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Design and Implementation Strategies for Peer-Led Team Learning in Organic Chemistry

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Southern Scholars Project

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Abstract

Peer-Led Team Learning (PLTL), which initially began as an effort to improve undergraduate chemistry education, has shown the potential to improve learning among college students in all disciplines. The model applies the desired qualities of teamwork to learning. This project is aimed at designing and setting up a PLTL Workshop at Southern Adventist University (SAU). Nine students currently taking organic chemistry at SAU volunteered to participate in the project. In order to determine the effectiveness of the project, test scores were collected and analyzed for any apparent trends, and an end-of-semester survey was conducted. The results indicate that the program was a success.

Introduction

Taking an organic chemistry course can be a challenging experience in college. The daunting task of memorizing the names and uses of over a hundred reagents often leaves students overwhelmed. More importantly, organic chemistry students must be able to assimilate and apply these reagents to complex synthesis problems—a difficult skill to develop. Because of the challenges associated with organic chemistry, students frequently seek the help of tutors and instructors in an effort to succeed. While these options are usually effective, Peer-Led Team Learning (PLTL), a recent addition to the resources available to students across the nation, shows promise in paving the road to success. The PLTL model enables students to actively engage in the learning process by having them solve carefully constructed "problems in small groups under the direction of a peer leader" (1). In this model, the peer leader is a student who has successfully completed the course. During weekly meetings, his or her function is to "guide the students to actively engage with the materials and with one another" (2).

It is important to note that the leader does not dispense answers; rather, he or she serves as a facilitator. The PLTL method utilizes the psychology of teamwork. In this case, members in a small group supportively collaborate in an attempt to reach a particular goal. Katzenbach and Smith, two Harvard researchers who studied the effectiveness of group work, define a team as, "... a small number of people who are committed to a common goal, a common working approach, and to one another's personal growth and success" (3). A team succeeds by pooling the skills and capabilities of individual members together. The success of a team is also dependent on its leader, an individual who helps to preserve the focus and direction of the group. He or she fine-tunes the progress of the team in order to effectively harness the positive, essential traits of a successful team. Katzenbach and Smith correctly note, "Team leaders act to clarify purpose and goals, build commitment and self-confidence, strengthen the team's collective skills and approach, remove externally imposed obstacles, and create opportunity for others.... Team leaders genuinely believe they do not have all the answers—so they do not insist on providing them" (3).

The PLTL model, sometimes called the Chemistry Workshop, was started and funded in the early 1990s by the National Science Foundation (NSF) as one of its efforts to advance undergraduate chemistry education (4). David Grosser, Jr. and Vicki Roth, pioneers in the establishment of PLTL, reported that during the first two and a half years of its implementation, over 6000 students participated in PLTL workshops for science-related disciplines. These workshops were conducted by 27 faculty members and over 800 peer leaders (4). Since then, the PLTL model has been "adapted" for use in other undergraduate courses such as computer science, biology, and physics (5). Thus, since the early 1990s, the PLTL method has been developed, tested, and extended into other areas of education apart from undergraduate

chemistry. The model has proven to be effective and holds promise for improving the quality of education received by students.

This promise stems from the many advantages the PLTL method has over its traditional counterpart. Traditionally, post-secondary education is primarily made up of lectures: "a method of presentation of concepts, models, content, and problem-solving methods by an expert to a group of listeners and note takers" (2). Lectures provide excellent opportunities for professionals to pass along information, encourage enthusiasm for learning, and set clear objectives for the course being taught (2). Unfortunately, this method of instruction is unidirectional—from professor to student. While students may endeavor to interact with the lecturer through questions, in large classes not all students will be able to actively participate due to time constraints. In addition, the sheer size of large classes intimidates shy students from asking questions. An obvious solution would be to have smaller classes; however, not enough professors are available to take on smaller classes. Recitations, which are attempts to improve student-teacher interaction, tend to become "problem-solving lectures" (2). Thus neither lectures nor recitation sessions present ample opportunities for student-teacher, and more importantly, student-student interactions.

