Observation** and **Semi-Structured Interviews**. Below is the analysis of the user responses based on the categories in which the interview questions were divided:

- **Leaderboard Design and Usability**: Seven out of the eight users appreciated the design of the leaderboard, describing it as *minimalistic yet informative*. They found it easy to understand and navigate without requiring significant effort. The intuitive nature of the design allowed users to quickly grasp their rankings and scores, enhancing the overall user experience. The simplicity of the leaderboard was seen as a strength, as it avoided unnecessary clutter while effectively conveying key information. This was also very obvious during the User Interaction Observation as none of the users showed any signs of confusion towards understanding the leaderboard or navigating through the leaderboard and the DiGaBo platform.

- **Competitiveness and Social Interaction**: Users generally welcomed the competitive aspect introduced by the leaderboard. According to six users, the competitive yet friendly nature of the platform is highly motivating to play more and more gamebooks. Upon further questioning regarding the level of competitiveness added due to leaderboard, most users said that the leaderboard is only acting as *a medium to somewhat connect with the rest of the fellow users* on the platform. Some users further commented that prior to the implementation of the leaderboard, the DiGaBo application could be interpreted as a solitary experience, primarily focused on individual engagement. However, the leaderboard transformed the platform into a more social and interactive space. Participants noted that it was *motivating to see how others were performing*, adding a sense of community and friendly competition.

- **Ranking System and Dynamic Scoring**: The feedback on the ranking system and scoring mechanism revealed a balanced mix of appreciation and suggestions for improvement. While half of the participants found the existing ranking system to be effective, clear, and efficient in displaying user standings, the other half expressed interest in incorporating a more dynamic scoring model to enhance engagement. Several users pointed out that the current static scoring system, though simple and easy to understand, could feel limiting in terms of reflecting individual effort and performance progression. They suggested that introducing a dynamic scoring mechanism—where scores could be adjusted based on difficulty levels, consistency, or improvement over time—would add an extra layer of motivation and competitiveness. For instance, a user who consistently improves their performance in a gamebook could be rewarded with bonus points, encouraging sustained learning and progress. Another case could be that the gamebooks support totally dynamic scoring which basically means that not just completing the gamebook would be rewarded but each section in the gamebook will hold points and the users will gain points for every correct answer hence providing a much better and dynamic experience to the users.

  Mixed responses from users and suggestions for improvement

  Additionally, some participants emphasized that while the leaderboard effectively displays total scores, it lacks granularity when it comes to tracking performance across individual gamebooks. They expressed a desire to see how they and others performed on specific gamebooks rather than just their cumulative ranking. This would not only provide a clearer sense of achievement in different areas but also help users identify areas where they could improve relative to their peers.

This feedback suggests that while the ranking system is generally well-received, incorporating more detailed and contextualized scoring metrics—such as per-gamebook rankings, progress tracking, dynamic gamebook scoring or bonus incentives—could further enhance user engagement and provide a more rewarding experience.

- **Engagement and Motivation**: All users unanimously agreed that the leaderboard played a crucial role in enhancing engagement and motivation on the platform. They reported feeling a strong sense of accomplishment and progression each time they checked their ranking after completing a gamebook. The leaderboard not only provided a measurable way to track their performance but also instilled a sense of curiosity and excitement about their standing relative to others. Many participants expressed that the leaderboard served as a motivational tool, pushing them to engage with more gamebooks and improve their scores. Some users even mentioned that *seeing their rank improve after a session reinforced a sense of achievement*, encouraging them to keep playing and learning.

- **Scoring Notifications**: Five users found the score notification alert (see Figure 3.2) to be a helpful feature, as it provided immediate feedback on their progress and reinforced their sense of achievement. The notification effectively confirmed that they had earned points after playing a new gamebook, which many users found encouraging. However, the rest of the participants suggested that the current alert, being a simple on-screen message, could be made more engaging and visually appealing to enhance the overall user experience. They proposed incorporating elements such as animations, sound effects, or a pop-up with a celebratory message to make the notification feel more rewarding and exciting. Additionally, a few users raised concerns about the lack of a clear visual cue when replaying a gamebook they had already completed. Since points are only awarded for playing new gamebooks, these users expected some form of feedback indicating that they would not receive additional points for a repeated gamebook. Instead, they had to manually check the leaderboard, only to realize that their score remained unchanged, which led to some initial confusion.

