

Gamification and Evaluation of the Use the Agile Tests in Software Quality Subjects: The Application of Case Studies

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Abstract: With the greater immersion of software development teams to agile methods and practices, it became necessary for students to have earlier contact with Agile Testing practices. Thus, this study aims to use the gamification concepts to stimulate the support to teach and engage the motivation of students in the Software Quality subject taught in postgraduate and undergraduate courses in computer science. For this, classes were set up to teach agile tests that used games elements as motivation for students. Therefore, this research resulted in an enrichment of the knowledge of these students in testing practices. This work aims to contribute to the teaching of agile test practices for students, aiming at a better preparation for the software development market. It was also verified that the use of gamification elements for the teaching of agile tests was efficient, because the participating students dedicated themselves more to the tasks and were participative in all the different types of classes.

1 INTRODUCTION

Software Testing is one of the main activities that are part of software quality assurance. Additionally, studies show the increasing adoption of agile methodologies in the software industry, where until the 2018 three out of four Information Technology companies in the world will be using the agile methodologies in their work, prioritizing the delivery of value, efficiency, security and assertiveness (Gartner, 2015). As one of the agile techniques, we have the Agile Tests, where, according to Nadalete and Kryszczun (2013), agile testing requires a strong adaptation in the routine and dynamics of the team in relation to the development process adopted.

However, the teaching of agile tests still has several limitations, since this topic requires that the student has a certain knowledge of programming and techniques of software quality, which may not happen the adequate absorption of these contents by the students when teaching is restricted to theoretical classes. Thus, the phenomenon of gamification (Werbach and Hunter, 2012), which consists in the use of the games elements outside their context, is used to mobilize the subjects to act, to help solve

problems and to promote learning (Kapp, 2012). Additionally, Kapp (2012) defends the proposal to use the games elements to involve the students to stimulate their learning. Perhaps one of the great advantages of using gamification in education is to provide a system in which students can visualize the effect of their actions and learning as the activity progress happens, making it easier to understand the relationship of the parts with the everything, as in games (Fardo, 2013).

In this context, we used a set of programming techniques adopted by agile development teams, such as DOJO (Luz and Neto, 2012) and LAB (Programming Laboratory), with the objective of providing a practical teaching of agile tests, giving a greater emphasis on practice of TDD (Test Driven Development). A technique developed by Beck (2010), which describes an evolutionary approach to development, where it must write a test before writing a sufficient production code to perform this test and perform its refactoring, thus doing that code is born tested. In parallel with these classes, students participated in a game, as in (Freitas et al., 2016), in which they got achievements in each of the classes.

Thus, the objective of this paper is to report and discuss the results obtained in the application of these techniques for the teaching of Agile Testing in

a Software Quality subject, which was taught in postgraduate and undergraduate courses in computer science. The study presented in this paper has the purpose of analyzing and discussing the results obtained by the classes with the teaching practices mentioned, considering the gamification as a motivating point. Thus, this research aims to contribute to the teaching of agile test practices for students, aiming at a better preparation for the software development market, and to discuss how the elements of gamification can contribute as a motivating teaching technique and trying to show that the gamification is much more than a set of points, medals and progress bars, as well as criticized (Chou, 2015).

One of the reasons for the concern with the teaching of Agile Testing with a focus on the practice of TDD is that in the research conducted by Elgrably and Oliveira (2017), it was verified that the TDD practice is one of the main agile test techniques used in the software development of Brazilian industry and most of the MPT-Br (Brazilian Test Improvement Model) consultants find it difficult to implement the technique, where one of the main reasons is the little or no prior knowledge of the technique by the developers.

2 RELATED WORKS

In order to identify works that propose the use of gamification as support to teaching, not necessarily to the teaching of Agile Tests, a search was made in the specialized literature with emphasis on published papers. No work found focuses on the teaching of Agile Testing, using gamification as a motivation to aid teaching. This already underscores the importance of this study, demonstrating the relevance and originality of the case studies carried out.

