Using gamification to teach forecasting in a business school setting

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Abstract. While gamification has been creatively embraced in education, recent studies emphasize the need for more experimental research on gamification impact on learning outcomes. Teaching forecasting is a challenging task due to the complexity that forecasting techniques entail, and due to their popularity in business environment. This study experimentally examines the impact of three pre-existing gamified implementations on the students' comprehension of specific forecasting topics using controlled and treatment groups. Our sample consists of 243 undergraduate students from the Business Administration Department in the School of Business and Economics of the University of Thessaly. Our findings show that gamification improves students' performance up to almost 15.80%, compared to traditional teaching methods, under certain conditions. These results are not in full alignment with previous findings, a fact which highlights the need for further research on the impact gamification can have in different academic majors.

Keywords: Teaching · Forecasting · Gamification · Business School

1 Introduction

The digital age has emphasized the need for statistical literacy [14]. Educational approaches to statistics mainly focus on data analysis [6], as competitive business environments require graduate students to interpret data and comprehend forecasting methods and applications [17, 24]. Many believe that teaching forecasting is a difficult task, due to businesses' high expectations concerning the graduates' forecasting skills, and due to the complexity, that such forecasting topics entail [7]. Consequently, both these factors act as deterrents for students. At the same time, gamification is increasingly used in education in an effort to motivate students to reach their learning potential [23, 37, 10]. However, the teaching of forecasting has not yet followed this trend. Gamification strategies have been moderately embraced in forecasting courses in the context of simple gamified learning exercises, aiming to improve learning outcomes. Thus, because of the increasing demand for forecasting courses, and because of their multidisciplinary nature and complexity that can impede student motivation, forecasting courses seem to be a suitable and illuminating field within which to investigate gamification' s effects.

This study examines the impact of gamification implementations, named: *Horses for Courses*, *JudgeIt* and *Metrics to Escape*, respectively, on learning outcomes in forecasting education. In our experiment, following the same experimental design as Legaki

et al. [26], we investigate the effect of gamification on learning outcomes compared to traditional teaching methods using treatment and control groups. The total sample is composed of 243 participations by first-year undergraduate students from the Business Administration Department in the School of Business and Economics of the University of Thessaly. We also compare our findings with findings from previous relevant research conducted using a sample of 261 students from the School of Electrical and Computer Engineering at the National Technical University of Athens, Greece [26].

2 Teaching Forecasting

2.1 Teaching Forecasting Principles in Business Schools

As described in [14], statistical literacy and the education on statistics are of critical importance, especially in the rapidly changing business environment. In light of the increased demand for analytical and statistical skills, the education on statistics focuses on data analysis [6], as competitive business environments require graduate students to interpret data and comprehend forecasting methods and applications [17, 24]. The importance of forecasting skills is not a new discovery [30, 17, 7, 28, 38, 1, 24]. Due to their multidisciplinary nature, forecasting techniques are an essential component in a number of fields such as: Business Statistics [40], Supply Chain Management [15], Decision Making and Management Science [30], Finance, Economics and other fields.

However, the eagerness of the business sector to equip students with a strong background in forecasting techniques is only partially reflected in the education that Universities and Business Schools offer. Hanke [18] conducted a survey regarding forecasting courses in Business Schools, in which he demonstrated that only 58% of the universities offered an independent forecasting techniques course. Even when offered, forecasting techniques courses were not compulsory and such courses were more common at the graduate, rather than the undergraduate level. More recent research by Kros and Rowe [24] showed that 34.48% of the surveyed Business Schools offered formal forecasting courses, as the majority of respondents included forecasting as part of another class. Additionally, less than 50% of the top 50 US Business Programs required a forecasting time series course [19]. Regarding e-learning modules, Gel et al. showed that there is a plethora of various *"e-learning-in-statistics initiatives"* [16] general modules but they do not concentrate on time-series and forecasting methodology as these would be taught at the undergraduate level.

