Gaming the Lecture Hall: Using Social Gamification to Enhance Student Motivation and Participation

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Abstract. The traditional lecture is a teaching format that offers students few opportunities for interaction turning them into passive listeners of the lecturers' presentations what negatively impacts on their learning. With audience response systems, that is technology supporting classroom quizzes, breaks that re-activate the students can be introduced into the lecturers' presentations. This article reports on an audience response system coupled with a social gamification of quizzes based on teams: Each student is assigned to a team and the students' answers to quizzes contribute to their teams' success. An immediate overview of responses to quiz questions and the team standings motivates students to participate in the quizzes. The contribution of this article is threefold: First, a team-based social gamification of quizzes aimed at boosting participation in quizzes and attendance at lectures, second, original technological tools supporting the proposed team-based social gamification, and third, an evaluation of the approach demonstrating its effectiveness.

Keywords: Gamification, Audience Response Systems, Online Learning Environments

1 Introduction

The traditional lecture – that is, a lecturer addressing an audience of variable size – is a teaching format offering students few opportunities for interaction: Asking questions and receiving answers is often the only possible form of interaction in a traditional lecture. As lecture audiences grow, students tend to ask less questions because of a well-known inhibiting social barrier: The larger the audience, the greater the fear of speaking out [22]. A vicious circle sets in: The students' reduced activity results in their reduced involvement what in turn results in their reduced learning performances [27] contributing to further reduce their activity.

The reduced interactivity in traditional lectures can be addressed by slightly modifying the teaching format. A widespread approach consists in introducing breaks in the lecturer's exposition that are used for re-activating the students, for example by posing questions to the audience, so called quizzes. While this is effective in lectures with small audiences of about 20, this turns out hardly practicable with audiences of a few ten and fully impossible with audiences of a few hundred students. Indeed, collecting and aggregating the answers of large audiences are time consuming tasks that disrupt the lecture. Audience response systems overcome the obstacle by handing these tasks to software. While such a use of audience response systems in lectures enhances participation and provides a number of students with “active breaks”, there are in our experience still students who remain passive and do not answer the quizzes [19, p. 75], as well as students skipping lectures altogether. Indeed, regular or occasional absenteeism is another widespread problem of lectures [13]. The audience of a lecture generally drops by half during the semester and students that skip lectures try to discover, understand, learn, and practice lectures’ contents one or two weeks or even only a few days before the lectures’ examinations what mostly results in failure in the examination.

With the aim of improving both participation in quizzes and attendance at lectures, a gamification scheme with a social component, referred to in the following as “social gamification”, has been devised. Social gamification is comparable to Nicholson’s [18] engagement dimension. With the proposed social gamification scheme, students are assigned to teams that compete against each other in quizzes conducted during lectures. Each team member gives an individual answer, thus keeping the personal involvement necessary for an effective learning, but doing so contributes to their team’s performance. After each quiz, updated team standings are shown to the audience. This article describes this social gamification of the lecture hall and reports on an experiment pointing to both the effectiveness of the approach and its positive reception by students.

The contribution of this article is threefold: First, a team concept aimed at boosting participation in lecture quizzes as well as attendance during lectures, second, original technological tools supporting the proposed team-based social gamification of quizzes, and third, an evaluation of the approach demonstrating its effectiveness.

This article is structured as follows: Section 1 is this introduction. Section 2 is devoted to related work. Section 3 gives a general overview of the concepts behind the team component and the interface elements supporting the team component. Section 4 introduces the lecture during which the team component has been evaluated and presents the results of the evaluation. Section 5 concludes the article and gives perspectives for future work.

2 Related Work

The social gamification of quizzes conducted during live lectures reported about in this article is a contribution to gamification and relates to audience response systems and peer discussion.

Gamification. Deterding et al. define gamification as “the use of game design elements in non-game contexts” [7, p. 10], a definition which leaves “game elements” open to interpretation. These authors cite Reeves [21] who identifies ten essential elements of games, among others feedback, "competition under rules that are explicit and enforced" [21, p. 80] and teams, and argue that these elements are not in themselves game elements and that it is their contextualization that turns them into game elements.

More support for teams and feedback as game elements or gamification mechanisms comes from Nicholson [18] who introduces various dimensions in which "meaningful gamification" can take place, one of them being "engagement" defined as "creating opportunities for participants to engage with others in meaningful ways" [18, p. 12]. According to Nicholson, leaderboards can be part of a gamification utilizing the engagement dimension for allowing comparison. Nicholson also argues that both cooperative and competitive elements can be implemented so as to achieve effects similar to those observed in sports: Cooperation within teams and competition between teams. Danelli [5] identifies competition and cooperation as drivers of engagement as well using various theories about games and play.

