

Designing a Gamification Analytics Module in the Context of Peer Assessment

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Abstract. The gamification analytics field is a part of the larger field of learning analytics. While learning analytics is a mature domain, with a lot of research in the last decades, the subfield of gamification analytics has been less investigated so far. Moreover, to the best of our knowledge, there are no studies that research the domain of gamification analytics applied in the context of peer assessment. Therefore, the current paper proposes a gamification analytics module dedicated for visualizing data collected from a gamified peer assessment platform. The module focuses on three distinct analytics dimensions: individual learner level, whole class level, and temporal level. Various graphic elements are featured, such as histograms, box plots, spline charts, pie charts, bar charts, and column charts, that facilitate the task of analyzing and visualizing the data.

Keywords: gamification analytics, learning analytics, peer assessment, educational platform.

1 Introduction

Gamification is defined as a design strategy where elements commonly met in games are employed in other contexts to induce experiences resembling the ones occurring in games [5]. Gamification has been adopted across a broad spectrum of environments, leading to an increase in the user engagement and satisfaction [8]. Its design requires continuous refinement due to different factors, such as: the intended goals are not currently achieved, the elements do not alter the student's behavior in the desired manner, or the engagement with some metrics declines - hence the gamification elements need to be adjusted [9].

Gamification is successful when the behavioral and psychological targets are accomplished [9]. Its outcomes are understood by collecting and analyzing usage data. The data is critical for providing insights and improving the process in several ways: oversee the user's behavior, assess the suitability of the gamification elements, or inform future design decisions. Learning analytics is the research domain that appraises, gathers, examines and reports data concerning learners and their settings with the intention of understanding and improving learning and the context where it happens [14]. In a similar manner, gamification analytics (GA) entails the data-driven approaches that support the monitoring and adaptation of gamification designs, with the purpose of attaining the gamification objectives. Several similarities between the two areas are mentioned in [6]: reliance upon learner data, generation of insights, and the goal of improving the educational results. However, most of the existing gamification platforms do not provide any analytics tools (i.e., visual components

such as detailed reports or comprehensive charts) for examining the resulting data. A systematic literature review on the monitoring stage of the gamification activity is available in [18], which was further extended by [7]. The reviews led to the identification of very few works that address the gamification monitoring stage, highlighting the limited research in the GA domain.

The combination between gamification and peer assessment can lead to several desirable outcomes for the learner, such as increasing their engagement [15]. Peer assessment is an educational approach that has been used for several decades to enhance the activity of both students and instructors. Some of its key strengths include: boosting higher order skills [17]; supporting students to assess their own learning [11]; or scaling assessment in courses with a high number of students enrolled, such as MOOCs [13].

A platform that incorporates both peer assessment and gamification is LearnEval, which has been applied with success for several years in educational contexts [1]. The system provides substantial support for both the instructor and the learner, integrating a wide range of modules and features. Apart from the tailorable peer assessment workflow, the instructor's activity is enhanced by other advanced functionalities, such as dynamic matching of the solutions to reviewers [2], or detailed scores and statistics [1]. The student's experience is also improved by gamification elements [3], or calibration options.

Our goal was to extend the LearnEval platform with a gamification analytics module that supports the visualization of gamification outcomes in the context of peer assessment. While previous research has explored gamification analytics in various settings, to the best of our knowledge, this is the first attempt to apply it specifically to peer assessment.

The next section synthesizes research in the area of gamification analytics. Subsequently, the gamification model featured by LearnEval is presented (section 3). Next, our gamification analytics module is introduced, and its main capabilities are depicted (section 4). Finally, the essential contributions are reviewed, and prospective research paths are envisioned (section 5).

2 Related Work

Existing literature offers limited research on learning analytics specifically designed for the gamification process. Here, we review some of the most relevant initiatives in this domain of gamification analytics.