Despite the demand for forecasting skills, Business Schools do not seem to follow this emerging demand for effective forecasting courses. The need to increase student motivation, especially in higher education, has been widely noted and recognized [8]. Business Schools' teaching methods and effectiveness have been criticized for not placing enough focus on the specific skills that will improve the students' future job performance [31] and career success [36]. In the case of forecasting courses, Business Schools have even more obstacles to overcome. Business forecasting or statistics courses are usually considered difficult [41, 13, 1, 38], and too technical and complex [7], making it challenging both for educators to teach the key concepts effectively and students to remain motivated and comprehend the material [7]. Accordingly, Donihue [11], Loomis and Cox [28, 27] and Chu [5] propose a variety of alternative teaching principles, such

as: less time spent on lectures, presenting students with real case studies, involving students in real forecasting problems, encouraging the use of technology, and familiarizing students with suitable software and data visualization. Apart from real-world problems and case studies, which have been proposed as effective methods [28, 29, 31], Love and Hildebrand [29] also highlight the need to update and improve educational methods, and they propose the integration of active learning in the educational process, which would also encourage student participation.

2.2 Gamified Interventions in Teaching Forecasting

The use of business simulation gaming and business games as educational tools in Business Schools has a long tradition and has undergone a rapid evolution, helped by advances in technology [12]. The complexity of these business games varies in accordance with their objectives and their application fields (for example marketing [43], strategic management [44] and others), which may contain tasks or modules on forecasting, due to the multidisciplinary nature of forecasting. However, this study focuses only on the teaching of forecasting principles via simple gamified exercises, and on gamification in terms of design activities or systems, usually including game mechanics [4] in a non-game context [9], in order to influence user behavior as games do [20].

Forecasting mixed with gamification elements has also been used in order to increase learning outcomes in other courses. One simple game, called FREDCAST, has been designed and published as an effective pedagogical strategy, applying experiential learning to the teaching of forecasting in macroeconomics [32]. Buckley and Doyle [3] have shown that the use of gamified interventions in Taxation Theory and Practice, in which students are required to forecast the value of the national budget using gamified learning interventions, has had a positive impact. However, they argue that special care must be taken when designing gamified activities in order to improve learning outcomes, and emphasize the need for more empirical results. Prediction Markets have also employed gamification elements [2] in an educational context, providing further evidence for the relationship between different types of learners and student participation in these gamified learning interventions.

In the context of forecasting courses mainly at the undergraduate level, some active learning exercises and the use of customized-software have been proposed [39] in order to improve learning outcomes. The majority of these studies use real data and spreadsheets for data analysis and forecasting, which are in keeping with forecasting principles. Basketball scores time series have been used as real data in in-class exercises, in order to encourage students to learn the importance of forecasting topics such as accuracy and biases [15]. Similarly, spreadsheets have been used effectively in teaching basic forecasting concepts in non-classroom-based exercises to make students feel that they are applying their learning in a real-life environment [1]. Additionally, Craighead [7] increased students' interest via in-class exercises which used virtual darts and kept score in order to introduce time-series forecasting. Another approach is the design and implementation of gamified exercises that aim to teach different aspects of forecasting. The use of *"Beat the instructor"* in-class active learning exercises [38], which included the use of spreadsheets and created competition between the students and the educator as well as the promise of a reward, increased student interest in the lectures.

Moreover, three gamified implementations have been used and assessed in a forecasting course using controlled experimental research with positive results regarding learning outcomes, using a sample composed of students from the School of Electrical and Computer Engineering at the National Technical University of Athens, Greece [26]. These implementations will also be referred to in this study. Gamification, under proper design guidelines and conditions, and with proper implementation, can successfully address the need to increase student motivation. However, in order to substantiate this, more controlled experimental research is needed, as numerous reviews of the effects of gamification in an educational context have noted [37, 23, 34, 25].