An example for a study in which teams were introduced into an education setting is the experiment conducted by Latulipe et al. [14] for a computer science class: Students in the class were randomly assigned to teams of about five. For the class, a flipped classroom design was adapted: Students studied the content before the lecture that was dedicated to running a set of quizzes; by answering the quizzes the students could earn points for their team. The authors report of a positive attitude among the students towards the team component deployed during the lectures.

Feedback – especially immediate and continuous feedback – is identified by McGonigal [16] as one of four defining traits of games, goal, rules, and voluntary participation being the other three. An area where gamified feedback is used are cars, e.g., for fostering safe or eco-friendly driving. In [24], a virtual passenger is simulated who reacts to the driver's driving style providing an immediate and tangible feedback to the driver. Eco-friendliness can be found in different implementations: From Chevrolet's system that requires to keep a green orb in a optimal position through eco-friendly driving to Ford's EcoGuide that makes the more leaves grow on a display, the eco-friendlier the driving [11]. In all cases actual optimization criteria are made tangible through a reification of the criterion instead of representing it, e.g., by an elusive numerical value (expressing, e.g., the fuel consumption).

While gamification often seems to produce positive results, there is criticism that most gamification systems are traditional "reward systems" motivating extrinsically (motivated by external rewards [23]) but not intrinsically (motivated by the task itself [23]) [18]. Nicholson argues that often the positive behaviour induced by rewards stops as soon as the rewards are no longer given if the user has no intrinsic motivation to further perform the task [18]. Indeed, Nicholson observes that there are situations where reward-based gamification can be positive, e.g., when used to teach a skill that has real-live applications because the learner most likely learns to the see value in the skill itself. While Hamari et al. [9] cite three studies coming to the conclusion that gamification has no long-term effects and that positive effects of gamification most likely may result from its novelty, they state that gamification generally does produce positive results.

Audience Response Systems. Audience response systems (ARS) allow lecturers to conduct quizzes during lectures and to provide immediate feedback to both, students and lecturer alike, on the correctness of quiz answers. In their survey of ARSs, Kay and LeSage [12] list various benefits of ARSs: Engagement, attendance, participation, and discussion among them. A meta-analysis conducted by Hunsu et al. [10] found that, among other, the use of ARSs had a positive effect on a number of learning outcomes such as knowledge transfer, but had no effect on other learning outcomes such as retention of the subject matter. ARSs come in form of clickers, that is, students are provided with a physical device that allows them to participate in quizzes, or in form of web-based platforms, which allow students to participate in quizzes using their own internet-capable devices. Examples of web-based ARSs are GoSoapBox [3] and Backstage [1].

Pedagogical Foundation. Peer instruction is a term coined, and a concept investigated, by Eric Mazur [15]. Peer instruction refers to posing questions to a lecture's audience, first asking the students to consider an answer on their own, then let the students discuss the value of their various answers, each student trying to convince their peers of their own answers [4]. The authors report on a positive effect of peer instruction on the learning performance of students. Byrd et al. [2] report on positive effects on academical results from using cooperative quizzes. It is worth stressing that peer instruction in the aforementioned form is hardly possible with lecture audiences of more than a few ten students and almost impossible with audiences of a few hundred.

An approach close to students' discussions of the subjects to learn is "learning by doing". This approach is traditionally deployed in science, technology, engineering, and mathematics (STEM) education. It is justified by Polya who states that humans "acquire any practical skill by imitation and practice" [20, p. 4]. The value for learning by imitation and practice is especially true for programming, a practical skill with deep mathematical foundations.

The importance of imitation and practice is clearly stressed by the emergence of "try-out" environments integrated in various educational software: Some MOOC platforms such as Codeacademy and freeCodeCamp make it possible to write and execute code directly from the learning material. Coding is thus closely integrated into the teaching material and therefore the learning activity. Stack Overflow, a question and answer platform for coding and software development, allows users to directly test answers in the browser if they are pieces of code in certain programming languages. Getting students to immediately try out code presented in a lecture is a highly desirable goal that can rarely be achieved in traditional lectures.

3 Team Competition

The team-based social gamification described in this article makes teams compete against each other in quizzes conducted during lectures. Participants earn points for their team by answering quizzes on their own. After each quiz, the points earned are computed and distributed and updated team standings are published.

