Adaptive teaching based on gamification: a pedagogical strategy for formative assessment in higher education

Aprendizagem adaptativa baseado na gamificação: uma estratégia pedagógica para avaliação formativa no ensino superior

Enseñanza adaptativa basada en la gamificación: una estrategia pedagógica para la evaluación formativa en la educación superior

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Abstract
This study aims at introducing and assessing a pedagogical strategy for formative assessment in higher education. Under such purpose, successive quick tests are applied as soon as new topics of the course are introduced to students. Thereby, learning weaknesses are identified, from which in turn makes it the focus of review by the student. In order to assess the effectiveness of this pedagogical strategy, two case studies were carried out at different undergraduate courses. As a result, there was a significant performance gain by the students. In conclusion, based on the analysis of statistical significance, it was possible to verify that the proposed pedagogical strategy constitutes a promising alternative for formative assessment in higher education.
Keywords: Learning gaps, Active learning, Adaptive teaching strategy

Resumo
O presente estudo tem como objetivo apresentar e avaliar uma estratégia pedagógica para a avaliação formativa no ensino superior. Para tanto, são aplicados sucessivos testes rápidos, assim que novos tópicos do curso são apresentados aos alunos. Desse modo, identificam-se os pontos fracos do aprendizado, o que, por sua vez, o torna o foco da revisão pelo aluno. Para avaliar a eficácia dessa estratégia pedagógica, foram realizados dois estudos de caso em diferentes cursos de graduação. Como resultado, houve um ganho significativo de desempenho por parte dos alunos. Em conclusão, com base na análise de significância estatística, foi possível verificar que a estratégia

pedagógica proposta constitui uma alternativa promissora para a avaliação formativa no ensino superior.

Palavras-chave: lacunas de aprendizagem; aprendizado ativo; estratégia de ensino adaptativa.

Resumen
El presente estudio tiene como objetivo presentar y evaluar una estrategia pedagógica para la evaluación formativa en la educación superior. Para ello, se aplican sucesivas pruebas rápidas en cuanto se presentan a los alumnos nuevos temas del curso. De esta forma, se identifican las debilidades del aprendizaje, que, a su vez, lo convierte en el foco de revisión por parte del alumno. Con el fin de evaluar la efectividad de esta estrategia pedagógica, se realizaron dos estudios de caso en diferentes cursos de graduación. Como resultado, hubo una mejora significativa en el rendimiento de los estudiantes. En conclusión, a partir del análisis de significancia estadística, se pudo constatar que la estrategia pedagógica propuesta constituye una alternativa prometedora para la evaluación formativa en la educación superior.

Palabras clave: Brechas de aprendizaje, Aprendizaje activo, Estrategia de enseñanza adaptativa

1. Introduction

According to Oliveira (1995), it is through learning process that we accumulate skills, values, knowledge, and other information that will be responsible for our interaction with the environment and social life. It is by interacting with this process that the individual's personality is formed (BRESSANE *et al*, 2017). Each person has innate characteristics, but an intense part of social formation will occur as this individual interacts, perceives and interprets the environment around him. These interpretations will give a sense of the meaning of the living environment.

In higher education, the professor's position should be that of an advisor, what means he should only be the mediator of a process where the student acts as a knowledge builder, reflecting, making decisions, and solving problems proposed by the professor (BRESSANE; BARDINI; SPALDING, 2021; LIBARDI, 2011; MORAN; MASETTO; BEHRENS, 2009; FREIRE, 2002). Otherwise, Hack (2009) points out that a change in the communication process is necessary, so that the learning process happens in the students, educating them as critics and allowing then to develop creativity.

This exposed view demonstrates the need to involve new technologies through educators, in order to promote inclusion and offer new opportunities for

knowledge construction. The traditional teaching and learning processes have long been questioned, not for ineffectiveness, but for models that are becoming obsolete in face of technological advances. Such advances make the student the focus, since the protagonism of the process must be in the student and not in the teacher, who should only perform the important role of information curator.