3 Description of Gamified Implementations

According to literature reviews [23, 37], the investigation into the impact of gamification in education using controlled experimental research with large samples is limited. As previously indicated, forecasting techniques courses are an educational field which needs to motivate and encourage students, and therefore these courses provide the appropriate context within which to explore the impact of gamified strategies on learning outcomes using simple gamified exercises. Consequently, this study aims to examine the impact of pre-existing gamified implementations on forecasting topics, and to record the learning outcomes, using a sample of undergraduate students of Business Administration Department in the School of Business and Economics of the University of Thessaly, in order to extend the research conclusions of the study by Legaki et al. [26]. More precisely, we employed the pre-existing web-based platform F-LauReL ^{xp} [26], which embodies three gamified web-based applications named: *Horses for Courses*, *JudgeIt* and *Metrics To Escape*. We chose these gamified applications because each of them is designed according to gamification design principles [45, 33, 22].

Furthermore, these applications were designed and developed as simple gamified implementations exclusively in order to support the teaching process regarding statistical, judgmental forecasting and forecasting accuracy. There is no need for either instructors or students to prepare, initialize the systems or install any additional software, note that a free-unity plugin browser is required for *Metrics to Escape*, since these applications have a user-friendly interface and are easily accessible with the simple use of a browser. Other reasons for this choice of F-LauReL^{xp} platform, are that its components, more specifically these three gamified applications, are web-based, publicly available, and can be used by following the on-line manuals. Hence, these applications can be easily used as a simple complementary in-class activity during a forecasting course, in order to teach specific statistical, judgmental and forecasting accuracy topics. Additionally the impact of these gamification strategies on student learning in schools with business or engineering majors can be investigated through these applications. The methods, data and the experiments are described further on.

3.1 Gamified Implementations

F-LauReL^{xp} is a web-based platform, which aspires to be a complementary educational tool when teaching forecasting. It is a modular platform that can host multiple gamified

applications which meet specific criteria, however up to now it is composed of three gamified strategies. They are the following:

Horses for Courses is a gamified application which aims to teach the application of the "Method Selection" protocol for fast moving and intermittent demand time series [35]. Participants have to first identify components and decision strategies for the real data time series they are presented with. Then in order to gain points, they have to choose the most suitable forecasting method on a case-by-case basis, having consulted the "Method Selection" protocol [35]. The aim is to gain a high rank in the final leaderboard. The gamification elements which are integrated in this app are: points, levels, challenges and the leaderboard.

JudgeIt aims to disseminate heuristics and biases that affect judgmental forecasting [42]. This gamified application contains animated videos, comics and a playful storyline, which all relate to some of the experiments presented in the respective paper. Participants are challenged to identify what kind of bias is hidden behind each of the illustrated experiments. The gamification elements integrated here are: points, levels, challenges, a meaningful story, and the leaderboard.

Metrics To Escape deals with the advantages and disadvantages of forecasting accuracy metrics. It aims to teach the usefulness of a new standard accuracy measure [21] named Mean Absolute Scaled Error (MAsE). To gain points, participants are asked to choose characteristics of different metrics and select the most appropriate metric in specific circumstances. The gamification elements integrated here are: points, levels, challenges, a leaderboard, a meaningful story and a time constraint.

3.2 Participants

The experiments were conducted during the fall semester of 2018 in the Business Administration Department of the School of Business and Economics, at the University of Thessaly, in the context of an Information Systems course. The Business Administration Department's curriculum contains forecasting topics whithin an Operational Research course. Our sample consists of 243 participants, who all have the same educational background and are first-year undergraduate students. Not all students participated in all experiments since their participation was only mandatory in order to successfully complete one laboratory exercise rather than the whole course, and there were no other incentives for them to take part in the experiments.

