

Analysis of outcomes from the gamification of a collaboration intensive course on computer networking basics*

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Abstract. The paper contains a comparison of the results of conducting a computer networking basics course in a gamified and non-gamified way. In the analysis we focus rather on students' learning outcomes, measured by exam scores, rather than on their satisfaction, and other subjective metrics. The experience presented in the article was gathered during last four years (2019-2022). The COVID-19 pandemic, which affected the way the classes were conducted in 2020 and 2021, gave us an opportunity to compare the same means of gamification used in the same course in different learning environments. The evaluation results show that gamification yielded better results when applied in an in-person environment.

Keywords: unplugged gamification, collaborative education, university education, computer networking

1 Introduction

Games – played by people for a few thousand years – strongly motivate the players to devote their time, money, and skills to achieve wins, accumulate points, reach levels, collect artifacts, etc. Computer games, which build upon that phenomenon, are one of the most popular ways of spending free time.

According to the Limelight Networks report [3], in 2020, online gamers spent 5-7 hours a week playing (average: 6.33). Apparently – according to market reports, the breakout of the COVID-19 pandemic did not result in significant growth in the number of gamers. That can be explained by the huge popularity of gaming before the pandemic – in 2020, 68% of adult U.S. population were gamers, while in the EU the ratio reached 50%. The numbers are expected to grow steadily in the future [7][12]. The Entertainment Software Association (ESA) in its 2020 report argues that most of the gamers declare a positive impact of gaming on their lives, including mental stimulation (80-87% responses), increase in teamwork skills (81%), and help in problem solving (63%) [11][2].

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The percentage of gamers in generation Z (18-34 years of age) reaches 81% [11]. In the group of 18-25 (which includes university students), weekly averages of time spent on gaming were 7.08, 7.78, and 7.48 hours in 2018, 2019, and 2020, respectively [1][3]. While the numbers can vary from one country to another, it is safe to assume that majority of IT students play games. That motivated us to experiment with introducing elements of gaming into an IT course.

The goal of this paper is to share our experience obtained from 4 years of leading the courses in a gamified way. The orientation on gamification in courses led by us started just before COVID-19 outbreak (i.e., in the academic year of 2019/20). Therefore, after initial experiences gathered by leading only in-person classes, we had to adjust the teaching method to remote, or blended learning modes. On one hand, we obviously perceived such changes as obstacles, but on the other they provided for making a few interesting observations.

A list of specific questions answered in this paper is as follows:

1. is there any relevant positive overall effect of introducing gamification into IT teaching practice?
2. if yes, can we characterize the group of students, in which the effect is especially visible?
3. does the effect depend on the teaching environment (in person / remote)?

In order to answer the questions we compared the effects of teaching between groups of students which were taught in a gamified way (we call them ‘gamified groups’) and groups which classes were lead traditionally (‘non-gamified’ groups). The material of the course was identical and the number of lectures and laboratory classes was equal to all groups. Moreover, all the students were given the same exam at the end of their courses, consisting of five parts, prepared by five different professors, one of which was teaching the gamified groups. The results of the exam formed the basis for answering the questions.

The structure of the paper is as follows. Section 2 surveys the important developments in the subject area. Section 3 shows how a selected course was augmented with gamification means. Section 4 discusses the results of conducting the course in a gamified way. Section 5 concludes the paper and points out the directions of future work.

2 Background and related work

Gamification is commonly understood as a “process by which elements of game play are incorporated into alternative contexts” [6]. The alternative contexts are not limited to education. Gamified approaches are used, for example, in construction industry [14], marketing [16], and human resource management [4], to name just a few. However, literature surveys show that education is the most studied area of applying gamification. Luckily, the researchers point out not only advantages, but also disadvantages of using gamified approaches in various contexts. For example, authors of [10] demonstrate a case study of a question answering website, in which introducing gamification leads not only to increased

quantity of answers, but also to their decreased quality. As correctly stated by the authors, most of research efforts stop on quantitative analysis, while lacking in-depth insight into operation quality. Therefore, we took *quality as one of guidelines for the presented research*.

The psychological and sociological backgrounds of gamification mechanisms are an active area of research. Many researchers devote their work to understand the mechanisms that make gamified activities popular and effective in multiple areas of daily life (consider, for example [9]). Arguably, gamification is commonly associated with technologies, especially with dedicated software. The author of [8] argues that the association is not obligatory. The paper introduces, or at least announces research on a systematic framework for so called ‘unplugged gamification’, not supported by IT. From our perspective, as university teachers, *“unplugged gaming” is a very interesting area for experiments*.