The learning process has been intensely stimulated and the advent of Technology, Information and Communication offers endless possibilities and tools that can leverage the learning process. Information Technology is supported by computer systems, which were created to facilitate the previously developed processes in a manual way, which demanded time, precision and greater effort and human attention, giving slowness to the various production chains. In general, technology drastically changes society's habits, as far as knowledge is concerned, because at this moment not only is what is known and where to look, but it is known that it is available.

We are currently experiencing the era of technological convergence (fourth wave), based on the connection, interaction, and integration between machines, and these with humanity (GILCHRIST, 2016; MORAN; MASETTO; BEHRENS, 2009). With such advances, unprecedented opportunities arise, as well as challenges to adapt professional training to the requirements related to the modernization of society (DABBAGHA; KITSANTAS, 2012; WODZICKI; SCHWÄMMLEIN; MOSKALIUK, 2012; MAO, 2014). In this context, resources based on emerging technologies could constitute an adaptive teaching strategy, enabling the training of professionals familiar with technologies that enable connection, interaction and even the updating of knowledge in real time (NOE; CLARKE; KLEIN, 2014; GREENHOW; LEWIN, 2016).

Learning Management System are virtual environments where content related to a syllabus of pre-defined subjects is organized. In accordance with the Brazilian National Education Policies (Decree 2,494/98 that regulates article 80 of the "Law of Guidelines and Bases" 9,394/96), it is allowed that traditional courses, already recognized, are offered within the limit of 20% of their hourly load, through online learning platforms. This stimulated the creation of learning platforms with content related to the most different courses. This content can be

studied without the need for an on-site teacher or requiring the student to be present in a physical environment to access the subjects.

Among different virtual platforms is the Kahoot (game-based learning platform), where students work with methodologies based on "gamification", acting in a playful way on the teaching and learning process. According to Kapp (2012), the term gamification means the application of elements used in the development of electronic games, such as aesthetics, mechanics, and dynamics, in other contexts not related to games. The game can be seen as a methodological alternative to overcome teaching and learning difficulties, as the mechanisms found in games can act as a motivational factor for the individual in the context of a task to be performed (FADEL, 2014; FARDO, 2013).

For data collection, we adopted the Kahoot platform (WANG; TAHIR, 2020), a game-based learning platform, freely accessible, and available at https://getkahoot.com/. This software allows creating questionnaires, discussions, or surveys that must be answered by users connected in a computer network through mobile devices (e.g., smartphones, notebooks, and tablets) or even by computers in a computer lab. From an activity previously created by the teacher, students will access a virtual room and join the game by private code. It is believed that the use of the gamification tool can stimulate the student, allows diagnosing its performance, and reinforce approaches in a customized way (adaptive learning). It also suggests the need for an increased understanding of how this developing assessment landscape might contribute to adaptive teaching and learning approaches in classroom and beyond (HONEY *et al*, 2005).

From the aforementioned, this study introduces and assess a pedagogical strategy. As general overview, such strategy comprehends successive quick tests along the discipline development when new topics are introduced to students. Such tests provide a kind of early detector of learning gaps and yield the students to focus on its own learning weakness. Thus, the objective is to verify the following research hypotheses: (H0) there was no significant effect of adaptive teaching on student performance; and (Ha) there was significant effect of adaptive teaching on student performance.

Beyond the proposed pedagogical strategy, this study also provides evidence about potential and usefulness of new information technologies in

teaching process. It is worth mention that this research follows a mixed typology. In that regard, we employ statistical techniques to verify the research hypothesis, and qualitative analyses to support our findings and conclusions.

This paper is organized as follows: Section 2 presents a summarized review concerning learning assessment and gamification; Section 3 introduces the proposed adaptive teaching protocol; Section 4 discusses the data collection and analysis; results are presented at Section 5; and lastly, Section 6 presents conclusions and future perspectives.