3.3 Experimental Design

The experimental design was based on the instructions of [26], where the gamified implementations were firstly assessed. Additionally, the design was followed strictly for all experiments. Three experiments were conducted, one for each of the respective gamified implementations, *Horses for Courses*, *JudgeIt* and *Metrics to Escape*; each one was linked to the respective forecasting topics: statistical, judgmental and forecasting accuracy. More precisely, apart from the paper related to the forecasting topic, a set of presentation slides, which explained the respective paper, a gamified application and a questionnaire, which aimed to test students' comprehension were needed for conducting each experiment.

Initially, all students attended a 15-minute lecture, during which the main conclusions of the respective research were explained. Then, they were randomly assigned to one of the groups: Control, Read, Play and Read&Play. Each group had 15 minutes to complete the tasks they were assigned. More precisely, the Control Group did not have any additional responsibility, the Read Group had to study the paper, related to the examining forecasting topic for another 15 minutes, and the Play Group had to be navigated through all the levels in the respective gamified application (named hereafter as play task) for the same time frame of 15 minutes. The Read&Play Group, had 30 minutes to accomplish the reading task and then the play task. Finally, all groups, including treatment groups and the Control Group, had to complete the on-line evaluation form, in which they were required to answer 30 equivalent questions, about the findings discussed in the initial lecture. This study focuses on the assessment of the questionnaire in order to show the impact of these gamification strategies on learning outcomes in different settings. These settings include the comparison or combination of traditional learning methods such as reading or attending a lecture, with gamification. For the analysis to be beneficial, each task has to have the same time duration. However, the fact that the groups did not have the same time for completing their assigned tasks, places limitations that should be acknowledged.

For instance, students who participated in the *JudgeIt* experiment attended a lecture, where the topic of biases and heuristics was presented. The lecture was based on the research by Tversky and Kanheman [42] and was employing specific examples. Students who had been randomly assigned to the Control Group had 15 minutes to fill the evaluation form, which was composed of questions about the biases and three heuristics that were discussed in the respective research, e.g.: *"Gambler's fallacy is another consequence of which heuristic?"*. Students assigned to the treatment groups had to do the respective tasks,i.e. read the paper [42], navigate JudgeIt by identifying the kinds of biases in the illustrated or animated examples, or do both, and then complete the evaluation form. Student performance was assessed based on the questionnaire, in the context of content comprehension, and it should not be confused with their game performance, which is beyond the scope of this study. The same procedure was followed for all three experiments, using the same time frames and treatment groups.

4 Results

Specifically, student performance on the evaluation form was calculated as the sum of right answers of the respective questionnaire, normalized to a maximum of 100, for each experiment. Results, along with summary statistics are presented in Table 1. Additionally, the distribution of performances is illustrated in percentiles with a boxplot diagram (see Fig. 1).

Overall, the groups that experienced the gamified strategies achieved greater mean values of performance than the other groups. More precisely, the Read&Play Group, which read the respective paper and used the gamified implementation, reached the highest mean performance of 39.08 out of 100, which is significantly higher than all the other groups. However, this treatment also featured the highest levels of deviation in results (sd=13.41). The Play Group, which only experienced the gamified imple-

Table 1. Students' Performances per Treatment Groups

Gamified Implementation	Group	n	%	Mean	sd	Median
Horses for Courses	Group Control	23	20.47%	27.04	8.97	28.13
	Group Read	16	21.29%	28.13	16.18	25.00
	Group Play	26	24.21%	31.97	15.19	28.13
	Group Read&Play	21	34.03%	44.94	17.07	43.75
JudgeIt	Group Control	17	24.29%	29.02	6.32	30.00
	Group Read	20	25.67%	30.67	10.41	30.00
	Group Play	19	23.93%	28.60	8.98	30.00
	Group Read&Play	25	26.11%	31.20	8.65	30.00
Metrics to Escape	Group Control	14	24.79%	39.86	11.57	38.71
	Group Read	18	23.29%	37.46	9.72	38.71
	Group Play	18	25.85%	41.58	7.08	40.32
	Group Read&Play	26	26.07%	41.94	10.32	43.55

