Gamification in Software Engineering—SoftEngame

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1 INTRODUCTION

Because of playing, childhood is one of the most beautiful times for any individual, but what about the job now? Imagine a world where the workplace is as exciting as playing a game. In this world, completing tasks earns employees points; overcoming challenges earns badges; and team collaboration is part of a fun multiplayer experience. This is not just a future idea, it's already happening with gamification in software engineering (SE) these days. By incorporating game elements into software development processes, we can greatly improve productivity and make developers work more satisfying. This paper looks at how combining gaming concepts with SE can be very beneficial, especially in a field where working closely together and following detailed steps are very important. Software development requires not only high technical skills but also a strong commitment to follow detailed procedures. Despite their skills, professionals often need better training to gain new skills, work well with others, and learn quickly. These abilities are important for meeting deadlines and avoiding delays. The need for effective tools to help with communication and teamwork becomes even more important when facing the pressures of tight deadlines, which can lower the quality and effectiveness of SE practices Costello [3], Yasrab and Razzaq [16]. A model by Costello helps us understand how decisions about time management under pressure often lead to focusing more on immediate needs over long-term benefits like thorough testing and detailed documentation [3]. Gamification concepts were first introduced by Nick Pelling in 2002 Deterding [5] and has grown to include using game design elements in non-gaming contexts. This approach has been very useful across different industries, including software engineering, where it has helped increase motivation and productivity by making developers more engaged and satisfied with their work Azouz and Lefdaoui [1], Beecham et al. [2], Ren et al. [13]. Research supports the idea that gamification can significantly improve engagement, motivation, and how efficiently work is done Rodrigues and Oliveira [14]. This research looks into the 'SoftEngame' platform, a new app that uses game elements to change the way developers and product owners behave. By combining work and learning environments, 'SoftEngame' aims to make software engineering more productive and focus on improving specific behaviors. We designed the system, which supports several languages, to enhance motivation, learning, and teamwork among developers and product owners. We will have 33 participants join a 30-week study to see how well the system works, starting with observing changes in behavior and then interviewing them to understand the effects on productivity

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and satisfaction. We expect the findings to give us valuable insights into how effective gamification is in professional settings, preparing us for an in-depth analysis of how gamification is changing SE practices.

2 BACKGROUND

Part1: Gamification for Learning

In the previous part, we examined the challenges faced in the field of software engineering in terms of learning and practices, focusing on the need to include gamification. Gamification has proven effective in integrating game like elements into SE education. The paper by Gensheimer et al. [6] explores the application of visual novels (VNs) to gamification in SE education. Users can communicate with VNs in a number of ways, like by grouping objects or choosing dialogue options. The study aims to motivate students and confirm their knowledge by introducing a waterfall model-focused VN-based learning scenario. This work's primary achievement is the successful development and implementation of a VN-based learning scenario for a SE course. The paper notes the need for empirical evaluation in actual educational environments and suggests expanding the scope by including multiple languages to appeal to more learners. The paper by John and Fertig [9] talks about the creation of a game-based course on Scrum methods for college students.There are some game-like parts in the course, like story-based, point-based, and quiz-based parts. A study looks at how well different game-like parts work to help students learn Scrum methods. The first attempt at using gamification with points had mixed results. The game-like elements motivated some students, but not others. The story-based gamification idea didn't work to keep students interested, possibly because the content was too long and the students weren't immersed in the environment. This suggests the necessity for additional research on the motivational impact of various methodologies. The study by de Sousa Pinto and Silva [4] assesses the effectiveness of gamification in improving student motivation and engagement in a SE specialization course. The study includes a variety of game-like activities, such as educational games, word searches, crossword puzzles, and assessments, culminating in a survey. The study's results show that gamification of learning makes students more interested, which shows its value. The authors suggest looking into how gamification can be used in other fields and how it might affect student learning and performance in the long term.