  How users perceived the scoring notifications

  Upon further discussion, it was revealed that such a notification does exist but is currently displayed only in the developer console, making it inaccessible to most users. When informed about this, users unanimously agreed that displaying this information directly on the webpage would be far more effective in reducing confusion. They suggested that a small pop-up message, a subtle color change, or an icon next to the gamebook title could clearly communicate that no new points would be awarded for repeated attempts. This was not possible to implement because of the multiple API calls problem faced during the implementation as the alerts about the user having played the gamebook already were being raised on every API call and this would be perceived as a flow of the application. If the issue of multiple API calls is resolved, this feature can be easily implemented and would greatly benefit the platform.

This feedback highlighted the importance of making system notifications more visible and user-friendly. Enhancing the clarity of score-related feedback would ensure that users always have a clear understanding of their progress without needing to search for information manually. Implementing these improvements would not only enhance usability but also contribute to a smoother and more engaging user experience.

- **Task-Based Interaction Analysis**: The task-based interaction phase provided valuable insights into how users navigated the leaderboard system while completing structured activities. Participants were instructed to play a gamebook, check their ranking on the leaderboard, play another gamebook, and check their ranking again to observe how their score changed. Among all the users, six to seven users, which is the majority of the users, completed these tasks seamlessly without requiring assistance, indicating that the leaderboard and gamebook mechanics were largely intuitive. Users were able to independently track their progress, reinforcing the leaderboard's effectiveness in providing a sense of accomplishment and motivation.

4.5 Discussion on overall impact of Leaderboard

Impact of the Leaderboard on User Interaction & Learning Effectiveness

The integration of a leaderboard into the DiGaBo application had a **strongly positive impact** on user interaction and learning effectiveness. Participants reported that the leaderboard fostered a sense of *achievement and progression*, motivating them to engage with more gamebooks to improve their rankings. The competitive aspect not only encouraged individual users to perform better but also created a more interactive and social learning environment. Furthermore, the leaderboard played a crucial role in sustaining user engagement over time. Instead of viewing the application as a one-time learning tool, participants felt encouraged to return and improve their scores, leading to **repeated engagement and deeper learning experiences**. The ability to track progress and compare performance with others provided additional motivation, making the learning process more dynamic and enjoyable.

Overall, the leaderboard was perceived as an **effective tool** for enhancing motivation, social interaction, and sustained engagement within the DiGaBo platform. While some improvements were suggested by the users—such as enhanced scoring notifications and dynamic scoring options—the general response was highly enthusiastic, reaffirming the leaderboard's value in fostering a competitive and interactive learning environment.

Chapter 5 Conclusion

This chapter summarizes the key findings of the study, highlighting how the leaderboard successfully fostered motivation and engagement among users. Additionally, it discusses design considerations for creating an effective leaderboard system, emphasizing the importance of balancing competition with inclusivity. The chapter also outlines potential future directions for improving the leaderboard, such as implementing dynamic scoring mechanisms, refining notification systems, and enhancing social interaction features.

By reflecting on the study's contributions and limitations, this chapter provides a foundation for future research and development in gamification-based learning environments. The findings serve as a guide for educators and developers looking to optimize leaderboard-driven engagement strategies, ensuring that learning platforms remain both interactive and rewarding for users.

5.1 Summary of Findings

This thesis set out to investigate the role of competitive leaderboards in enhancing motivation and engagement in educational settings, specifically within the DiGaBo platform. The findings from this study reinforce the idea that well-designed gamification elements, such as leaderboards, can significantly influence user behavior and learning outcomes. The research aimed to understand how the integration of a leaderboard affects user motivation, engagement, and interaction within the platform while also assessing user perceptions of its fairness and effectiveness.

effect of leaderboard on users

The first research question sought to understand **how competitive leaderboards affect user motivation and engagement in educational activities**. The user evaluation revealed that the leaderboard successfully motivated participants to engage with the platform more actively. Participants reported feeling encouraged to check their rankings frequently, which in turn motivated them to play more gamebooks. Additionally, users felt a strong sense of accomplishment when they saw improvements in their rankings, reinforcing continued engagement. Overall, the users perceived the leaderboard as an effective tool for tracking progress and enhancing the overall learning experience.

