PEER-LED TEAM LEARNING EVALUATION

BENEFICIAL EFFECTS OF PLTL PERSIST TO LATER COURSES AT PENN STATE SCHUYLKILL

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Penn State University is a complex system of 24 campuses widely distributed throughout Pennsylvania. The main campus, University Park, is in the geographic center of the state in State College; the other campuses serve as feeders for the main campus, as standalone colleges, or as "special mission" campuses. Fourteen of the branch campuses, Penn State Schuylkill included, serve primarily freshmen and sophomores, after which the students typically transfer to University Park or to another of the standalone colleges to finish their degrees. Schuylkill offers only three baccalaureate degrees, none of which is in science. Thus, students at Penn State Schuylkill can only take chemistry courses that would ordinarily be offered during the first two years of a degree program.

In their first two years of study, science and engineering majors at Penn State will encounter five different chemistry lecture or lecture-related courses. For the discussion and data that follow, it is helpful to have a ready reference to these course numbers and descriptions:

Chem 6: An optional problem-solving course to accompany Chem 12 (1 credit)

Chem 12: First-semester general chemistry (Gen Chem I, 3 credits)

Chem 13: Second-semester general chemistry (Gen Chem II, 3 credits)

Chem 38: First-semester organic chemistry (Org Chem I, 3 credits)

Chem 39: Second-semester organic chemistry (Org Chem II, 3 credits)

Chemistry laboratory courses for science and engineering majors at Penn State are separate from the lecture courses. Chem 14 (Gen Chem I lab; 1 credit) is usually, but not always, taken by students at the same time as Chem 12. Likewise, Chem 15 (Gen Chem II lab; 1 credit) is taken along with Chem 13, and Chem 36 (Organic lab; 2 credits) is taken by most students in Chem 39. We do our best to have the laboratories reinforce the lecture material in the corresponding course, but we cannot organize the content or activity of our lecture courses based on the assumption that all students will enroll in the closely related laboratory at the same time. Thus, we do not have the option of using lab time for PLTL workshops.

<u>How We Use PLTL</u>

Chem 6 is an optional, 1-credit problem-solving course designed to accompany Chem 12. Its purpose is to aid at-risk students in persisting through the lecture course, but it is open to any student who wishes to improve his or her performance in Chem 12. Chem 6 is taught by various means around the Penn State system, including the traditional recitation format. Chem 6 is not available at every Penn State campus, and Schuylkill only began offering it in Fall 2000. The first time through, I used the recitation style for teaching this course: I stood in front of the class, solved homework and practice test problems, and answered students' questions. This was a decidedly ineffective approach (see Table 1, 1999 vs. 2000). The Fall 2000 participation rate for Chem 6 was low (30%), and the benefits to students overall were negligible. Very little improvement in withdrawal rates was seen, and the average Chem 12 grade in Fall 2000 was actually slightly lower than in Fall 1999.

Around the same time, however, I began learning about PLTL through a variety of conference presentations and workshops: a brief introduction at the 16th BCCE (University of Michigan, July 2000); a three-day Chautauqua short course (Philadelphia, June 2001); and the 2001 PLTL National Leadership Conference (Goucher College, July 2001). By the end of the Goucher meeting I was convinced that PLTL was *the* way to teach Chem 6.

We had to make preparations for Fall 2001 quickly, but in less than two months we secured administrative support for initiating a PLTL program, recruited and trained six peer leaders, and involved the Center for Academic Achievement (the campus' Learning Center), first with handling payroll, and later with leader training. In our inaugural semester we wanted to ensure a high rate of participation. To do this, we secured the cooperation of the advising center to lower the placement standards so that anyone who qualified for college algebra I (instead of normal requirement, algebra II) was permitted to sign up for Chem 12, as long as they concomitantly registered for Chem 6. We were convinced that PLTL was going to help students enough to justify relaxing the entrance requirements for General Chemistry. This dramatically increased our enrollments in both Chem 12 and Chem 6 for Fall 2001 (see Table 1, bottom line). It is quite noteworthy, therefore, that the improvements seen in Chem 12 (i.e., an increase in the average course grade and a decrease in withdrawal rates) occurred *in spite of* the fact that we were working with "less qualified" students on average than we had in previous years. Based on the noteworthy success of PLTL in Fall 2001, we have chosen to use this method for teaching Chem 6 in every subsequent semester.

