Analysis of a Small Gamification Addition to Labs

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Abstract

One small gamification aspect was incorporated into senior chemical engineering labs. "Bragging Points" were awarded for certain things that the students should be doing in classes anyway, such as arriving on time and following instructions for reports. Bragging Points were awarded only to teams to encourage students to hold their teammates accountable. Approximately 70 Bragging Points were available during the course. Twenty Bragging Points could be converted to course grade points as extra credit on either individual exam grades or formal reports. Extra credit on multiple exams or reports was allowed, one for each block of 20 Bragging Points. A display board in the lab control room let students see which team was doing the best in the points race. Students themselves noticed that the teams with students with reputations for earning good grades also had the most Bragging Points. Anecdotally, students were on time to classes and meetings more when they received Bragging Points that in earlier semesters without them, and the faculty felt greater pressure to be on time to class, too! An analysis of the correlation of grades with Bragging Points earned and compliance with course expectations will be presented in this paper.

Introduction

Laboratory courses are a dreaded part of the chemical engineering curriculum for both faculty and students. Students see long hours working with a team of peers that they may or may not like, gathering data, analyzing data, and writing "endless" summary reports of their findings. Faculty see the long hours making sure the equipment works, training TAs and students to use the equipment, repeating safety rules on a daily basis, and helping student teams work out their interpersonal problems only to then be faced with hours of grading lengthy reports. And, although the students only have to complete the work once, for faculty, the cycle repeats annually.

Two years ago, we attended a presentation on gamification in a laboratory course[1]. Although the plan used in that paper did not suit us, the idea of adding an element of fun and competition to the Unit Ops Lab had a certain appeal. We brainstormed ways to incorporate the game concept and fix some of the small annoyances of teaching the lab courses. The small gamification addition was dubbed "Bragging Points". The idea would be to recognize the students for doing something right (that they probably should have been doing anyway) and let them turn those points into small rewards (course points). We developed a preliminary list of "pet peeves" and kicked off the game in Fall 2013.

Intent

At the University of Tulsa, this lab course uses two professors working as a team. One is responsible for the physical aspects of the lab course: pre-lab work, modifying equipment and procedures, training TAs, and supervising the experimental phase. The other is responsible for the reporting phase of the lab course: meeting with each team to discuss their data analysis,

guiding them through the report write-up, then grading the final report. We thought about the attributes of the more successful students and the shortcomings of the less successful students to create a list of ways to earn bragging points. We also added an option for them to impress us in ways that we had not foreseen.

The list of opportunities for Bragging Points is given below, along with the points available for each. Approximately 70 points were available. We planned to track points earned during the semester and report them on a leader board in the lab once a week, such as shown in Figure 1.

- Creating a team logo (1 pt)
- Having no safety violations (1 pt per lab day, 6 lab days)
- Leaving the lab clean (1 pt per lab day, 6 lab days)
- Everyone in the team arriving on time to lecture, lab, or calc session (1 pt per session, 17 sessions)
- Submitting a minimal number of files for each report (1 pt per report, 15 reports)
- Having no number abuse in reports or oral presentation (correct presentation of numerical results, 1 pt per report, 13 reports)
- Having no first-person errors in formal reports (not available for the revision, otherwise 1 pt per report, 3 reports)
- Submitting a complete presentation draft (1 pt)
- Asking good questions after oral presentations (1 pt per presentation, 2 presentations)
- Submitting videos under 500 MB (1 pt per video, 2 videos)
- Making a fun/interesting video (1 – 3 pts per video, 2 videos)
- Making the best video, the one selected for next year's class (6 pts for the entire class, 2 pt maximum per team)
- Congeniality winner (team named by the other teams as working together the best, 6 pts for the entire class)
- Being caught doing something good (discretionary)

Figure 1. Bragging Points leader board made from foam board and cup hooks, with cardstock points cards and a small Post-it note with the date points were last posted.

At the end of the semester, students could convert their Bragging Points into extra credit. Each block of 20 Bragging Points became an extra credit opportunity for either adding 5 percentage points to an exam or multiplying a formal report grade by 1.05. The two exams counted for 15 to 17% of the course grade, and the four formal reports were 20% of the course grade, meaning that an exam extra credit opportunity was 0.375% to 0.425% of the course grade and a formal report opportunity was 0.25%. Students could choose individually how to apply their bonus points opportunities. The most a student could gain directly from Bragging Points was 0.85% of the course grade.

