Using Gamification to Orient and Motivate Students to Contribute to OSS projects

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***Abstract*—Students can benefit from contributing to Open Source Software (OSS), since they can enrich their portfolio and learn with real world projects. However, sometimes students are demotivated to contribute due to entrance barriers. On the other hand, gamification is widely used to engage and motivate people to accomplish tasks and improve their performance. The goal of this work is to analyze the use of gamification to orient and motivate undergraduate students to overcome onboarding barriers and engage to OSS projects. To achieve this goal, we implemented four gaming elements (Quests, Points, Ranking, and Levels) in GitLab and assessed the environment by means of a study conducted with 17 students, within a real OSS project (JabRef). At the end of the study, the students evaluated their experience through a questionnaire. We found that the Quest element helped to guide participants and keep them motivated and points helped by providing feedback on students' performed tasks. We conclude that the gamified environment oriented the students in an attempt to make a contribution and that gamification can motivate and orient newcomers' to engage to OSS projects.**

Keywords - newcomers; open source software; engagement; gamification; motivation; students

I. INTRODUCTION

The Open Source Software (OSS) model has become an important driving force in today's software development, resulting in many prominent projects that are used extensively through the entire development stack, from kernels to sophisticated end-user applications. Therefore, it is no surprise that the OSS movement attracts a large, globally distributed community of volunteers. In addition, the number of job vacancies valuing open source knowledge and experience has been rising on a regular basis [1]. This fact motivated students to contribute to OSS projects, and teachers to bring OSS practices and process to the classroom and foster students contributing to OSS projects [1–3].

Exposing students to OSS projects is beneficial both to OSS communities and students. From the perspective of the communities, more professionals will be in touch with OSS, ultimately leading to a higher number of contributions, since students are potential OSS contributors. They usually have the basic theoretical knowledge to contribute to a project, but lack practical skills and knowledge about the underlining technologies. From the perspective of the students, contributing is beneficial since working on OSS projects enables them to learn real-world skills, attitudes, and experiences [2], [3], which might increase their confidence when applying for industry jobs. One can claim that this is also beneficial since the future workforce of software developers is being prepared practicing in a real scenario.

However, it is already known that newcomers, including the students, face many barriers while attempting to contribute to OSS [4–6]. Some barriers they face include orientation issues that can potentially demotivate newcomers from placing their first contribution. Many recent studies had being conducted aiming to engage and motivate newcomers to OSS projects [4], [7–9].

Gamification, which consists on the application of game elements in non-gaming contexts [10], is calling attention recently since it has been successfully applied to motivate and engage contributors of online and collaborative communities and business [11], [12]. These gaming elements had been successfully applied to different domains, including Software Engineering [12–14] and learning [15], [16]. From the best of our knowledge, there are no initiatives or studies focusing on the use of gamification to engage and support students or newcomers to overcome barriers to join OSS projects.

Therefore, the goal of this work is to propose and analyze the use of gamification elements to motivate and support undergraduate students to overcome the orientation barriers to contribute to OSS projects. To achieve this goal, we have selected four game design elements to help students: Rankings, Quests, Points, and Levels [14], [16], [17]. For each of these elements, we defined a set of rules to describe the operation of the gamified environment and implemented them on GitLab[1]. To assess the environment, we conducted a study with 17 undergraduate students, who evaluated their experience by means of a questionnaire. This was a preliminary study towards a gamified environment that can be used to foster contributions from students, benefiting both projects and students. The contributions of this study include presenting a gamified version of GitLab; assessing the use of Rankings, Points, Quests, and Levels to motivate and support newcomers to contribute to OSS projects; and proving insights to community building teams on how to use gamification elements to guide newcomers.

[1] http://www.gitlab.com

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II. Related Work on Gamification and Software Engineering

Gamification is defined by Deterding et al. [10] as "the use of game design elements in non-game contexts." Gamification has being growing in the last years, presenting great impact in different areas [11], [18], [19] , mainly as a means of engaging and motivating people [11]. For example, StackOverflow and Wikipedia make use of badges and points that can be earned by the users when they perform some tasks.