A number of survey articles referring to the gamification area exist. One of them [13] shows that the list of game elements used in empirical scenarios typically includes points, challenges, badges, and leaderboards. However, the actual list of elements should be selected based on the target audience, and expected outcomes. The target audience can be analyzed in terms of players’ personalities, and the set of gamification means can be adjusted accordingly. An interesting discussion of the reasonability of such adjustment is presented in [15].

Typically, gamified environments incorporate elements of competition. However, we agree with authors of [17], who indicate the needs for incorporating mechanisms of cooperation or collaboration into such environments. Intuitively, we also decided for *promoting collaboration in our experimental story line*. Moreover, the design of the story line and the assignment of roles within teams are meant to promote group integration rather than in-group competition.

3 Selection of the experimental course

The computer networks basics course is obligatory for all IT students at our department. The course was designed to contain 15 lectures (each of which lasts 90 minutes), and 15 labs (also 90 minutes each). While the lecture is led for all the students at once, the labs – which require convenient access to hardware – are conducted for groups of 12 people each, in the way described in section 3.1. At the end of the semester all the students were given a 90-minutes written exam, covering all the course material.

Because the course is obligatory, it is not necessarily of top interest for all the students. Therefore, their attitudes towards the classes differ. While the course curriculum is well-defined, we experiment with teaching methods during the laboratory classes. Introducing gamification into the course has been such an experiment conducted for three to five groups each year. The course was augmented with a story (see section 3.2), inspired by a popular comic book, which encompassed both in-class, and out-of-class gamification means. The term ‘in-class gamification’ refers to compulsory activities, performed synchronously

by groups of students, while ‘out-of-class gamification’ refers to activities which are voluntary, and may be performed asynchronously.

The main reason for which we selected the particular course was that during the lab classes students are split into teams of two to four people, who are collaborating on common tasks. Therefore, as opposed to courses in which the students work on their own, this course offered more possibilities of introducing gaming elements, as well as of drawing interesting conclusions.

3.1 The laboratory classes sequence

Traditionally the laboratory classes were split into three stints, each of which lasted up to five weeks (see figure 1). The first stint, focused on OSI model layers 1 and 2, consisted of four labs (one per week) and one written test (in a lab-free week). The second stint was focused on layer 3, especially on IP addressing and routing. It also lasted five weeks, and also consisted of four labs and a written test. The third stint encompassed L3/L4 boundary (i.e., PAT and firewall basics) and case study lab exercises, built upon the previous labs. Just as in the case of the first two, it ended with a test, but that test consisted of hands-on and oral parts. The final stint lasted three to five weeks, depending on the year and even the day of week the particular group had their classes on, because of holidays, etc. In general, the organization of the course was perceived as adequate, so we decided that the gamified course should *in general follow the pattern*.

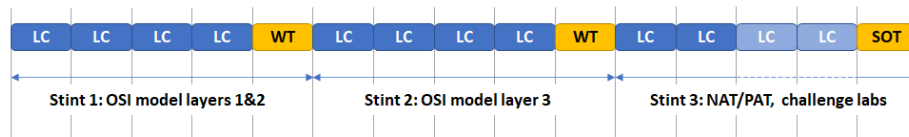


Fig. 1: The flow of computer networking basics course.

Legend: LC = lab class; WT = written test; SOT = skills-based exam and oral test

Occasionally, during the lab classes, the students were requested to fill in a short test, so that their preparedness to the labs was verified. The short tests were not announced in advance. Typically, during a semester, each group of students was given three to four such tests. The progress of the course, as well as the grades received by the students, were reflected in the learning management system (LMS) operated by the university. The LMS was deployed as a customized instance of Moodle, and provided sufficient support for conducting the classes.

From the lab teacher’s point of view, sustaining students’ focus on learning the course contents, has always been the key for their success at the end of the semester. Week-long breaks between laboratory classes were perceived as too long, and – as the students did not have any real incentive – trusting that all of them will learn systematically, proved to be only a wishful thinking. Therefore the second of the guidelines of development of a gamified version of the course was to *add some activities in between regular classes*.

