

9-5-2022

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Recommended Citation

Arpita Vats, Gheorgi Guzun, and David C. Anastasiu. "CLP: A Platform for Competitive Learning" *Educating for a New Future: Making Sense of Technology-Enhanced Learning Adoption* (2022): 615-622. https://doi.org/10.1007/978-3-031-16290-9_58

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CLP: A Platform for Competitive Learning

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Abstract. We introduce the Competitive Learning Platform (CLP), an online continuous improvement tool that provides automatic partial performance feedback to students or groups of students on individual or collaborative assignments. CLP motivates students to do their best and come up with new solutions that can lead to improved assignment results before the assignment deadline. In this work, we describe the CLP system and present the results of a comprehensive set of analyses aimed at gauging the impact of utilizing this platform on student motivation, engagement, and performance. The analyses are based on a rich dataset containing CLP submission, student outcome, and student feedback data obtained from a variety of undergraduate and graduate classes using the tool at two universities over a period of five years. The sample includes 18 courses, 606 students, and 15782 CLP submissions. Results indicate that CLP is beneficial in this setting, leading to active student participation and improved motivation.

Keywords: interactive learning · competitive learning · continuous improvement · immediate feedback

1 Introduction

In the classic lecture-based educational environment, the professor introduces basic concepts during class and students are required to complete homework assignments to strengthen the knowledge they acquired in class. In general, there are few opportunities to compare solutions with those of peers. This traditional way to educate is especially good for those cases where there is a defined set of right answers and where the focus is on correct results, rather than the approach used to achieve them. While this approach has been successful over the years, it does not greatly encourage creative thinking or stimulate enthusiasm in students.

In this work, we introduce the *Competitive Learning Platform* (CLP), an online tool that provides automatic partial performance feedback to students on continuous improvement problems/tasks, motivating them to do their best and come up with new solutions that can lead to further performance improvements. Student submissions for homework problems are evaluated in real-time and anonymously shared with peers as a motivating factor for subsequent solution refinement. In this paper, we describe the CLP system and present the

results of a set of analyses aimed at gauging its impact on student motivation, engagement, and performance. An early analysis of the usefulness of the CLP system, based on only 5 courses, was presented in [6].

2 Competitive Learning Platform

We developed a Competitive Learning Platform (CLP) system that engages students in active learning through peer contests. CLP was developed with the aim to motivate students and promote student engagement in a course, and, unlike systems such as Kaggle³, is not limited to solving machine learning problems. Students are assigned a (homework) problem they must solve to the best of their ability. Then they submit their assignment results in the CLP on-line portal and, in real time, are given an evaluation score on their submission.

For a particular student, a general CLP dashboard displays a leaderboard with the top three current scorers in the class plus their best score and rank, a graph displaying the class score distribution, a graph displaying the trend of personal submissions, and a table containing all the submissions of the student and corresponding scores. To avoid discouraging students from participating in CLP, only the top 3 scores and the student's own score and rank are displayed. To reduce the potential stress such a competitive environment can pose on some students, CLP provides an option to not display the competition leaderboard.

The CLP system remains open for submission for the duration of the assignment, in most cases 2-3 weeks, and students are allowed a finite number of submissions a day. Students may choose any of their submissions to be counted as their final submission used for grading.

3 Method

The purpose of this study is to gauge the effectiveness of CLP at improving student engagement and learning. To achieve this goal, we have gathered a comprehensive set of data from 18 courses, 606 students, and 15782 CLP submissions at 2 universities. In this section, we will describe these data and the analyses we performed using them.

3.1 Sample

The CLP system has been in use as an active learning tool in more than 20 Computer Science and Engineering classes at San Jose State University and Santa Clara University over the past six years, taught by 3 different faculty. Of these, 3 undergraduate and 15 graduate courses were included in this study. Table 1 lists the number of students in each course and the classification of those students (G/U).