Part 2: Gamification in Workplace

The study by Hammerschall [8] examines the application of gamification principles in SE processes. The major research objective is to study the potential of gamification to improve the software development process, including its role in stimulating behavior modification, engagement, learning, and problem-solving in SE projects. The article provides examples of gamification's application in SE settings, such as using Planning Poker to estimate user stories and the Quality Language Game to find errors in graphical user interfaces. The study highlights the need for further empirical research to assess the impact of gamification on SE tasks like requirement elicitation, quality assurance, and knowledge sharing. The paper by Ren et al. [13] emphasizes the value of gamification in boosting software development efficiency and enhancing software engineers' performance. The authors propose a four-part gamification processing model for software development: (1) preparation, (2) platform, (3) gamification design, and (4) development. With features like points, rankings, badges, and feedback to change user behaviour, this model aims to provide a complete framework for adding gamification to the software development life cycle. The paper doesn't give any real-world examples or case studies to back up the models that are being suggested. The authors acknowledge that the next step is to test the gamification processing model and the metrics model for software engineer contributions and evaluate their impact on software engineers' behaviors and performance. The study by Stol et al. [15] investigates whether developer engagement mediates the relationship between job satisfaction and gaming participation. The study shows that participation in

gamification challenges positively correlates with developer engagement and job satisfaction. However, it notes a need for more research into the long-term effects of gamification initiatives in SE. The paper by Grünewald et al. [7] discusses how organizations apply game principles to business contexts, using practical case studies of gamified educational and training programs. It shows how incorporating elements like challenges, rankings, points, and badges can increase employee motivation and engagement, while immersive learning environments enhance knowledge retention and application. The study highlights the need for additional empirical evidence to understand gamification's long-term effects and suggests integrating it with other technologies like virtual and augmented reality. The paper Miri and Macke [12] explores the impact of gamification on employee engagement and motivation in the workplace. The study shows that effective gamification requires appropriate planning and integration into company systems, with scoring, feedback, and rewards. The study cites the Bravi Quiz application as a successful case but emphasizes the need for more emphasis on motivation and engagement at work. The paper by Meder et al. [11] explores the application of gamification in the workplace, focusing on its potential to enhance user motivation and participation. Researchers conducted an experiment using a gamified enterprise bookmarking system, surveyed employees to understand their perception of gamification principles and analyzed users' actual interaction and engagement. Results showed that while some employees were familiar with gamification and believed it could have positive effects, a majority were undecided or not convinced that gamification could serve as intrinsic motivation. The study found a relationship between perceived and actual gamification principles in the workplace but argued that using questionnaires and interviews to determine user preferences may be biased. The researchers proposed an alternative approach using predictive models and matrix factorization to automatically assign game design elements to users based on their interaction data. The study contributes to the growing body of research on gamification in the workplace and suggests further research on predictive models and matrix factorization. This paper by Latip et al. [10] examines the role of gamification in employee training and development, focusing on its potential to enhance motivation, engagement, and performance. The research aims to investigate the factors influencing employees' acceptance of gamification in training and development programmes. The hypotheses suggest that perceived usefulness, perceived ease of use, and social influence are significant factors influencing employees' acceptance of gamification. The study will employ a quantitative research approach, distributing questionnaires to white-collar workers in Malaysia, and analysing the collected data using Smart PLS techniques. The findings will provide valuable insights into the factors driving employees' acceptance and utilisation of gamification in professional development, helping organisations design and implement more effective programmes. The study contributes to the existing literature on gamification in the workplace by addressing a gap in understanding the factors influencing employees' acceptance. Future work could include expanding the research to include a broader range of industries and employee profiles and exploring the actual usage and performance outcomes of gamification in training and development.

The proposed research aims to fill the gaps in previous research by developing and evaluating a multilingual gamified app for SE education and workplace integration. This app will provide support in English, French, Chinese, and Arabic, addressing the language gap and making learning accessible to diverse users. The app combines educational modules on key SE concepts, such as Scrum methodologies , with practical workplace scenarios and challenges, creating an easy transition between learning and professional application. Interactive elements, including visual games, enhance engagement and knowledge retention. We will evaluate the app's effectiveness over a 30-week period, measuring learning outcomes, engagement, and professional application. Interviews enable researchers to delve deeper into the user's satisfaction with the app, and field studies allow researchers to observe users in their natural environments, providing insights into how users interact with the app in real-world situations. Researchers will conduct an evaluation

of the app's impact in both educational and professional contexts, providing valuable insights into its long-term impact on SE education and practice.