3.2 The story line of the course

In this section, the story line of the course is presented. For the sake of brevity, some elements of low importance were omitted. The story was originally written in Polish, therefore the translation lacks some word-play. Nonetheless, we did our best to save its parodic style. Therefore, the professor is called a Bloodthirster, the students are Unfortunates, a grade is a mace, everything happens in a dark forest, and so forth.

Unfortunates in the Bloodthirster Forest

As every year, a bunch of Unfortunates were sent to the Dark Valley. Four different roads lead to it, including the sinister one – leading through the Bloodthirster Forest. Legend has it that the Bloodthirster strives every year to transform the Unfortunates into Utmost Thugs through elaborate tortures. Therefore, tempted by the mirage of future glory, some of the Unfortunates entered the Forest. They would spend four ghastly months there, hoping that what didn't kill them would make them stronger enough to walk away with a sneer.

General rules

1. The forest is ruled by the Bloodthirster.
2. At the entrance to the Forest, each Unfortunate gets a barrel – empty and divided into four casks. They can fill it according to the Bloodthirster rules only to be able to tame him at the end of the season and receive a mace from him when leaving the Forest (available mace sizes: 3.0-5.0).
3. The Bloodthirster won't let anyone out of the Forest until he finds at least two casks of oil in the barrel (produced by the Unfortunate's head¹).
4. Any Unfortunate can appeal against the Bloodthirster's judgments at any time – the Bloodthirster likes listening to the echoes of voices...

Filling the casks

The casks that form an Unfortunate's barrel can be filled in four distinct ways.

Cask 1: wandering in the Forest, Surprises and oil pressing

The Bloodthirster regularly – once a week – lets the Unfortunates go for walks in the Forest. During the walk, the Unfortunates may (but do not have to) reach the destination set by the Bloodthirster, where they can pour the oil into the first cask. Typically Unfortunates wander in groups of three, although the Bloodthirster allows smaller and larger groups. The walks may be enriched with Surprises prepared by the Bloodthirster – every Unfortunate struggles with the Surprises alone.

The first – lonely – walk. On their first walk, the Unfortunates meet the Bloodthirster for the first time. He introduces them with the rules of the forest.

¹ That comes from a Polish idiom 'mieć olej w głowie', which is used for describing a person as a smart one – it would be literally translated as 'to have oil in the head'.

As a result of the meeting, each Unfortunate braids a rope...

Reward: 0 (words zero, null, nada, nicht).

Subsequent walks (at least nine) – filling the pots. Starting with the second walk, the Unfortunates huddle in teams of three. Each team tries to complete the tasks set by the Bloodthirster, using ropes (a.k.a. cables) and scrap metal found in the Forest (a.k.a. hardware). As a reward for the effort, the Bloodthirster pours a certain amount of oil into the first cask of each Unfortunate. Prizes are awarded individually to each Unfortunate and also to a group - in the event of a rare case of completing the task in the allotted time. The group reward is shared equally among the group members.

At the beginning of a walk, roles of Overseer (OS), Cablemaster (CM), and Scribe (SC) are assigned to the members of each team – by drawing lots and ordering (see table 1). If a team is created only by two Unfortunates, there is no Overseer role. The possible fourth member takes the role of Drunkard, who helps in both topology building and documentation, but lowers the other team members' rewards (see table 2).

Table 1: Roles assigned to team members

Role	Assigned by	Responsibilities
Overseer	draw	Supervision over the construction, configuration, and documentation of the group's achievements
Cablemaster	Overseer's choice	Building topology and preparation of materials
Scribe	Overseer's choice	Lab documentation
Drunkard	Overseer's choice	Up to the group members

Table 2: Rewards assigned to team members (as of the first edition of the course)

Member count	Group reward	Overseer reward	Cablemaster reward	Scribe reward	Drunkard reward
2	6 quarts	not applicable	2 quarts	2 quarts	
3	9 quarts	sum of CM and SC rewards	2 quarts	2 quarts	
4	8 quarts	sum of CM and SC rewards	2 quarts	2 quarts	2 quarts

At the end of the season, each Unfortunate can use up to three pots of oil earned during the walks. Any excess oil can be used for gambling purposes (see: Gambling) or poured into the Sand of Indulgences.