In software engineering, gamification has become a topic of interest recently [20], and already was target of secondary studies [14], [16]. Singer and Schneider [25], for example, used newsfeeds and ranking to gamify a version control system to foster more commits from students. Similarly, Melo et al. [21] proposed the use of a newsfeed and ranking elements to encourage collaboration and commitment of developers. Lotufo et al. [22] investigated whether a gamified bug tracking system, based on reputation and rewards, would encourage teams to increase the frequency and the quality of their contributions. Also worth to mention, Snipes et al. [23] investigated the use of a gamified system to motivate developers to use more efficient development techniques, and Bacon et al. [24] investigated the adoption of scoring systems in the context of software development.

In addition, there are some studies that report experiences and analyze the use of gamification on Software Engineering Education. For example, Sheth et al. [12], [25] showed that by gamifying a software engineering course it is possible to increase student involvement on development, documentation, bug reporting, and testing activities. Thomas et al. [26] presented a gamification proposal focused on training people on defect tracking. Other examples of areas that have taken advantage of gamification to foster learning are agile processes [27], mutant testing [28], and design patterns [15].

From software engineering perspective, we see that the literature brings approaches to improve existing processes and motivate developers to produce more or better. From the academic perspective of software engineering, we see that gamification is mainly used with the purpose of improving teaching and learning. In contrast, in this paper we make use of gamification as a strategy to help students overcoming previously evidenced barriers faced to join OSS projects [5], [29], avoiding demotivation while they attempt to place their contribution. From the best of our knowledge, there is no initiative to gamify an OSS environment to engage students in OSS projects, without focusing on teaching and learning. Given the attention being given to OSS on the academic environment and the importance of OSS for the society, we claim that this work will add to the state-of-the-art by presenting a new way of engaging students in OSS.

III. Method

To achieve our goal of assessing the use of gamification elements to engage and support undergraduate students overcoming barriers to contribute to OSS projects, we followed the research method depicted in Figure 1 and its steps are explained in the following subsections.

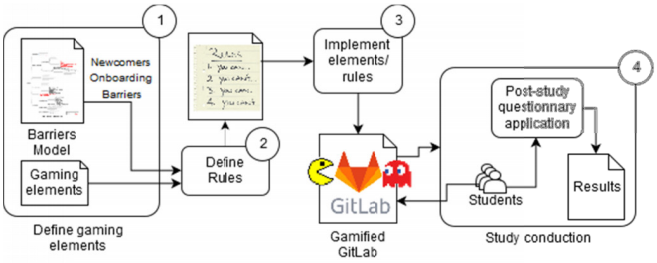

Figure 1. Overall method followed

A. Step 1: Defining the gaming elements

The first step is defining the game elements that would be suitable for supporting our goal. Based on the knowledge about the orientation barriers from our previous work [4], [5] and on studies on gamification applied to software engineering [14], [17] and to learning contexts [16], we selected the following four elements, since they are in line with our goals, and are the widely used: quests, levels, points, and ranking.

Quests are assignments or tasks with a clear and well-defined goal that needs to be performed. The rewards of accomplishing the tasks may be, for example, points, level change or external rewards [13]. The *level* element is very connected to the *quests*, since more challenging *quests* can be unlocked, enabling the users to acquire new skills. **In the context of this work, we want to assess how *Quests* motivate and support newcomers overcoming orientation barriers** [4]**.** Quests can be used as a step-by-step that users follow to achieve the goal of placing a contribution.

Levels groups different quests and tasks, enabling users to unlock specific and contextualized set of actions. Csikszentmihaly [30] describes the *flow theory* as a way to keep users in a set of challenges aligned to their skillset. If the level is too hard or too easy, the player can easily lose motivation and stop playing. **In our context, *Levels* were applied in conjunction to *Quests* to make students focus on a given step before moving ahead on the contribution process.**

Points is the most applied element as showed in previous work [13], [14], [16]. It provides feedback and shows progress to the users. Acquiring points means that the actions performed by the users are in accordance with what was expected. Point can be earned by means of different actions performed by the user. For example, in OSS, a user can earn points by having a *pull-request* accepted, helping other users, solving a *quest*, or working on a review suggested by a project member. **In this work, *Points* were chosen to keep users motivated and to support them overcoming orientation barriers, more specifically, providing feedback on their actions.**

