

A Systematic Strategy to Teaching of Exploratory Testing using Gamification

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Abstract: The Exploratory Testing (ET) is a growing approach in the industrial scenario, mainly in reason of the emerging utilization of agile practices in the software development process to satisfy the time to market. However, it is a subject little discussed in the academic context, for this reason, this work aims to use elements of gamification as a systematic strategy in the teaching of ET to keep a strong engagement of the students and stimulate a good performance, with that, obtaining as results, trained students to use this test approach in the industrial and academic context.

1 INTRODUCTION

Software testing is an essential activity for software quality assurance, which the tester can use various methods or techniques to find defects. Among the existing methods in the literature, the present work focuses on the exploratory testing (ET), which Cem Kaner conceptualized, in 1983, as a manual test approach that emphasizes the freedom and responsibility of the testator to explore the system (Kaner, 2008). In addition, Cem Kaner, James Bach and Swebok also define as an approach that treats the planning, testing design, execution, and interpretation of results as support activities performed in parallel during the testing process, thus allowing the tester acquire knowledge of the program while performing the tests, since the test cases are not established in a pre-defined test plan (Pfahl, 2014).

The points cited above are able to provide flexibility and quick feedback in test results, however, because of the need to make this approach more structured and systematic, and also the lack of sufficient documentation to support the management of test process, is that test management techniques have emerged to supply these needs (Itkonen and Mantila, 2013). These management techniques also make it easier to inspect test coverage, tracking, measure, and manage tests (Bach, 2004).

Thus, observed that the Session-Based Test Management (SBTM) technique has been widely used and more widespread among others techniques,

according to the results of the systematic literature mapping (SLM) about the ET efficiency and effectiveness. With this, the present work integrated the SBTM in the applications or in the teaching of ET.

Therefore, it is noticeable the need to research the subject of ET, as well as, the exploration techniques and the specific management techniques of this approach, in order to improve the understanding of where, when and how this can be applied during the system life cycle. In this way, it is pointed out that with traditional teaching students may do not absorb so much details with only theories and some basic exercises, thus impairing learning and future performance in the professional life, in these circumstances the strategy of teaching with gamification is fundamental to improve the students' performance. For Werbach and Hunter (2012) gamification is the use of game elements outside their context, that is used to mobilize individuals to act, help, solve problems, interact and promote learning.

One of the greatest benefits of gamification in education is to provide a systematic structure, which students can visualize the effects their actions, performance in learning and how this happens progressively, becoming a facilitator in the relationship between the parties involved in teaching, immersed as in a game (Fardo, 2013).

In this context, the present work aims to apply a systemic strategy to teaching of ET using game elements, where the use of SBMT also collaborates to systematize the practical application of this test

approach. The application of ET in this present work focuses on the achievement of functional testing, specifically, on the online test and simulation system - SAW (Alcantara, 2018). The achievement of functional testing becomes quite adequate in the application of ET, because according to the SLM performed previously, it was evidenced that the ET allows finding, mainly, the defects of graphical user interface (GUI) and usability.

2 RELATED WORKS

Initially, a research was carried out in the specialized literature, in relation to published articles, to identify the papers that present a similar proposal to this present study. The research focused on work using the gamification approach as supporting teaching and learning of ET, however, no work was found, so the related work described in this section covers teaching of testing in general. This highlights the importance, relevance and originality of this study.

Herbert (2016) presents four standards to the teaching of testing for non-software developers. These standards were extracted from the experiments in the testing course for graduate students of the Federal University of Health Sciences of Porto Alegre (UFCSPA), in this context, the functional testing approach and risk-based strategy were the most feasible to apply, given that individuals had extensive knowledge of the domain and context of the system under test (SUT). However, the author does not report details about the approach used in teaching (resources, lesson content, tools and etc.), in addition, the standards emphasize more the description of concepts and good testing practices.

Benitti (2015) presents an evaluation of learning objects to the teaching of software testing, using an instructional design matrix for the analysis and design stage, and Wilcoxon for statistical analysis. These objects compose a systematic structure of contents essential for the teaching of testing, being identified from documentary research in the menu of several Brazilian undergraduate courses and IEEE, MPS.BR and others standards. Although the author posteriorly built a tool to aid in the teaching of testing following the systematic structure, the applied approach did not involve the participation of a specialist to help in clarifying doubts, and this can negatively affect the student performance, since the specialist has an important role contributing his/her knowledge and technical experience on the subject in question and so on.

