Studying the impact of combining online-homework and Peer-Led Team Learning on students' attitudes and performance in General Chemistry

Issa I. Salame, Chemistry Department and School of Education, City College of New York
Nathan J. Hershberger, Chemistry Department and School of Education, City College of New York

Abstract

Peer-Led Team Learning (PLTL) has been an invaluable source as students struggle to learn difficult chemistry concepts. The financial issues of effectively implementing the program have become somewhat troubling in today's learning environment. Online-homework use has become routine at many schools, but when currently used, there have been some questions of its efficacy. To alleviate the issues facing either alone, a combination of Peer-Led Team Learning (PLTL) and Online-homework was studied to determine its effect on students' learning of chemistry, and their attitudes towards the subject matter. Participants in this study were 180 CCNY students enrolled in the second-semester of general chemistry during the spring of 2010. Our methods included a Likert-type questionnaire, an open ended-questionnaire, and an interview. Our data shows positive results as seen in the student population with the integrated model. In general, the students have responded well to the new format with the results showing an increase in student performance and retention.

Introduction

Originating at The City College of New York, Peer Led Team Learning (PLTL) has become a national model for science education (http://www.pltl.org). PLTL has been very helpful in restoring small class pedagogies to large format lecture courses, and fosters an environment that encourages students interactions, active learning, and emphasizes time on task. PLTL provides cooperation in problem-solving (1) and discussions over problems that enhance cognitive development for the students (2).

The PLTL model forms from a collaborative, small group that emphasizes active learning through participation in a peer-led workshop. In PLTL, students who have previously done well in a course are recruited to be "peer leaders", students who facilitate small groups of students in problem-solving workshops that meet each week for two hours (3). The groups engage in debate and discussion of scientific ideas under the guidance of this peer leader. The size of the group varies from eight to twelve as they work together on carefully structured problems. Peer leaders are trained during a one-semester education course to encourage and facilitate collaboration among students and thereby enable a supportive environment that helps students build upon their problem solving skills.

A nationwide study of 20 PLTL courses (4) and other individual studies (5-8) show that participation in PLTL increases student retention and deepens understanding. PLTL especially fosters rapport among students and helps to teach teamwork and cooperation by reaching into the "zone of proximal development" that Vygotsky (9) describes, because students can, at times, convey concepts on a level closer to their peers than a professor.

PLTL has shown tremendous benefit for the leaders as well. Past leaders have remarked how much more their conceptual learning was enhanced as they helped their group make their way through the material. This position seeks to solidify strong leadership and communication skills, as well as helps to develop an understanding and tolerance of

many diverse cultural backgrounds. Leaders are found to take these skills they learn into their future graduate work and careers (10).

Although the program has been very successful, there have been financial challenges to implementing the current model. PLTL requires one leader for, on average, 10 students, which turns out to be a burden on a department that is under-funded. Because PLTL has had so many positive effects on student learning, finding a format that seeks to enhance the student experience while mitigating the costs would be beneficial.

Research has also shown that incorporating information and communication technologies into science and mathematics can positively affect reasoning and learning (11-13). The web has evolved over the past several years to include functionalities that can contribute to the improved educational lives and experience of learners (14). Infusing the use of the Internet into the classroom has the potential to transform educational offerings, making education more seamless (15).

At the Collegiate level, the use of online-homework systems such as Wiley Plus, OWL, CAPA, Connect, and Mastering Chemistry, has become routine over the last decade. Numerous arguments support the use of online-homework systems, such as allowing students to obtain more practice in the content area in terms of quantity and frequency, which also helps students to keep up with the material (16). This is important because many instructors believe that the best way for students to learn how to solve problems is by attempting to solve problems (17). Other tremendous benefits include the ability to grade each and every problem on assignments and a simple way for the instructor to monitor the progress of a large course throughout the semester. Positive benefits have continually resulted from their use (18-21).

Furthermore, online-homework provides students with immediate feedback and enables them to master the material by providing step-by-step guidance to solve problems (16). Immediate feedback is extremely important because it allows students to identify errors in their work so they can quickly correct it (22). The feedback that students obtain from online homework can also promote student retention (22) as students have even been found to complete more assignments when online-homework is administered (23). It has been shown that students using online homework score significantly higher on exams compared to those using traditional homework models (24).