Filling cans (Surprises) On a given signal (and a signal can be given at any time) the Unfortunate tries to pour the oil (as ordered by the Bloodthirster) to a can. Whoever misses the signal does not fill the can. Everyone keeps three best-filled cans at the end of the season, the others can be poured into the Sands of Indulgences or used for gambling purposes (see: Gambling).

Cask 2: November Hunt

November nights make the Bloodthirster especially oppress the Unfortunates. After four walks, the Unfortunates take part in the November Hunt. During the hunt, the Unfortunates are plagued by a series of Bloodthirster's Riddles. Solving each riddle is awarded with oil, which fills the second cask. The amount of the oil collected by each Unfortunate is known about ten days after the hunt.

Cask 3: Mighty frost

Long and cold nights lead the Bloodthirster to seek entertainment - at the expense of the Unfortunates, of course. After eight walks, it's time for the second hunt! As a side effect of the hunt, the third cask is filled in.

Cask 4: Finches' songs

At the end of the season, the Bloodthirster organizes the Festival of Forest Songs. In the beginning, the Unfortunates, who already took at least ten walks in this forest, in groups of three appointed by the Bloodsucker, implement his bizarre ideas. After that each of them - alone - sing sad songs about the means of transport used in the forest and goods which are transported.

Additional rules

Measurement units. Simply put, each barrel contains four casks, each cask contains 18 pots, and each pot contains four quarts. Each can contains five pots, i.e., 20 quarts. The maximum amount of oil one can collect is 288 quarts.

Sand of Indulgences grants an Indulgence in exchange for pouring one can (20 quarts) of oil into it. The oil poured in the Sand of Indulgences must come from the first cask. Note: it is perfectly fine to borrow oil (see: Usury).

An Indulgence allows skipping one Surprise or annihilating one Bloodthirster riddle.

Riddle annihilation. Indulgence can be used to annihilate a riddle during a hunt. As a result, only the riddles that have not been annihilated will be taken into account when evaluating the effects of hunting (for) the Unfortunate who had the Indulgence. This rule also applies to singing (Cask 4) - an Indulgence can be used to ignore one of the melodies.

Usury. In case an Unfortunate lacks oil (e.g., to pour in the Sands of Indulgence), they can borrow oil from the Bloodthirster. Repayment must be made before the end of the season. As long as the loan is repaid with oil from the first cask, the Bloodthirster will not charge interest. Repaying the loan with oil from the second or third cask results in the need to pay an additional quart for each can of oil. The Unfortunate cannot be indebted to more than one cask of oil.

(Un)fortunate initiative. The Unfortunates can propose a hunting date common to all groups. This will allow them to take an extra walk.

Gambling - the way the Unfortunates pass the time between walks. It is about bidding and solving other people's problems. The Unfortunates organize auctions for the privilege of solving the problems of others. The winner risks a declared number of quarts of oil from the first cask. If he succeeds, he is rewarded with three quarts of oil. His bliss also generates oil for the Cablemaster and

Scribe of the group that reported the problem (they get their share of the group reward) as well as the Overseer (he gets half of his reward). The Bloodthirster cares about the integrity of the Unfortunates' veins, so he allows anyone to win the bid no more than three times during the season.

Ranks. As the course progresses, each Unfortunate is assigned a rank – starting with Hamster, ending with Bonebreaker. The ranks reflect progress in the course. Moreover, in case there is only one Bonebreaker in the group, he automatically takes the Overseer role.²

Badges. A number of badges can be earned by an Unfortunate. Any Scribe who prepares three perfect documentations, becomes a Chronicler. Any Cablemaster who builds three perfect topologies, becomes a Tangler. Anyone who was nominated three times for helping other group during the walk, becomes an E.U.Genius. The one who won three problem auctions, becomes an A.B.Normal.

3.3 Mapping the story to the course rules

While designing the story line we did not follow any specific gamification framework rules. Rather, we strictly observed the guidelines, listed in section 2, and paid attention not to overwhelm the students with the story and game mechanics, and preserve the structure of the course. The course was the first one in our department to be led in a gamified way, and therefore we did not have any previous experience with gamification. As a consequence we decided to develop a story around the leveraged sequence of the course rather than to develop a new course sequence in adherence to a story. Our goal was also to gain experience from subsequent courses and adjust the usage of gamification means accordingly.