3.2 Instruments

CLP submissions and survey: CLP keeps track of all student profiles and their submissions and partial and full scores for those submissions. For most

³ <https://www.kaggle.com/competitions>

Table 1: Classes and Student Distribution

| Class | Subject | Session | Students | G/U | Survey | Engagement |
|-------|-----------------------|---------|----------|-----|--------|------------|
| 1 | Data Mining | Sp 17 | 29 | G | Y | N |
| 2 | Data Mining | Fa 17 | 40 | G | Y | N |
| 3 | Data Mining | Fa 17 | 29 | U | Y | N |
| 4 | Data Mining | Sp 18 | 46 | G | Y | Y |
| 5 | Data Mining | Sp 18 | 42 | G | Y | Y |
| 6 | Large-Scale Analytics | Sp 18 | 46 | G | N | N |
| 7 | Data Mining | Fa 18 | 47 | G | Y | N |
| 8 | Data Mining | Fa 18 | 25 | U | N | Y |
| 9 | Data Mining | Fa 18 | 42 | G | N | Y |
| 10 | Large Scale Analytics | Sp 19 | 50 | G | N | Y |
| 11 | Data Mining | Sp 19 | 45 | G | N | Y |
| 12 | Data Mining | Wi 20 | 31 | G | Y | Y |
| 13 | Machine Learning | Sp 20 | 28 | G | Y | Y |
| 14 | Machine Learning | Fa 20 | 30 | U | Y | Y |
| 15 | Data Mining | Wi 21 | 21 | G | Y | Y |
| 16 | Deep Learning | Sp 21 | 31 | G | Y | Y |
| 17 | Data mining | Sp 21 | 46 | G | Y | Y |
| 18 | Data mining | Sp 21 | 41 | G | Y | Y |

classes using CLP, we administered a survey at the end of the course to get feedback on the CLP system from the students in the course. In order to reduce bias, the survey consisted of both negative and positive questions, which spurred students to carefully read the survey questions and choose appropriate answers. The survey contains ten closed-ended questions and four open-ended questions. Some of the closed-ended questions were a modified version of the system usability scale [2]. Answers were coded 1–5 in the following order: *Strongly Disagree*, *Somewhat Disagree*, *Neither Agree Nor Disagree*, *Somewhat Agree*, and *Strongly Agree*. Table 2 presents the questions asked in the survey and their polarity (positive or negative). Moreover, Table 1 (*Survey* column) shows which of the classes used the survey instrument.

Table 2: Survey Questions

| ID | Question | (+)/(-) |
|----|---|---------|
| 1 | I would prefer to use a competitive learning platform for my homework assignments. | + |
| 2 | I found that the leader board function in CLP discouraged me from trying to improve. | - |
| 3 | I thought the CLP system was easy to use. | + |
| 4 | I hope I never have to compete in a homework assignment again. | - |
| 5 | The leader board function in the CLP motivated me to try my best. | + |
| 6 | I found the CLP system unnecessarily complex. | - |
| 7 | I would imagine that most people would learn to use the submission system in the CLP quickly. | + |
| 8 | I found the information provided by the CLP was insufficient. | - |
| 9 | The personal submissions table and graph summary were helpful to gauge my progress. | + |
| 10 | I found the personal submissions graph for a given assignment unhelpful. | - |
| 11 | What were the most useful features of the CLP? Why? | + |
| 12 | What were the downsides of using the CLP system? Why? | - |
| 13 | How, if at all, did you approach solving a CLP homework assignment in a different way than you would have approached a normal homework assignment? | +/- |
| 14 | Did you choose to display leaderboards before submission deadlines? If you could go back to the beginning of the semester and change you choice, would you? Why or why not? | +/- |

Learning management system data: Courses at both universities use the same learning management system (LMS), which provides both student outcome and engagement data. For each class using CLP, we retrieved student assignment grades for all CLP assignments. Additionally, the LMS provides, for each student, two engagement scores, namely the number of page views and a participation score. We used assignment grades and these scores to gauge the correlation between CLP engagement and course engagement and success. While grades

data were available for all but one course, LMS engagement data were only available for more recent courses, as this feature was only recently introduced in the LMS system. Table 1 (*Engagement* column) shows for which of the classes we obtained student engagement scores.

4 Results

As a means to understand the usefulness of the CLP system toward improving student motivation and engagement, we are interested in answering the following research questions:

A. Do students believe CLP is a helpful tool in their learning in the classes that use it? After being introduced to the CLP system at the start of each course, even though they are given the option to treat assignments as they do in other classes, the overwhelming majority of students choose to compete in CLP assignments. Fig. 1 shows the percentage of students that opted in to the competition for each class. On average, 96.16% of graduate students opted in, while only 88.07% of the undergraduate students did. However, when asked at the end of the course whether they were happy with their opt-in choice or they would have changed it (Q14 of our survey, see Table 2), out of 606 students, only 6 that opted in (0.99%), and 4 that opted out (0.66%), would have chosen otherwise.