Ranking enable users to follow their performance and compare to other players. It creates a sense of competition, in different levels (global, regional, per project, etc.). *Rankings* are usually closely related to ***Points***, and are presented as a sorted list, with the best players at the top. According to

Deterding et a . [10], ranking is a commonly used techni ue o gamify an environment. **In our context, the goal of us ng *Ranking* was to motivate the students, who can g ain prestige amor g the colleagu es.**

B. Step 2: Defining the rule

Rules, whe n combined, make up a set of provisions hat condition the execution of a game promoting challenges hat can be completed, but are not easy enough to demotivate the players. The ules adjust the complexity level of a ta sk, stimulating ar d keeping the players engaged. The ru les definition is related to the goal of the game and the ga me elements chos n. Figure 2 presents a graphical descriptio on how the rules a nd elements are interrelated.

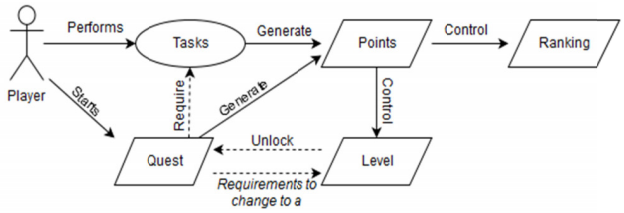

Figure 2. How game elements interact according to the rules

The first ac tion of a playe r is to perform a defined tas k in he system. Ea ch task, when completed, is rewarded wit n a given amount of *points*. To avoid repetition some actions are rewarded only once and some can only be performed a gi ven number of times (or have its reward reduced). The player can also choose to join a *quest*. A given set of *quests* is unloc ked according to the user *level*, and to advance to a given le vel one or more *quests* are required to be completed. The *qu sts* can comprise tasks, and, when completed, sum *points* to the user. *Points* are used to co ntrol the *ranking* of users. In addition, wher the player achieves an amc unt of *points* nd complete requ ired *quests*, they move to another *level*.

An initial s et of tasks, qu ests, and level s were define in accordance to the steps newcomers need to take in orde to place a contribution, learn project practices, and interact v ith he community . The tasks we re created to orient newcom rs, following the flow defined by Steinmacher et al. [5] at FLOSScoach portal. Some examples of tasks are preser ted n the following section.

C. Step 3: De igning and Im plementing the Gamified Environment

To apply the elements ar d their rules, we created a f ork of GitLab and implemented the necessary features. GitLa is an open source environment that provides Git reposit ory management, code reviews, issue tracking, activity fe eds, and wikis. Figure 3 brings an example of the gami ied environment. In the figure, it is possible to see on the dashboard the number of points and the le vel of a user 1). By clicking or the links, the user can see more details ab out he points earned and the level, respectiv ely. Also on the dashboard, the user has acces s to the Ranking and the Qu sts (2). In the exa mple, we pres ent the Quests GUI (3), wh ere he user can se e what can be done, what is blocked (and the level required to open them) and the number of points that can be earned by completing the task. When a user clicks in an unblocked quest, a full description of the *quest* and *tasks* that need to be accomplished are presented.

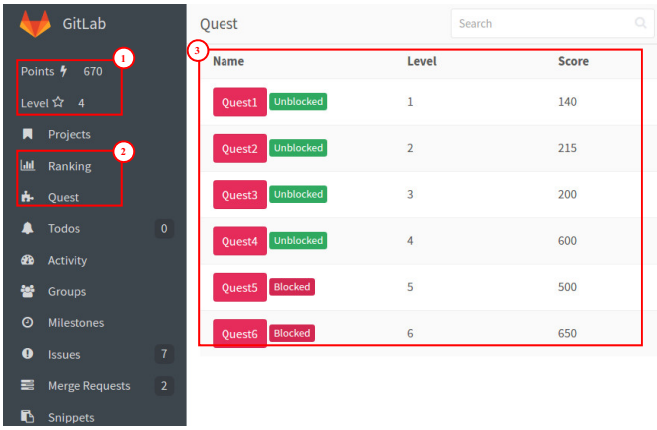

Figure 3. Quests screen of gamified GitLab

For example, for Quest 1, the user should accomplish three tasks:

1. Post something on the issue tracker (generally an introduction or a question)
2. Fork/Clone the repository
3. Setup the local workspace

To implement the rules on GitLab, we made use of already existing features: issue tracker, thumbs up (similar to the like button on Facebook), and tags. When performing a task, the player was required to tag the issue identifying that the post was related to a gamified task. For example, when players want to accomplish the task 2 of Quest 1, they need to create an issue fulfilling the requirements of the task and choose the tag "quest1_2" (representing the task 2 of quest 1). To approve or disapprove the task, a project owner or a player on a given level needs to approve it by means of liking the post (using the Thumbs up feature). An example of the usage of tags and thumbs up is presented on Figure 4.Figure 3.

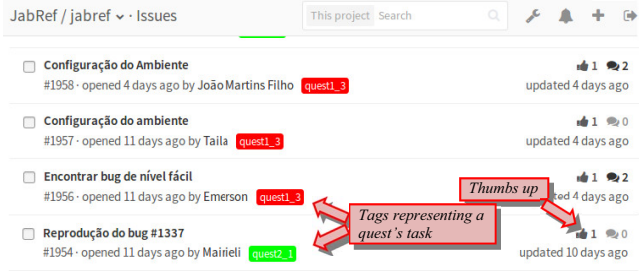

Figure 4. Example of issues usage to implement game rules

Examples of tasks and the way they were implemented are presented below:

- **Clarifying a doubt with the community** via issue tracker: to earn the points the player places a question and a project owner needs to approve the entry and

answer it. The way this approval is made in our environment is via thumbs up.

- **Cloning the repository**: the players need to provide evidence by posting a video or a set of screenshots that prove the completion, and a project owner (or a user on a higher level) needs to approve it using the thumbs up.
- **Setting up a local environment**: similar to clone the repository.
- **Finding a bug to work with**: by following some hints, the players can select a bug, and asking the community (via comment) whether they can work on the bug or not. An owner or a user on a higher level can answer and approve the assignment, and often provide support.
- **Reproducing a bug**: reproduce a bug locally, provide evidence of it in a comment to the bug, which needs to be validated by an owner or user at a given level.
- **Submitting a *pull-request***: submitting a pull-request related to a reported issue, independently of its acceptance.
- **Having a *pull-request* accepted**: after being accepted and merged, the player earns points.

D. Step 4: Study conduction

After implementing the rules on GitLab, we designed a study to assess how the element would motivate and support the students overcoming orientation barriers on their first steps towards contributing to an OSS project. Firstly, we chose a project: JabRef[2], an open source bibliography reference manager. JabRef is written in Java and is a consolidated OSS project. In addition, one of the authors is one of the project maintainers, which facilitated instrumenting it.

JabRef project was imported to a local private instance of GitLab, including all its versioning history and issues. The most recent issues were tagged according to their level of difficulty, until 50 easy tasks were tagged.

The study was conducted with students attending to the Open Source Development course, in the last year of Computer Science major at Federal University of Technology – Parana. In this course, students generally are requested to contribute to an OSS project as an assignment. In this instance of the course, the assignment was changed so they would contribute using the gamified environment during some time. Out of 18 students, 17 accepted to use the environment and consented to be part of the study. Students' ages varied from 20 to 25 years old, including 5 females and 12 males.

Before starting their assignment, a two-hour class was dedicated to explaining the environment, the rules of the game, and presenting JabRef. In addition, the students received a document presenting the rules and some guidance about the study. After that, the instructor handed-over the assignment, which basically consisted of attempting to contribute with code to JabRef in 20 days. It was not expected that the students succeeded by the end of the 20 days period. However, surprisingly, from the 17 students, 9 placed a contribution by the end of the assignment (53%), which is a good number, if compared to our previous experiences [5].