Introduction of the story did affect the course grading rules especially with regard to the lab classes and short tests (Cask 1). Following the guidelines for gamified courses, the number of points (quarts) that could possibly be collected, exceeded the number taken into account when grading. In the described case, the number of points possible to collect during ten labs and six short tests was $10 \cdot 7 + 6 \cdot 20 = 190$, more than twice as much than 72, which was set as the maximum.³ Therefore, each of the students was able to collect up to five 'Indulgences', i.e., trade the points for eliminating questions during the stint tests. Three of the six short tests were organized online, outside the classroom, three days after last class, in order to make the learning more systematic. Note that the participation in the tests was optional – anyone who skipped the online tests still was able to collect 116 points on average (max 130) – more than 72.

Casks 2 and 3 still represented the results of written tests (after fourth and eighth lab class). Because they counted for 50% of the total grade, they still were the main components of grading. Each test was graded using a 72-point scale. The tests consisted of 14 questions each. The average number of points that

² The names of consecutive ranks follow characters of a popular comic book – they cannot be translated into English directly.

³ On average, due to the inequality of rewards for people having different roles, the number was 176 – still two times more than the maximum in Cask 1.

could be earned for answering the question was just above 5. The annihilation of a question resulted in taking it out from grade calculation. For example, if a student decided to eliminate a question ‘worth’ 6 points, the test result was calculated as sum of the points collected from other answers multiplied by $72/66$.

Similarly, Cask 4 represented skills-based and oral tests conducted during the last lab class. The maximum grade was also 72 points. Two thirds (48 points) could have been earned during the skills-based part, one during short oral exam. The oral exam consisted of three questions, which could have been annihilated – just as in the case of Casks 2 and 3. The differences between gamified and non-gamified courses with regard to point counts are summarized in table 3.

Table 3: Comparison of maximum numbers of points that could be collected in gamified and non-gamified courses.

Course module	Labs and short tests	Stint test 1	Stint test 2	Stint test 3	Total
gamified	190	72	72	72	406
non-gamified	72	72	72	72	288

At a first glance, it seems that the gamified course was much easier to pass, because the passing threshold was not changed, and stayed set to 144. Therefore the possibility of collecting up to about 280% of the threshold value seems to make passing the course much easier. However, that’s not exactly true, because simple sum of points serves only as a criteria for earning respective ranks, which are given for surpassing the thresholds of 20, 60, 110, 160, 200, and 240 points. The final mark was calculated without the excess from Cask 1, which could only be traded for Indulgences. During the four conducted courses, the real average ‘worth’ of an Indulgence was 3 points⁴, and each of the students was able to gain two or three Indulgences. Therefore, in reality, the students could earn 6-9 points by trading.

4 Reflection on conducting the course in varying environments

As presented in section 3.3, the discussed course was gamified in a conservative way. Taking out the story, there were only five elements of gaming introduced, namely: ranks and badges, assignment of roles by a draw, a pool of points that could be traded for elimination of questions during the tests, and bidding for problems to be solved. In this section we share our observations from four subsequent years (2019-2022) the course was conducted in the gamified way. Noteworthy, our experience covers courses led both in person, and remotely (due to the COVID-19 pandemic).

⁴ A stint test contained 14 questions, each graded $72/14=5.14$ point on average; the average score on such a test was 60%.

4.1 Teachers' subjective reflection

Introduction of gaming changed the students' attitude towards the classes' organization. First of all – there was absolutely no trouble in establishing dates for stint tests, common to three or four groups of students. The reward of additional lab (which could have been 'converted' into a few points) was sufficiently motivating. Second – the engagement in conducting lab exercises was visibly increased. Taking into account that the computer networking course is obligatory for all the students, that – in our opinion – was the main positive change. Third – making the additional tests an opportunity rather than an obligation resulted in participation of more than 80% of the students.

Introduction of the Drunkard role proved to be a good idea too. Before introduction of gamified rules, the students were much more willing to work in a single team of four, than in two teams of two. The small reduction of the number of points awarded to the members of larger groups changed the preferences. During the four years of experimenting with the gamified course there were no teams of four students formed.

On the other hand, the initial design of the course proved to be too optimistic in two aspects. First, the bidding for problems was never organized. That resulted both from the limit of lab time (everybody tried to resolve the problems until the very end of the lab class), and the organization of computer network classroom – the equipment used by the students is detached from the Internet, so it was quite hard to obtain a snapshot of configuration. Moreover, the current LMS did not support such kind of activity properly. Second, the badges were assigned too late (they should have been assigned instantaneously). Although the idea was welcomed by the students, who liked collecting badges 'just for fun', the lack of automation of evaluating badge assignment criteria resulted in the need to export grades from university LMS, and evaluate them in an external spreadsheet. That process simply took too much time.