Table 1.
Comparisons of enrollments, average course grades, and grade distribution—1999-2001

Fall Semester	Enrollment in Chem 12	Enrollment in Chem 6	% in Chem 6	Average grade in Chem 12	% ABC (#)	% DF (#)	% W (#)
1999	69	--	--	2.38	64% (44)	23% (16)	13% (9)
2000	67	20	30%	2.34	73% (49)	6% (11)	10% (7)
2001	90	69	77%	2.48	84% (76)	10% (9)	6% (5)

Note: 1999 was the year prior to the introduction of Chem 6 on our campus; 2000 was after the introduction of Chem 6, but before PLTL; in 2001 we began teaching Chem 6 via PLTL. No attempt is made in this table to segregate the performances of those students who *did* take Chem 6 vs. those who did not. The data in the table above reflect the performance of *all* Chem 12 students during the semesters shown.

Evolution of the Program: How We Do Things Now

Grading in Chem 6: In the first two years, students in Chem 6 were graded merely on attendance (20%), completing the workshop problem sets (50%), and peer evaluations (30%) of their performance as a productive and cooperative group member (15% from their fellow group members, anonymously, and 15% from their peer leader). This policy placed peer leaders in the awkward position of being "above" the students as opposed to working "alongside" the members of the group. It also discouraged any specific preparations in advance of the workshops, or any accountability on the part of the students for actually learning or retaining the ideas the workshops are designed to reinforce. More recently we have modified the grading policy to include a required self-test (10%) based on pre-reading, which prepares students for the workshop. Attendance (33%) and solving workshop problems (22%) still count, and it is at this point where peer leaders may assess the contributions of group members. In rare cases, leaders dock students who do not participate or who are otherwise uncooperative. Each workshop session ends with a quiz (24%, individual work) based on that day's activities. This encourages students to pay attention and to try to get something out of the workshop itself. Finally, rather than having students grade each other on their effectiveness as cooperative members of the group, students participate in the anonymous on-line "SALG" survey (Student Assessment of Learning Gains, 11%) as part of a national research effort aimed at determining whether students are experiencing the sorts of learning gains that PLTL hopes to promote.

Linkage of Chem 12 with Chem 6: I have taught Chem 6 every semester for each of the past four years, while my colleague, Dr. Susan Barrows, has taught all sections of Chem 12 (two in fall, one in spring). Dr. Barrows and I work together closely to ensure that the weekly workshop problems reinforce the material covered in lecture. To help promote high participation rates in Chem 6, Dr. Barrows describes the purpose and benefits of Chem 6 to all of her students during the first week of class, actively encouraging them to register for the course. She also offers a minimal direct incentive for Chem 6 participation through the Chem 12 grading system. Specifically, students who elect to take Chem 6 may replace their lowest unit exam score (but not the final exam) with the average of that exam score and their Chem 6 course score. Although this has an almost negligible impact on students' grades in Chem 12, it helps to ensure their attendance in Chem 6, and it prevents students from falling into the "I give up" malaise following one bad exam score. (It is vitally important to note that this "low test averaging" policy accounts for almost none of the difference seen in Chem 12 grades for the Chem 6 vs. the non-Chem 6 students; see Table 2.)

Table 2. Grades and Retention in Chem 12—Academic Years 2001-2005

Academic Year	Enrolled in Chem 6	Not enrolled in Chem 6	% in Chem 6	Average grade in Chem 12	% ABC (#)	% DF (#)	% W (#)	Avg. ACS Exam* (curved)
01-02	84	—	79%	2.55	92%	8%	0%	N/A
	—	23	—	2.14	52%	26%	22%	
02-03	68	—	73%	2.66	99%	1%	0%	78.9
	—	25	—	1.46	24%	28%	48%	67.9
03-04	57	—	58%	2.34	82%	16%	2%	61.4
	—	41	—	1.87	51%	27%	22%	55.7
04-05	57	—	54%	2.31	72%	23%	5%	54.2
	—	48	—	1.80	39%	17%	44%	53.9

Peer Leader Recruitment, Training, and Compensation: In Fall 2001 severe time constraints prevented us from organizing any formal peer leader training program prior to the start of the semester. In all subsequent years, however, the Center for Academic Achievement (CAA) has included peer leaders in a 15-hour training program, originally developed for academic tutors, immediately prior to the fall semester. Because of their well-established payroll system for tutors, the CAA has been a further benefit to us by handling all aspects of payroll for our peer leaders. The CAA enjoys a symbiotic relationship with PLTL here, in that many of the students recruited as peer leaders, having undergone the summer training, are quite willing to become tutors as well, covering courses in science and math for which tutors are historically quite difficult to find.