[2] http://www.jabref.org

At the end of the period of 20 days, the students were asked to answer a questionnaire composed of a set of 5 points Likert-scale items, and some open-ended question to enable students to share their feedback. The goal of the questionnaire was to assess to what extent each element and the gamified environment motivated and helped the students to overcome orientation barriers. A half-hour, informal debrief session was conducted to help us to understand some results.

IV. RESULTS

In this section, we bring the results of our study, relying mostly on the answers we obtained from the questionnaire administered after the assignment period. The questionnaire was organized in the following way: one section composed of Likert-scale items to assess how each games element motivated and supported newcomers' first steps; one section with four closed-ended questions enabling the students to grade and compare the elements as motivators and means to support newcomers; one last section with four Likert-scale questions to assess the future use of a gamified environment. To facilitate the understanding, we present the results reflecting the questionnaire structure.

A. Quests and Levels

The **quest** element was chosen to help creating a step-by-step process to guide newcomers, keeping them motivated and oriented. The **level** element is linked to the quests, and shares the goal of guiding newcomers. Therefore, the students answered these three 5-points Likert-scale (from Completely Disagree to Completely Agree) items:

Q1. The quests steps guided my contribution process;
Q2. Quests were useful to orient me to place my contribution;
Q3. The quest element kept me motivated to perform the proposed tasks and to contribute;
Q4. The possibility of unblocking new quests motivated me to change levels.

As it can be seen in Figure 5, Quests allied with Levels were viewed by the students as good motivators, since 12 students evaluated Q3 positively and 14 evaluated Q4 positively.

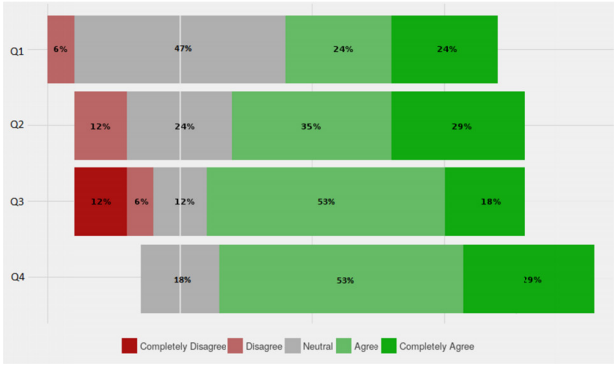

Figure 5. Results for Quests-related questions

In addition, most part of the newcomers found it useful to orient the contribution. However, regarding the use of quests as a guide, 9 people became neutral or disagreed. During an

informal debrief session after the study, we found that a possible explanation for the difference from Q2 answers to Q1 answers is that quests are good to orient the way that needs to be trodden, but, the obligation to fulfill all specific tasks within a quest bothered some participants.

In summary, our results indicate that **quests** and **levels** are good to motivate the students. **Quests** were also considered good to show the steps that need to be followed by the newcomers, however, adding more flexibility on how to perform the steps would be beneficial.

B. Points

The main goal of choosing **points** was to motivate the students and give them feedback about their actions. Therefore, the following items were administered:

Q1. Points element motivated me to keep contributing.
Q2. The more points I got, the more I was motivated to earn, so I could increase my Level and my Ranking.
Q3. Points were useful to provide me feedback on the tasks I performed.

As presented by Figure 6, the answers to items Q1 and Q2 are similar. They show a balance between positive and negative answers. The points themselves were considered motivator for approximately half of the students, but more than 30% disagreed with at least one sentence related to motivation. During the debrief session, it was possible to feel that there are other factors that influence students' answers. For example, the profile of the players, the public exposition, or the absence of a reward related to the points.

On the other hand, when we observe the results for Q3, we see no disagreement, indicating that Points were good on providing feedback on the tasks performed by the students.