There are studies that propose the use of gamification as teaching support, without the use of software or applications, only the elements of gamification to support students. Thus, authors of the (Freitas et al., 2016) work created a gamified environment for the subject of Fundamentals of Computer Architecture. The central element of the game was the duel of knowledge among students enrolled in the subject, either individually or in a group, where the purpose of the game is to accumulate points that were the final mark of the student in the subject. The work described in this paper has the differential of application of techniques used by agile development teams, such as

DOJO and Programming Laboratory; to be more real challenges for students, because it motivates them to learn in depth techniques to be able to meet challenges of programming that were developed.

Finally, in the work of Matsubara and Silva (2017), the authors present a process of gamified experience with volunteers in a laboratory, aiming the teaching of the subject of Software Engineering, in order to know if “the elements of games and the game design enhances learning in a Software Engineering subject?”. In this work, the game elements are well defined using elements such as: points, levels, challenges, and feedback, among others. The work being presented in this paper has the differential of having been carried out the Case Study in a Software Quality subject, so different from volunteers the competitive aspect was more impacting, as the result of the Case Study reflected directly in grades of the students in the subject, and later the Case Study was replicated making changes that were collected through interviews in class with students at the end of the case study, enabling an improvement in the learning process and in the structure of the gamification.

3 THE SOFTWARE QUALITY SUBJECT

The Software Quality subject, which used in the Case Study described in this paper, is offered every semester to regular and special postgraduate (master and doctoral courses) and undergraduate students in Computer Science. It is a subject considered as optional for the training of these students in the Software Engineering research area. Currently, the course is taught by a professor with a broad academic experience (with a master's, doctoral and postdoctoral degree in Software Quality, having graduated more than 40 master's and doctoral students in this research area) and professional (being certified in MPS.BR, CMMI, CERTICS, MEDE-PROS – Software Product Quality Assessment Method). All students of this professor act actively in the administration of this subject based on monitoring and practices. The discipline discusses aspects related to Software Engineering and its subareas and its content is made through expository classes, debates, exercises and elaboration of practical works accompanied by the responsible professor and his monitors.

4 THE GAME OF AGILE TESTING

The Software Quality subject was the context of the case study that will be presented and had the following Research Question (QP): *Does the use of gamification aid the engagement of the class and increases the learning about the topic of Agile Tests in the Software Engineering area?*

In order to answer this QP, a gamified classroom was created for this case study, which has the following elements: physical space (classroom); players (students); judges (monitors and professor); the applied teaching methodology and rules of the game; and other gamification elements that were used, detailed in the next subsection.

4.1 The Methodology of the Case Study

The stages of accomplishment of the case study are represented in Figure 1.

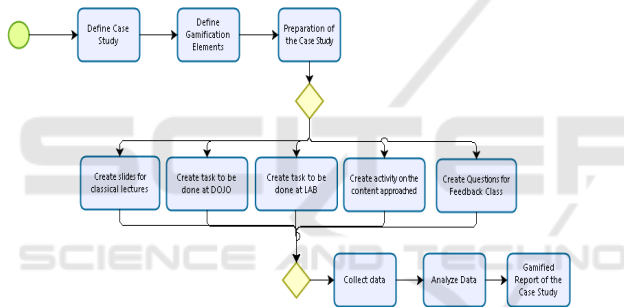


Figure 1: Stages of Realization of the Case Study.

The case study was carried out twice, the first in a postgraduate class, divided in 6 days of classes, being: 2 days of classic lectures with the Software Testing theme, as well as their history, types of Software Tests, Software Testing in traditional and agile contexts, and especially the agile practice of TDD and the "Agile Testing Quadrant" created by Marick (2003) and modified by Gregory and Crispin (2014); in the third class students participated in a DOJO of the Randori type; in the fourth class there was a LAB practice with pairing; and in the sixth class all students in the Case Study participated in a feedback class on the practices used for teaching and if the gamification met the expectations of the QP. The second case study was carried out in an undergraduate class and the feedback that was collected in the first case study was taken into account, so there was an addition of one more class.