In spite of its limitations, the traditional method of instruction harbors important objectives, such as the acquisition of expert views, which cannot be dismissed. The PLTL model effectively combines the important role of the lecturer with active student participation. This model is beneficial to all who are involved. Grosser comments that PLTL not only helps students perform better in class, it also builds enthusiasm for learning science. For the peer leader, the opportunity to cooperate with faculty and assist others through a difficult course can be a positive, "unforgettable" experience. Grosser adds that for the professors, "the model opens new

dimensions of teaching, free from the constraints of the lecture" (2). Project Kaleidoscope, a prominent coalition of educators focused on the enhancement of undergraduate learning in the nation, reiterates in a newsletter, "the PLTL Workshop provides an active, participatory learning experience for students that also creates a leadership role for undergraduates and engages faculty in a creative new dimension of teaching" (1).

Evaluation of initial attempts to implement PLTL as part of undergraduate studies identified several essential components of the Peer-Led Team Learning Model: (6)

- The peer-led team Workshop sessions are integral to the course and are coordinated with other elements.
- The faculty member(s) teaching the course(s) are closely involved with the PLTL Workshops and with the peer leader(s).
- The peer leaders are students who have successfully completed the course. They are well trained and closely supervised, with attention to knowledge of the Workshop problems, teaching/learning strategies, and leadership skills for small groups.
- The Workshop materials are challenging at an appropriate level and, integrated with the other course components, intended to encourage active learning and to work well in collaborative learning groups.
- The organizational arrangements, including the size of the group, space, time, noise level, and teaching resources promote learning.
- The institution, at the highest levels of administration and pedagogy, and at the departmental levels, encourages innovative teaching and sufficient logistical and financial support.

This project is aimed at designing a PLTL model workshop for a Southern Adventist University (SAU) Organic Chemistry class (CHEM 311-312). The above critical components of a Workshop were utilized to ensure the success of this project.

Methods

One PLTL group, consisting of nine students currently taking organic chemistry at SAU, met once a week for about two hours to discuss organic chemistry using PLTL study methods. A typical meeting began with a review of basic concepts, followed by the presentation of prepared PLTL materials, and ended with a summary of the concepts learned during the session. In order to integrate fun with learning, the review of basic concepts involved group members picking questions out of a hat and explaining the answers to the rest of the group. The fun came from being lucky to pick easy questions. This was because picking a slightly difficult question meant the rest of the group would ask that particular member questions. Of course no one wanted to be singled out, especially if he or she did not have a firm grasp on the concept at hand. After the review came the presentation of prepared PLTL materials. These were questions specially designed by the course instructor and the peer leader to encourage discussion. Here, the peer leader presented the questions, and the group collaborated on answering them. Finally, depending on the amount of time available, one or two members would be chosen to summarize the material learned during the session. During the meeting, the peer leader maintained a learning atmosphere. In addition to asking questions meant to steer the group in the right direction, the peer leader explained concepts the group was having difficulty understanding.

To both quantitatively and qualitatively gauge the success of the project, data collected included total points earned on tests, points earned on a test question requiring critical analysis, averages of the rest of the class, and the results of a survey conducted at the end of the semester. The data was then analyzed for any trends that verified the validity of PLTL model claims.

When one undertakes an education research project, the ideal situation would be to have a large sample size. Kenneth Lyle and William Robinson, who analyzed the results of an early

PLTL study, argue that while some find it difficult to classify education projects as true research due to the lack of a control group, such case studies significantly adds to our growing knowledge of the learning process (5). W. J. Haynie, an education researcher, points out:

> When a single experiment is conducted…there is a chance of error that must be accepted in the one experiment. But, if the researcher then follows this experiment with another one that avoids the potential errors of the first (while possibly accepting some of the other risks avoided the first time) and both experiments attain the same results, there can be more confidence that some truth is being brought to focus. When still a third experiment, with yet different risks, confirms those same findings, more power is given to the argument. (7)

Thus, even if it seems like a project falls short of conventional science's definition of an experiment, valuable insights can be gained upon careful analysis and implementation of such case studies.

Selection of Students

Students were selected on a volunteer basis because of the large time commitment involved. This method of selection meant that participants could be composed of both highly driven students who wanted to improve and poor students who recognized this project as a potential learning resource. There was also the risk of having volunteers who wanted to simply test this new idea. With this mind, nine students were allowed into the group instead of the recommended six to eight. Another reason for allowing a slightly larger than recommended group size was the likelihood that not all members would be able to consistently attend meetings. A slightly large group was meant to ensure that at least six members were present for each session. As Haynie points out, educational research involving human subjects are difficult to control. He notes that acquiring a "perfect mix of homogeneous students" is virtually impossible

(7). With this in mind, the goal of projects such as this is to explore possible avenues aimed at strengthening the educational system.