Introduction of the ranks did not affect the course much. The only effect that was observed, was the positive students' reaction to first aggregate report sent to them, entitled "There are no more Hamsters in the forest", which notified them of their good progress at the start of the semester. The subsequent reports were almost unnoticed.

4.2 Course statistics and educational outcomes

In the academic year of 2019/2020, 35 (out of 145) students took part in the gamified course. On average, each of the students received 28 grades, most of them evaluating their work during the laboratory classes. The average score at the end of the semester was almost 177 points (61%). That was a little greater than the baseline from the previous year, which equaled 167 point (58%). The difference was reflected in the exam score – the exam results of the students who participated in the gamified course were on average 5% better, than their counterparts whose classes were led in the traditional way. Similar statistics from the following years are presented in table 4.

Table 4: Comparison of the average grades received by the students in gamified and non-gamified courses.

Academic year	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023
Laboratory classes score	167(58%)	177(61%)	215(75%)	214(74%)	206(72%)
– gamified?	no	yes	yes	yes	yes
Average Exam score					
– in gamified groups	n/a	62%	67%	76%	50%
– in non-gamified groups	57%	57%	67%	71%	46%
Standard deviation of scores					
– in gamified groups	n/a	16%	7%	9%	13%
– in non-gamified groups	15%	20%	11%	19%	15%
Coefficient of variation (CV)					
– in gamified groups	n/a	26%	11%	11%	26%
– in non-gamified groups	27%	37%	16%	28%	34%
Exam pass ratio					
– in gamified groups	n/a	80%	98%	98%	64%
– in non-gamified groups	72%	61%	96%	89%	43%
Number of observations					
– in gamified groups	0	35	60	54	33
– in non-gamified groups	167	110	125	147	129

The numbers presented in table 4 cannot be interpreted directly, because of the changes in courses' environments – in the years of 2019/2020 and 2022/2023 the classes, as well as exams, were led in the 100% in-person mode, as opposed to 2020/2021 and 2021/2022, when classes were organized in remote or blended modes, and exams were conducted remotely. However, a few conclusions can be drawn from our experience. First and foremost, introduction of gamification resulted in an improvement of the exam results. Although the average score increased a bit, the most important difference was visible in the passing ratios. The students who participated in the groups which classes were gamified, were much more likely to pass the exam on their first attempt, both in remote and in-person cases. On the other hand, the number of students who received the highest marks, stayed almost unchanged. Therefore – based on our four years' experience – we concluded that introduction of gamification increased motivation mainly in the group which could not be characterized as enthusiasts of the course subject. The observation is confirmed by the values of standard deviation and coefficient of variation – lower values mean that the scores were closer to the average in the gamified groups. That resulted in more students passing the 50% threshold on the exam and getting positive grades. The distributions of grades are depicted in figure 2.

It should be noted that the effects of introducing gamification are more visible in cases of in-person laboratory classes and exams (2019/2020 and 2022/23). From our perspective, this could be a result of a lack of proper tools to be used cooperatively during the labs. During remote classes, the students cooperated