The design, implementation, and evaluation of an interactive gamification analytics tool, developed as a Moodle plugin, is presented in [19]. The tool provides the instructor information on learners' engagement with the gamified environment, and integrates metrics on users' actions and statistics about game elements usage. The module is built upon existing gamification elements featured by the Level up! plugin and badge system: experience points, levels, and badges. Different gamification indicators are displayed for students and teachers. The student dashboard features gamification elements such as progress bars, badges, or leaderboard. The teacher section is extensive, providing information on a wide range of aspects, such as: the number of daily changes in the state of the gamification elements; experience points distribution; badges distribution; average number of days necessary to attain a level; number of times each gamification tab was accessed.

The conceptualization, implementation, and monitoring stages of gamification strategies are investigated in [4]. The proposed model supports strategy experts focus on the aspects relevant for the strategy success. The monitoring information offers real-time analytics to the designers and real-time feedback to the users of the gamified environments. The tool provides support to perform different tasks, such as: define

KPIs to assess the user behavior throughout the gamification experience, get an overview and particular statistics about the gamification components used, define conditions to automatically notify strategy experts about a shift in the value of a specific metric, or define ways to convey information to users about their performance throughout the gamified experience. The model was used to develop and monitor the gamification approach applied in an educational context supported by Moodle.

The integration of learning analytics in a gamified learning environment is summarized in [10]. The environment features a variety of elements, such as badges, experience points, virtual goods, or redeemable points. Learning analytics was used to facilitate students' comparative analysis of their performance relative to their peers, in addition to providing a visual representation of individual progress. It extended existing information with elements that focus on performance and progress. The gamification-related data is available on the student profile page. The page features different sections and elements: a progress bar that provides students the ability to assess their experience points in relation to the class average; a Challenges section that displays the eligible missions, along with the badges earned upon their completion; a leaderboard where the learners can view their rank, avatar, total experience points, or level; a Redeemable Points Transfer section where the learners see the received and donated points.

Another gamification system, called GamiTool, is presented in [12]. The system uses learning analytics indicators to provide rewards to learners when certain conditions are met. The goal of the platform is to enhance the student involvement with the tasks and learning content. The tool allows the design and representation of many learning analytics criteria that can be set up by the instructor as gamification triggers. Some examples of variables that can be tracked by the tool include: number of gained rewards, period to claim rewards, or leaderboard rank. The system can retrieve behavioral data from LMS, such as Moodle or Canvas, or from other tools, such as Google Spreadsheet.

Three dashboards that offer illustrations about learners' engagement with the learning resources and gamification elements are presented in [16]. Their data is retrieved from a real gamified learning system that features points, levels, and missions. The following visual representations are included in the gamification analytics dashboard: the total number of students enrolled in the course; the mean value of students' gamification points; the number of learners who reached proficiency in a topic; a timeline of the class progress, highlighting interactions with learning resources and indicating when the teacher introduced missions; the number of learners and their names by gamification level; the number and names of learners who successfully completed each mission assigned by the instructor.

To sum up, there are few gamification analytics tools that provide comprehensive statistics, reports, and insights into learner engagement with gamification elements. The literature highlights the need for additional such tools, particularly in the context of peer assessment, where no dedicated solutions currently exist. To address this gap, the present study proposes a visualization-based gamification analytics module designed to enable an in-depth exploration of the gamification process within peer assessment.

3 LearnEval Gamification Model

The proposed gamification analytics module is integrated as part of an extensive gamification model featured by LearnEval platform [3]. The model is intended to incentivize learners to carry out various kinds of peer assessment activities. It does this by employing popular gamification elements, such as badges, experience points,

levels, and leaderboards, as well as other elements, such as virtual identity, progress bars, increasing difficulty, timers, or notifications.

The model follows a circular workflow comprising the following stages:

- a) the student undertakes peer assessment-related activities
- b) the student wins badges upon accomplishing specific tasks
- c) each badge offers a reward consisting in a defined quantity of experience points (XP). Based on the XP, various levels of proficiency are attained: basic, intermediate, advanced, or expert
- d) XP allows students to reach a higher position in the leaderboard in comparison with peers that are less involved in the peer assessment process
- e) aspiring to a higher position encourages competition which can foster students to engage even more with the peer assessment, resulting in a self-reinforcing process.