While this is encouraging, it is important to note that several of these studies only show online-homework having little impact as compared to traditional pencil and paper homework; yet, these studies make the best case for using such systems in today's classrooms. In the study done by Bonham et al. (17), a full time grader was employed. They remarked that this was much more extensive than normal, because schools don't usually have the resources, financial and time, to spend on such endeavors. Online-homework was, in essence, tested against the ideal situation instead of the real one that so many institutions face. Bonham et al (16) earlier noted that it doesn't matter who wields the "red pen," meaning that the result is the same whether the assignment is graded by human or computer. Cole and Todd (22), came to the conclusion that, "The potential for personalized, detailed, rich feedback to the students at low cost to the instructor in terms of time spent grading is an advantage that should not be overlooked." When compared to the ideal, a computer grader fares the same as a human grader in each case, but the cost effectiveness of online-homework is what makes it so attractive.

Within the last decade, online-homework systems have been dramatically improved. At their inception, the systems only recorded the final answer and, typically, students would have several attempts to input their answer. Pascarella (25) noted the flaw in this early version of online-homework, finding that it "hindered metacognitive behaviors." Essentially, the students were guessing their way to the final answer without having gained any conceptual knowledge in the process. Students also frequently printed out the assignment and returned later to enter the answer, thus, they eliminated the instant feedback online-homework could provide. The programmers of these systems have, in many cases, set to remedy these situations by offering guided solutions to problems and answer specific feedback, but this might not be enough, because conceptual learning with online-homework is hindered without a human component (26). In other words, human interaction is necessary to fully understand a topic. Another significant aspect about online-homework is that it reduces and sometimes eliminates cheating by providing every student similar questions with alternate variables (16), personalizing the assignment to each student. The improvements in technology, matched with the cost effectiveness for the institution, personalization, and positive results seen for so many students are why online-homework systems should be continually used and studied.

Research Hypothesis

Integrating online-homework into PLTL might be an effective solution to the issues facing either alone. The popular group workshop technique can be an excellent fit here because it provides a social interaction component into what would otherwise be only a solitary experience. This, matched with the fact that positive effects on the group members of a collaborative environment that uses the Internet have been seen (27-28), could provide additional benefits to today's students.

In the new format, students will have a combined 90-minute PLTL/online-homework session once a week, but the students will work on their personalized online-homework assignment chosen by the professor, rather than the problems chosen by the peer leader. Instead of having one peer leader per 10 students, the ratio will increase to one per 40. Immediately, the cost benefit would be recognized. The peer leader will still facilitate discussion, emphasize time on task, and foster a social and collaborative atmosphere, but because the online-homework program also provides guidance, the peer leader will be able to handle this larger group size.

By pairing a peer leader to online-homework, a human component will be added that could increase conceptual learning. Students will be able to work at their own pace and not fear getting stuck, as help will be continuously available. Still, working as a group, students will be able to discuss problems and solutions, like the original model of PLTL as the students are working on conceptually similar problems. This will force them to solve their own problems, though, as the solutions will be unique. The volume of instant feedback will increase, as this model does not allow for the printing out of assignments because students will work on their homework directly in front of the computer.

This community, comprised of students, instructors, and peer-leaders, has been shown to help in the organization of students' work and promotes camaraderie and positive attitudes towards learning, as it moves the group as a whole toward improved techniques (29). Because evidence has shown that collaborative experience with the use of technology improves critical thinking, problem solving, and communication skills (30), by integrating

online-homework into Peer Led Team Learning, an improvement in student performance is expected.

The following research questions will be addressed as part of this study:

(1) Does combining online-homework and PLTL help improve student learning, attitudes, and performance, in introductory chemistry courses?

(2) How does combining online-homework and PLTL help improve student learning, attitudes, and performance, in introductory chemistry courses?

Research Design and Context of Study

In order to properly assess the impact the integrated approach would have on student achievement, data were collected in several ways that measured the effect it had on performance and the students' attitudes toward it. This was broken down into a likert-type questionnaire, a short answer questionnaire, student interviews, and a comparison of the percentage of passing (A, B, C) grades over four semesters. The surveys were done anonymously and the interviewees were picked at random.

The likert-type section included seven questions that asked the students to rate between strongly disagree and strongly agree. The likert section was scored on a five-point scale: (1) Strongly Disagree, (2) Disagree, (3) Neutral, (4) Agree, and (5) Strongly agree. For each question, an average was computed to determine how the students felt about the new PLTL, online-homework combination.