In addition to the bonus points, we planned to offer the team who had the most Bragging Points at the end of the semester a selection from the prize box of dollar store items that one of us keeps.

Implementation

Bragging Points were implemented for Lab I in Fall 2013 and Lab II in Spring 2014. We attempted to keep track of points earned in the Excel spreadsheet gradebook for the course, and a tally of points was posted on the leader board every week or so. Implementation problems were found in remembering to award points, tallying points, communicating whether or not points were earned, and naming Congeniality winners, as discussed below.

In Fall 2013, the first time we were using Bragging Points, a separate Bragging Points tab was added to the course Excel gradebook. As each team earned points, the number, date, and reason were entered on the Bragging Points tab. A total for each team was kept at the top of the worksheet for easy reporting to the teams. Although this allowed us to easily keep track of the Bragging Points, it did not remind us to award them and it did not clearly communicate to the students why they were earning points.

Since we found ourselves frequently forgetting as we were grading reports to award Bragging Points, we added Bragging Point rows to the bottom of the grading rubric for each report for Lab II in Spring 2014. An added benefit was that the returned gradesheets directly communicated to the teams if they earned Bragging Points. It also meant that the Bragging Points were reported on the spreadsheet tab for each team, scattered over 700 rows for each team. One professor continued to enter Bragging Points on the Bragging Points tab, but the other professor reported them only on the team tabs. The reported tallies (taken from the Bragging Points tab) were artificially low all throughout the semester until the Bragging Points were collected on one tab at the end of the semester. Although having the Bragging Points on their own tab and throughout the team tabs was better at reminding us to award them and at communicating them to the students, we did not do a good job of calculating and reporting tallies.

Since we did not use the Bragging Points tab well in the Spring 2014 semester, for Fall 2014 the Bragging Points were recorded only on the team tabs. A section was added to the bottom of each team's tab to track Bragging Points not associated with reports. Whenever a tally was needed, the professor used the filter function to show only the rows associated with Bragging Points and mentally added. The sort function created many rows with #REF that made it difficult to know

which rows to tally. The gradesheet was stored on Office 365, which does not support the filter function in Excel Online. Since making the tallies required downloading the file, filtering, and mentally adding, we reported tallies only every two weeks. The best solution to the reminding, tallying, and communicating issues discussed so far seems to include rows on the grading rubric and a separate Bragging Points tab.

As initially implemented in Fall 2013, the students knew how many Bragging Points they had earned but not why. Adding rows to the grading sheets let the students know when they earned points on reports, but roughly half of the available points are not associated with a report. We created a slip of paper (1.2" tall x 3.33" wide) for each Bragging Point opportunity, as shown in Figure 2. At the end of each lab and lecture, slips were posted just inside the door of the departmental computer lab, the main gathering space for our students, as shown in Figure 3. If a team earned a Bragging Point, the instructor put the team name and date on the slip. If the team did not earn a point, the instructor crossed off "Bragging Point" and the type of point but also wrote why the team did not earn the point (left equipment on, for example) as well as the team name and date. The combination of Bragging Point rows on the grading rubrics and the Bragging Point slips posted in the lab meant that the students knew why they were or were not earning Bragging Points.

ChE 4013 Bragging Point Left Lab Clean	ChE 4013 Bragging Point No safety violations

Figure 2. Example slips for reporting Bragging Points not associated with reports