3.1 Team Building and Reward System

The core component is a team building system that can be adjusted along three axes to fit the actual context it is deployed in:

- *Duration*: For what time span will the teams exist?
- *Formation* Who forms the teams? Teams can be formed by lecturers, the software, or by students themselves.
- *Size*: How many students are there in a team?

The team building system does not offer one single team configuration expected to fit all situations. Indeed, a team configuration is heavily dependent on the context, and even for a same context different configurations may make sense.

Another component is the reward system that determines what, and under what circumstances, rewards are given to students' teams for their team members' answers to quizzes. After a quiz, one and only one of the following holds for every student:

1. The student participated and answered correctly.
2. The student participated and answered incorrectly.
3. The student was logged in and did not participate.
4. The student was not logged in.

For each of these four outcomes, an effect on the student's team score can be defined. In the experiment reported about below, both (1) and (2) were rewarded with points since the goal of the experiment was to improve participation. The points awarded for participation act as positive reinforcement (see [25]) for participation. Another possibility, but by no means to only one, would be to punish non-participating students with negative points what would act as positive punishment (see [25]). In the experiment reported about below, (3) and (4) had no effect on the student's team scores.

Subtracting points for non-participation could potentially have a stronger impact on participation because of loss aversion [26] but could also demotivate since it could be perceived as punishment to those team members who participated because through their team they would be punished for the actions of others.

3.2 System

This section introduces the underlying ARS and and its extension with the team-based social gamification described above, in the following referred to as the gamification component. The gamification was built as an extension to the existing ARS of the original teaching and learning platform Backstage.[1] Backstage's ARS provides the usual features: At any time during a lecture, a quiz can be conducted, students can answer using their laptop, the answers are aggregated, and the aggregated results are displayed in the lecture hall or on the students' screens.

Backstage was extended with an interface displaying in real-time the team participation, an overview of all teams' scores, and a dashboard displaying for each student the current score of their team. For quizzes, both multiple choice and fill-in-the-blank quizzes were used.

The display of a running quiz was extended with a real-time overview of the teams' participation. In this overview, each team was represented by a bar of a bar chart with each bar built from segments representing the team's members. Each segment is coloured in one of three colours: Light grey for students who are not logged in, dark grey for students who are logged in but have not yet answered, and blue for students who have answered. Representing each student as a unique segment serves as an immediate feedback and gives students a tangible representation of their contribution or of the absence thereof, respectively.

There are two reasons for including a live overview of team participation: First, a real-time overview of the teams' participation gives lecturers an opportunity to make quizzes more engaging by acting as moderator. As moderators, lecturers can for example call to participation members of teams with a low participation. Calling out specific teams should have a better impact on the participation than calling out to the whole audience because of "diffusion of responsibility", that is, the larger the group, the less responsible individuals feel [6]. While "diffusion of responsibility" is only researched for smaller group sizes and emergency situations, it is conceivable that the results are transferable to other settings, such as the education setting at hand. Latulipe et al. [14] included a live overview as well, but their implementation only contained the team standings, not a real-time overview of team participation.

Second, a real-time overview of the teams' participation directly influences all students to participate so as to contribute to their teams' score by providing both, *intra-group comparisons* (that is, how many people of my team have participated?) and *inter-group comparisons* (that is, how is the participation of the other teams compared to my team?). Social comparison theory [8] teaches that people generally aspire to reach the performance of people similar to themselves, and one could argue that team members and the rest of the audience fit this criterion. Mekler et al. [17] came the the conclusion that leaderboards – an element allowing comparison – tend to motivate people.

After a quiz has been conducted, updated team standings are displayed to all students what again provides both intra-group and inter-group comparisons. The

[1] `https://backstage2.pms.ifi.lmu.de:8080/about/`

updated team standings give information on participation and answer correctness both for each team and for the whole audience as well as possible changes in team placements.

On their own screen, each student is provided with an overview displaying the student's answers, the correct answers, and how many points the student has contributed to their team's score, again, providing a tangible and personalized feedback. Additionally, students are provided with an overview of the current team standings when logging into the ARS in form of a dashboard element.

4 Evaluation

A first evaluation on the effects of the team-based social gamification of quizzes on participation in quizzes and attendance at lectures has been conducted during a small-class lecture, the lecture part of a software development practical. In this practical, students are tasked with developing a browser-based game in the programming language JavaScript in groups of three to four students. The groups were created by the instructor and used as teams for the team-based social gamification of the quizzes run during the lecture.

