GLiDE: Integrated Gamified Learning Dashboard Environment

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Abstract

The Integrated Gamified Learning Dashboard Environment (GLiDE) project aims at fostering student engagement, teamwork, and project performance in software engineering education. By integrating gamification elements and enhanced user experience in an existing Learning Dashboard, GLiDE offers a novel approach to learning in team-based software development projects. This paper discusses the motivation behind GLiDE, its current status, and the open research areas. This project offers an opportunity to gain valuable insights into the fields of educational technology and software engineering education.

Keywords

Learning Dashboard, Information Systems Education, Gamification, User Experience

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1. Introduction

Team-based software development projects provide an excellent opportunity for students to experience the challenges of teamwork and project management that they will face in the industry [5]. When students are introduced and motivated correctly, they become enthusiastic about working in teams [9]. However, the actual experience may sometimes fail to meet students' expectations [5]. For this reason, we decided to investigate whether a learning dashboard could assist student teams when working on development projects in the context of software engineering courses [2]. Learning Dashboards are information systems in the education domain designed to support students and instructors in their learning/teaching activities [12].

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This paper presents an ongoing research project, Integrated Gamified Learning Dashboard Environment (GLiDE), which leverages our initial Learning Dashboard [2] to design and implement an enhanced version aimed at improving student motivation and engagement, team collaboration and cohesion, project performance, and quality of the artifacts produced while working on Software Engineering projects.

2. Context

Software Engineering Project (SEP) and *Web Applications and Services* (WAS) are two subjects of the Bachelor's degree in Informatics Engineering of the Faculty of Informatics of Barcelona (Universitat Politècnica de Catalunya, UPC). Both subjects apply project-based learning by developing a software project, which the students carry out organized in teams.

In the 2021/2022 academic year, we launched the project "Implementation of a learning dashboard to visualize and monitor the achievement of learning objectives in subjects based on the team development of software projects," partially financed by the UPC [10]. With the addition of the *Learning Dashboard* (LD) in the SEP and WAS subjects, we intended that through its use, students and teachers of these subjects could receive accurate feedback on the individual and team learning process and also make informed decisions about how to prioritize and plan their actions during the development of software projects.

LD leverages the *Q-Rapids Dashboard*, initially aimed at monitoring and evaluating software production in agile environments [7], and integrates data from various software development tools used by student teams, such as Taiga, GitHub, and Google Sheets. From these data sources, metrics, factors, and strategic indicators are calculated to provide a global view and assessment of the project. An interactive graphic interface shows the current state and also the historical evolution of these metrics, factors, and strategic indicators. The values are classified and displayed according to predefined thresholds, which the teacher can customize to evaluate the project's performance. Figure 1 shows two screenshots of the LD.

Access to LD was given to roughly half of the teams to have a control group. Its use was not promoted or encouraged, nor used for evaluation purposes to avoid discrimination against teams without access to the tool. Students and teams using the tool answered questionnaires addressing the understanding of metrics, perceived usefulness of metrics, and perceived clarity of visualizations and complemented with personal interviews with a member of each team [13, 2]. The obtained feedback can be summarized as follows:

- Students infer the purpose of the metrics but sometimes have difficulty understanding the intricate details of their definitions and making sense of the resultant values.
- Students do not perceive that metrics help them manage their projects or achieve their objectives.
- While the LD offers a clear user experience, it lacks the visual appeal and engagement necessary to truly captivate users.

- Most students cite time constraints and inadequate LD training as barriers to regular use, feeling overwhelmed by the prospect of integrating “yet another tool” into their workflow.