In both case studies, at the beginning of the first day of class, the students were informed that they would be participating in a gamified classroom on Agile Testing, and a spreadsheet with a gamification was presented, an instrument responsible for punctuating all the practices that the students would exercise in the subject, such as: Daily Penalties, which could be Fouls without Warning, Fouls with Warning, Delays and Penalties (use cellphone, disrupt class, use of laptop, etc.); Daily Bonuses, which could be the presence of the students, an initiative to question something about what was being taught, suggestions for possible improvements of the classes and participation, which would be any other question about the classes that generated a discussion in the class; General Bonus of Case Study, are unique bonuses that were worth more points for students.

These punctuation generated the gamification score, in which the result of the first case study for the postgraduate students had that the student with the highest grade received a prize, and also generated part of the grade of the students in the Software Quality subject, using the following formula: $LAB * 0.04 + EvaluativeActivity * 0.04 + Participations * 0.2$. It is worth emphasizing that for the participations were added all the Daily Bonus, and the students who obtained more than 10 participations would receive the maximum score, otherwise they would have the participation number multiplied by 0.2. In the second case study, the formula was slightly updated in order to increase the students' competitiveness and performance: $LAB * 0.04 + EvaluativeActivity * 0.04 + Participations * 0.032$ (Number obtained through a rule of 3 with the highest grade of participation in the case study). It is worth emphasizing that the student with the most participation points in the gamification level scored the grade of the group above in Participations, which were 62 points of participation.

4.2 The Game

The main element of the game is the competition between the students, in which the knowledge on the subject of Agile Testing was verified.

At the beginning of each class was presented the previous result of the competition, showing the points and the current Ranking of gamification, this was done with the intention of promoting a fierce competition among students, as in the (Hanus and Fox, 2015) work. All the activities of the game, when performed successfully, gave points. In Table 1 we can identify which elements of gamification

were used in each class and also the forms that the students were able to score in each of them.

Table 1: Relationship between Class Types and Gamification Elements and Points.

Class Types	Gamification Elements	Grades on the Spreadsheets
Classical Expository Class	Points, Ranking, Narrative	Presence, Participations and Suggestions
DOJO Class	Points, Ranking, List of Challenges, Learning Curve and Activities in Teams	Presence, Participations, Suggestions, Initiative and Participation in DOJO
LAB Class	Points, Ranking, List of Challenges, Learning Curve, Monitoring	Presence, Participations, Suggestions, Initiative, Participation in LAB, Concluding of LAB and Mini Game (LAB)
Evaluative Class	Points, Ranking, List of Challenges	Presence and Grade in the Test
Feedback Class	Points, Ranking, Winning Prizes	Presence and Participation

In the first class was made the narrative of the importance of the students' participation in the case study, how the gamified classroom would work and the punctuations. It was reported that there were two judges (monitors) who were responsible for punctuating the students' participation and at the end of each class they would discuss the results that had been obtained. From the beginning it was encouraged that the students did not miss and participate as actively as possible in the classes, since their attendance and participation would generate points for gamification.

In the classical expository classes the topics covered in the Case Study were presented to the students, an introduction to Software Testing was done, later presented the main techniques and tools used in the Agile Testing quadrant, with a greater emphasis on TDD. In these classes the students scored with their presence, active participation with questions and discussions, making suggestions of new topics that could be approached and improvements that could be made in the material used.

In the third class there was a greater focus on the agile practice of TDD, presenting a kind of class of DOJO of the Randori type, in which a list of challenges related to code construction and testing. In Table 2 it is possible to visualize the functionalities and the test cases of this challenge.

In the beginning of the challenge one of the monitors performed the first functionality and the first test case with the support of the students participating in the case study. Afterwards, the

students stayed in pairs, one pilot and the other co-pilot, to finish the list of challenges and the other students were as audience, being able to analyse what was being done by the pair and discuss the decisions, and to build strategies for when their respective times of action in the challenge. Each student had a time of 5 minutes in each function.