The core elements of the model are badges, experience points, levels, and the leaderboard. The role of the badges is to encourage learners to perform desirable actions, such as deliver solutions, conduct reviews, perform back-reviews, or provide more thorough feedback. The learner earns a badge when achieving a specific milestone related to the peer assessment activity. The badges are organized in several categories, based on their focus: *number of reviews submitted*, *number of assignments completed*, *number of back-reviews performed quickly*, *special badges related to involvement*, and *special badges related to reviewing skills*. A complete list of the badges featured by the model is available in Table 1.

It should be noted that when creating an account, students can establish a virtual identity by selecting a nickname. This virtual identity, rather than their real name, is displayed on the leaderboard. However, students also have the option to conceal their virtual identity, in which case the leaderboard displays the message "*Hidden Nickname*" for the other learners. Nonetheless, instructors have full access to the gamification data associated with each student, along with additional information that supports the grading process.

Table 1. Badges featured by the gamification model integrated in LearnEval [3]

Category	Badges
<i>Number of reviews submitted</i>	1 / 5 / 10 / 15 / 20 / 25 / 25+ reviews submitted
<i>Number of assignments completed (i.e., solution submitted plus all the mandatory reviews performed)</i>	1 / 2 / 3 / 4 / 5 / 5+ assignments completed
<i>Number of back-reviews performed quickly (i.e., within 48 hours)</i>	2 / 4 / 6 / 8 / 10 / 10+ back reviews done quickly
<i>Special badges related to involvement</i>	1 solution submitted, All solutions submitted, Mandatory reviews done, All mandatory reviews done, Mandatory and extra reviews done, All reviews done
<i>Special badges related to reviewing skills</i>	> 1500 characters for a review, All reviews performed in a day, ReviewScore > 9.7 and > 6 reviews done

4 Gamification Analytics Module

According to the literature, there are two ways of designing a gamification analytics solution [4]: develop it as part of a gamified platform, or build it as a custom tool. Our approach belongs to the first category, being developed as a module integrated into the LearnEval platform.

The module features multiple visualization components (see Table 2), that can be classified into three dimensions: individual learner level, class as a whole level, and time-related level. Each dimension is presented in detail in the following three subsections respectively.

Table 2. Visualization components featured by the Gamification Analytics module in LearnEval

Visualization component	Description
<i>Earned badges chart</i>	The earned badges and the progress over time of the experience points and level for a selected learner are displayed using a spline chart.
<i>Experience points distribution chart</i>	The distribution of experience points is displayed using a histogram.
<i>Levels distribution chart</i>	The distribution of the levels reached by learners is displayed using a pie chart.
<i>Badges distribution chart</i>	The badges distribution as frequency with which each badge was earned is displayed using a bar chart.
<i>Time required to earn badge chart</i>	Temporal data regarding the timeframe required to obtain each type of badge is displayed using a box plot chart.
<i>Time required to reach level chart</i>	Temporal data regarding the timeframe required to reach each level is displayed using a box plot chart.
<i>Gamification module accesses chart</i>	The frequency with which students accessed the gamification module is displayed using a column chart.
<i>Leaderboard nickname display status chart</i>	The proportion of learners who opted to anonymize their identity with respect to their peers in the leaderboard is displayed using a pie chart.
<i>Leaderboard table</i>	The top-performing students are displayed on a leaderboard table.

4.1 Analytics about an individual learner

The earned badges and the accumulation of experience points over time for a particular learner are illustrated using a spline chart (Fig. 1). The *x-axis* depicts the moment when the badge was gained, while the *y-axis* depicts the amount of XP the student reached after gain. In addition, the threshold for each level (*Intermediate / Advanced / Expert*) is illustrated to readily identify the badges that allowed the learner to attain a specific level. On hover, the same information is available in a more concise format. This type of chart is accessible also to the learner, not just the instructor. Thus, the chart helps students track their progress, providing insights into learning achievements, encouraging continuous participation and improvement.