Data Analysis

The numerical data collected were analyzed graphically for any apparent trends in the performance of participants on tests compared to the rest of the class. First, the class average was compared to the average score of the PLTL group. Second, the range, which is the difference between the highest and lowest score and the standard deviation, which measures the spread of scores around an average, were determined for the PLTL group. These calculations were used to determine the variation of scores within the PLTL group. Finally, because the volunteers were from a class assumed to be normally distributed (that is the distribution of scores resembled a symmetric, bell-shaped graph), student t-tests were used to test the significance of any score differences between the class and the PLTL group. The group was treated as a single unit because no significant discrepancies in attendance were noted. For the t-test, the variance is the standard deviation squared. The p-value is the probability that the observed difference in the scores occurred by chance. The assumed normal distribution permitted the use student t-tests rather than a nonparametric method for statistical hypothesis testing.

Results

Figure 1 shows the test scores for the nine PLTL students and the class average (in bold). Along with the class average, table I shows the range and standard deviation of the PLTL group.

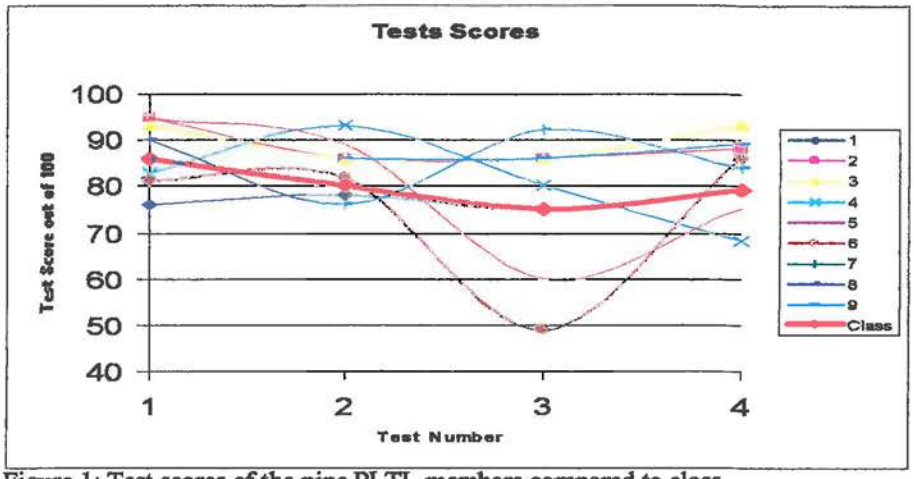

Figure 1: Test scores of the nine PLTL members compared to class average (in bold)

Table I: [illegible]tical data on PLTL test scores

Spread of Test Scores				
	Test 1	Test 2	Test 3	Test 4
Class average	86.10	80.00	75.10	79.20
PLTL average	87.12	83.00	76.78	81.33
PLTL range	19.00	22.00	43.00	25.00
PLTL standard deviation	7.12	6.91	13.94	8.80

Figure 2 presents the PLTL group test averages along with class averages in a graphical format.