Table 2: Functionalities and Test Cases of DOJO Challenge.

Functionalities	Test Cases
It must make a Deposit	Making a Deposit
It must consult the Balance	Making a Bank Draft
It must make a Bank Draft	Duplicating a value of a deposit
Is must add up to Investment	Cashing out if value is less than what is available
It must validate if a Bank Draft is valid	Invalidating the Bank Draft greater than available

In the fourth class of the second Case Study the focus was on unit testing. The students performed this mini-game in the format of LAB, thus formed pairs for one of the activities, in which the students made a list of challenges, with the possibility of adding more test cases to increase their scores. In this challenge the system codes were delivered to the pairs and they had to build five test cases at least as seen in Table 3.

Table 3: Test Cases of LAB Challenge.

Store System Challenge	
Test Cases	testingProductsValues; testingProductsAmmount; testingAddProducts; testingSearchProducts; testingRemoveProducts

In the fourth class (fifth class in the second case study) the focus continued to be the use of TDD and the students are in pairs to perform one of the activities with greater grade of the case study, the LAB. In this activity the students performed a list of challenges, with the possibility of adding more test cases to increase their scores. Table 4 shows the list of challenges.

In this challenge, the monitors observed the performance of the students and evaluated the following criteria for the grade: if the activity was completed; if the cycle of TDD was used by the students; and whether the refactoring was used in the development of functionalities; in addition to completing the gamification with suggestions given by the students about the LAB activity, evaluating the initiative of each one in the activity to perform functionalities and test cases more than what was requested in the challenge.

Table 4: Functionalities and Test Cases of LAB Challenge.

Challenge 1	
Functionalities	Writing Sum Function Refactoring Sum Function (If necessary)
Test Cases	summingTwoPositiveNumbers summingPositiveNumberWithNegative summingDecimalNumbers summingTwoZeroNumbers
Challenge 2	
Functionalities	Writing Subtraction, Multiplication and Division Functions Refactoring the Created Functions (If necessary) Treating Division by Zero
Test Cases	Performing tests that validate its operation (Operation with two positive numbers, positive number with negative, decimal numbers and operations with two zero numbers)
Challenge 3	
Test Cases	Making a test function with an assertion, with the result of the expression (using the classes already created): $((30 + 10) - 10) * 2$

In the fifth class (sixth class in the second case study), the results of the lessons learned were evaluated, where an evaluation activity was carried out with 9 objective questions and 1 discursive on the topic of Agile Tests. This activity had greater grade in the final score of the gamification, and from it would be possible to analyze the students' learning through the teaching practices that were chosen.

Finally, the sixth class (seventh class in the second Case Study) was used to receive feedback from students about what they found of the use of gamification and the types of class adopted for the case study, analyzing their interest in gamification, agile testing, TDD, etc. In this class the students earned punctuation with their presence and from the following scale of participation: Little participation, Regular Participation, Good Participation and Excellent Participation.

5 THE EVALUATION OF THE USE OF AGILE TESTING AND THE STUDENTS MOTIVATION

In order to evaluate the learning, the results of the LAB and the evaluation activity were used. Table 5 shows the LAB result from the first Case Study and Table 6 from the second Case Study. In these tables the ST acronym represents the Student.

Table 5: Results of the LAB II Challenge of the First Case Study.

	Challenge 1				Challenge 2				Challenge 3				TO TAL
	AC	FT	UR	ND	AC	FT	UR	ND	AC	FT	UR	ND	
ST 1	1	1	1	10	0	1	1	7	0	0	0	0	60
ST 2	1	1	1	10	1	1	1	10	1	1	1	10	100
ST 3	1	1	1	10	0	1	1	7	0	0	0	0	60
ST 4	1	1	1	10	1	1	1	10	1	1	1	10	100
ST 5	1	1	1	10	0	0	0	0	0	0	0	0	40
ST 6	1	1	1	10	1	1	1	10	1	1	1	10	100
ST 7	1	1	1	10	0	0	0	0	0	0	0	0	40
ST 8	1	1	1	10	1	1	1	10	1	1	1	5	90
ST 9	1	1	1	10	1	1	1	10	1	1	1	10	100
ST 10	1	1	1	10	1	1	1	8	0	0	0	0	66
ST 11	1	1	1	10	1	1	1	10	1	1	1	5	90
ST 12	1	1	1	10	1	1	1	8	0	0	0	0	66
ST 13	0	0	0	0	0	0	0	0	0	0	0	0	0
ST 14	1	1	1	10	1	1	1	10	1	1	1	10	100