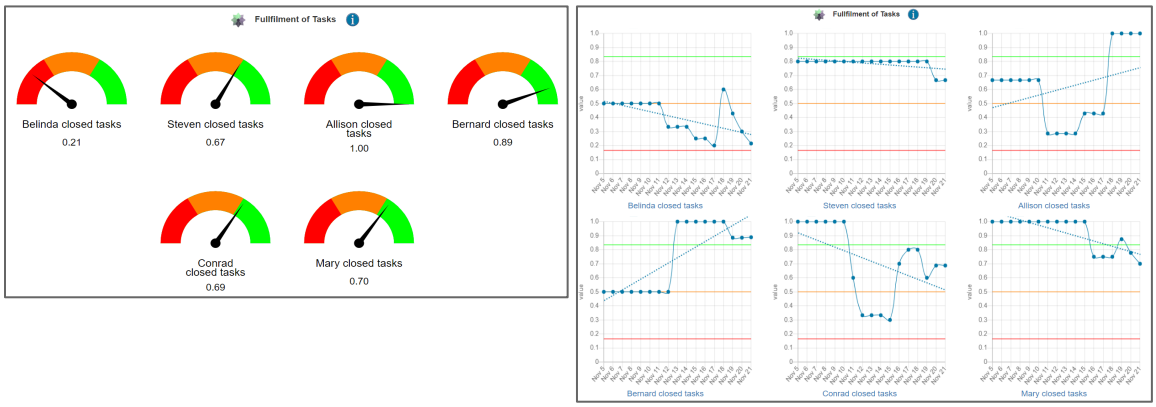

Figure 1: Screenshots of the Learning Dashboard. On the left, a snapshot of the values of the metric "Fulfillment of Tasks". On the right, the evolution of these values over a period of time.

3. Objectives

Our evaluation of the Learning Dashboard (LD) implementation has been generally positive, although it has not fully realized its potential. We have identified three primary barriers that limit the LD's effectiveness: 1) a lack of student motivation stemming from insufficient incentives and ambiguous promotion; 2) students' limited understanding of how the LD can enhance teamwork and goal achievement; 3) a functional yet unengaging user experience that fails to maintain student interest. To address these issues, we aim to improve the LD by developing an updated version, named GLiDE, with the following objectives:

- **Increased Student Engagement and Motivation**: We plan to redesign the LD’s user experience to make it more user-friendly and attractive, adding gamification elements such as points or badges to foster engagement.
- **Enhanced Team Dynamics:** GLiDE will incorporate new features to facilitate better communication and coordination.
- **Improved Team Performance**: GLiDE will include tools that allow teams to monitor and compare their progress against others through a gamified interface, promoting a healthy competitive environment that encourages productivity.
- **Higher Quality of Project Outputs**: By implementing gamification strategies that recognize and reward high-quality work, GLiDE will motivate students to produce superior artifacts.
- **Exploring Innovative Gamification Strategies**: We aim to investigate novel gamification techniques tailored for software engineering education and beyond. This includes focusing on personalized learning experiences, seamless integration

with various development tools, and evaluating the potential for adaptability to other team-based project settings.

These targeted improvements are designed to overcome the LD's current limitations and maximize its impact as an educational tool.

4. Relevance to Advanced Information Systems Engineering

The GLiDE project aligns closely with several topics of interest for the CAiSE community:

- **Human-centered techniques**: GLiDE's focus on user experience and gamification aligns with human-centered design principles, which are essential for creating engaging and effective information systems. By prioritizing students' needs and motivations, GLiDE aims to make the learning process more interactive and responsive.
- **Visualization techniques in IS**: The project leverages advanced visualization techniques to make complex data understandable and actionable for students. These techniques are critical in helping them visualize their progress and the dynamics of their team interactions within software development projects.
- **Educational Systems and Learning Analytics**: GLiDE is a prime example of innovation in educational systems and learning analytics. It's designed to enhance the learning experience in software engineering education through a gamified dashboard that provides real-time feedback and analytics.

The funding of the GLiDE project by a university grant emphasizes our dedication to improving educational tools through practical engineering. While the project incorporates significant engineering activities, its research aspects are equally vital. GLiDE tests and expands upon theories of gamification and user experience in real educational settings, contributing new insights into their practical applications. This blend of engineering and research ensures that GLiDE not only implements but also innovates, providing valuable data and theoretical advancements to the field of Information Systems Engineering.

5. Current status

As a result of the activities carried out during the project, we have achieved the following outcomes.