In the work of Valle et al. (2015) a SLM was

conducted to identify the approaches that aid in teaching of testing. The results indicate that there are more occurrences of research on teaching of testing with programming and use of educational games, focusing mainly on the phase of test case design. The author also identifies the highest occurrence of the empirical evaluation for analysis of research results; however, it is not shown how this approach has been. In addition, few studies were observed, and most of them presented partial results.

The work of Ribeiro and Paiva (2015) presents an educational game for software testing learning. The iLearTest is destined, specifically, for the assistance of professionals who aim to obtain ISTQB certification; however, all content is addressed only to the foundation level based on the syllabus (study material produced by ISTQB).

As it can be observed, no paper presented treats the practice of the teaching of testing using any strategies with gamification elements for exploratory testing. Although Benitti (2015) present a tool to provide a learning more interactive, and Ribeiro and Paiva (2015) present an educational game destined to testing learning in a playful way and also from Valle et al. (2015) show that educational games are highly observed in research, is still noticeable the need for a systematic strategy to provide greater student engagement. In this context, the present work differs by presents a systematic strategy with the use of several playful elements in the form of facilitating, improving engagement, minimizing differences between students and, above all, boosting the teaching on ET in the academic context.

3 THE GAME APPROACH

Considering the ET approach, the present work uses gamification elements, following the theme of treasure hunting because this having similar ideas, for example, exploring some areas by creating strategies and solving puzzle to uncovering treasure (bugs) hidden or lost.

The experiment should be applied as part of the Software Quality course in the postgraduate in Computer Science of the Federal University of Pará, Brazil. This course is offered every semester for postgraduate students, who they can be enrolled as regular (engage in postgraduate from the selection process) or special (they have not yet engaged in the master's degree). Currently the course is taught by a teacher with great academic and professional experience in the field of software engineering, because of this, many students who participate has a

lot of interest in software engineering subjects.

3.1 The Methodology of the Experiment

In the gamification planning, the games elements were defined based on octalysis gamification framework created by Chou (2015). In figure 1 the core driver can be observed in the inner part of the octagon and the corresponding elements involved in the external part, which are referenced by the blue margin. The blue margin is proportional to the amount of elements used of the core driver in question.

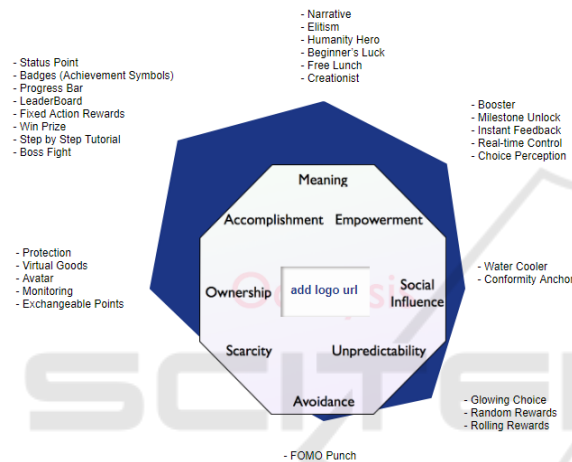


Figure 1: Mapping of the game elements.

The experiment will be run twice in different classes, and the feedback obtained the first time should be analysed and used to improve the next run. Figure 2 shows the activities performed from the idealization of research and planning to evaluation.

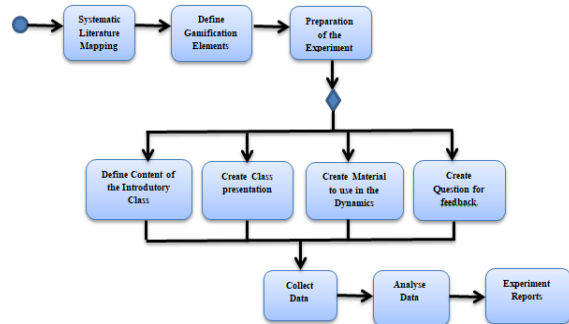


Figure 2: Methodology of the experiment.

3.2 Game Mechanics

According to Zicbermann and Cunningham (2011) the act of playing a game involves a set of functional elements that makes it possible to guide the actions of the player, which these elements are the basis of game design, in this sense this is understood as the game mechanics. Some of the elements considered primary that can be combined according to the specificity of gamification are: rewards, points, distinctive, levels, leader board.