The result obtained in the LAB activity had criteria for the total grade of the students, where from the three challenges the student needed: to complete the activity (AC); to use the TDD flow to perform each activity (FT); to use the code class or the test class refactoring (UR). If the student completed the criteria in the activity, he / she would receive a flag of 1, otherwise a flag of 0. In the end, one of the monitors would correct the code and give a grade between 0 and 10 points, of the Challenge Grade (ND). The formula of the total calculation for each challenge was: $AC * 4 + FT * 3 + UR * 3 + ND * 2$, which totalled 30 points per challenge, and all participants were rewarded with 10 points for participating in the LAB. In the first case study it was evaluated that the 3 challenges would each be worth 30 points plus the bonus, worth 10 points, totalling the final value of the LAB challenge in 100 points. In the second case study it was continued that each of the 3 challenges would be worth 30 points each, but the bonus was changed so that the Tests and the extra methods performed by the students' pairs had a value of 0 to 10 points, as can be seen in Table 6: Daily Bonus in Participations Class (PA5). This was done with the intention of stimulating the competitiveness and trying to extract the maximum of the effort of the pairs in the activity.

Table 6: Results of the LAB II Challenge of the Second Case Study.

	Challenge 1				Challenge 2				Challenge 3				PA 5	TO TA L
	AC	FT	UR	ND	AC	FT	UR	ND	AC	FT	UR	ND		
ST1	1	1	1	9	1	1	1	9	1	1	1	10	6	92
ST2	1	1	1	10	1	1	1	10	1	1	1	10	8	98
ST3	1	1	1	10	1	1	1	8	1	1	1	10	5	91
ST4	1	0	0	10	0	0	1	7	0	0	0	0	0	41
ST5	1	1	1	9	1	1	1	9	1	1	1	10	6	92
ST6	1	1	1	10	1	1	1	9	1	1	1	10	2	90
ST7	1	1	1	10	1	1	1	10	0	0	0	0	0	60
ST8	1	1	1	10	1	1	1	10	1	1	1	10	8	98
ST9	1	1	1	10	1	1	1	10	1	1	1	10	8	98
ST10	1	1	1	10	1	1	1	9	1	1	1	10	2	90
ST11	1	1	1	10	1	1	1	10	0	0	0	0	0	60
ST12	1	0	0	10	0	0	1	7	0	0	0	0	0	41
ST13	1	1	1	10	1	1	1	10	1	1	1	10	8	98
ST14	1	1	1	10	1	1	1	9	0	0	0	0	0	58
ST15	1	0	1	10	1	0	1	10	1	1	1	10	10	94
ST16	1	1	1	10	1	1	1	9	0	0	0	0	0	58
ST17	1	0	1	10	1	0	1	10	1	1	1	10	10	94
ST18	1	0	0	10	0	0	1	7	0	0	0	0	0	41
ST19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ST20	1	1	1	10	1	1	1	8	1	1	1	10	5	91

The students' results in the LAB class in the first case study were considered satisfactory, with a mean of 7.7 as a grade, with the exclusion of the missing student. The possible causes cited by the students as determining factors for the successful execution of this challenge were highlighted in the feedback class, such as: the use of pairing in the activity; and in the pre-LAB class a DOJO of the Randori type was performed. Student 13 missed the LAB activity; soon he received the grade 0.