The second research question aimed to examine **how users perceive the use of leaderboards in the DiGaBo application**. Most users viewed the leaderboard positively, appreciating its minimalistic design and ease of use. They found it to be an effective tool for tracking progress and enhancing the overall learning experience. However, some users raised concerns regarding the fairness of static scoring and

suggested that incorporating a dynamic scoring mechanism based on difficulty, consistency, and improvement over time could provide a more balanced competition. Additionally, participants noted that while the leaderboard provided valuable insights into overall performance, they would like to see performance comparisons for specific gamebooks to better understand their relative strengths and weaknesses.

Benefits of adding the leaderboard in the DiGaBo platform

The third research question focused on **how the integration of a leaderboard into the DiGaBo app influences user interaction and learning effectiveness**. The findings suggest that the leaderboard introduced a competitive element in DiGaBo that made learning more interactive and engaging. Users reported that it encouraged them to actively participate in more gamebooks and experiment with different challenges to improve their scores. Users also expressed that the leaderboard only acts as a medium to connect with the rest of the users on the platform making it a more social and interactive space. Some participants emphasized the lack of granularity in terms of performance tracking. To mitigate this, implementation of per-gamebook rankings, progress tracking, dynamic gamebook scoring or bonus incentives could further enhance user motivation resulting into higher learning effectiveness. Additionally, improvements in feedback mechanisms—such as enhanced notifications when points are not awarded—could further clarify scoring outcomes and enhance the overall user experience.

Balance competition and inclusivity

One of the key takeaways from this research is the importance of designing leaderboards that balance competition with inclusivity. While competition can be a strong motivator, it is essential to ensure that lower-ranked users do not feel discouraged. Future improvements should explore adaptive leaderboard systems that provide personalized feedback and alternative ranking mechanisms to cater to diverse user preferences.

Adaptive leaderboards and personalized feedback needed

Additionally, the study highlighted the value of qualitative research methods, particularly semi-structured interviews and task-based interactions, in understanding user experiences. The combination of observational and interview-based insights provided a comprehensive understanding of how users interact with the leaderboard and the specific design elements that influence their motivation.

Looking ahead, future research should examine the long-term effects of leaderboard integration on learning behavior and knowledge retention. Further exploration into how leaderboards can be adapted for different educational domains and learner demographics would provide valuable insights for optimizing gamification strategies in education.

Explore long-term impacts

In conclusion, this study confirms that competitive leaderboards are an effective gamification tool for fostering engagement and motivation in digital learning environments. By refining design elements and addressing user feedback, educational platforms can leverage leaderboards to create more dynamic, interactive, and rewarding learning experiences.

5.2 Improvements and Future Work

Based on the findings of this study, several key areas for improvement and future research have been identified to enhance the effectiveness of leaderboards in the DiGaBo platform or in any educational platforms.

5.2.1 Enhanced Dynamic Scoring Mechanisms

One of the primary suggestions from users was the introduction of a **dynamic scoring system** that extends beyond traditional static rankings. While the current system effectively tracks cumulative scores, participants expressed interest in a more nuanced approach that takes multiple factors into account, such as *difficulty level, improvement over time, and consistency in engagement*. A dynamic scoring model could better reflect individual progress and learning effort, making the competition more engaging and personalized. A **difficulty-based scoring mechanism** would assign higher point values to more challenging gamebooks, ensuring that users are rewarded fairly based on the complexity of the task they complete. This can be achieved by *allowing gamebook creators to set the points for their gamebooks based on predefined criteria*. This would encourage learners to engage with more advanced content rather than repeatedly playing easier gamebooks for quick points. Additionally, this approach would encourage the gamebook creators/authors to design more engaging and meaningful learning experiences. Another approach to a scoring mechanism is an **improvement-based scoring system** that could track users' performance over multiple attempts, awarding extra points for demonstrated progress rather than just raw scores. This would motivate learners to refine their understanding of concepts rather than focusing solely on their initial performance.

Examples of dynamic scoring mechanisms and how they benefit the platform

Furthermore, a **consistency-based reward system** could incentivize regular engagement with the platform. By introducing streak-based bonuses or progressive score multipliers for consecutive days of activity, users would be encouraged to sustain long-term participation. This could be especially beneficial in maintaining engagement over time, preventing the leaderboard from being dominated by only occasional high-scoring performances. Moreover, **contextualized performance tracking**, where users can compare their scores on individual gamebooks rather than just cumulative points, would offer deeper insights into strengths and areas for improvement.