In total, 24 students were partitioned into 7 teams: 3 teams consisted of 4 students and 4 teams consisted of 3 students. There were four lectures that introduced concepts required for the development of the software project. Lecture 1 had six, lecture 2 four, lecture 3 three, and lecture 4 four quizzes.

The configuration of the team-based social gamification (see Section 3.1) used in the evaluation was as follows: Lecturer-defined teams with a size of around 4 that lasted for the whole duration of the lectures were used. A correct answer was rewarded with 12 points, participation (regardless of the correctness of the answer) with 3 points. Every other action of a student had no effect on a student's team's score.

Methods. To evaluate the effects of the team-based social gamification on the participants of the course, two data sources were polled: the software tracking the students' actions and a survey conducted during the final lecture of the course. The survey covered questions of different types:

1. A first group of questions referred to the student's course of study, current semester, and gender.
2. A second block of questions aimed at measuring the motivation brought by the team-based social gamification.
3. A third block of questions aimed at measuring the engagement brought by the team-based social gamification.
4. A fourth block of questions collecting self-assessments of participation.
5. Two questions with free-text answers allowing students to give further feedback.

For (2), (3), and (4) the answers were given on a 4-point answer scale from *strong agree* to *strong disagree* with no neutral choice. Data collected directly from the system was quiz participation, team participation, and the history of team standings.

Results. The data acquired from the software refer 22 students for the first lecture and 24 students for all subsequent lectures. The reason for the difference in numbers is that two students had not registered to the software system by the time the first lecture took place. In the last lecture, a total of 19 students took part in the survey, 9 of them were female and 10 male. The students' current semester ranged from 2 to 8. With one exception, all participants enrolled in a computer science course of study.

Figure 1 shows how the team standings developed over time after each quiz. There seem to be two groups: A first group consisted of Team 7, Team 4, Team 1, and Team 2 – those teams participated in the competition for a place on the winner's podium. Team 5, Team 3, and Team 6 did not take part in the race for the first places: Team 6 took part at the beginning but starting with the third lecture the difference to the leading group grew steadily. Teams 5 and 3 show a nearly identical progression, the difference between the two being caused by the last quiz of the second lecture. The competition ended with four teams on the winner's podium, as the race between Team 1 and Team 4 ended in a draw.

Table 1 shows the teams' participations over the time-sorted lectures. The participation in quizzes increased for the first three lectures then dropped sharply. The average participation in quizzes was 75% with four of the teams beating the average and three teams performing below average, two of which were teams with three members.

Table 2 shows the survey results: The team competition seems to motivate the students to participate in quizzes with the real-time overview standing out as motivator (Block 2). The team-based social gamification of quizzes fostered engagement: Students discussed answer options with their team members before answering and tested the code the quizzes were referring to. The students expressed that the team-based social gamified quizzes make a lecture more engaging and more fun (Block 3). The majority of students would have taken part in the quizzes and brought a device even if there would have been no team competition. Only a minority of the students would have preferred to answer quizzes without the team-based social gamification (Block 4).

Discussion. The results indicate that the team-based social gamification had a positive effect on the participation in and on the engagement during the lectures. An experiment comparing participation in and on the engagement during the lectures with and without social gamification is outstanding and will be conducted in the forthcoming months.

The team standings given in Fig. 1 show that the team-based social gamification of quizzes introduces a competition: Indeed, there are changes in rankings, overtakes, and comebacks. While team standings alone are not an indicator of how students perceived the competition, the survey results clearly show that students perceived the competition introduced by team-based social gamification of quizzes and were motivated by that competition. The cooperation that

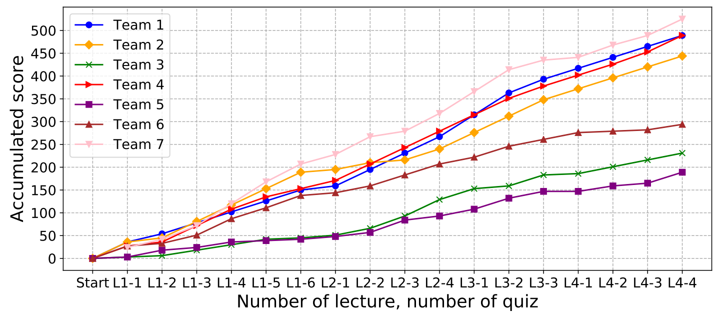

Fig. 1. Development of the accumulated team scores after each quiz (the x-axis represents the time-sorted quizzes, the y-axis represents the accumulated scores).