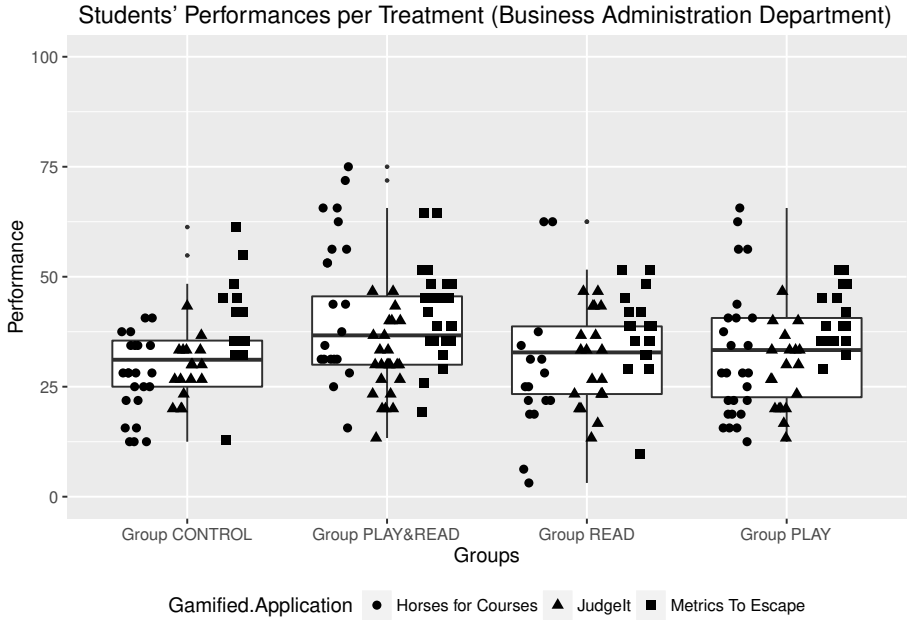

Fig. 1. Students' Performances per Treatment Group for all Gamified Implementations

mentations, had the second highest mean performance of 33.70 out of 100 (sd=12.55). The Read Group follows, with a slightly lower mean performance of 32.18 out of 100 (sd=12.59). Finally, the Control Group had the lowest mean performance, 30.99 out of 100, but also the lowest standard deviation (sd=10.35). Additionally, in order to study the significant differences in the average scores of all groups' performances and given that the assumption of normality was violated, based on Shapiro-Wilk test on the ANOVA residuals, we ran the non-parametric Kruskal-Wallis rank sum test. The null hypothesis of equal differences is rejected (chi-squared= 13.101, df=3, p= 0.004 $<$0.05) and we could therefore establish significant differences between the groups.

Finally, we gathered and divided the data of students' performance on all the gamified applications into two different and larger groups according to Legaki et al. [26]. The first group, named "nonGamified" is composed of the performances of students who belonged to the Control Group and the Read Group, who did not experience a gamified approach in each experiment. The second group, named "Gamified" is composed of the performances of students from the Play Group and the Play&Read Group, who experienced the gamified implementations. This strategy is justified since all the gamified applications are designed according to the same guidelines, the experiments were conducted in exactly the same laboratory conditions and the students have exactly the same educational background. Fig. 2 depicts this alternative grouping of data. The "nonGamified" group had an overall performance equal to 31.58 out of 100 (n=108, sd=11.48) while the "Gamified" group's overall performance was equal to 36.57 out of 100 (n=135, sd=13.25). Since the ANOVA test's assumptions are violated, we ran the Mann-Whitney U test, which is not parametric. By doing this, we are able to demonstrate significant differences in the students' performance within the non-gamified and gamified conditions (W= 59049, p $<$0.001).