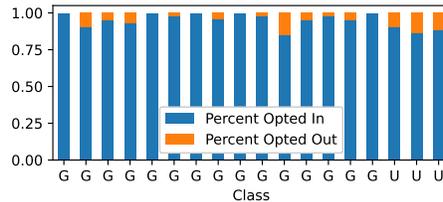


Fig. 1: Competition opt-in distribution for each class in the study.

Fig. 2 shows aggregate results for the survey closed-ended questions, after first inverting the negative questions. An overwhelming majority of the students gave 4 or 5 responses, indicating a strong positive perception toward CLP. This means they agreed with all 5 positive questions and disagreed with all 5 negative questions in the CLP survey. While the agreement was more definite for graduate students, with 80.7% of the answers ≥ 4 , 70.2% of the undergraduate student answers were also positive (code ≥ 4).

Fig. 3 shows the results of our sentiment analysis on the open-ended survey questions. While Q11 and Q12 were positive and negative questions, they show a slightly positive and neutral sentiment polarity from respondents, respectively. Q13 and Q14 are designed as neutral questions that could be answered either positively or negatively. Their sentiment polarity is decisively positive (0.40 mean and 0.14 standard deviation), indicating students enjoyed the platform.

B. Does using CLP encourage students to try different solutions that they may have not previously considered? One of the major purposes of CLP is to encourage students to approach the homework assignment differently, try multiple solutions, and come up with solutions they did not previously think

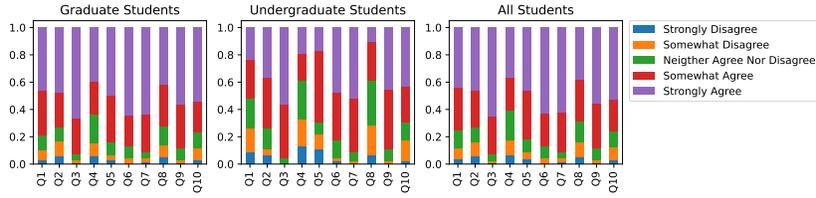


Fig. 2: Response distributions for the closed-ended survey questions.

of. To analyze whether CLP promotes trying a different approach, we studied the sentiments of students in responses to Q13. This question focuses on student attitude towards solving a CLP homework assignment and its comparison with a normal homework assignment. Our analysis shows that sentiments for this question are predominately positive, with a mean of 0.28 and a standard deviation of 0.14. Undergraduate students in Class ID 3, which had the lowest sentiment score of -0.02, complained that the class was structured more like a graduate course and had too many assignments (besides the CLP assignments), which may have affected the sentiment score for this class.

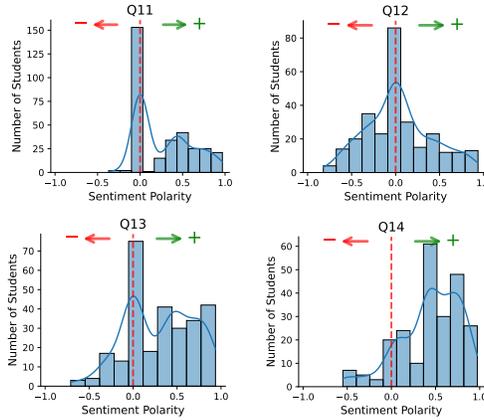


Fig. 3: Sentiment polarity for open-ended survey questions.

Fig. 4 shows the distribution of the number of submissions by students in each assignment of each class. The number of CLP submissions can be thought of as an indicator of how willing students are to modify their solution and try to improve their score. As the figure shows, the vast majority of students try more than 5 solutions for each assignment, with some students trying as many as 50 solutions. The average number of submissions for most classes, represented in the figure by the horizontal dotted line, is above 10 for most classes.