Table 1. Team participation in quizzes over the time-sorted lectures.

	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7	Average
Sizes	4	3	3	3	3	4	4	–
Lecture 1	0.78	1.00	0.33	1.00	0.67	0.67	0.88	0.76
Lecture 2	0.75	0.67	0.83	1.00	0.92	0.50	1.00	0.81
Lecture 3	1.00	1.00	0.67	1.00	0.67	0.50	1.00	0.83
Lecture 4	0.50	0.67	0.58	0.83	0.42	0.31	0.75	0.58
Average	0.76	0.84	0.60	0.96	0.67	0.5	0.91	0.75

Table 2. Results for the questions of the survey grouped by the blocks described in Methods. Strong agree was assigned a value of 4, agree a value of 3, disagree a value of 2, and strong disagree a value of 1.

Statement	Mean	SD
Block 2: Motivating Components		
Motivated by the live overview of submitted responses	3.32	0.75
Motivated by competition with other teams	3.16	0.83
Motivated by the chance to contribute to team's score	3.21	0.71
Block 3: Engagement through Team Component		
Lecture became more engaging through the team component	3.16	0.69
Discussed answers with the team to get answer correct	3.21	0.63
Tried out quiz' code before answering to get answer correct	2.79	0.63
Competition was fun	3.16	0.60
Block 4: Participation without Team Component		
Would have participated without team component	3.16	0.83
Would have brought device without team component	3.16	0.83
Would prefer to solve on my own without points	1.90	0.57
Would prefer to solve on my own with points	1.84	0.69

took place within teams is evident: The majority of the students discussed their answers with their team before submitting them.

The participation in the competition increased steadily during the first three lectures but dropped sharply from the fourth lecture onward. One could think that the positive effects of the social gamification are short-lived, but the authors presume another reason: The structure of the practical required students to actively start coding starting from the first week. Due to bank holidays, the fourth lecture took part in the sixth lecture week at which most teams were already deeply involved in the project and probably had already learned the techniques of lecture 4 on their own, therefore not seeing the point of attending the lecture. The effect on participation will be further investigated in further courses with larger audiences what should provide more conclusive answers. As of attendance to lectures, the same seems to be true: With the exception of the last lecture, no more than four students were skipping the lecture.

The survey shows that the competition had motivating effects on the students with each of the survey items in the category motivation (Block 2) ranging from "agree" to "strongly agree". According to the survey's results, one motivating factor for participation was the real-time overview. Thus, the results of the evaluation suggest the conclusion that the overview worked exactly as intended. Students favour the competition introduced by the teams over doing the quizzes by themselves and without being rewarded points. While the majority of students answered that they would have brought their device and participated in quizzes regardless of the team-based social gamification, 2 and 3 students respectively, answered that they would not have brought devices or participated without the team-based social gamification, which is no small proportion of the 19 students who took the survey.

The team component thus seems to introduce new layers of engagement: The majority of the students discussed their answers with their team mates before answering, and a smaller majority of the the students also tried out the code referred to in quizzes before answering. The team-based gamification of quizzes is perceived as introducing a fun element into lectures. The lecturers themselves had the feeling that the lecture audience was more lively during the quizzes than during the presentations.

A point of criticism expressed by several students was that the size of a team had an impact on the team's success since teams with four members always had the possibility to gain a 12 point advantage over teams of three per conducted quiz. The reward system will be corrected in the future so as to avoid such an effect.

5 Perspectives and Outlook

Learning from STEM lectures is often hindered by a low level of student activity what negatively impacts learning. To address this drawback of traditional lectures and make lectures with audiences of varying size more interactive, this article introduced an audience response system coupled with a team-based social gamification of quizzes. With this approach, teams compete in quizzes run during lectures, the individual participation of a student to a quiz contributing to their team's score. An evaluation conducted during a small-class lecture has shown the potential of the approach: It enhances interactivity and participation and adds new layers of engagement to lectures.

For future work, further game elements could be introduced to the team component like for example "power ups". Furthermore, the reward system must be adjusted so as to avoid giving larger teams an advantage over smaller teams.

Gamification injected directly in live, or face-to-face or traditional, lectures has the potential to make lectures more fun and more engaging for students – two factors of more positive learning outcomes. This article has demonstrated the positive effect of such an approach based on a team-based social gamification of quizzes.

Acknowledgements The authors are thankful to Jacob Fürst for the implementation of the quizzes and the groundwork for the team-based social gamification described in the article which he did as part of his unpublished bachelor's thesis.

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