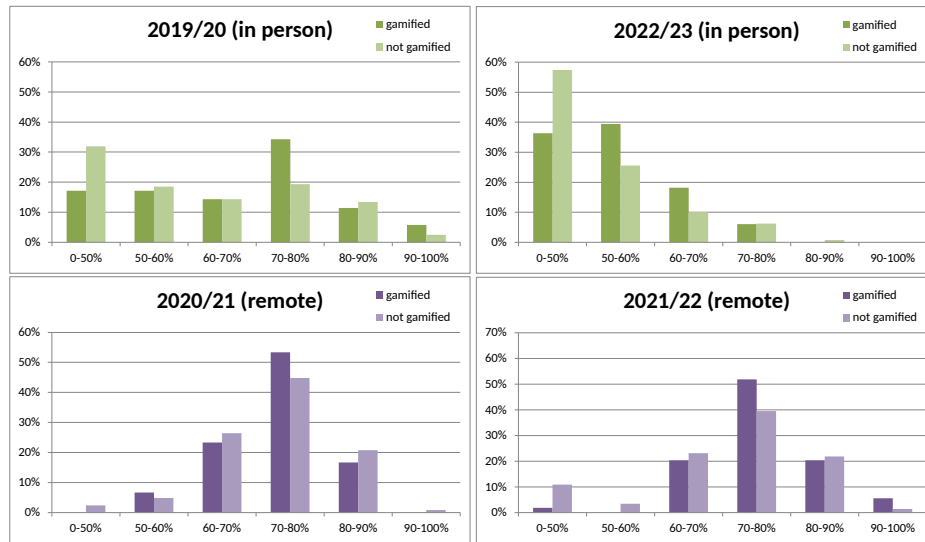


Fig. 2: Distribution of exam grades in gamified and non-gamified groups.

only by sharing a screen with a network simulator run and configured by one of them, therefore making the laboratory experience not very engaging.

4.3 Adjustments to mapping and roles

Over the years, the initial story line, and its mapping to course rules underwent a few adjustments. First of all, the threshold set for the Bonebreaker rank proved to be too high. The first Bonebreaker ranks were awarded just before the end of the semester – too late to use the ability of grabbing the Overseer role more than two times. Therefore, the threshold was lowered to 220, and later to 200. Other thresholds were adjusted accordingly – in 2022/2023 their values were 20, 50, 80, 120, 160, and 200. The change did not result in a dramatic change during the conduct of the course, but resulted in 76% of the students reaching the highest rank at the end of the semester, thus bolstering their satisfaction. In the previous years, the ratios were 50%, 49%, and 33%, respectively.

A more important change, which was suggested by the students in the surveys conducted after the classes, applied to the rule of calculating Overseers' rewards. Starting from 2022/2023 the Overseer gets an average (not sum) number of points earned by the Scribe and the Cablemaster. This change eliminated the tensions that were sometimes observed during the role draws.

5 Conclusions and future work

Based on the experience presented in this paper, collected from four editions of the course, we feel able to answer the main questions listed in section 1.

First of all, the anticipated positive effect of introducing gamification means in the course was observable, although not as big, as some literature sources suggest. That could result from multiple reasons, including our inexperience with gamification. Second, the effect was observable mainly in the group of students who were either not very interested in the course subject, or not very diligent (as they stated themselves in the post-course surveys). The difference in the pass/fail ratio between gamified and non-gamified groups exceeded our expectations. With regard to the third question, we conclude that the effect of gamification was more visible in case of in-person learning environment, as opposed to remote. Although we agree that the observation can be biased by the overall better exam results in the pandemic years, it is worth to note that similar observations were also reported by other researchers [5].

From the perspective, we observed two main obstacles in introducing elements of gamification into daily practice. First of them was our (teachers') reluctance to exit our comfort zones, and evaluate an unusual way of teaching. Second – which can be attributed to the “unplugged” approach, which we opted for – is the amount of time needed to conduct the gamified course. Even simple calculation of the number of grades that need to be given to the students shows the overhead, which is further increased by game mechanics, such as point trading, bidding, etc. Therefore, in the future we'll opt for using IT support for out-of-class activities. Note that the support provided by a typical LMS was not sufficient.

Our future work plan is guided by the outcomes of (voluntary) post-course surveys, in which just above 50% of students took part. 94% of responses to a question ‘would you choose a gamified group again?’ was positive, which is very motivating for gamifying the course in the future. Asked for the reasons for the acceptance, students typically answered that the classes did not lose on merit, and gained on the atmosphere, mainly by the introduction of some humorous elements. As a drawback, some of the students pointed out the complexity of grading rules, and postulated creation of a ‘tactical textbook’ containing practical hints. The scopes of duties associated with the roles were in general accepted (89%), but the draws were unwelcome (37% acceptance before the change in the Overseer role award calculation – at the time of writing we did not collect the surveys from 2022/23 edition of the course). The number of points that can be traded was in general perceived as adequate (58%). Some of the students (21%) postulated organizing more online quizzes in order to increase the pool of points.

From other changes suggested by students, we selected two as the guidelines for further development of the course. First – we are going to associate special abilities with the ranks (for example, trading will be possible only after reaching a certain threshold). Second, we are going to introduce the possibility of collecting “knowledge pills”, i.e., short pieces of information on the course topics.

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