3 PROTOTYPE

The proposed "SoftEngame" system integrates four interconnected use cases designed to enhance learning, collaboration, and project management in the software engineering field.The multilingual support and user authentication use case aim to improve the platform's user experience and security while ensuring safe access to user accounts in different languages. The e-learning use case offers multimedia content and interactive exercises to improve the skills of software developers and product owners, rewarding them for completing courses. The workplace use case provides a collaborative platform for implementing projects with methodologies such as Scrum and rewards teams and product owners upon achieving milestones, facilitating effective project execution. The Project Management module enables project managers to set project parameters, monitor progress, distribute rewards, and track team performance and skill development. This comprehensive system aims to bridge the gap between education and workplace applications, fostering a seamless transition between learning and practice, thereby enhancing SE education and workplace productivity.

3.1 Use Case 1: Multilingual Support and User Authentication

Actors are software development teams, project managers, and product owners. System: Authentication server and language configuration service. The goal is to allow users to access the platform in their preferred language and enable secure user authentication through login for registered users and sign-up processes for new companies to register. The precondition is that the user must choose one language: English, Chinese, French, or Arabic.The system has an authentication mechanism in place for user login and registration. The trigger is that user visits the platform and selects a language preference. user chooses to log in or sign up. The basic flow is that, language Selection. The user selects their preferred language from the main languages UI. upon selection, the system dynamically updates all text elements and user interface components to reflect the chosen language. Log In, the system displays a login form, the user enters their username and password. The system verifies the credentials against the stored data. If the credentials are correct, the user is granted access to their account dashboard. If not, an error message is displayed in the selected language. The alternate Flows are that forgot password. During the login process, if the user selects "Forgot Password," the system prompts them to enter their registered email address. The system sends a reset password link to the provided email. The user follows the link to create a new password, and is then able to log in with the new credentials.

3.2 Use Case 2: E-learning software engineering techniques

This use case facilitates the training and development of SE skills through multimedia content and interactive exercises. The system rewards players during the course and after they finish. Actors, or learners, are software developer teams and product owners. The system is an e-learning platform. The goal is to enhance the SE skills of software developer teams and product owners on software processes to encourage engagement and active participation in projects through the gamification method. The stakeholders are project managers, software developer teams, and product owners. The primary actors are learners (software developer teams, product owners). The preconditions are that the platform must have multimedia content that is uploaded and accessible. Project managers must have registered software developer teams and product owners. The triggers are that the user (software developer or product owner) enrols in a course on the e-learning platform, initiating the training or development process. The basic flow is that the user logs in and navigates to the desired course.The user engages with multimedia content such as videos, slides, and documents. To

assess understanding, we present interactive exercises after each module and award points based on user performance. The system keeps track of progress and assigns rewards and points based on user performance, then provides feedback on the exercise performance of users to the project manager monitoring platform. The alternate flow is that we suggest additional resources to improve understanding.

3.3 Use Case 3: Workplace Software Engineering Techniques

This use case describes how SE processes interact in a collaborative environment, following the chosen methodologies (Scrum) and offering rewards and points for software development teams and product owners upon task completion. Actors are software developer teams, and product owners. System is a collaborative SE platform. The goal is to execute software projects efficiently while fostering motivation and collaboration among team developers and product owners. The stakeholders are software development teams, project managers, and product owners. The primary actors are software development teams and product owners. The preconditions are that project parameters and methodologies (Scrum) are defined by project managers, software developer teams and product owners, who have appropriate access rights based on their roles. The trigger is when the project manager selects a project methodology, registers users and initiates it. The basic flows are that the project manager selects the methodology and outlines the project scope and stages, product owners and software development teams receive notifications, and they have access to project dashboards. Software development teams and product owners will earn points and rewards for achieving milestones as they complete tasks. Collaboration tools within the platform allow for ongoing communication and problem-solving, we generate regular updates and reports to monitor progress and adjust strategies as necessary. The alternate flow is that if a task misses its deadline, the system prompts a review session to discuss and remedy the delay. Product owners can request changes, initiating a re-evaluation of project stages and goals.

3.4 Use Case 4: Project Management setting and Monitoring users.

This use case involves the project manager setting, choosing methodology (Scrum), a Gantt chart, picking reward packages, and monitoring skill development and project progression. The actors are project managers. The system is a project management system. The goal is to ensure project milestones are met and educational goals are achieved. The stakeholders are project managers. The primary Actor is a project manager. The precondition is that all project data settings, and user profiles are set up and integrated into the system. The trigger is that the project manager logs into the platform and selects a project type. The basic flows is that the project manager put project settings. The project manager reviews the progress on the dashboard, highlighting areas of concern or achievement, and rewards and points gained by users, Rewards and recognition are allocated based on performance metrics and milestone achievements,.Skills tracking identifies gaps in team capabilities and suggests targeted learning modules, The system generates performance analytics to guide future project planning and team development. Feedback from developer teams and product owners is gathered to refine the learning and project execution processes. The alternate flows are that if a project is at risk of failing to meet deadlines, the system proposes an intervention strategy to realign the project with its goals, and continuous improvement suggestions are made based on analytics of users learning and workplace performances.