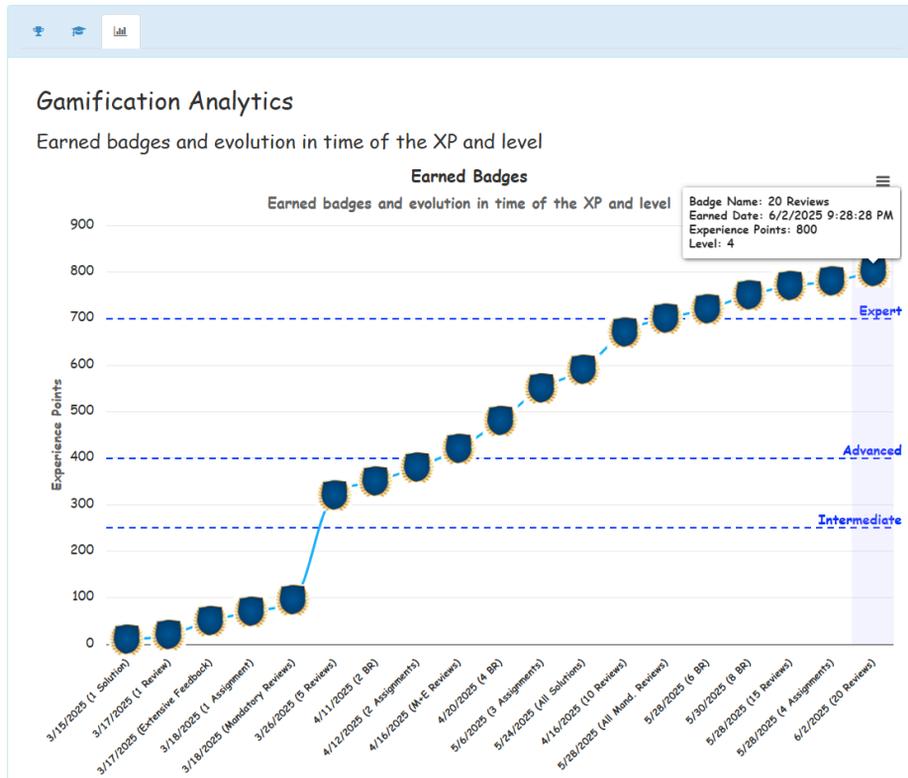


Fig. 1. Earned badges chart

4.2 Analytics about the class as a whole

The experience points distribution is displayed using a histogram (Fig. 2). The chart superposes two different aspects. The bins' heights represent the share of students within a specific XP interval, while the students' XP are depicted using dots. The chart helps the teacher analyze the distribution of experience points among students, identifying trends, disparities, and engagement levels. It enables informed decision-making to adjust learning activities, provide targeted support, and enhance student motivation.

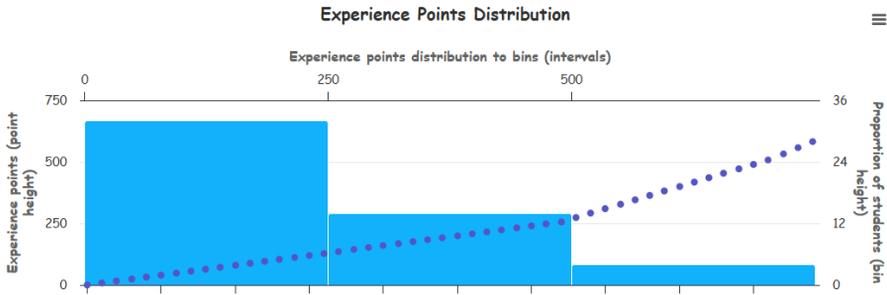


Fig. 2. Experience points distribution chart

The distribution of experience levels attained by learners is presented in a pie chart (Fig. 3). Each slice displays the level name and percentage of students, using a different coloring. On hover, the slice offers more detailed information, such as the total number of students and the absolute number of learners that reached the level. The chart allows the teacher to visualize the allocation of students across the experience levels, helping to identify progress patterns and disparities in achievement.