C. What is the impact of using CLP on student performance? The CLP system is expected to aid student performance by encouraging them to engage more in class. Our hypothesis is that, when students engage more in the class, they perform better. To gauge whether student performance is affected by the level of engagement, we studied the relationship between assignment grades and the number of submissions. Results indicate that the students with the

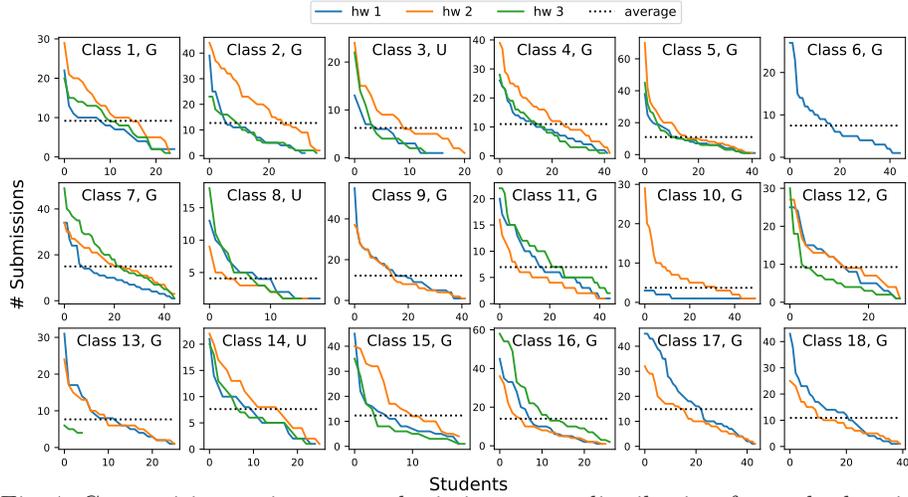


Fig. 4: Competition assignment submission count distribution for each class in the study.

best assignment grades have, in general, more submissions than other students with average or low grades, both at the undergraduate and graduate levels. The Pearson correlation scores between class engagement and number of submissions are mostly positive, indicating that students who engage more in CLP will also likely engage more with other class materials.

5 Related Work

CLP aims to improve student learning by combining real-time feedback and competitive learning. In this section, we review the body of literature related to this study, including benefits of feedback and competition for student learning in institutions of higher education.

Feedback in Education: Feedback is an integral part of the educational process. It provides learners with a comparison of their performance to educational goals with the aim of helping them achieve or exceed their goals [8]. Studies show that, in general, feedback is a key catalyst for learning [1].

Researchers found that, for tasks such as programming and mathematics, immediate feedback benefits learners [3]. Guthrie and Carlin found that students were generally positive about systems with instant feedback and preferred to take courses that used them. The student response rate approached 100% in class sessions where PRS was used due in part to anonymity, ease of use, and the ability to see how many others answered in the same way [5].

Learning and Competition: Many research studies have focused on utilizing active learning techniques, including collaboration and competition, to enhance student success.

If carefully designed, competitions motivate students and encourage them to do their best [4]. Competitions can enhance student motivation, self-esteem,

and learning outcomes. Regueras et al. used competitive and collaborative active learning approaches to motivate students by creating an environment where students collaborate within their group to submit questions to their classmates and compete by answering questions posed by other groups [7].

6 Discussion and Conclusions

In this study, we describe the features of a Competitive Learning Platform (CLP) and evaluate their effectiveness on improving student engagement and learning. We present analysis results based on data collected from the usage of the CLP system over 5 years across 18 courses and 2 universities. Based on end-of-term survey results, the overwhelming majority of students found CLP helpful in their learning (Fig. 1), and only 6 out of 606 students would have opted-out of the competition style learning instead of opting-in. The undergraduate opt-in rate was slightly lower when compared to the graduate rate: 88.07% vs 96.16%. We found that CLP encourages students to try different approaches on our problem solving assignments. Fig. 4 shows that students submitted, on average, 10 or more solution submissions, while some students tried up to 50 solutions per assignment. The student CLP activity is correlated with improvements in the assignment objective scores and the assignment grades. In 75% of courses, the CLP activity is also correlated with higher overall engagement in general course activities, as measured by the learning management system. Overall, the rich usage data we collected shows that CLP is effective at encouraging students to try different solutions for their assignments, with significant improvements, while achieving a high user satisfaction as measured by the end of term surveys.

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