2. A brief theoretical background
2.1 Learning assessment

Assessment is part of the pedagogical tools that teachers use, or should use, in order to verify and monitor the construction of knowledge, in addition to providing basis for enhancing learning. It must be carried out in the most comprehensive manner possible so that it does not become just a mechanical and formal instrument (BITENCOURT, *et al*, 2013; LUCKESI, 2002).

In higher education, the evaluation also has the function of support in professional qualification of the student, not only to verify the learning of the syllabus (BORBA *et al*, 2007). As part of teaching practice, it must be present throughout the teaching-learning process, giving the possibility for the students to understand their difficulties and take actions to remedy them (BITENCOURT, *et al*, 2013). Grillo (2003) suggests that the result of the assessment should be a diagnosis of the student's real level of learning, showing the acquired knowledge and its shortcomings. In turn, it enables the reorientation of learning.

The traditional method of assessment, called "summative" or "classificatory" (standardized tests), is usually carried out at the end of the course, aiming assigning a grade or establishing a concept to the students, and ordering them (PELLEGRINI, 2003). In this traditional practice, the concept of evaluation is not applied as a continuous process of analysis and monitoring students, without the possibility of assistance in their difficulties (MENDES, 2005; LUCKESI, 2002). The summative assessments (standardized tests) are usually external, imposed, and the results are used for selection purposes instead of helping the learning process (CHEN, 2015).

Several researchers believe that summative measurement, especially through standardized testing, was bad for students and their learning (DENEEN; BROWN, 2016). However, some proponents suggested that this is not an issue of malpractice, but a more fundamental problem with conceptualizing assessment as measurement (GIBBS; SIMPSON, 2004; SHEPARD, 2000). In contrast to these traditional forms, the "formative" assessment emerges, which has a continuity characteristic and aims to contribute to improving the learning in progress (PERRENOUD, 1999). Thus, the evaluation will only be formative for the student if he is informed of the results; the attitude of changing the detected reality is what makes the educator a good evaluator (PELLEGRINI, 2003; MENDES, 2005).

For Chen (2015) and Andrade (2010), the essence of formative assessment is on how the information about learning is managed and used; and the purpose of using information generated from the assessment process is improving future teaching and learning. Formative assessment should be enclosed in teaching and be conducted as part of instructional activities. According to Sant'Anna (1995), formative assessment does not have the premise of classifying or selecting. It is based on learning processes, on their cognitive, affective, and relational aspects. This assessment is called formative in the sense that it indicates how students are changing towards goals (IRONS; ELKINGTON, 2021).

Black and Willian (1998) affirm that the assessment for learning should play dual roles: measure the learning and act as part of the learning process itself. According to Torrance and Pryor (1998), the formative test focus should be a test for learning, and testing is only a part of evaluation. Yin and Buck (2015) stated the concept of formative assessment: "[…] we consider formative assessment as any planned or spontaneous pedagogical strategy used to elicit students' conceptual development and use the elicited information to inform subsequent teaching and learning" (p. 721-722).

The formative assessment shows the students' conceptual status as well as their real problems in learning, which guided the teacher to change his later instruction practice; feedback must present educationally useful information and this information must be used to advance learning and instruction (CHEN, 2015).

Improvement focuses on assessment informing teachers and students, considering that students need to learn next and how this may guide learning (BROWN, 2008).

The assessment should support quality education, providing prompt feedback due to the supporting idea that learners cannot learn without feedback (HUDA; FREED, 2000). Thus, the most valuable function of feedback is fostering communal participation in disciplinary discourse (HICKEY; TAASOOBSHIRAZI; CROSS, 2012). Therefore, feedback is an important part of teaching and learning processes. It supports the identification of strengths and areas for improvement, allowing self-assessment and self-regulation of behavior, both for students and teachers (BOUD; MOLLOY, 2013).