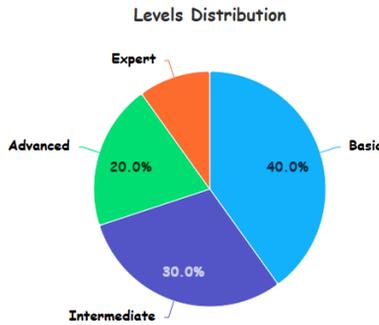


Fig. 3. Levels Distribution chart

The distribution of badges, expressed as frequency with which each badge is earned, is displayed in a bar chart (Fig. 4). The y-axis depicts the badge name, while the x-axis depicts the number of times it was gained. On hover, the bar provides more detailed information, such as the complete description of the badge. The chart helps the teacher analyze the frequency of badge attainment, identifying which achievements are common or rare among learners. It provides insights into engagement patterns, allowing for adjustments to specific peer assessment activities.

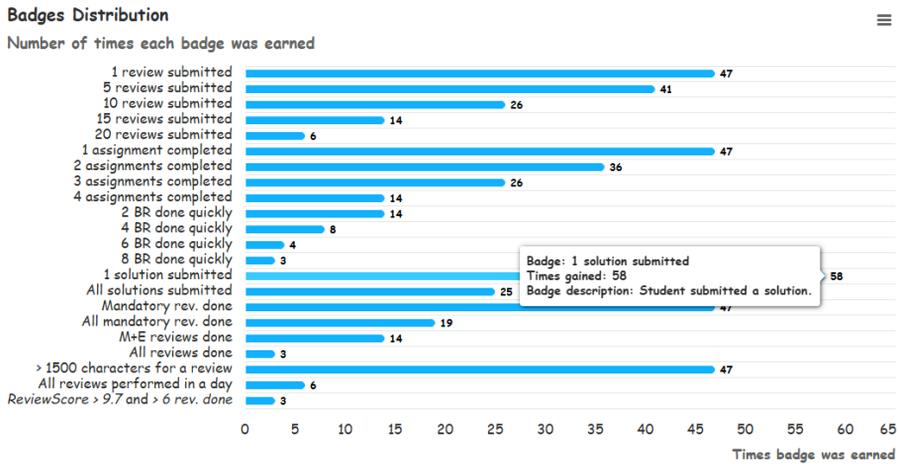


Fig. 4. Badges Distribution chart

The frequency with which students access the gamification module is displayed in a column chart (Fig. 5). Only the students with more than 5 accesses are shown to not clutter the chart with data. On the *x-axis* is displayed the student's name, while on the *y-axis* is displayed the number of gamification module accesses. The chart allows the teacher to monitor student engagement with the gamification module by tracking access frequency. It helps identify trends, assess the module's impact, and make informed adjustments to enhance participation and motivation.

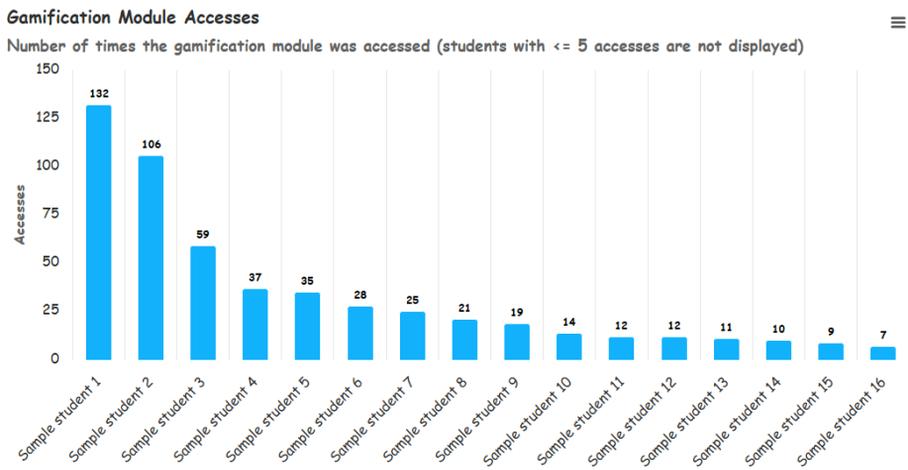
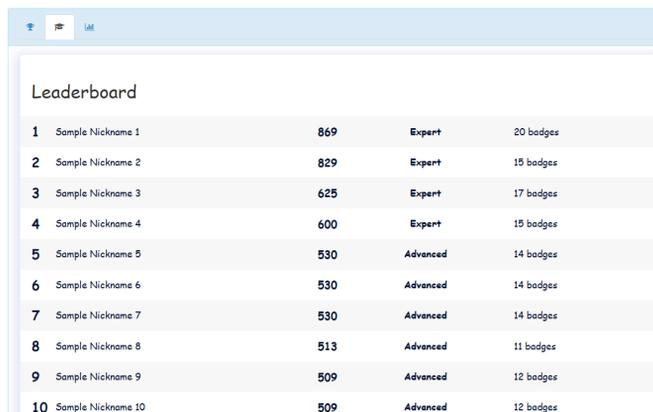