During the semester, mock workshops are conducted each week in which the peer leaders take the role of students, and I take the role of peer leader. This gives me a chance to model effective workshop facilitation, and it gives the leaders a chance to review the workshop problems while simultaneously anticipating potential stumbling blocks that could interfere with the Chem 6 students' learning.

At one point we gave academic credit to the peer leaders for the training sessions, and paid them only for the workshops they conducted. However, our administration was bothered by the proliferation of one-credit, "special topics" courses that didn't get students any closer to graduating. Now peer leaders receive financial compensation (~$7/hr) for all the time they spend in pre-semester training, in-semester training, and for conducting the workshops themselves. As for recruitment, peer leaders (as well as the instructors) are constantly on the lookout for current Chem 6 students who exhibit an appropriate blend of content mastery and "people skills." These students are invited to an informational pizza party at the end of the spring semester, told about what it means to be a peer leader, and asked to submit an application if they are interested. Typically 50-60% of those students who are recruited end up as peer leaders.

Evaluation of Program Effectiveness

Some of the common ways in which comparisons are made between groups that do or do not take courses taught via PLTL are % quality grades (ABCs), average course grades, changes in withdrawal rates, ACS exam scores, and survey results. We have used most of these methods for assessing the effectiveness of our PLTL program. The specific types of data we have collected to date include:

- comparisons of overall Chem 12 grade distribution, course grade average, and withdrawal rate before and after the implementation of PLTL for teaching Chem 6;
- comparisons of grade distribution, course grade average, and withdrawal rate for students in Chem 12 who *did* take Chem 6 versus those who did *not* take Chem 6;
- grades for students in subsequent chemistry courses, comparing those who were versus those who were not enrolled in Chem 6 in the intro course;
- persistence data through *subsequent* chemistry courses (Chem 13, 38, 39) comparing those who *were* versus those who were *not* enrolled in Chem 6 along with Chem 12;
- a comprehensive survey of student attitudes toward Chem 6 (Fall 2003-Spring 2005).

Summaries of data of each type are shown in the sections that follow.

Direct Effects of PLTL on Chem 12: Improved Grades and Increased Retention

Table 2 highlights a number of significant benefits for those students taking Chem 6 as contrasted with those who opt against it. The data in this table deserve some careful scrutiny. First, there is an undeniable correlation between using PLTL for teaching Chem 6 and improved Chem 12 grades by every measure: average course grade, percentage of quality grades, and higher ACS exam scores. (*Note: In Chem 12 we do not cover all the material found on the ACS first-semester general chemistry exam. Therefore, when this exam is administered, it includes only those questions pertaining to topics to which our Chem 12 students have been exposed. Furthermore, the raw scores are curved to make the class average match the class average from the first three unit exams.)

Perhaps more important than grades, however, is the dramatically increased persistence rate through Chem 12 enjoyed by those students who simultaneously take Chem 6. Notice in particular the *nearly complete absence* of Ws among the students taught via PLTL. Translating the percentages shown in the table into raw numbers reveals that in the eight semesters we've taught Chem 6 via PLTL, only four out of 266 students (1.5%) withdrew from the companion lecture course, Chem 12. By comparison, 47 of the 137 students (34%) who *didn't* take Chem 6 withdrew from Chem 12. Perhaps the chief benefit of PLTL, at least in our hands, occurs through a "learning community" effect. In other words, the support of group members with shared goals, which characterizes PLTL, helps students believe they *can* succeed in general chemistry. And they *do* succeed.