In this way, below are the basic elements involved in this dynamics. Emphasize that most element names and stages of dynamics make analogies to pirate items:

- Profile:** The three profiles involved in gamification are: a) Expert: it is the driver of the gamification, is the one who solve the doubts and analyses the reports; b) Tester: they are students, posteriorly also is considered the team, since from the stage of "commands to treasure hunting" should be formed teams composed of two students; c) Judge: it is the one who must observe if the students are performing the activities to fill the scoring table according to the items under analysis.
- Activities:** They are specific actions existing in the stages which the student should perform.
- Scoring:** They are rewards attributed to the activities, where the team can get depending on their performance.
- Medals:** They are rewards that the student must receive proportional to the points obtained in the stages.
- Gifts:** They are rewards specifically for the personal benefit of the team, such as books, sweets, etc. and is not offered any advantage in the dynamics. The gifts are utilized to stimulate the idea of team superiority.
- Bitskull:** They are the coins that students must earn by achieving a maximum score in each stage and must use it to purchase resources.
- Cards:** The cards can be of three types, which are destined to equip the avatar; gives access to resources that aid in the detection of defects; or receive an unknown reward.

The advantages offered by the first kind of cards are: a) Self-defence card: provide a resource (shield, helmet, etc.) to defend against possible attacks by enemies; b) Attack card: provide an armament to attack the enemies; c) Accessory cards: provide an accessory for avatar customization.

The advantages of the second kind of cards are: consulting a system requirement, consulting a part of the system tutorial, consulting the description of an

exploration technique, or being able to receive a tip from the specialist about a defect in the program which must be registered in the defects catalogue.

The third kind of cards can offer any advantage described in the first type of cards, in addition can to offer a certain quantity of *bitskull* or a gift to the team, however to obtain one of these advantages will depend on the resolution of a puzzle. It should be noted that the resource cards can penalize, which is the case of subtracting team points. The penalty order from highest to lowest in the subtraction of points is: receive tips, refer to the user manual, consult a requirement and refer to the description of an exploit technique.

- **Defects Catalogue:** This is a document of specialist consultation that containing several defects that have been intentionally inserted into the program under test. The registered information about the defects are: unique identifier, description, route to find it and priority level.

- **Bonus:** It is a score attributed specifically to the participatory actions, which are composed by the evaluative items. There are items that increase the score and items that decrease the points. Thus are actions that earn points: presence, participation, question, suggestion and teamwork; while the actions that lost points are: lack, does not perform the activity and disrupts the activity.

The following is a description and justification of the items evaluated as participatory actions refers to the bonus points that can be received or lost:

- **Presence:** The student must be present time on from beginning to end of the activity. This item is important to understand the dynamics, and consequently being able to participate in the dynamics, as well as, stimulating a good relationship between the participants.

- **Participation:** The student should participate by interacting with the specialist or with the classmates to be commenting, answering questions. This item is important because it indicates that the students are attentive in the dynamics and seeking to engage in activities.

- **Suggestion:** The student should suggest something that contributes to gamification. This item indicates that the student is seeking to contribute to the subject in question.

- **Question:** The student should ask questions or look for more details about the subject, approaches, rules and other factors of the dynamics. This item is important because it characterizes that the student is taking an interest in the dynamics and seeks the total understanding to be participating or acting correctly according to dynamics flow.

- **Teamwork:** It is the responsibility of the judge and the specialist to observe if students on the same team are interacting and cooperating with each other. This item characterizes student engagement, seeking to exchange knowledge.

- **Missing:** It is the absence of the student in the activities, so the team loses points if it is not present;

- **Does Not Carry out the Activity:** The non-performance of the activities assumes the student's lack of interest in the dynamics, so the team loses points if they do not perform the activity, even if they are present in the classroom.

- **Disrupts the Activity:** The team loses points if it damages the performance of the activities and performance of other teams, because it assumes that the student is inattentive in the activity.

- **Level:** There are four levels that the student can achieve, and this is based on the type of avatar.

Below are the rules for classifying what level of avatar the student should reach:

- **Avatar Activity:** The student must perform the activities that are specific to each stage and according to the score obtained reaches an avatar level. If in certain activities the student reaches the maximum score, then he should receive medals and *bitskull* as a reward.

- **Participatory Action Avatar:** The student should always be present and participate in class. Thus, the student must achieve an avatar level that is related to the performance their participatory actions. If the student achieves the maximum score, soon receives medals and *bitskull*.