2.2 Gamification

Low performance and waiver in education can be cited as the boredom and lack of engagement, promoting the student a less willing to come back to school, and most importantly, being distracted by technology such as smartphones and Internet. These behaviors hinder absorption of information and spoil the effectiveness of teaching.

A learning tool very effective is the use of educational games, by helping to develop skills such as problem-solving, collaboration, and communication besides having motivational power by encouraging people to engage with then, just for the joy of playing and the possibility to win. An essential key element in this process is the educator. Beyond intermediating the game, it is also responsible to propose and develop an inclusive activity able to allow the participation of less apt students without lead to embarassing situation.

According to Deterding *et al*. (2011), gamification is the use of game elements in non-game contexts that has become a popular tactic to encourage specific behaviors and increase motivation and engagement. It helps educators find the balance between achieving their objectives and evolving student needs (HUANG; SOMAN, 2013). In recent years, gamification has seen rapid adoption in business, marketing, corporate management, and wellness and ecology initiatives. The penetration of gamification trend in educational settings seems to

be still climbing up to the top, as indicated by the amount and annual distribution of the reviewed works.

Liebman (2010) proposed that, in education, games can be used as vehicles to convey course content; as "texts" that students "read" and analyze through gameplay; as media in which students create their own games; and as an overall approach to pedagogy that incorporates "game-like motivational systems" into course and assignment design.

According to Tavakkoli *et al.* (2014), the pedagogical use of games covers two kinds of literature: education and technology. The latter embraces rhetoric and composition, which studies the visual domains as "texts" and sees these spaces to compose rhetorical claims.

Lastly and most importantly, applying gamification strategies and/or technology to curriculum may often do a better job of teaching. However, it does not mean it should be a replacement for a comprehensive curriculum or face-to-face instruction. Instructors must be careful not to depend on extrinsic motivators in the game to modify student behavior. In the same way, the habit created during the gamified process may not sustain once the extrinsic reward is gone. And finally, instructors must not disregard the importance of human teaching.

Furthermore, the use of the game benefits learning without making it a tedious activity, as perceived by students who perform these tasks with traditional paper and pencil methods.

## 3. Adaptive teaching as a pedagogical strategy

An adaptive teaching protocol is introduced in this section. As a general view, this protocol follows a teach-and-test scheme. In each class, the students are submitted to two quizzes. The first quiz regards the content of the previous subject, and the second quiz stands for the current subject (i.e., introduced on that day). Additionally, the first quiz is applied when the class begins and the second one before the class ends.

Given the quizzes of the present topic (i.e., the second quiz) are applied, the students' performances are measured in terms of the number of right/wrong answers. Regarding only the wrong answers, which define a "learning gap", a study plan is structured to "fill in" such gaps. Then, we reassessed at the

beginning of the next class through a similar quiz in terms of content, but distinct concerning the questions. This process occurs similarly over the course, along with the classes. Finally, at the end of the course, a global analysis is performed regarding the effects of the investigated teaching strategy. Figure 1 depicts the entire process.

Figure 1 - The pipeline of adaptive teaching protocol
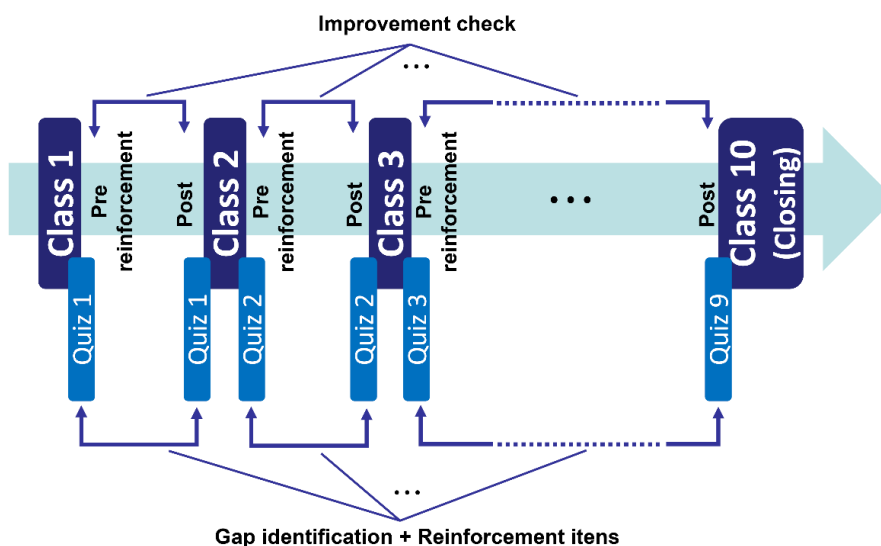
Source: the authors.