5.1. Analysis of the state of the art in gamification techniques

The GLiDE project started with a comprehensive review of the state of the art in gamification techniques for software engineering activities and learning dashboards. The studies analyzed from the literature confirm that gamification has been applied successfully to several software engineering activities in industry and education, including software requirements, development, testing, and project management [4]. This literature review identifies different gamification strategies and techniques, such as organizing projects as a

set of challenges or incorporating gamified elements, such as points, badges, virtual coins, levels, leaderboards, voting, and feedback [8]. Although the literature suggests that these techniques can improve users' engagement and motivation, we also identified some negative effects that need to be considered during the tool's design [1].

5.2. Creating an enhanced user experience for the Learning Dashboard

Questionnaires and interviews from past semesters revealed that students were reluctant to use the LD regularly, citing time limitations and a lack of interest in incorporating "yet another tool" (see section 2). As a first attempt to explore new avenues to encourage using the LD, we developed a Chrome extension that integrates metric visualizations directly into Taiga, one of the tools used by student teams. This solution aimed to provide immediate access to essential metrics, eliminating the need for an additional platform and reducing the number of tools students must manage, thus addressing the concerns raised in the feedback. A screenshot of the Chrome extension integrating the visualization of the LD within Taiga is depicted in Figure 2.

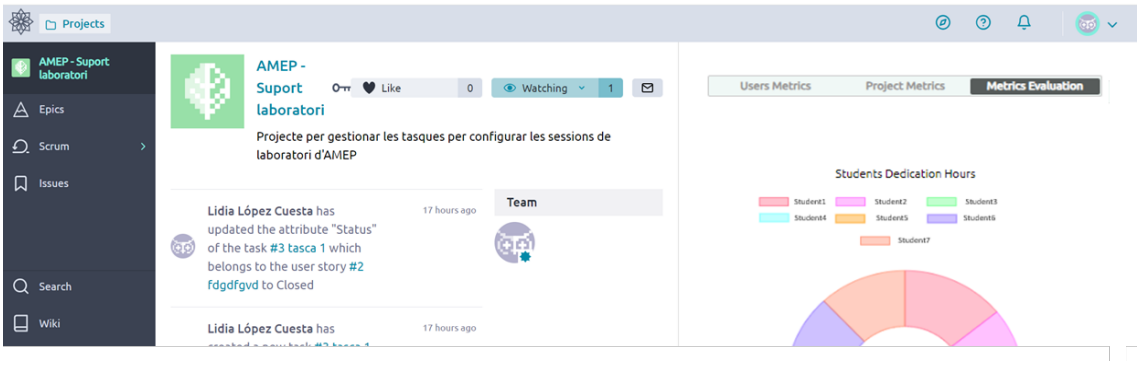

Figure 2: Screenshot of the Chrome extension of the Learning Dashboard.

5.3. Evaluation of the enhanced Learning Dashboard

In the Fall 2023 Semester, students from the subjects WAS and SEP started to use the Google Chrome extension following the same protocol as the one followed in previous semesters (see section 2): approximately half of the student teams were given access, and online questionnaires were handled to assess students' perceptions, supplemented by personal interviews.

These questionnaires incorporated questions to analyze the System Usability Scale (SUS), widely recognized as the most commonly used tool for assessing usability [6]. The SUS scores obtained in the WAS and SEP questionnaires have been 64.25 and 61.59, respectively. Considering that scores over 68 (0–100) would be considered above average, the results suggested that there was still room for improvement during the execution of the GLiDE project.

In addition to the questionnaires, personal interviews were conducted, selecting one team member as a representative. The feedback can be summarized as follows:

- Some students see a utility directed at them, especially to evaluate large projects and group performance, while others see a utility directed at facilitating teacher control.
- Generally, individual metrics (e.g., tasks completed by a developer) are more appreciated than project metrics (e.g., unassigned project tasks). However, there is no consensus among students on whether having a large number of metrics (some of them being considered insignificant) may become a problem.
- The user interface (GUI), user experience (UX), and usability are generally well-valued. Nevertheless, some problems were identified (e.g., the need to scroll down to see all metrics, the difficulty of understanding the meaning of some metrics), and some feature requests were gathered (e.g., the capability to visualize specific metrics directly using more advanced filters).
- Students find gamification a well-considered idea to encourage LD use, especially in each sprint. However, gamification must only apply to certain metrics. In general, students regard a relationship between their gamification winnings and their subject marks favorably.
- Inter-team gamification and knowing the status of the other groups can lead to healthy competitiveness. However, intra-team gamification can lead to counterproductive competitiveness inside the same team.