- **Final Avatar:** From the definition of the avatar of activity and participatory action, the final avatar of the stage in question is generated. The generation of the level achieved in the final avatar depends on the amount of medals you have gained. The final avatar has a weight grade, which is proportional to the level reached and this weight note is used to generate the general avatar;

- **General Avatar:** The general avatar is calculated at the end of the dynamics (beginning of the "Reward Pirate Captain" stage), from the arithmetic mean of the weight grade of the final avatars obtained. The general avatar indicates the average performance of the student.

The classification of the activity avatar and participatory action should occur at all stages, except in the "Help" stage because it is a non-mandatory stage that provides to the student help. Regarding the levels, the student can reach any of the existing 4, which are described below. As already mentioned that gamification refers to the game of treasure

hunting, so the avatar profiles refers to the movie Pirates of the Caribbean.

- **Level 1:** It is the lowest level called Marty because he is like a boarder who is present, but remains quiet, not wanting to get involved with the activities, besides not having special abilities. The weight grade for this level is 1;
- **Level 2:** It is an intermediate level called Will Turner II because he represents a navigation master who has ability to teamwork, has skills, however, is still irresponsible or cannot making good decision. The weight grade of this level is 2.
- **Level 3:** It is an intermediate level called Joshamee Gibbs by the fact of representing a battle officer who manages to make good decisions, exercises leadership, and works well with his team, always interacting with responsibility. The weight grade of this level is 3.
- **Level 4:** This is the last level named Jack Sparrow by the fact of always to exercise the leading role, acting strategically, being able to work very well as a team and always showing interest in the dynamics. The weight grade of this level is 4.

The Figure 3 shows the complete flow of the gamification, where it begins with the "Pirate Training" and ends with the "Reward Pirate Captain", where the students must reach the level of pirate captain to have the opportunity to find the treasure. In this flow, it is important to observe that before entering the awards stage of the winners, three iterations should occur in the cycle that starts in the "Treasure Hunt" stage, following until "Buy resources".

The flow has a chronological order as follows (see Figure 3).

- **Pirate Training:** The students should participate during 4 hours of introductory classes, divided into two days, on the concepts of testing (see Table 1). Before starting the classes, the students must complete the initial form about the subject and at the end of the classes they are submitted to an evaluation of all the content presented, this is intended to provide data to the specialist to identify the degree of knowledge of these students before and after classes.

During the classes three fixation exercises are applied for the purpose of improving understanding. Thus, the specific activities of this stage are: completion of the initial form, resolution of the exercises and a final test. In order to stimulate the good performance the student must receive medals and *bitskull*, in case of reaching the maximum score in the exercises and in the test, however the student is penalized if he does not fill out the form.

Table 1: Contents of the introductory class based on IEEE standards.

Tips	Content
Software Testing Foundation	Terminology, Relation with other areas, key question
Test Level	Where apply it, Goal
Test Techniques	Structural vs Functional, Expertise Based Test, Requirement Based Test, Risk Based Test, Usability Testing, etc.
Metrics Regard to Testing	SUT Evaluation, Testing Evaluation
Testing Process	Question regard to management, Activities

- **Commands for Treasure Hunting:** In approximately 15 minutes the specialist must present the purpose and rules of the dynamics, as well as briefly narrate a story about the lost treasure for students feel immersed in the pirates' world. In addition, the specialist should inform the pre-defined teams and provide all the materials needed to initiate the dynamics of treasure hunting. The materials are: Leader board, letters, program under test, installation tutorial and etc. The pre-defined teams also have a name that refers them to a pirate that existed in the past and known in history.

The teams are predefined based on the data analysis of the activities in the introductory classes, and thus to form balanced teams, that is, to join two students where one has presented a higher level of knowledge than the other. At this stage it is only observed the participatory actions, because it only requires the concentration and attention in the explanation of the specialist.

- **Outfit the Pirate:** The students must complete two basic activities in approximately 10 minutes, which are: a) Set up the test environment: install the program under test strictly following the installation tutorial; b) Customize avatar: request twice the accessory cards, however the team has one more opportunity to choose if it obtains 10 or more medals. The benefit of the third opportunity is to stimulate student participation in the previous stages, since anyone who obtains the avatar with more accessories at the end of the game should receive a gift. In this context, the specific activity of this stage that must be observed is the fulfilment of the steps established in the installation tutorial, as well as, to analyse the participatory actions.
- **Treasure Hunt:** The students should focus on exploring of the program, in order to find the maximum of defects within the time of 30 minutes.