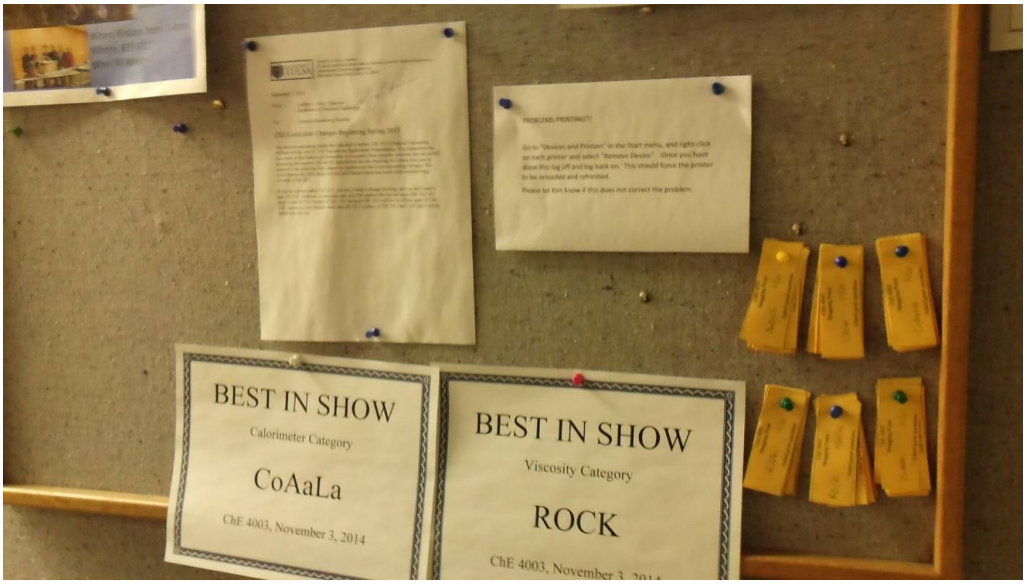

Figure 3. Bragging Points slips (lower right) on the bulletin board of the departmental computer lab.

Naming Congeniality winners was abandoned less than halfway through the first semester that Bragging Points were used. The plan was to encourage students to observe how other teams functioned. Each team met with a professor every other week to discuss calculations and plan for presenting results. During these calculation sessions, we planned to ask each team for its vote for the Congeniality Bragging Point. We kept forgetting to ask the teams during the calculation sessions. We were unable to award the points without votes for the most congenial team. There is no grade associated with the calculation sessions for us to add a row in the gradesheet to remind ourselves. The Congeniality Bragging Points were dropped because we simply forgot to gather votes for them.

Analysis

In this paper, we compare one year of laboratory courses taught without Bragging Points with a year taught with Bragging Points. A summary of basic descriptors of the course is shown in Table 1. Students are required to take both Lab I which is taught in the Fall semester and Lab II which is taught in the Spring semester. Students are encouraged to take them in that order, but schedule issues occasionally result in students taking these courses out of sequence or taking a year off between Lab I and Lab II. Fall 2012 and Spring 2013 have 19 students in common. The number of students is 40% larger in the second year and the number of teams is 50% larger. Fall 2013 and Spring 2014 have 32 students in common, and there are two students in common with Fall 2012 and Spring 2014. Team size of three is considered optimal for the Fall course and four is optimal for the Spring course, but team size is largely dependent on distribution between the time options available during enrollment. One instructor was the same for all four times under study, however the second instructor varied during these four semesters.

Table 1: Basic Information about the Sections Being Compared in this Study

Semester	Fall 2012	Spring 2013	Fall 2013	Spring 2014
Bragging Points Used?	No	No	Yes	Yes
Students Enrolled	25	25	36	34
Number of Teams	7	7	12	9
Experimental Instructor	Ford	Ford	Ford	Ford
Report Instructor	Wisecarver	Sublette	Patton	Johannes

We hypothesized that the structure of our game would improve teamwork and the points that are earned uniformly by all members of the team. Table 2 compares the various components of the course grading for the four semesters with indications whether the grade was recorded uniquely by individuals or by the team as a whole. Oral and Video Presentations earn approximately half of their points based on contributions of the team while the other portion of the points are based on individual presentation style. It should be noted that there was no Safety Lab grade in the Spring of 2013 as the Safety Lab was simply the pass/fail completion of a SACHE certificate.

Table 2: Comparison of Individual and Team Performance

Semester	Fall 2012	Spring 2013	Fall 2013	Spring 2014
Bragging Points Used?	No	No	Yes	Yes
Individual: Exam Scores	79	78	88	71
Individual: Pre-Lab Quiz Scores	91	94	93	96
Individual: Safety Lab Report	92	n/a	97	98
Individual: Teamwork Score (Mid)	86	94	90	94
Individual: Teamwork Score (End)	96	91	95	93
Individual: Professionalism	98	85	91	95
Combination: Oral Presentations	90	84	91	92
Combination: Video Presentations	86	90	87	89
Team: Pre-Lab Reports	81	81	81	85
Team: Formal Reports	88	86	88	91
Team: Informal Memo Reports	85	83	88	89