Fig. 5. Gamification Module Accesses chart

Student ranking is displayed in a leaderboard, which includes the total number of points, the experience level, as well as the number of badges obtained (Fig. 6). The leaderboard allows the teacher to quickly identify the high achievers and those needing support. It provides insights into engagement and progress, enabling data-driven interventions to enhance learning outcomes.



Rank	Nickname	Score	Level	Badges
1	Sample Nickname 1	869	Expert	20 badges
2	Sample Nickname 2	829	Expert	15 badges
3	Sample Nickname 3	625	Expert	17 badges
4	Sample Nickname 4	600	Expert	15 badges
5	Sample Nickname 5	530	Advanced	14 badges
6	Sample Nickname 6	530	Advanced	14 badges
7	Sample Nickname 7	530	Advanced	14 badges
8	Sample Nickname 8	513	Advanced	11 badges
9	Sample Nickname 9	509	Advanced	12 badges
10	Sample Nickname 10	509	Advanced	12 badges

Fig. 6. Leaderboard table

The proportion of learners who opt to anonymize their virtual identity with respect to their peers in the leaderboard is displayed in a pie chart (Fig. 7). This chart helps the teacher understand privacy concerns and social dynamics in the class and supports informed decisions on fostering a comfortable and inclusive learning environment.

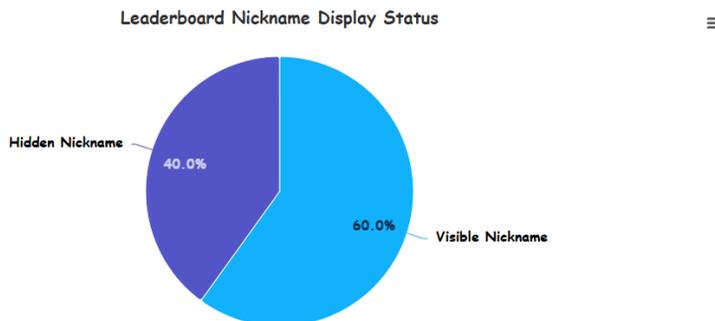


Fig. 7. Leaderboard Nickname Display Status chart

4.3 Time-related analytics

Temporal data regarding the timeframe required to obtain each type of badge is displayed using a box plot chart (Fig. 8). On the *y-axis* is displayed the badge name, while on the *x-axis* is displayed the number of days required. Each box plot depicts the median time required to earn the badge, the minimum and maximum period, as well as the first quartile and third quartile. On hover, the box plot shows the metrics as numeric values. The chart helps the teacher analyze the time students take to earn different badges, identifying trends in learning pace and engagement. It enables data-driven adjustments to badge criteria or support strategies to optimize student motivation and progress.