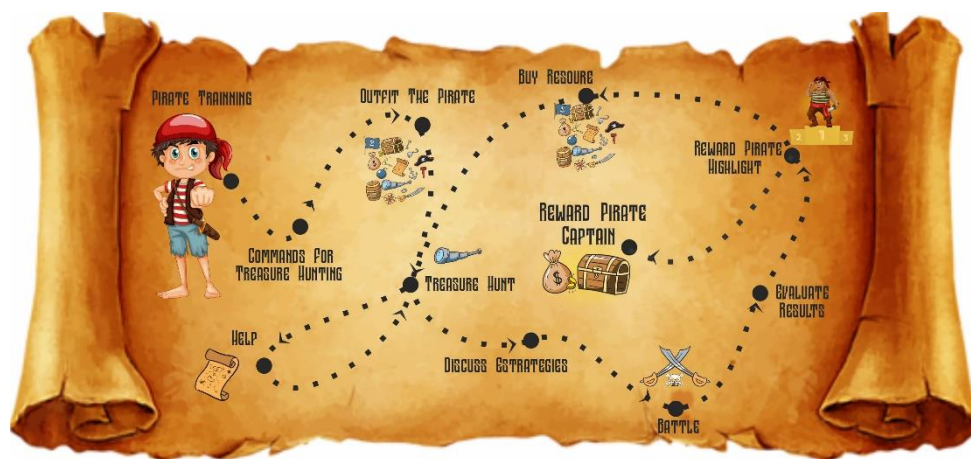


Figure 3: Gamification flow.

This time reserved to this stage is based on kind of test session specific of the SBTM technique, called “short”. During the exploration it is possible to opt for the purchase of aid of some resource cards, to facilitate the detection of defects. The team may request only three times, however, from the second time, the value of the card is doubled. It is emphasized that according the student finds the defects the other immediately must register it in the defects report.

If the team finds a defect remaining 3 minutes to complete this stage, immediately the team must inform to the specialist, and then 2 minutes will be added for the defect record. Thus the evaluative items are: a) Time compliance: when registering defects found within the established time, this indicates that they have time control; b) Defects found: at this moment only the counting of the number of defects is performed. The strategy of using resource cards is to avoid questions to the specialist; this way the team stays focused on defect detection.

The team should receive an extra score if they detect more than 5 defects, for example, if the team finds 8 defects, soon are 3 defects above 5, then the team should receive 30 bonus points. This bonus is to stimulate the detection of defects and also serves as recognition of good performance.

- **Help:** This stage is optional and provides the opportunity of the team to acquire self-help resources to assist in the defect detection. The cards must have a penalty character if the team requests in the first 10 minutes of the test session, because it characterizes that the team does not want to make an effort to use their creativity in the defects detection, on the other hand, if the resource is requested in the final minutes, indicates that the team may be having difficulties and thus need help to boost their creativity in the

exploring the program. The time of this step is included in the "look for the treasure" step.

- **Discuss Strategies:** The team has an estimated time of 5 minutes to analyse and discuss the strategies used in the test session, in addition, the team should perform the prioritization of the defects found. The discussion of the strategies is an activity inherent to the SBTM technique, and used after the test session. Regards to prioritization of defects, three levels can be classified, where 1 is more priority than the others. At this point, the judge should only check that all defects recorded in the defect report have been prioritized.

If the team prioritizes all defects recorded, then receives the maximum score, and consequently receives medals and *bitskull* as reward, otherwise, the team receives only half of the points and also no rewards are received. This bonus and/or penalty objective to keep students more attentive and not forget to prioritize each registered defect.

It should be noted that the defect report is a document inherent in the SBTM technique; therefore it is used because it is fundamental to have some record of the test process for further analysis.

- **Battle:** The teams must exchange defects report with other team. Each team has 30 minutes to analyse the following aspects: a) Prioritization: write a justification if it is in disagreement with the priority level of the defects defined in the report of another team; b) Clarity: analyse if the script of each registered defect is well inscribed, that is, there are no ambiguous words, wrong words and incomplete sentences; c) Reproducible: check if only with the registered script of each defect it is possible to reproduce it, otherwise, the team should highlight the inconsistencies found in the script described.

The result of the analysis of the three aspects is described in the analysis report, and at the end of the analysis, the team gives a general note of the defect report analysed and also must justify this note, posteriorly, delivery to the expert to carry out an evaluation of both the reports.