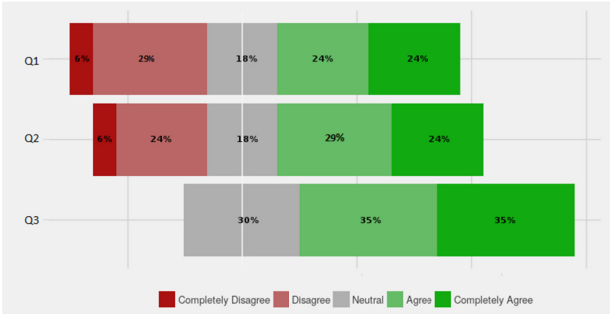

Figure 6. Results for Points-related questions

Therefore, our results indicate that **points** are good on providing feedback to the newcomers, and can motivate some players, but not others.

C. Ranking

Allied with points, the main goal of Ranking was to motivate the students. In this case, only two items were used to assess the element:

Q1. I wanted to perform more tasks and quests so I could improve my Ranking.
Q2. The Ranking motivated me because I could compare my performance with my colleagues.

As it is possible to notice in Figure 7, just over half of the students (9) agreed that the Ranking element was a motivational factor, while few others disagreed (4 on Q1 and 3 on Q2). The results are, somehow, aligned with the results obtained for the points, which makes sense, since points and ranking are expected to be complementary. Once again, there can be other factors that influenced these results. So, another study analyzing the profile, goals, and attitudes of the students along with the gamified environment, would provide us explanation on these results.

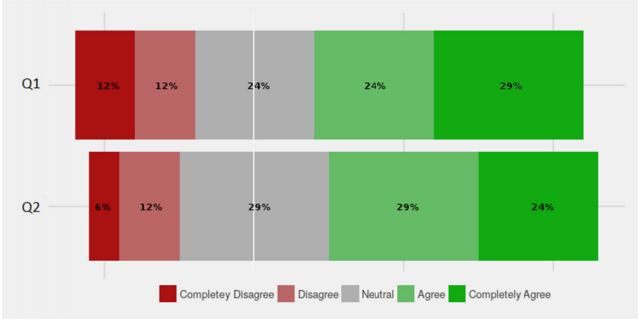

Figure 7. Results for Ranking-related questions

Our results indicated that **Ranking**, just like **Points**, can motivate some players, but not others.

D. Comparing the elements

On the second part of the questionnaire, the students were asked to grade the elements according to how much orientation the elements provide. They also had the opportunity to choose which elements motivated them and were useful on orienting the contribution process.

Figure 8 presents the distribution of the grades provided by the students when we asked *"Regarding the barriers related to newcomers' orientation, in a 10-point scale, how much have each element helped to mitigate/reduce these barriers?"*

As it is possible to observe, and in consonance with the results presented before, the *quests* played an important role on orienting the students towards their contribution. By looking at the raw data, we can see that seven people evaluated quests with an 8, three gave a 9, and one gave a 10.

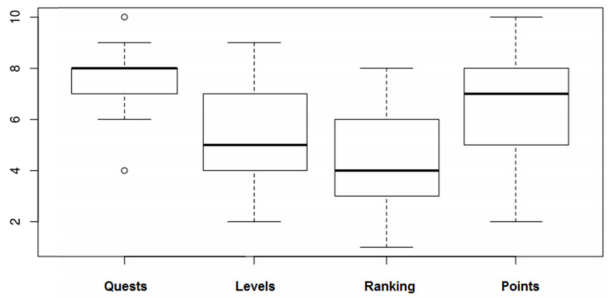

Figure 8. On a 10-points scale how much have each element helped to mitigate/reduce these barriers

Points were also well graded. More than a half of the students evaluated with 7 or a better grade (including two

10). The possible explanation relates to the results presented in Section IV.B, which shows that points are good on providing feedback to students.

Levels and *Ranking* had worse results, presenting most part of the grades equal or below 5. These results for the *Ranking* element are not surprising, since the goal of this element was not orienting, but motivating the players. However, we expected a better evaluation for *Levels* element, since it plays an orientation role along with the *Quests*. From the debrief, we understand that a possible explanation is that the students evaluated the level of information offered without considering it as a part of the flow that guided them from one quest to another.