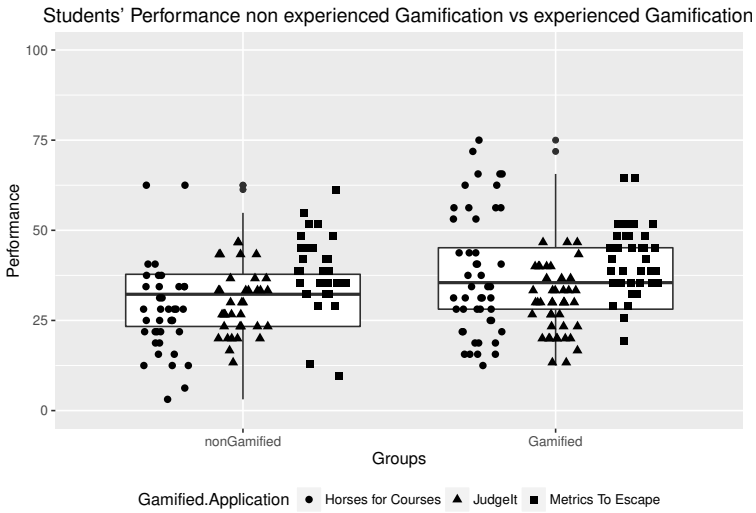

Fig. 2. Performances of nonGamified and Gamified Groups.

5 Discussion

This study presents the results of the application of three pre-existing gamified implementations versus traditional teaching methods, using control and treatment groups, in teaching forecasting in a Business Administration Department class in the School of Business and Economics of the University of Thessaly. Since these gamified implementations (*Horses for Courses*, *JudgeIt* and *Metrics to Escape*) have already been used in a sample composed of students in the School of Electrical and Computer Engineering at the National Technical University of Athens, Greece, we strictly followed the same experimental design. The aim of this study is to examine the impact of these specific gamification strategies on learning outcomes and to make a preliminary comparison between these results and previous findings using the same gamification implementations in different samples. Our results show that gamification may improve student performance in the aforementioned Business School by up to 15.80%, taking into account their average scores and comparing them to traditional teaching methods under certain conditions. The results are not in full accordance with previous findings [26], where the use of the same gamified applications in the School of Electrical and Computer Engineering at the National Technical University of Athens delivered an improvement in student performance of almost 34%. Nevertheless, in both schools, gamification did improve students' performance, under the described certain conditions, in agreement with relative literature [23, 37].

Overall, while these gamified strategies have a positive impact on learning outcomes for both Engineering and Business School students, some limitations should be acknowledged in relation to the results of this study and the design of the experiments. The results demonstrate that gamification can positively influence the students' learning outcomes. However, performances of all groups were compared directly, focusing on the assessment of questions in assessment groups, even though the treatments did not have the same duration, as tasks had. Moreover, it is worth noting that the overall performances of students, discussed in this study are lower than those of engineering students. This is probably a result of the fact that students are at an earlier stage in their studies. Additionally, another possible limitation which should be taken into account, is that there is a marked difference in incentives between the students from two schools; in this study, students participated in terms of a mandatory laboratory exercise instead of having grade as incentive as in the research of [26].

Our study positions gamification as a useful educational tool in teaching forecasting to students in different majors under the discussed circumstances, but also acknowledges its limitations. In terms of further work, a detailed quantitative analysis of this data in comparison with published data from previous experimental research is encouraged, in order to arrive at more robust conclusions. Since gamification literature suffers from a lack of research conducted in a controlled experimental environment, a wide sample, composed of a broad spectrum of students from different backgrounds, educational levels and practitioners, would be of great assistance in order to compare gamification's impact on different populations. Such a form of research would be beneficial to both students and educators, and help them learn and teach forecasting methods more effectively. Last but not least, the design and the implementation of other gamified

applications which could be embodied in F-LauReL^{xp} and deal with other forecasting topics, might further enhance the scope of the research and further refine its findings.

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