In order to get a better sense of how the students responded to the program, and to give them a chance to more freely state their opinion, a set of short answer questions followed. To make the data more manageable, a rubric was created that scaled their results. This allowed for a standardized way to understand the data that the students provided. For the first four questions of the short answer section, the answers were scored on a rubric from one to five. Five was given to answers that were completely positive, while one was given to answers that were completely negative. Four was given if a student gave an overall positive answer, yet had something they disliked, and two was given if the answer was practically negative, but they made some comment of an aspect of the program they did like. Answers that fell into these categories had typical "yes, but" or "no, but" type responses. A score of three was given if the answer was neutral or if the student liked the online-homework and disliked PLTL or vice-versa, meaning the positive effect was cancelled by what was perceived as negative. The scaled score was coded and averaged for the first four short answer questions in the same fashion that the likert-type questionnaire was.

The final two questions in this section could not be scored on this scale as they asked for specifics about the program. Instead of scaling the answers, the responses were broken down into categories grouped by their similarity.

Interviews were conducted on 10 randomly chosen students. The questions asked were the same as the short answer section, but the students were given the opportunity to talk freely about their answer. This also opened the door to follow up questions to help clarify what the student meant if the answer was somewhat ambiguous.

Passing grades (A, B, C) were compared from two semesters when the integrated model was used (Spring 2011, Fall 2011) to two semesters when PLTL and online-homework were administered independently (Fall 2010, Spring 2012). All of the examinations were written by the department to keep the difficulty level consistent. The same instructor's class was used each semester and final grades were never curved.

Admissions criteria for the students were also constant and GPA/SAT/ACT scores were static. This method provided the best control, as it would be unethical to split the class in half and test the model on only a portion of the students.

RESULTS

A total of 180 students from General Chemistry II responded to the survey. The results of the likert-type questionnaire showed that students had a favorable view of the new combined PLTL and online-homework format. The average for each section was nearly 4, with the highest rated section being that they felt the new format helped them to learn chemistry (Likert 1). Table 1 presents the questions on the Likert-type questionnaire and Figure 1 shows the average score for each of the likert-type questions.

Table 1. Questions used in the Likert-Type questionnaire.

1	The combination of online-homework and PLTL helped me learn the course material.
2	The combination of online-homework and PLTL helped me improve my problem solving skills.
3	The combination of online-homework and PLTL helped me develop a better understanding of the concepts covered in class.
4	The combination of online-homework and PLTL motivated me to study.
5	The combination of online-homework and PLTL prevented me from falling behind in my reading because I had online homework due weekly.
6	The combination of online-homework and PLTL provided me with useful guidance on problem-solving.
7	The combination of online-homework and PLTL was worth the time and effort I put into it.

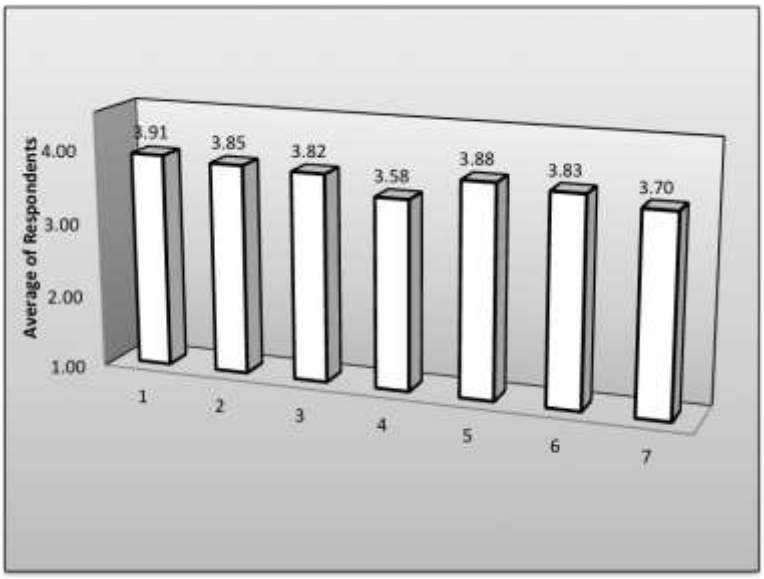

Figure 1. Average score for the Likert-type questionnaire.