Regarding the application of quizzes and data collection, we adopted the Kahoot platform. In such sense, from the quiz set (questionnaire) created by the teacher, students access a virtual room and participate in the game. The access to the virtual room and answers by the students were made in synchrony with the classes.

Firstly, the questions are exposed, and the students receive in their devices the alternatives of each question that should be chosen. Subsequently, since the students have chosen the answers to each question, the correct answers and the score obtained by the students are exposed. At end, the performance of each student is tabulated for disclosure and individual assessment as well as for future statistical analyzes of teaching strategy under study.

4. Experiment design

4.1 Data Collection

To verify the viability and effectiveness of the teaching protocol discussed in Section 3, two case studies[1] were carried out during the second semester of 2017 on Human Resources and Administration undergraduate courses. While the Human Resource class has 25 students, the Administration class has 33 students, and the "Market Compound" discipline was observed in both courses. A total of 18 quizzes applied along 10 classes were considered in this study to collect the data (see Figure 1).

It is worth mention that the participants of this research (students of the cited classes/discipline) were under the supervision of Prof. Paulo Rodolfo Martins, who applied the quizzes as well as collected and organized the data. The other authors of this research, also professors with experience in undergraduate learning, focused on quizzes planning, data analysis, and interpretation.

For the sake of exemplification, four regular quizzes are presented in Table 1. Usually, the quizzes embrace a "brief" question followed by two or four alternatives, where only one is correct. Ten minutes are imposed for the students to answer the complete set of quizzes when applied.

Table 1 - Examples of quizzes

We should focus on people in Organizations. Why?	The democratization of knowledge means:
(a) We live in the age of technology (b) We live in the age of knowledge (c) We live in the new age (d) We live in the era of robotics	(a) Who only has access to knowledge, who acts democratically (b) The dictatorship has no access to knowledge (c) Everyone has access to knowledge (d) Only have access to knowledge that is in formal school
The statement "sensations drive behavior" is:	**The statement "our perception is not related to our behavior" is:**
(a) True (b) False	(a) True (b) False

Prior to the collection of information, this research was previously evaluated by the Research Ethics Committee Involving Human Beings and approved with

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[1] According to Bromley (1986), a case study comprises an examination of a particular case from a real-world context.

respect its ethical requirements. For further details, please refer for CAAE#78702217.6.0000.0077.

4.2 Data analysis

According to Siegel and Castellan (2008), statistics provide means to formalize and standardize decision-making processes. Research was based on two classes, 58 students, and 18 quizzes. As data collected may not meet assumptions as continuous nature and Gaussian distribution, the non-parametric techniques are an alternative to the statistical analysis. Non-parametric statistics do not require that the sample distribution be characterized by certain parameters, as well as being useful in the analysis of small samples and/or whose data are resistant to transformations.