Residual Effects of PLTL on Post-Chem 12 Chemistry Classes: Chem 13, 38, and 39

On our campus, PLTL is only used for teaching Chem 6, and Chem 6 is only used along with Chem 12. Thus, we wished to know: Do any of the direct benefits of PLTL for the Chem 12 students persist in terms of improved performance in subsequent classes? Data shown in Tables 3 and 4 suggest there are residual benefits of having taken Chem 6, both in terms of a correlation with higher grades in later classes, *and* in terms of an increased rate of persistence to and through the more advanced courses. For example, in every semester so far, Chem 13 students who did take Chem 6 along with Chem 12 outperformed the ones who had not taken Chem 6 (Table 3). In other words, whatever benefit students get from PLTL sticks with them to the higher-level course.

Table 3. Grades for Chem 13 students based on exposure to PLTL (Chem 6) - 2001-2005

	DID take Chem 6		Did NOT take Chem 6	
Semester	n	Avg. course grade	n	Avg. course grade
01-02	35	2.87	9	2.71
02-03	14	2.92	3	2.00
03-04	24	2.70	11	2.44
04-05	13	2.67	8	2.13

Similar results are seen in the sophomore year in organic chemistry. By examining Table 4 one can see that students who had Chem 6 earned higher grades (in all but one semester) than the students who did not take Chem 6. Another feature of this table is noteworthy. During the three years for which we've collected data, a much higher proportion of the students who were exposed to PLTL *persisted* from Chem 38 on to Chem 39. Specifically, over this two-year period, 26 of 32 students (81%) who *had* taken Chem 6 moved from Chem 38 to Chem 39, whereas only 6 of 12 students (50%) who had *not* taken Chem 6 were retained into the second semester. Although the number of students involved is too small to be statistically significant, the results are suggestive and encouraging.

Table 4. Grades for Chem 38 and 39 students based on exposure to PLTL (Chem 6) - 2001-2005				
Semester (Fall=Chem 38)(Sp=Chem 39)	DID take Chem 6		Did NOT take Chem 6	
	n	Avg. course grade	n	Avg. course grade
Fa '02	20	2.78	3	3.00
Sp '03	16	2.71	2	2.17
Fa '03	6	2.50	5	2.33
Sp '04	5	2.80	2	2.67
Fa '04	6	2.89	4	2.42
Sp '05	5	3.33		3.17

Effects of PLTL on Peer Leaders: Higher Grades and Better Retention

One might suspect that peer leaders, given their extra responsibilities for attending training sessions and running Chem 6 workshops, might not do as well as their non-leader counterparts with lesser responsibilities. This has not proven to be the case. Peer leaders for Chem 6 consistently have higher grades in the concurrent organic courses than their non-leader classmates (see Table 5). And with peer leaders we may again consider persistence to the next level. ALL of the peer leaders went from Chem 38 to Chem 39; and ALL of the withdrawals occurred among the non-leader cohort.

Table 5. Grades for leaders vs. non-leaders in concurrent organic chemistry classes - 2001-2005				
Semester (Fall=Chem 38)(Sp=Chem 39)	IS a Peer Leader		Is NOT a Peer Leader	
	n	Avg. course grade	n	Avg. course grade
Fa '02	10	2.87	13	2.77
Sp '03	10	2.83	8	2.42
Fa '03	2	3.17	9	2.38
Sp '04	2	3.00		2.67
Fa '04	3	4.00		2.42
Sp '05	3	3.67		2.75

Effects of PLTL on Student Attitudes toward Chemistry: SALG Survey

Members of the Fall 2003-Spring 2005 Chem 12 classes participated in the online survey instrument "Student Assessment of Learning Gains" (SALG) to determine which aspects of the course helped their learning most. Data for Fall 2003 and Spring 2004 are representative, and have been combined in Table 6. Numbers appearing in parentheses correspond to a 5-point Likert scale, with 5 being "helped a great deal" and 1 being "didn't help at all." Some questions prompted only students involved in Chem 6 to respond, while others were open for response by all Chem 12 students. Although the data shown in Table 6 do not completely segregate the responses of students who were involved from students who weren't involved in PLTL, we *can* say a few things definitively about differences between these two groups. According to students involved with Chem 6 (34 respondents), the top three items that "helped their learning in Chem 12 most" were all related to the Chem 6 course. Interestingly, each of these three items was ranked higher than any of the next five items most highly ranked by all students (45 respondents total, i.e., 11 non-Chem 6 students plus 34 Chem 6 students) in the course. Additionally, the items ranked most highly by all students in terms of learning gains and skills students will carry with them to future courses all correspond to skills promoted in Chem 6: communicating ideas, working with others, and problem solving.