Table 2 presents the four questions that were asked in the short answer questionnaire. The average of the short answer questions, as can be seen in Figure 2, showed that the students generally viewed their time spent on the new format as positive and favorable (Q1), that they remained motivated (Q4), and that the combination helped them understand the concepts (Q3).

Table 2. The four questions from the short-answer survey.

1	Please provide a description of your experience with the combined online-homework and PLTL approach.
2	Would you recommend the combined online-homework and PLTL approach for general chemistry to other students? Why?
3	Do you think that the combined online-homework and PLTL approach has helped you understand chemistry concepts better? How has it helped you?
4	Did the combined online-homework and PLTL approach motivate you to study the chemistry material? How?

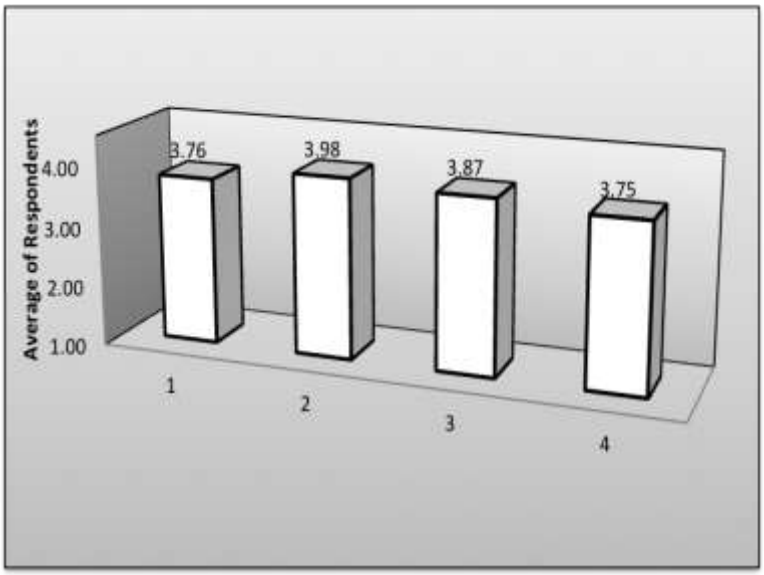

Figure 2. Average of short answer questionnaire for questions one through four.

Table 3 presents the final two questions of the short answer questionnaire sections and Figure 3 shows a representation of the student responses with the resultant categories. In both cases, the *Hints, Guided Solutions and Answers* had the highest response, followed by the *Practice Problems* and *Human Component.*

Table 3. Short answer questions five and six.

5	What did you appreciate most about the combined online-homework and PLTL approach?
6	List three things you found useful about the combined online-homework and PLTL approach

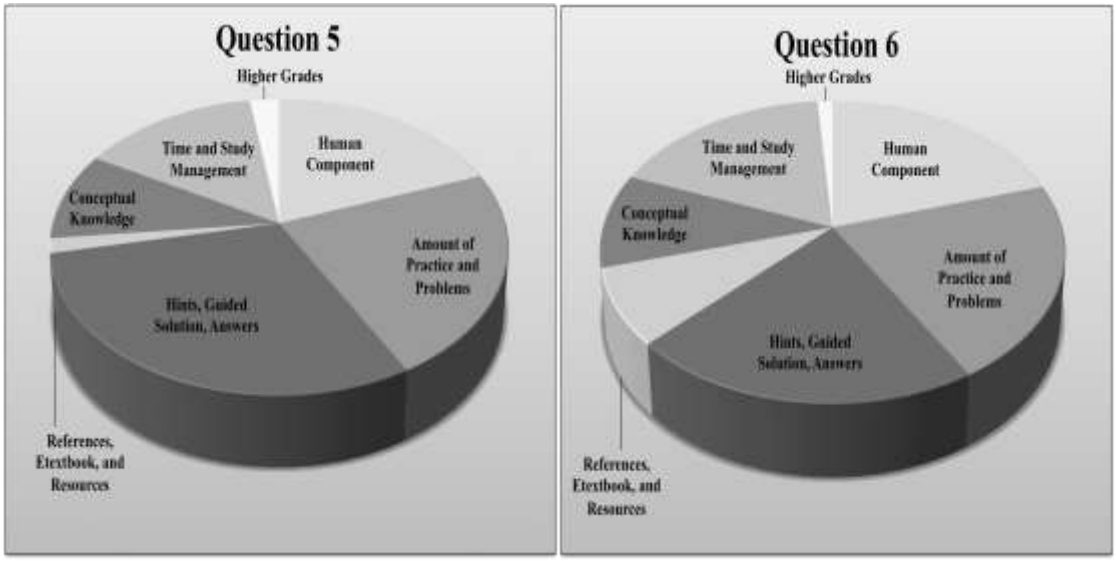

Figure 3. Short answer questions five and six with the resulting categories.