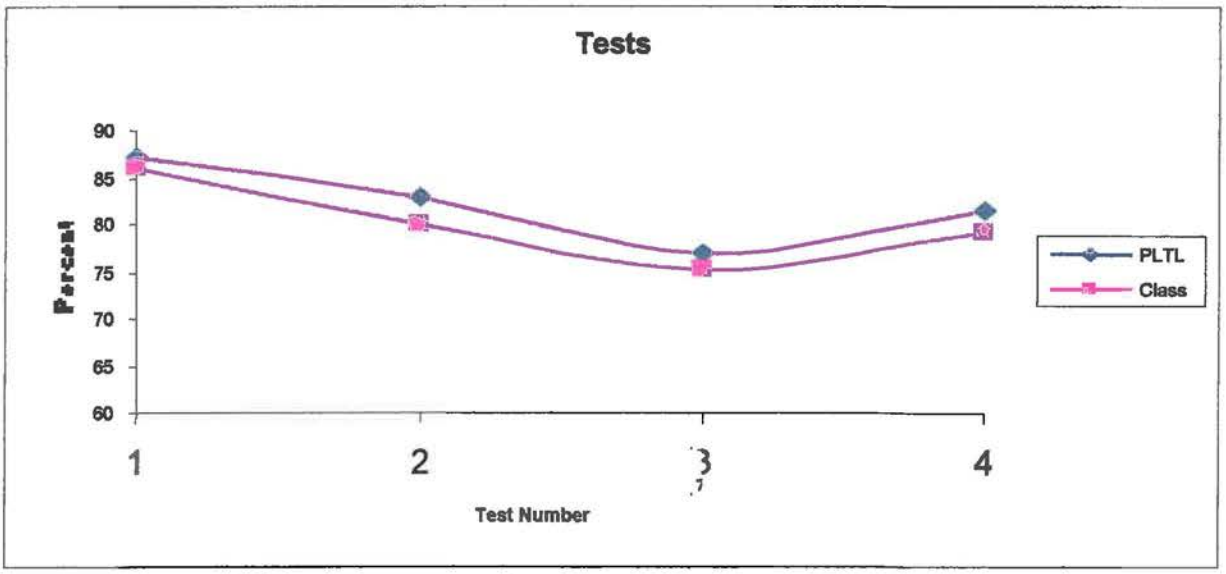

Figure 2: Average PLTL test scores compared to class average

Table II (below) reports the findings of the student t-test hypothesis testing for the four tests analyzed.

Table II: t-test results for test

t-Test: Two-Sample Assuming Equal Variances		
	Class	PLTL
Mean	80.1	82.05902778
Variance	20.60666667	18.32257909
P value	0.553164163	

In addition to overall scores, the performance of students on one question which required critical analysis (thought questions) was examined for each test,. Figure 3 shows the percent of the total points earned on these questions.

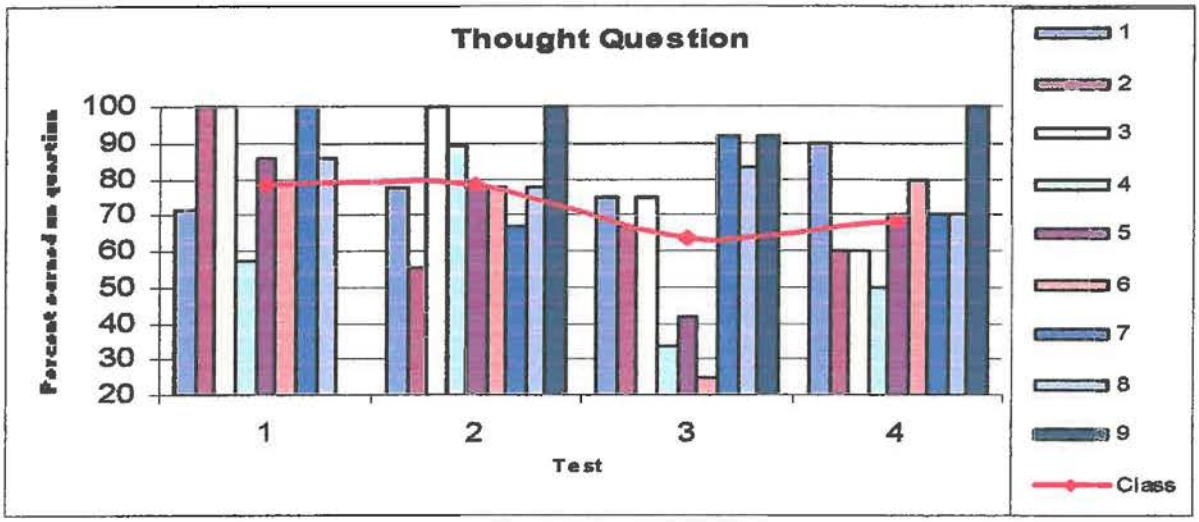

Figure 3: Percent of total points earned on thought question by the nine PLTL members along with the class average of these thought questions.

Table III (below) shows the variation of scores on the 'thought question' among the PLTL members. The variation is shown in the form of ranges and the standard deviations.

Table III: Statistical data on PLTL scores

Spread of Scores (%) on Thought Questions				
	Thought Q 1	Thought Q 2	Thought Q 3	Thought Q 4
Class average	78.10	78.20	63.59	67.80
PLTL average	84.82	80.25	64.81	72.22
PLTL range	42.86	44.44	66.67	50.00
PLTL standard deviation	15.48	14.46	25.27	15.63

Figure 4 compares the averages of the class and the PLTL group.