According to the methodological steps outlined in Section 3, the application of successive quizzes between subjects made it possible to verify whether the provision of reinforcement activities provided the filling of possible learning gaps. In the context of this work, the Wilcoxon, Sample's Iteration, and χ^2 (for a single sample) tests were applied in order to:

- Wilcoxon test compares if there was an improvement between quizzes on the same subject – it is evaluated whether the pedagogical strategy to stimulate the student to study focused on his learning gaps, making him evolved from one quiz to another;
- Sample's iteration test to verify if the improvements, or worsens, do not happen at random. Assuming that the oscillations of improvement/ worsening are not systematic, it is possible to state that the student, when fulfilling the proposed study plan, tends to evolve in the learning process, and consequently, the pedagogical strategy has an effect;
- χ^2 (for a single sample) test to verify if the improvement differs in relation to the expected median behavior. The $\chi2$ test for a sample is applied in this case to verify the mentioned behavior.
  A significance of 5% should be considered in this analysis.

5. Results and discussion

Based on the statistical analysis of collected samples, it was possible to verify that there is a significant improvement in the performance of students after submitted to the proposed pedagogical strategy. Figure 2 presents the results of formative evaluations right after the classes and post detected/fill the learning gaps. As previously discussed, this process covered the content introduced along nine classes regarding Human Resource and Administration courses.

Figure 2 - Students' performance in assessments before and after reinforcement. Human Resource course at left and Administration at right. Error bars denoting one standard deviation.
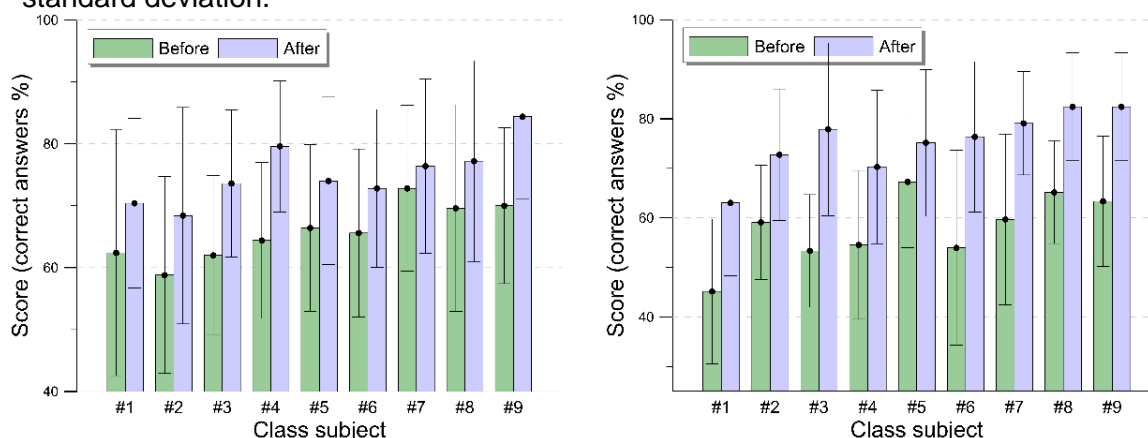
Source: the authors.

Overall, the average number of correct answers after the classes was 67%, increasing to 75% after considered the proposed learning protocol. Figure 3 shows the individual increases along the classes/contents.