The percentage of passing (A, B, C) grades for each semester are shown in Table 4. During the two semesters when the integrated program was implemented (Spring and Fall 2011), passing grades were 10 percentage points higher than when PLTL and online homework were administered separately (Fall 2010 and Spring 2012).

Table 4. Percentage of Passing (A, B, C) Grades at the end of each semester.

Semester	Percentage of Passing Grades (A, B, C)
Fall 2010	74
Spring 2011	84
Fall 2011	84.5
Spring 2012	75

Discussion

The results suggest that the students had an overall favorable opinion to the new, integrated model of online-homework and PLTL. When asked to talk about their experience, one student remarked, "*The Online homework pushed me to study the material in a timely manner and the PLTL allowed me to find help for questions and problems I did not know how to do.*" This student simply stated that the reasons he liked the format were the same

reasons it was designed. The new model emphasizes time on task and collaborative learning, and the peer leaders are specifically trained to lead groups that foster this type of discussion.

The results from Short Answer questions 5 and 6 suggest the students liked the new format because it was a place they could do their homework, work with their peers, and get help from multiple sources when they needed it. Because of this, the students said they would recommend the new format (Short Answer 2) as it helped them understand the material and keep up with the lessons in the lecture (Short Answer 3 and 4). The students were given the opportunity to complete their homework in a setting that encouraged discussion and provided ample help, which seemed to motivate them to complete the assignments correctly.

Conceptual learning was found to be very important to the students (Short Answer 3) and they liked the fact that the problem sets matched so perfectly with the course. *"…online-homework contained several challenging questions, which more or less could be on future exams. Thus, I became more motivated,"* was a typical response to Short Answer question 4. Because the instructor chose problems that integrated seamlessly with the course, the homework seemed to have more validity to the students, and completing the homework became extremely important.

While, it is clear that a computer provides adequate help to a certain extent, the data suggests that because a human was involved that could interact with the students, the program became valuable in their eyes (Short Answer 5 and 6). This result gives much credence to the validity of the findings by Swan 2004 (26), in that, the websites provide very useful guidance, but a computer does not make up for the social interaction component that has generally been missing when online homework was previously administered independently of PLTL.

While the data shows that a majority of the students found the new format helpful (the averages of the Likert questions were all nearly 4), it also shows that the students liked it for the practice and help they received (Short Answer 5 and 6) instead of simply being motivated by the website to complete the online-homework. The fact that online-homework was a part of their grade was hardly mentioned as a reason the new format was liked (Short Answer 5 and 6). Many of the students, however, did appreciate that time was purposefully built into the schedule to complete their assignments. This would suggest that setting up their schedule in this manner is what made it easier for them to stay on track.

Giving the students guidance by specifically focusing their schedule seemed to make a difference, so it is of no surprise that the number of passing grades was highest when the integrated format was implemented (Table 4). While grades without a reference point can be quite meaningless, the fact that the only significant difference between semesters was the way in which PLTL and online-homework were administered, the 10-percentage point increase becomes important. Because this trend was found over several semesters with large enough class sizes (around 200 each time), the grade changes become significant.

In the end, the students were given time, attention, and continual focus throughout the semester, and this had a clear impact on their performance, attitudes, and retention of the material.

Conclusions

Today, Colleges and Universities are seeing record numbers of attendees and are at the same time facing financial issues due to the economy. Contact between students and faculty is more difficult as the student to teacher ratio has increased. In the past, online-homework was troublesome for many students because they had issues with the interface when they were going at it alone. This model helps to resolve this by providing a social, interactive component, and the students respond positively. It is not surprising that so many good responses are seen from the combined approach, as the percentage of passing grades was higher in both semesters that the model was implemented. The results thus far help to substantiate the sound pedagogical methods of the integrated approach as a viable, cost effective model to help improve teaching and learning. This is important because finding ways to employ sound teaching pedagogies, yet remain within the confines of the budget is of the utmost importance.

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