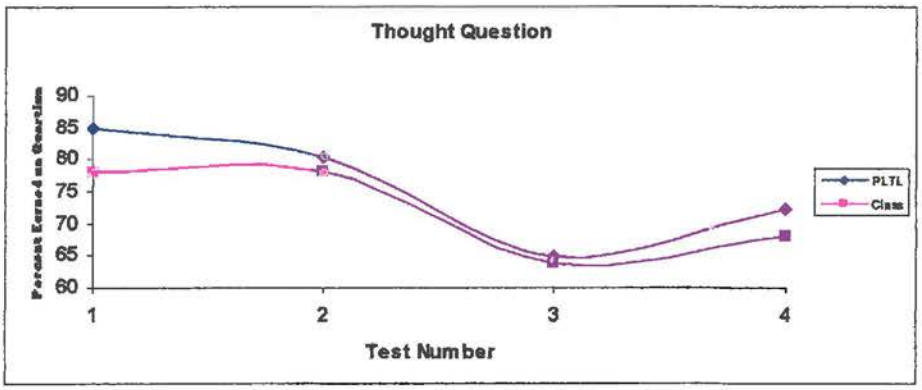

Figure 4: Averages of PLTL group and class on thought questions

Table IV: t-test results for thought questions

t-Test: Two-Sample Assuming Equal Variances		
	Class	PLTL
Mean	71.9217665	75.5263448
Variance	54.68186175	78.11215085
P value	0.554612947	

At the end of the program, a survey was taken in order to receive feedback from the Workshop participants (8). Tables V and VI show the results of this survey.

Table V: Survey analysis on quality of PLTL materials and use of time during Workshops

Survey on Quality of PLTL Materials								
Item #		Average	Standard Deviation	Excellent	Very Well	Rather Well	Somewhat	Not at All
				5	4	3	2	1
				%	%	%	%	%
	The Materials are:							
1	Well connected with the lecture	4.4	0.5	42.9	57.1	0.0	0.0	0.0
2	Challenging	4.7	0.5	71.4	28.6	0.0	0.0	0.0
3	Developed to review fundamentals	4.6	0.5	57.1	42.9	0.0	0.0	0.0
4	Useful for group work	4.1	0.7	28.6	57.1	14.3	0.0	0.0
5	Motivational	3.7	0.8	14.3	42.9	42.9	0.0	0.0
6	Helpful for individual study	3.9	1.2	42.9	14.3	28.6	14.3	0.0
7	Useful for reinforcing concepts	4.9	0.4	85.7	14.3	0.0	0.0	0.0
Amount of Time Spent on Specific Items								
Item #		Average	Standard Deviation	A Great Deal	Moderate	Some	Little	None
				5	4	3	2	1
				%	%	%	%	%
1	The workshop leader presents ideas and methods	4.0	0.6	14.3	71.4	14.3	0.0	0.0
2	The leader responds to student questions	4.4	0.5	42.9	57.1	0.0	0.0	0.0
3	Students work on problems in pairs or small groups	2.4	1.3	0.0	28.6	14.3	28.6	28.6
4	Students work on problems alone	2.3	1.0	0.0	0.0	57.1	14.3	28.6
5	Students present solutions	4.7	0.5	71.4	28.6	0.0	0.0	0.0
6	Hands-on activities	3.1	1.8	28.6	28.6	0.0	14.3	28.6
7	Technology and computer simulations	1.0	0.0	0.0	0.0	0.0	0.0	100.0