Table 6. SALG survey data for Fall 2003 and Spring 2004

"What helped your learning in Chem 12 the most?"

Chem 6 students only [n=34]

- Workshop problems in Chem 6 (4.18)
- Teamwork and interactions with peers in Chem 6 (3.91)
- Working with peer leaders in Chem 6 (3.73)

All students [n=45]

- The grading system used (3.73)
- Quality of contact with the teacher (3.58)
- Feedback received on graded activities and assignments (3.53)
- How class activities, labs, reading, and assignments fit together (3.53)
- Group work in class (3.52)

"How much has this class added to your skills in the following?"

All students [n=44]

- Communicating ideas to others (3.59)
- Working effectively with others (3.48)
- Solving problems (3.30)

"To what extent did you make learning gains in the following?"

All students [n=45]

- Working effectively with others (3.58)
- Communicating ideas to others (3.53)
- Solving problems (3.49)

"What will you remember and carry with you to other classes?"

All students [n=45]

- Communicating ideas to others (3.84)
- Working effectively with others (3.80)
- Ability to think through a problem or argument (3.64)

Effects of PLTL on Peer Leaders: Opportunities for Pre-Professional Growth

Peer leaders enjoy many opportunities for pre-professional growth. Besides the obvious advantages of having a bona fide teaching experience, PLTL provides these students with a chance to review chemistry content in preparation for further study or graduate school. One of our peer leaders (Tudie Ann Henry) from 2002-2003 was the recipient of a prestigious American Chemical Society Scholars Award. The stated criteria for this scholarship include "demonstrated leadership ability," and Tudie Ann's involvement with PLTL played a role in her receiving this award. In March 2004 another of our peer leaders, Zachary Runkle, traveled with me to Housatonic Community College in Bridgeport, Connecticut. There he assisted with two 2.25-hour long workshops on PLTL as part of the NSF-sponsored Multi-Initiative Dissemination Project (MID). We hope to have additional peer leaders participate in professional meetings in the coming years. We have and will continue to use a SALG survey to assess leaders' views of their PLTL experience, as well as tracking their success in any and all fields they choose to enter. We are especially interested in knowing if any of our peer leaders are influenced to choose careers in science teaching as a result their experience with PLTL.

Professional Development Opportunities for Faculty Using PLTL

Opportunities for professional development as a result of involvement with PLTL are numerous and varied. First, I am grateful for invitations to speak on behalf of PLTL in various venues, including the 18th Biennial Conference on Chemical Education; several ACS meetings, both regional and national; and at various locales around the Penn State system. As a member of a team, I have been privileged to present workshops on PLTL at both the Mid-Atlantic Discovery Chemistry Project meeting and as part of several two-day Multi-Initiative

Dissemination Project workshops. Much of the work described in this paper has been presented in poster form, both at National Leadership Conferences on PLTL and at the Gordon Research Conference on Chemical Education Research and Practice.

Second, there are various sources of grant money to support PLTL activities. This past year our campus received a WPA grant, sponsored by the NSF and administered through the PLTL project. Our involvement with the WPA grant program has allowed me to make contributions to an ongoing, nationwide effort to assess the effectiveness of PLTL via SALG survey data and otherwise. Additionally, a variety of local funding sources exist for promoting student-centered active learning techniques, including the newly-established "Fund for Peer-Led Team Learning," which supports the activities described in this paper.

Finally, peer-led team learning ties in directly with the strategic planning goals of the University at large. Through the Strategic Plan, we are asked to "enrich the educational experience of all Penn State students by becoming a more student-centered University." This includes "improving the teaching/learning environment by promoting more learner-centered approaches." Peer-led team learning is nothing if not "learner-centered," and I am proud to have a chance to utilize the PLTL methodology for the benefit of the students of Penn State.

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Originally presented at BCCE in 2004. Data include updated figures from the 2004-2005 academic year.

Cite This Article as: Eberlein, T. (2012). Beneficial effects of PLTL persist to later courses at Penn State Schuylkill. Peer-Led Team Learning: Evaluation. Online at http://www.pltlis.org.
Originally published in *Progressions: The Peer-Led Team Learning Project Newsletter*, Volume 6, Number 1, Fall 2004.