The students' results in the LAB class in the second case study were considered very satisfactory, because even with the stimulus of competitiveness in which only one pair obtained the 10 points in Participations in the class, the general average of the students was of 7.8, the student 19 missed. The possible causes cited by the students as determining factors for the successful execution of this challenge

were highlighted in the feedback class, such as: the use of pairing in the activity; in the pre-LAB class a DOJO of the Randori type was performed; and the use of a non-evaluative LAB that enabled a first experience with the practice. The student 19 missed the LAB activity; soon he received the grade 0 in this practice.

The other activity used for performance evaluation was a traditional evaluative activity (Test). The students also had results considered very satisfactory. The spreadsheet used in the first case study, containing the results that were obtained in addition to several observations, is available at: <https://drive.google.com/file/d/0B1VyGWbovbpVckItbm1JbW h0c3c>. Still on the result obtained in the traditional evaluative activity of the first case study, a peculiar case happened with the Student 6, who obtained a maximum score in the LAB class, having the largest number of participations in the case study, but obtained one of the lowest grades in the evaluation activity and in the feedback class. The student when asked about the evaluation method of a traditional test stated that he always had a great difficulty concentrating and excessive nervousness when he participated in activities of this nature. Most of the students present agreed that evidence in the traditional model could cause a considerable amount of stress for everyone.

The spreadsheet that was used in the second case study is available at <https://drive.google.com/open?id=0B1VyGWbovbpVSVpwUXItVnNwZjA>. In this second case study there was another peculiar occurrence, where the Student 3 obtained excellent grades in Evaluative LAB, 91, and evaluative activity, 9, but it was verified that he had some difficulties of expressing himself and of speaking. Thus, in the extra participations of the gamification he only punctuated in extra activities of codes without at any moment having interacted with the class. However, his results and learning was great and raised a question for the authors of this paper that will be taken into account in future case studies: can gamification be used with any type of student and situation? Or how to adapt the gamification so that it is not punitive to some student who has some difficulty or special need?

On students' motivation in the context of the case study, regarding the use of gamification as a motivating tool was unanimity among the students present in the feedback class, evaluating the use of gamification as positive.

5.1 Comparison between the Results Obtained

The quantitative data that were collected for the analysis of these Case Studies are allocated in the spreadsheets of each respective case study, while the qualitative data were collected by audio and analysed by the authors of the paper.

5.1.1 Quantitative Results

Some of the feedbacks collected served as a way to improve the gamification, aiming to improve the students' achievement in the subject. This resulted in a good increase in student participation in the second case study, as can be seen in the graph of Figure 2, which shows the sum of all the Daily Bonuses obtained by the students in the case study, divided by the number of students and number of classes.

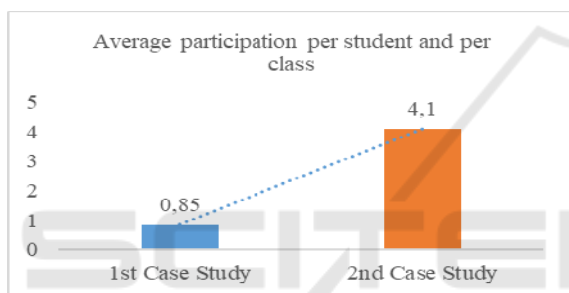


Figure 2: Comparison the participations between the case studies.

It is apparent that the stimulation of the visualization the gamification results and its competitive made that the students' grades were levelled in the gamification in the second case study by the student with greater participation in the classroom, causing an exponential increase in the participation of the students. However, as the highest student levelled the grade in the classroom and this

student was very participative, this made the grades of many students fall, as can be seen in the Figure 3.

As can be ascertained, using the levelling factor, where there was a student with a total of 62 participations in the game, and taking into consideration that the average participation of the class was 31 participations, excluding the student 19 who only participated in the last day of the Case Study, it can be concluded that most of the students lost a grade compared to the average parameter that was used as the levelling factor of the first case study.

Analysing a comparison of concepts between the classes, it was noticed that when we increased the difficulty of gamification, imposing a levelling by the greater participation, this portrayed directly in the concepts of the students.