Due to the small number of students, no effect was statistically significant; however, some observations may be made. Individually scored technical items (exam, quiz and report scores) increased from 2012/13 to 2013/14 with the exception of the Spring exams. A weighted average of the individual technical items increased from 87 in 2012/13 to 91 in 2013/14. The individual soft skills (teamwork and professionalism) increased from 92 to 93. The team items increased from 84 to 87. Since the teacher pairings had changed each semester, we examined the items that were graded by the same professor in all four semesters: Pre-Lab Quiz Scores and Pre-Lab Reports. The individual work (Pre-Lab Quiz) increased by 2 points from 2012/13 to 2013/14. The team component (Pre-Lab Reports) was unchanged for the Fall semester, but showed a 4 point increase in the Spring semester for an average increase of 2 points from 2012/13 to 2013/14.

The course averages are computed based on the weightings for the course. They vary slightly from semester to semester, but the numbers are summarized in Table 3. It can be seen that the course average increased more than 2 points from 2012/13 to 2013/14. The number of bragging points earned by each team was averaged. Since more points were available in Spring 2014, these were weighted as a percentage of the maximum earned by any team. Most of the students enrolled in Spring 2014 had also been enrolled for Fall 2013 and all teams had a majority of students who were on-track. It is our belief that the students worked harder to earn the bragging points as they began to figure out the system and see their scores on the scoreboard. Therefore points increased late in the Fall semester and continued to increase in the Spring semester.

So what was the effect of turning the bragging points into course points? The number of course points possible to earn was approximately 1 point and resulted in a grade change for 1 student each semester. In previous semesters, instructors had elected to curve the course grades in order to achieve a grade division that matched the historic grade distribution for this course. Those curves were typically 1 to 2 points. The semesters where bragging points were used, no additional curve was deemed necessary.

Table 3: Course Grades

Semester	Fall 2012	Spring 2013	Fall 2013	Spring 2014
Course Average	87	85	89	88
Bragging Points Earned, Average	n/a	n/a	51	59
Weighted Bragging Points Earned	n/a	n/a	88	92
Curve Given	1.5	1.0	0	0
Earned A before curve	1 (4%)	7 (28%)	18 (50%)	11 (32%)
Earned B before curve	24 (96%)	12 (48%)	18 (50%)	23 (68%)
Earned C before curve	0 (0%)	6 (24%)	0 (0%)	0 (0%)
Earned A w/ curve or Bragging Pts	8 (32%)	8 (32%)	19 (53%)	12 (35%)
Earned B w/ curve or Bragging Pts	17 (68%)	11 (44%)	17 (47%)	22 (65%)
Earned C w/ curve or Bragging Pts	0 (0%)	6 (24%)	0 (0%)	0 (0%)

Although the improvements to course grades were small, the biggest effect was on the tone of the class. Students would walk into the lab each week and check out the scoreboard and discuss ways that they could pull ahead of the leaders. The relationship between faculty and students improved because they were being recognized for what they did right. Although no student explicitly mentioned the bragging points in course evaluations, there was a more positive tone to all comments from students in the semesters with bragging points. There were fewer complaints about the level of work or that they were graded too harshly for the amount of time put in on the reports. The authors of Reference 1 noted similar changes with their gamification of lab. We noticed more collegiality within and between teams and the students treated us more as a coach than a taskmaster. Faculty were also pleased that no curving of the course was necessary. The grades were better already.

Conclusion

A small aspect of gamification was added to the senior unit operations laboratories to give incentives to do what it takes to earn higher grades. Bragging Points were awarded to teams for being on time to class, correctly presenting numerical results, following instructions for reports, and other actions that successful students do. Blocks of points could be converted to extra credit for exams and formal reports. Keeping track of and reporting the Bragging Points presented some management difficulties which have been worked out. Some individual and team grades were slightly higher with Bragging Points than without, which was just enough for the faculty to no longer curve the course grades. In addition, interactions between students and faculty and between teams were more pleasant and cooperative with Bragging Points. Similar incentives for doing the things successful students do could be added to lower-level courses, particularly at the first opportunity to train students in the major.

Bibliography

1. Daniel Burkey, Daniel Anastasio, and Aravind Suresh, Improving Student Attitudes Toward the Capstone Laboratory Course Using Gamification, 120th ASEE Annual Conference and Exposition, Atlanta, GA, June 23 – 26, 2013.