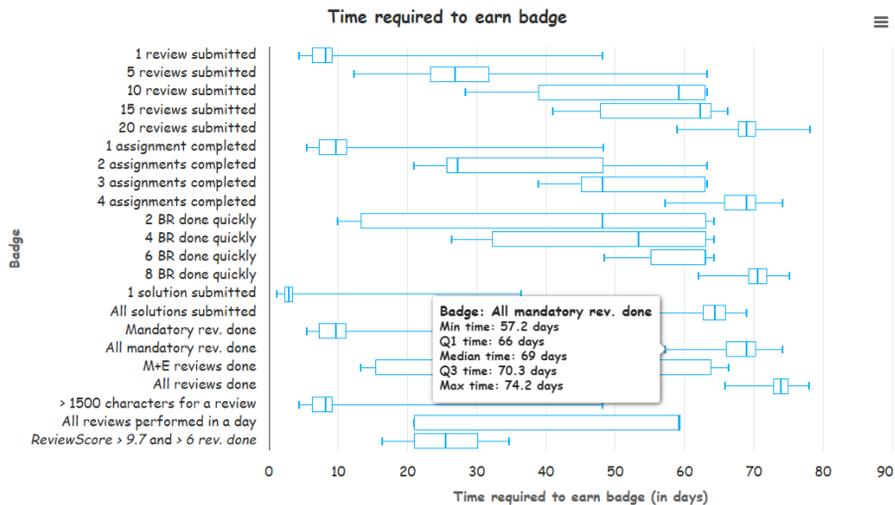


Fig. 8. Time required to earn badge chart

Similarly, temporal data regarding the timeframe required to reach each experience level is displayed using a box plot chart (Fig. 9). On the *x-axis* is displayed the level, while on the *y-axis* is displayed the time span in days required to reach that level. Each learner starts as a *Basic* user and can attain 3 other levels (*i.e. Intermediate, Advanced, and Expert*); thus, the chart displays 3 box plots. Each box plot depicts the median time required to reach the level, the minimum and maximum period, as well as the first quartile and third quartile. On hover, the box plot shows the metrics as numeric values. The chart helps the teacher analyze the time students take to reach different levels, highlighting variations in learning progress and engagement. It enables data-driven interventions to support struggling students and optimize the gamification design.

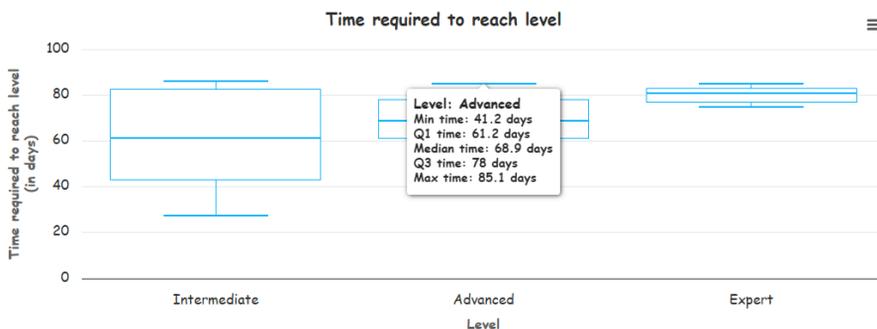


Fig. 9. Time required to reach level chart

5 Conclusions

The current paper proposes a learning analytics module for investigating the outcomes of the gamification process applied to a peer assessment activity. The module covers

three types of analytics: individual learner level, whole class level, and temporal level. It features a wide range of visualization elements that support the instructor in having a better understanding about the process: histograms, box plots, spline charts, pie charts, bar charts, or column charts. Thus, the module provides insights into student activity trends and participation levels, identifying patterns and disparities; this is the starting point for data-driven interventions aimed at refining the gamification design, providing targeted support and enhancing engagement. As such, the paper brings a significant contribution to the scarcely explored area of gamification analytics for peer assessment.

The GA module is currently being applied in real world settings, in the context of a computer science course at the University of Craiova. As future work, we will report on the empirical validation of the module and provide an in-depth analysis of the collected data. Moreover, the module could be further extended to include notifications for certain events of interest, adding complex filtering options, as well as integrating additional visualization components in order to enhance the learning analytics process.

CRedit author statement. **Gabriel Badea:** Conceptualization, Methodology, Software, Writing - Original Draft. **Elvira Popescu:** Conceptualization, Methodology, Writing - Review & Editing, Supervision.

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