Figure 3 - Increase of the students' performance in assessments. Human Resource course at left and Administration at right. Dashed red line at background denotes the average performance.
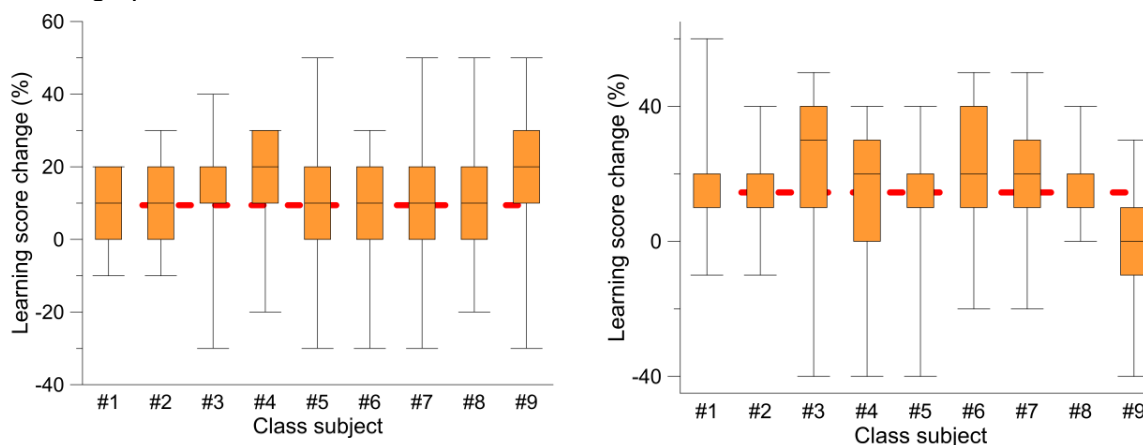
Source: the authors.

As aforementioned, to verify the statistical significance when comparing the previous student's performance before and after the proposed pedagogical strategy, the Wilcoxon, the sample's iteration, and χ^2 (for a single sample) tests were adopted. Regarding an analysis of "improvement between quizzes on the same subject", the Wilcoxon test reveals that in the most cases the null hypothesis is rejected, proving then a positive interference of proposed pedagogical strategy.

Particularly, while this strategy implied the rejection of null hypothesis in all comparisons/classes regarding Administration students, the same was not observed for Human Resources class. Table 2 shows the p-values obtained from each statistical comparison and the decision reached with a 95% confidence. These results raise the idea that offering study plans focused on the students learning gaps may represent an important support tool to enhance their progress in the classes subjects.

Table 2 - Significance analysis obtained by Wilcoxon test for Human Resource and Administration courses.

Comparison (befor-after)	Human Resource		Administration	
	p-value ($\times 10^{-5}$)	**Decision**	**p-value ($\times 10^{-5}$)**	**Decision**
#1	14532.5	Do not reject H_0	1.4	Reject H_0
#2	2575.5	Reject H_0	6.6	Reject H_0
#3	162.7	Reject H_0	0.07	Reject H_0
#4	12.9	Reject H_0	19.0	Reject H_0
#5	5242.4	Do not Reject H_0	5052.4	Reject H_0
#6	7277.5	Do not Reject H_0	0.84	Reject H_0
#7	33936.1	Do not reject H_0	0.27	Reject H_0
#8	7033.2	Do not Reject H_0	0.02	Reject H_0
#9	41.0	Reject H_0	0.004	Reject H_0

Source: the authors.

Based on the sample's iteration test, it was found that for most students the characterization of "improvement" or "worsening" on its performance does not occur randomly. While 19 students (of 25) from Human Resources group tested positive to non-random improvements (i.e., rejected the null hypothesis for random behavior), with respect the Administration students, just for one student it was not verified a non-randomly improvement.

Finally, with respect to the $\chi 2$ test for a single sample, when applied in order to compare the number of times that each student showed improvement in performance, among the 9 "before-after" comparisons made, whose expected median behavior is 4.5; it was found that the null hypothesis ("the observed performance does not differ from the expected") is rejected for both subjects/courses analyzed, with a p-value approximately equal to zero.

6. Conclusions

With advances in information and communication technologies, traditional teaching methodologies and learning process can be innovated. In face with this motivation, this research sought to verify the effectiveness of an adaptive teaching as a pedagogical strategy, whose objective is to support the teaching and learning process.

Such strategy focuses on identify the students' learning gaps and then propose individual study plans aligned to their needs. Two case studies had been carried out during a semester, and students of distinct courses were submitted to the proposed method. Supported by statistical tests, the results pointed favorable evidence that adaptive teaching, based on gamification as a pedagogical strategy for formative assessment in higher education, allows a significant improvement in student performance.

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