Table VI: Analysis of survey on overall impression of PLTL

Survey Results								
Item #		Average	Standard Deviation	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
				5	4	3	2	1
				%	%	%	%	%
1	The workshops are closely related to the material taught in the lectures	4.9	0.4	85.7	14.3	0.0	0.0	0.0
2	Workshops help me do better on tests	4.0	0.8	28.6	42.9	28.6	0.0	0.0
3	Interacting with the workshop leader increases my understanding	4.3	0.5	28.6	71.4	0.0	0.0	0.0
4	The workshop materials are helpful preparation for exams	4.3	0.8	42.9	42.9	14.3	0.0	0.0
5	The workshop materials are more challenging than most textbook problems	3.6	1.1	28.6	14.3	42.9	14.3	0.0
6	I believe that the workshops are improving my grade	3.9	1.1	28.6	42.9	14.3	14.3	0.0
7	I regularly explain problems to other students in the workshops	2.9	1.1	14.3	0.0	42.9	42.9	0.0
8	Interacting with the other group members increases my understanding	4.1	0.7	28.6	57.1	14.3	0.0	0.0
9	I would recommend workshop courses to other students	4.7	0.8	85.7	0.0	14.3	0.0	0.0
10	In the workshops I am comfortable asking questions when I do not understand something	4.9	0.4	85.7	14.3	0.0	0.0	0.0
11	The lecturer encourages us to participate in the workshops	3.7	1.4	28.6	42.9	14.3	0.0	14.3
12	The workshops are often dominated by one or two students	2.3	1.4	14.3	0.0	14.3	42.9	28.6
13	Noise or other distractions make it difficult to benefit from the workshops	1.7	0.8	0.0	0.0	14.3	42.9	42.9
14	Students who are uninterested or unmotivated made it difficult for others to benefit from the workshops	2.0	1.4	14.3	0.0	0.0	42.9	42.9
15	I felt comfortable with the workshop leader	4.7	0.5	71.4	28.6	0.0	0.0	0.0
16	The workshop leader is well prepared	4.9	0.4	85.7	14.3	0.0	0.0	0.0
17	I am uncomfortable asking questions in the lecture	2.7	1.9	28.6	14.3	0.0	14.3	42.9
18	The workshops are a big help in solving problems	4.0	0.8	28.6	42.9	28.6	0.0	0.0
19	I would like to be a workshop leader in the future	2.4	1.4	14.3	0.0	28.6	28.6	28.6
20	In the workshops I enjoyed interacting with the other students	4.7	0.5	71.4	28.6	0.0	0.0	0.0
21	The workshop experience led me to join formal or informal study groups related to other courses	2.1	1.6	14.3	0.0	28.6	0.0	57.1

Below are some selected responses to the survey question:

Tell why you think PLTL was helpful:

- Help each other, learn things missed or not well understood in class
- He makes us get up in front, holds you accountable. Also does not just allow us to guess until we get it right. Makes us know them right
- Sometimes problems goes over things not yet learned
- Reinforces key concepts; Practice time
- Helps to review and retain important concepts
- It gets me to study for the subject before the night before the test
- I get more practice and a better understanding of the material

Below is a suggestion provided by a participant:

- Allow opportunity to share how to study on my own time

Discussion

On average, the group consistently performed better than the class on all four class tests analyzed (these were the first four tests in the course). This corresponded with the results of a similar project analyzed by K. S. Lyle and W. R. Robinson—the PLTL groups performed better than their non-PLTL counterparts (5). An interesting observation was a gradual drop in average test scores for both the class and the PLTL group. It is possible that this may have resulted from the tests increasing in difficulty or the general level of understanding of the material decreasing. More realistically however, the drop in the test scores may have been due to the cumulative nature of a typical organic chemistry course. Also, the range and standard deviation for test three revealed a spread of scores much larger than the other three tests. This could have been due to the fact that time conflicts prevented a few members from attending the PLTL meeting before

that test. In addition, most members admitted that they had not memorized all the required reagents. Earlier, the group had requested a review session with the peer leader a few days before tests. Due to time conflicts, a review session was not held for test three. This may have also contributed to the larger spread of scores on that particular test.

An interesting observation was seen in the performance on the questions requiring critical analysis. Here the difference in scores between the class and the PLTL group decreased significantly over the four tests analyzed. Once again, the same reasons that may have contributed to the decline in average test scores may be applied to the performance on the thought questions. According to the t-tests, the observed difference between the means was not statistically significant. For both the overall test scores and the thought questions, the probability of obtaining these same results due to chance alone was slightly more than 55%. This is significantly larger than the accepted 5% cutoff. This can simply be attributed to a small sample size. In other words, many more tests scores need to be analyzed for the results to gain statistical significance. K. S. Lyle and W. R. Robinson noted that in a similar project where over a thousand participants were involved, the p value was less than 1% (5).