At this stage the specialist and the judge should only check whether the tests contained in the defect report were analysed by the assessment team. If all the defects were analysed, then the team receives the maximum score and also more medals and *bitskull* as a reward, otherwise it receives only half of the possible points and no reward is received. The purpose of this bonus and/or penalty is to keep the team always aware of the details of the information in the reports.

- **Validate the Results:** The specialist should evaluate both reports, which are: a) defect report; b) analysis report. In the first, it is evaluated whether the defects found are in the catalogue of defects, if present the team receives a certain score, otherwise it receives a higher score, because certainly is one defect not purposely inserted. In the second, the specialist must evaluate if the three aspects were well analysed, if the defects are not false positives and also if the general note and justification are coherent. The specialist should give a general note for the defect report and compare it with the grade suggested by the assessment team, so the team should receive a score according to the specialist's note and should also receive a score by the analysis performed.

In order to carry out this evaluation, more time and attention is required for specialist, so it is an extra class activity, since it should organize the results to present them in detail in the classroom, in approximately 30 minutes. In this context, the specialist's note, the evaluation team's note and the coherence of the analysis of the three aspects are observed. This way as the team cannot receive point about participatory action items, then the team must receive bonus according to the performance in the activities. Thus, it is important to carry out this assessment because students can observe how to improve their analysis.

- **Pirate Highlight:** It is destined an approximate time of 15 minutes for the specialist to reward the highlights of the stage of "Battle". The team receives a gift and the opportunity to choose an accessory card or an unknown reward card, however the team must solve a puzzle before withdrawing this card, otherwise if the answer be wrong then the team receive only the gift. It is important to reward the highlights for students perceive that they are performing well.

- **Buy Resources:** The team must request the purchase of two cards using the *bitskull*, and only the unknown reward card is not allowed, because this buying activity aims to prepare the team to the next testing session, by equipping the avatar or acquiring some resources to aid in the detection of defects. However, it is emphasized that before removing these cards, the team must solve a riddle. Emphasize the importance for the students self to prepare for the next testing session, because is a way to stay competitive with a goal of winning the game. With this, the time for this stage is estimated to be 15 minutes.

- **Reward Pirate Captain:** The specialist must reward the team that reached the level of pirate captain in the general avatar. Before starting the awards, the team must solve three riddles, and the answer is directed to hidden treasure within the classroom. The purpose of having a treasure within the classroom is to provide the feeling of immersion in the world of treasure hunting and also to stimulate engagement by the playful artefacts.

It is emphasized that all the riddles are about the content of the introductory classes, except at the awards stage of the winners that should direct the team to places where the treasure can be found within the classroom. Another observation is that all this dynamics must be performed during 7 days of class, according the Table 2, because each class day has duration of 2 hours, for example, the "Pirate Training" stage will be 4 hours of introductory class.

Table 2: Execution planning of the stages.

Day	Stage
1 st , 2 nd	Pirate training
3 rd	Commands for treasure hunting, outfit the pirate, Treasure hunt, Help, Discuss strategies, Battle
4 th , 5 th , 6 th	Evaluate Results, Pirate highlight, buy Resources, Treasure hunt, Help, Discuss strategies, Battle,
7 th	Reward Pirate Captain, Feedback

4 EXPECTED RESULTS

As a result of this work, a satisfactory level of learning is expected based on student performance considering the potential of the gamification approach, which students are influenced and always engaged and motivated to be present and participatory, interacting with each other, answering questions from the specialist and collaborating with the subject.

In order to prove the expected results, this work should compare the data of four activities: data of the initial forms, data of the exercises, data of the test on the content of the theoretical classes and the feedback. This comparative and qualitative analysis is fundamental to understand the gaps not unresolved, the level of progression of the students, points of improvement, critical suggestions and contributors, points that were well treated, as well as to evaluate didactics and other factors related to the process of ET.

As a result, the students are also expected to understand the subjects and dynamics to achieve good performance and, finally, to be prepared to act in testing procedures by applying the ET in the academic and professional context.

5 CONCLUSIONS

In this present study has been described a systematic strategy to teaching of ET using the gamification approach. Initially, this experiment should be applied, twice in different classes of postgraduate, in order to improve students' engagement to maintain a good performance in classes related to software engineering, especially in software testing. In addition, it is noticeable the importance of this study contributing to the diffusion of the subject and encourage further research on the teaching of ET in the academic context and from the results possibly provide the application in the professional context.

The preparation of these undergraduate students on ET aims at balancing the levels of knowledge on this subject and as well as providing a sufficient aptitude to act in the industrial context, given that there is a great lack of professionals specialized in software testing.

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