4 SYSTEM DESIGN

Field studies as a quantitative approach and interviews as a qualitative approach emerge as the most suitable methodologies for investigating and evaluating the application of gamification in software engineering. These approaches offer direct access to real-world contexts, enabling researchers to observe and engage with participants in their natural

environments. Through field studies, researchers can gain valuable insights into the implementation and experience of gamification strategies in actual software development settings. Additionally, interviews provide an opportunity to delve deeper into participants' perspectives, attitudes, and experiences related to gamified practices. Together, these methodologies offer a comprehensive approach to understanding the impact and effectiveness of gamification in SE.

- Null Hypothesis (H0): The gamification system does not significantly impact SE motivation, collaboration, productivity, and learning outcomes compared to traditional SE education and project management approaches. Furthermore, system users do not report higher satisfaction with the gamification system.
- Alternative Hypothesis (H1): The gamification system significantly improves SE motivation, collaboration, productivity, and learning outcomes compared to traditional SE education and project management approaches. Additionally, system users report higher satisfaction with the gamification system.

4.1 Participants

There are three real-world projects (P1, P2, and P3) to use the gamification application with one methodology (Scrum). All participants should give their consent before the study starts. The selection process aims to include participants from diverse backgrounds to enhance the richness of the sample. We selected participants with varying levels of education experience, ranging from novices to those with extensive high-level learning backgrounds, to offer a comprehensive perspective on the reception and utilization of the SoftEngame system. The selection also aimed to cover a range of demographic backgrounds, including gender, age, ethnicity, and professional experience in software engineering or related fields. All participants should speak English well to remove language barriers. There is one SE project manager, 9 developers and one product owner for each project, and we have 3 projects from three different IT companies in the UK. Felid study participants: there are 33 participants (27 developers, 3 product owners and 3 project managers). Interview participants: there are 33 participants (27 developers, 3 project managers, and 3 product owners).

4.2 Procedure

The field study spans approximately 30 weeks, from June 2024 to December 2024, allowing sufficient time to complete projects using software engineering methodology (Scrum). All of the projects follow the same high-level SE methodology, and each project manager has a high degree of flexibility in how they run their own projects. While they had a rich understanding of these SE concepts from previous work over 10 years, their previous focus had not been on motivational strategies through gamification. However, we are now attempting to apply gamification to SE e-learning and the workplace environment for both the developer and product owner sides. Each course or development life cycle will be a stage of the game. The "SoftEngame" platform will gather information about users performances on both the learning and workplace sides and provide feedback to the project manager in each project. The post-study interviews, averaging 60 minutes per participant, will be transcribed and analyzed using an inductive thematic analysis. Initially, open coding will be applied to the first few interview sessions, yielding categories. These codes will be organized into a table, with memos defining each code and sample quotes. The first author, along with two other researchers, will then discuss and refine these codes. Subsequently, the researchers will search for semantic themes, examining similarities and differences, and removing any codes deemed irrelevant to the research questions. Axial coding will then be applied to the remaining high-level themes to identify categories and relationships among them. Finally, each theme will be mapped into sub-themes that form the primary findings.

4.3 Setup and Materials

The study employs iterative methods, including a pilot study before launch, to identify and address potential issues. Data from the field study and interviews are analyzed to refine themes and provide actionable insights. We have to backup laptop batteries, audio recorders, extra paper, and data backup. Studies will continue to prioritise data security, particularly sensitive participant data, to maintain the integrity of research findings. Field study: Setups is the environment of field study that takes place across three real-world software engineering projects at three IT companies in the UK, each following a Scrum methodology. The projects involve a total of 33 participants, including three project managers, 27 developers, and three product owners. The structure of each project adheres to the same SE curriculum and methodologies, allowing project managers the flexibility to customize the project's execution. The study utilizes a gamified SE platform ("SoftEngame") that integrates e-learning and project management features. Materials are gamified Learning Platform: The "SoftEngame" platform serves as the primary resource, offering three interconnected modules E-learning, Workplace Collaboration, and Project Management. Participants use tablets with internet access to interact with the platform. The platform itself is accessible through a tablet app, ensuring compatibility across multiple operating systems. Interview: : At the end of the 30-week study, post-study interviews are conducted with all participants to evaluate the impact of gamification on motivation, productivity, and teamwork. Interviews are transcribed and analyzed using inductive thematic analysis to categorize and refine findings. Questions of interviews with participants:

1 Could you please state your gender identity and educational background?
2 How easy did you find it to navigate and use the SoftEngame platform?
3 How did the gamified elements (such as points, badges, and leaderboards) affect your motivation and daily activities?
4 How do you think the gamified elements impacted project execution and milestone achievement? Did they increase productivity or focus?
5 How well did the SoftEngame system integrate into your daily work routine? Did it feel natural or disruptive?
6 How satisfied are you with the SoftEngame platform? Would you recommend it to others?
7 Are there any specific features or aspects of the system that you would suggest changing or improving?
8 What do you think about the SoftEngame system's potential to influence your software engineering practices in the long term?

4.4 Measurements

A field study offers a practical setting for observing and measuring the effects of gamification elements in a real-world setting. Through learning and applying SE in the workplace environment, researchers examine the potential benefits of using game-like components to change behaviors. This methodology allows researchers to observe and measure the operational behavior of these components, including productivity, such as leaderboards, badges, and point systems, which can serve as motivators to improve and increase productivity among developers. We can measure this by tracking project completion rates over time and overall project efficiency. Engagement and collaboration, gamification's ability to increase engagement and collaboration among software development teams and product owners. We can evaluate this important aspect using metrics like participation in team meetings, engagement in project discussions, and collaborative problem-solving. Learning and skill development, the implementation of gamified e-learning modules provides opportunities to measure learning outcomes and knowledge. Progress through modules, performance in interactive exercises, and feedback can offer views on how gamification influences learning and skill development.

Interview effective in gathering qualitative data from project managers, developers, and product owners. These interview questions aim to elicit more in-depth insights, allowing respondents to share their experiences, and opinions, such as demographic, usability, learning outcomes, collaboration, productivity, satisfaction, and improvement questions. This approach provides richer data for analysis, helping to better understand the impact of gamification on various aspects of SE practices.

5 LIMITATION AND FUTURE

While the "SoftEngame" system demonstrates significant promise in enhancing software engineering practices through gamification, there are several limitations to consider. The current system focuses on software development methodologies such as Scrum. Expanding the app's scope to include methodologies like Waterfall, XP, V-Model, and Lean would offer greater flexibility to SE projects. Further development should also explore integrating AR (augmented reality) and VR (virtual reality) into the gamified experience, enhancing engagement and interactivity. Finally, incorporating visual novels into future iterations of the system would offer a unique learning experience, enriching both education and workplace applications. Addressing these limitations and expanding the system's features will improve its inclusivity and impact on SE practices. Ensuring that the gamification platform is compatible across various devices and operating systems can increase accessibility and user engagement, especially in diverse workplace environments.

6 CONCLUSION

At the end, we anticipate that the "SoftEngame" system will significantly enhance software engineering practices through the use of gamification. By integrating game-like elements such as points, badges, and leaderboards into SE processes, it aims to increase motivation, engagement, and productivity among developers and product owners. The system also includes collaborative features designed to foster effective teamwork and ensure efficient workflow management. The expected benefits include improved skill retention, enhanced learning outcomes, and better overall job performance due to the combined professional application and educational content in the e-learning module. Participants are likely to find the platform user-friendly and enjoyable, which could promote long-term adoption within SE practices. Additionally, by supporting multiple languages, the system aims to enhance accessibility, boost inclusivity, and facilitate cross-cultural collaboration within the SE community. This would potentially broaden the impact of the system across diverse global teams. We will conduct a thorough evaluation, involving field studies and interviews over a 30-week period, to ensure these outcomes and measure the system's impact on SE education and workplace productivity. The research aims to provide significant insights into the effectiveness of gamification in professional settings, with a focus on expanding the research to include more comprehensive methodologies and exploring the integration of advanced technologies like AR and VR to enhance the gamification experience.

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