In addition to the previous results, it can be added to the conclusions that there has still been little use of the LD, generally due to overwork. When employed, its usage tends to be more for monitoring than supporting decision-making.

5.4. Gamification Framework

GLiDE will base its gamification proposal on the existing framework GOAL [3, 8]. GOAL defines an ontology with three central concepts (behaviors, achievements, and game rules) that will be used in GLiDE to articulate the gamification artifacts. Achievements are rewards given for exhibiting specific behaviors in accordance with game rules. GLiDE will reward students based on learning objectives and team practices. For example, medals and points could be used to encourage collaboration, leadership, and teamwork.

5.5. GLiDE Tool

Figure 3 depicts the architecture for the GLiDE tool, which comprises three main modules: Gamification Manager (blue components on the left of the figure), Integration Manager (red components on the right of the figure), and a central database (purple component in the middle).

The two user roles drive component differentiation: students and teachers will use the basic modules *Basic Gamification Manager* (BGM) and *Basic Interaction Manager* (BIM), but only teachers will have access to *Analytical Gamification Manager* (AGM) and *Advanced Interaction Manager* (AIM). The current implementation of the LD backend will remain a black box used by the new components through its REST API.

The implementation of the GLiDE tool is ongoing, with two MSc. students working full-time following the Scrum methodology and four three-week sprints. The first two sprints target basic components (BGM and BIM), while the third and fourth sprints target advanced components (AGM, AIM).

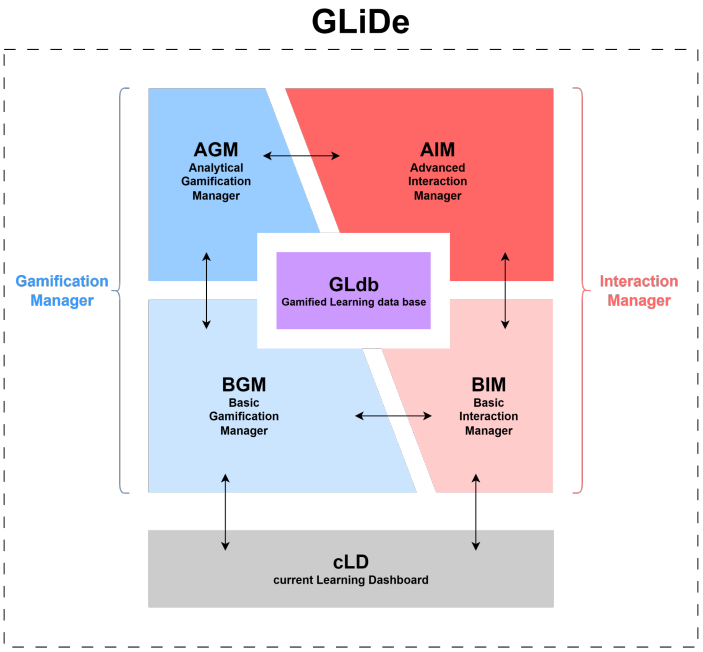

Figure 3: GLiDE architecture.

6. Open lines of research

As the GLiDE project advances to completion, several research challenges must be addressed, opening prospects for future work:

- **User Engagement and Interaction Analytics**: Comprehensive analysis of how students interact with the GLiDE tool, focusing on engagement metrics, usage patterns, and feedback to refine gamification strategies and dashboard functionalities.
- **Impact Assessment on Learning Outcomes**: Evaluating the effectiveness of the GLiDE tool in enhancing learning outcomes, particularly in following key software engineering practices, teamwork, and project management skills.
- **Dashboard Customization and Adaptivity**: Research into adaptive features of the dashboard that can tailor the learning experience to individual or team needs, including personalized challenges, feedback mechanisms, and learning paths.
- **Gamification Mechanics Optimization**: Investigating the optimal mix of gamification elements (e.g., points, badges, leaderboards) that maximizes motivation and engagement without overwhelming or distracting students from their learning objectives.