By implementing these dynamic scoring mechanisms, the leaderboard would become a more **adaptive, fair, and engaging tool** for learners. It would encourage diverse learning strategies, reward persistence, and create a more **inclusive competitive environment** where improvement and effort are as valued as high scores. This approach would ultimately make the DiGaBo platform not only more interactive but also more **educationally meaningful** by reinforcing positive learning behaviors.

5.2.2 Refined Notification System

User feedback highlighted the need for improved visibility of scoring-related notifications. The current system lacks real-time, on-screen feedback, particularly when users replay gamebooks they have already completed. Enhancing the notification system with visually engaging, interactive messages or pop-ups can help users better

Enhancing scoring notification improves user experience

understand why they are or are not receiving points, reducing confusion and improving overall user experience. A more comprehensive notification system could include distinct visual indicators for different scoring outcomes. For instance, a dynamic pop-up message could explicitly inform users whether they earned points, with color-coded cues—green for successfully earned points and yellow or red for cases where no additional points were granted. Furthermore, sound effects or subtle animations could enhance engagement, making the feedback more intuitive and noticeable without being intrusive.

Additionally, integrating a notification history feature could allow users to review their recent scoring events. This would enable learners to track their performance and understand their scoring trends over time. By making these enhancements, the notification system would not only improve usability but also reinforce learning behaviors by providing immediate, clear, and engaging feedback.

5.2.3 Collaborative Features, Long-Term User Engagement & Scalability

Add social features, study long-term effects, and test adaptability across domains

While the leaderboard introduced a competitive element, future iterations could explore additional social and collaborative features to further enhance engagement. Features such as team-based leaderboards, discussion forums, or interactive challenges could create a more community-driven learning experience, reinforcing both competition and cooperation within the platform.

Further studies should investigate the long-term impact of leaderboards on user engagement and knowledge retention. While this research provided valuable short-term insights, longitudinal studies tracking user behavior over extended periods would offer deeper understanding into how leaderboards influence sustained learning and motivation.

Finally, expanding the leaderboard system to different educational domains and learner demographics could provide insights into its adaptability and effectiveness. Future research could explore how leaderboard-based gamification impacts various subjects, skill levels, and institutional settings, ensuring that its benefits extend beyond a single application or learning environment.

By addressing these areas of improvement and exploring future research directions, educational platforms can continue to refine leaderboard-based gamification to maximize engagement, motivation, and overall learning effectiveness.

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Semi-Structured Interview Questions

1. How would you rate the ease of use and design of the leaderboard feature?
2. Do you think the leaderboard provides enough information, or would you like to see additional details?
3. How easy is it for you to understand and navigate the leaderboard?
4. Task: Play any gamebook, then check your ranking in the leaderboard. After this play another gamebook or the same one and then again go and check your ranking in the leaderboard.
    a) When completing the task of playing a gamebook and checking your score, how intuitive was the process?
    b) Did you experience any confusion while navigating between the gamebook and the leaderboard? If so, what improvements would help?
5. Do you find the ranking system fair and accessible to all users?
6. Do you believe tie-breaking by gamebook difficulty would make the ranking system fairer? Why or why not?
7. What are your thoughts on the competitive aspect introduced by the leaderboard?
8. How has the leaderboard influenced your motivation to engage with the course content?
9. Do you find yourself checking the leaderboard frequently after completing a gamebook? Why or why not?
10. Has the presence of the leaderboard altered the way you approach the learning activities?
11. If the leaderboard didn't exist, would you still try to attempt as many gamebooks as you could?
12. Have you felt encouraged or discouraged by seeing others' rankings on the leaderboard? Why?
13. If given the opportunity would you like to play more gamebooks in the upcoming future to improve your score?
14. Do you think the leaderboard makes DiGaBo feel more social, or do you still see it as an individual experience?
15. What are your final feedbacks about the leaderboard feature?

Declaration:
AI tools have been used in the entire thesis to make the content continuous, fluent and well structured.

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Acknowledgement

Thank God, this is over :)