As aforementioned, to cross-check our results, we asked the students to tell which elements were motivators and useful for orienting them. The results are presented in Table I. It is possible to notice that the results are, partially, aligned with previous results. *Points* and *Quests* played an important role on orientation, and, to some extent, motivated the students during their contributions. We also see that Ranking element was considered as a good motivator by 47% of the students.

It is also possible to observe in Table I that *Levels* were not considered important to provide orientation or to motivate students. Once again, this can be related to how students think of *levels*, as an independent element or something that works in conjunction with *quests.*

TABLE I. IMPORTANCE OF ELEMENTS WITH REGARD TO ORIENTATION AND MOTIVATION

	Quests	Levels	Points	Ranking	None
Which element(s) were useful to ***orient*** *your contribution?*	10 (59%)	4 (24%)	9 (53%)	3 (18%)	-
Which element(s) ***motivated*** *you to keep contributing?*	10 (59%)	2 (12%)	10 (59%)	8 (47%)	-
Which element you ***would not use*** *anymore?*	1 (6%)	5 (29%)	3 (18%)	7 (41%)	5 (29%)

E. Evaluating the environment

The last section of the questionnaire aimed to quickly evaluate the experience of the students with a gamified OSS environment. The students answered two Likert-scale items, provided with the following sentences:

Q1. I would use the gamified GitLab in the future.

Q2. The gamified GitLab supported me during the contribution process.

As it is possible to observe on Figure 9, 8 students (53%) agreed that they would use the gamified environment in the future, and three (13%) disagreed with the sentence. More interestingly, 14 students (82%) pointed that the gamified environment supported them during their contribution process.

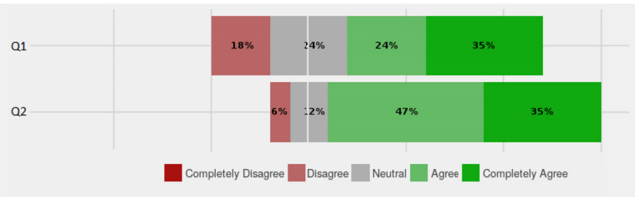

Figure 9. Results for the evaluation of the gamified GitLab as a motivator and a way to orient the students

V. CONCLUSION

In this paper, we presented a preliminary study on how a gamified environment can help orienting and engaging students to contribute to OSS projects. We specifically analyzed a subset of gaming elements and assessed their ability to motivate students to overcome orientation barriers inherent to place a first contribution to an OSS project.

By conducting this study with students, we could observe that using *quests* composed of objective and sequential tasks, were effective on mitigating/reducing the orientation related barriers and supporting newcomers' first steps. The structure of the *quests* provided a step-by-step towards the contribution. The use of *points* was also viewed as a good strategy to provide feedback to the students, and keeping them motivated to contribute.

In addition, we could observe that Quests, Points, and, to some extent, Ranking, can be used to motivate students to keep contributing to OSS projects. In this preliminary study, no external reward was provided to the students. A possible way to boost the motivation would be to reward the students using their points and/or ranking.

Unlike the other elements, according to the students, *Level* did not seem to keep students motivated, or to help them overcoming orientation barriers. However, students pointed that the possibility of unlocking new *quests* motivated them to change levels.

The results presented here, although preliminary, can potentially benefit OSS communities, who can make use of game design elements to support newcomers and help engaging and motivating their first steps. We highlight the quests as a good way to orient newcomers towards a first contribution and keep them motivated during this journey.

Although the results indicate that a gamified environment can support newcomers, we are not able to say whether this can foster more contributions or keep newcomers engaged. It is important to observe that our goal was to motivate students in an academic environment, to put them in touch with a real codebase and issues, and to contribute for the first time to an OSS project. This process is different from the process of keeping a community active or of retaining contributors. Further and long-term research would be necessary to investigate it, since it would be necessary to change communities' internal processes, which can lead to other types of problems.

In the future, we plan to further evaluate these elements in a longer study, focusing on analyzing behavior and assessing the use of external rewards. It is part of this project to use the gamified environment to host projects conducted by students and faculties of the university and create a program to reward top contributors and to validate contributions as credits for their courses. We plan to use this environment as a test bed for new elements and to evaluate engagement and retention of students.

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