- **Scalability and Broader Applicability**: Assessing the scalability of the GLiDE approach to accommodate larger class sizes and its potential applicability to other team-based project settings like the onboarding of new employees.
- **Seamless Integration with Developer Tools**: Leveraging our experience with the Taiga plugin, we plan to explore avenues for integrating or ensuring the interoperability of the GLiDE tool with other developer tools such as Jira.

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References

[1] Almeida, C., Kalinowski, M., Uchôa, A., Feijó, B.: Negative effects of gamification in education software: Systematic mapping and practitioner perceptions. Inf. Softw. Technol. 156, 107142 (2023).
[2] Farré, C., Franch, X., Oriol, M., Volkova, A.: Supporting Students in Team-Based Software Development Projects: An Exploratory Study. In: RCIS 2023. pp. 568–576 (2023).
[3] García, F., Pedreira, O., Piattini, M., Cerdeira-Pena, A., Penabad, M.: A framework for gamification in software engineering. J. Syst. Softw. 132, 21-40 (2017).
[4] García-Mireles, G.A., Morales-Trujillo, M.E.: Gamification in Software Engineering: A Tertiary Study. In: Mejia, J., Muñoz, M., Rocha, Á., Calvo-Manzano, J.A. (eds.) CIMPS 2019. AISC, vol. 1071, pp. 116-128. Springer, Cham (2020).
[5] Iacob, C., Daily, S.: Exploring the Gap between the Student Expectations and the Reality of Teamwork in Undergraduate Software Engineering Group Projects. J. Syst. Softw. 157, 110393 (2019).
[6] Lewis, J.R.: The System Usability Scale: Past, Present, and Future. Int. J. Hum.–Comput. Interact. 34(7), 577-590 (2018).
[7] López, L., Martínez-Fernández, S., Gómez, C., Choraś, M., Kozik, R., Guzmán, L., Vollmer, A.M., Franch, X., Jedlitschka, A.: Q-rapids Tool Prototype: Supporting Decision-Makers in Managing Quality in Rapid Software Development. In: CAiSE-Forum 2018, pp. 200–208 (2018).
[8] Pedreira, O., García, F., Piattini, M., Cortiñas, A., Cerdeira-Pena, A.: An architecture for software engineering gamification. Tsinghua Sci. Technol. 25(6), 776-797 (2020).
[9] Raibulet, C., Fontana, F.: Collaborative and Teamwork Software Development in an Undergraduate Software Engineering Course. J. Syst. Softw. 144, 409-422 (2018).
[10] Universitat Politècnica de Catalunya: Resolution of the UPC's 2021 call for teaching innovation projects (2021). https://ice.upc.edu/ca/suport-a-la-docencia/convocatoria-millora-docent-UPC/resolucio-de-la-convocatoria_22jul2021.pdf

[11] Universitat Politècnica de Catalunya: Call for grants to carry out teaching improvement and innovation projects Galàxia Aprenentatge (2023). https://ice.upc.edu/ca/suport-a-la-docencia/ajuts-per-a-la-realitzacio-de-projectes-de-millora-i-innovacio-docent-galaxia-aprenentatge-2023
[12] Verbert, K., Govaerts, S., Duval, E., Santos, J.L., Assche, F.v., Parra, G., Klerkx, J.: Learning Dashboards: An Overview and Future Research Opportunities. Pers. Ubiquit. Comput. 18, 1499–1514 (2014).
[13] Volkova, A.: Specification and design of a dashboard for monitoring the learning process in software projects developed by teams of students. MSc Thesis, Universitat Politècnica de Catalunya (2022). https://upcommons.upc.edu/handle/2117/371383