There was a greater balance in the concepts in the first case study, even comparing that on average the grade of the evaluative LAB in the first Case Study had a mean achievement of 77.8% versus 78.1% of the second Case Study. In the issue of the test grade, the first case study group was 7.2 versus 7.0 of the second case study, disregarding the student who missed the activity. Therefore, the main factor of difference of the concepts comes from the choice of levelling of gamification.

Only one student achieved the concept of excellent in the second Case Study, and considerably increased the difficulty of the students who participated in this model with levelling by the participant with more points in the gamification.

5.1.2 Qualitative Results

The qualitative results were collected from interviews in the feedback class with all the students and the review of the quality of the codes obtained during the Case Studies.

As in (Matsubara and Silva, 2017) work, there were a lot of positive effects observed by students.

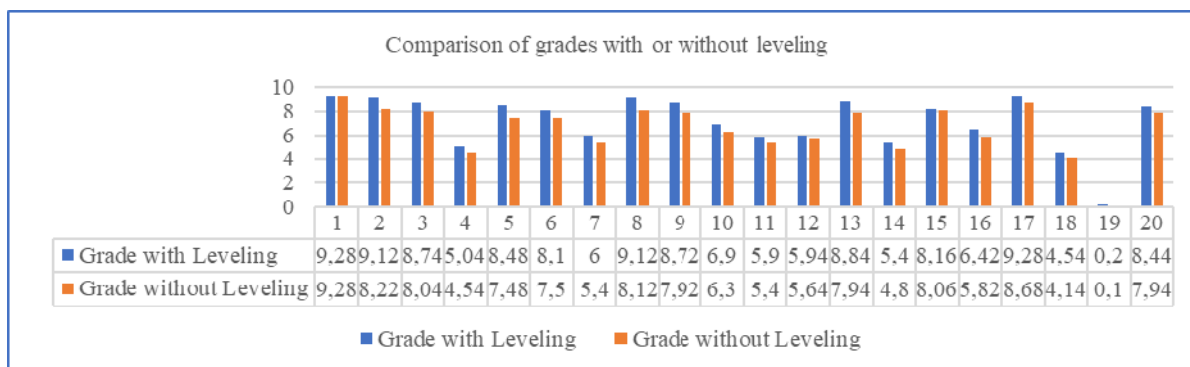


Figure 3: Comparison the grades between the case studies.

The most cited changes were: the support in the study process; the greater stimulus for the study of the subject; the better reception of students in doing practical activities with techniques from Software Engineering that have been adapted to become gamification challenges. Other positive points were: the greater interactivity of the class, which improved communication among students; the greater objectivity of the subject to come with a greater focus on practical teachings, rather than theoretical classes; the participation of motivated students in motivating the other students; and the environment being more open to questions, bringing more dynamism to the subject. Another point highlighted by the students was that the use of penalties for use of mobile devices during the classes, causing the students to pay more attention during the class, thus participating and learning better the subject content.

Some of the difficulties highlighted by the students were little practical knowledge of the Java programming language, but they said that this fact was not a great impediment and generated a lot of learning in the language. Another negative point for students that happened potentially in the first Case Study was the poor understanding of how gamification worked and how they should score.

6 CONCLUSIONS

This paper presented the results of a case study that allowed improving the teaching of Agile Testing in. The results obtained with the spreadsheet and feedback from the participants make possible the response of the QP that was presented, where the use of gamification as a tool to support teaching contributes positively to learning.

As future work, some improvement points are possible in the game environment such as: implementing a tool that supports learning using the gamification concepts and serious games and can return instant feedback to students; using a digital coin that can be computed both in activities in the tool and in activities outside it; creation of medals for challenges and milestones to motivate student participation; adapting the gamification to students' cases who have some difficulty in communication and learning, so as not to exclude them from the game; performing an analysis between how to level the gamification grade for an upcoming Case Study; adding to the case study the use of pre and post questionnaires, seeking to know the previous knowledge of students in Agile Testing and TDD.

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