In a project like this, it is critical that the performance of the group compared to the class be interpreted with the human element in mind. One significant influence needs to be addressed. It is possible that some members of the PLTL group may have been poor students who recognized this project as a potential learning resource. In this case, the PLTL Workshop may have helped these students go from being poor to average. Such an effect would not reflect as a high difference between the group and the class. Thus, the group's consistently high performance may have been due to the influence of average or highly driven members performing above

average in the course. Once the human influence is accounted for, it becomes even more important to evaluate the success of the project based on how participants viewed the project.

Therefore, several results of the survey need to be highlighted. First, the average response to the level of correspondence between PLTL material and class lectures was 4.9 out of 5. This indicated that the goal of making the Workshop session integral to the course was reached. Hence, the effort to create an effective network between faculty, PLTL leader, and PLTL participants was established. This important component of a successful Workshop ensured that material covered during a session was not superfluous information, thus serving as more incentive for participants to attend. David Grosser, one of the pioneers of PLTL, emphasizes that ensuring that the Workshop sessions and the course are intimately linked plays a critical role in the success of the program and cannot be dismissed (2). The survey also indicated that the peer leader was effective in conveying necessary information as well as ensuring the smooth running of individual sessions. Along the same lines, weekly meeting of the peer leader with the faculty member teaching the course greatly enhanced the effectiveness of the Workshop. These meeting with the faculty member provided excellent opportunities for the PLTL leader to ask questions and review important concepts. In addition, leading the meetings was an eye-opening experience for the peer leader. Patience and confidence were two of the biggest lessons learned by the peer leader. Similar experiences were reported by other peer leaders in other studies. One such peer leader noted that being a workshop leader teaches students how to be an effective leader. This peer leader admitted, "There is more preparation than I had anticipated, and more patience required than I had thought" (4). Thus, in addition to the PLTL participants, peer leader gain invaluable experiences in leadership.

In terms of individual meetings, the survey revealed that the Workshop materials were challenging at a suitable level (4.7 out of 5). These were neither too easy, nor did they create frustration from being too difficult. Instead, the materials encouraged discussion during Workshop sessions. Finally, the Chemistry Department's willingness to support the program pointed to the institution's philosophy of encouraging innovative methods for ensuring the success of students. Hence, the critical components of a PLTL Workshop were utilized in ensuring the success of the program. Leo Gafney, an acclaimed proponent of PLTL, maintains that the method quickly falls apart and the intended gains are lost if any of the critical components are omitted (9).

On another level, mere observation of the participants revealed a few notable trends. As expected, as the group members got more comfortable with each other, more interaction took place. In fact, the survey clearly revealed that the participants enjoyed interacting with other students in the group (4.7 out of 5). This highlighted the critical element of student-student interaction which is the key to the PLTL model. During the early stages of the project, the generalization was made that most participants were not confident in their knowledge of the discussion materials. Aaron E. Black of the University of Rochester reported that in similar studies, efforts by the Workshop leader to encourage student autonomy enhanced the experience of the participants and improved their performance (10). Thus during this project, the peer leader would often purposely question the responses of the group members simply to test their confidence and encourage autonomy. This made the members think more carefully before providing answers. By the end of the project, members carefully deliberated answers and were more confident with their answers.

Overall, the workshops were a success. Perhaps the biggest weakness was a sudden drop in participation during the second semester of the Workshop. During the first semester, all the members regular attended the sessions. The sudden drop in participation was mainly due to time conflicts. Because of schedule changes between the fall and winter semesters, several of the members were unable to attend the meetings. For instance, only one member was able to attend the first meeting of the second semester. For the next few sessions, only two or three members were able to consistently attend. A potential solution to this problem would be to have two or more PLTL groups. Hence when a semester change comes along, members can rearrange to form groups with compatible school schedules. Of course this will require more than one peer leader, and will require the re-creation of a new group dynamic within the reorganized PLTL groups.

With the results of this pilot project in mind, a suggestion is for this program to be continued in future years. Notably on the survey, the PLTL members indicated a strong willingness to encourage others to participate in Workshops (4.7 out of 5). In a busy academic setting, students tend to recommend only what they find valuable, and this response highlighted the fact that participants viewed the project as a worthwhile expenditure of their time. Clearly, designing and implementing PLTL methods can be done for any course being taught at the university. The effectiveness of the Workshops increases when used for large classes. In addition, peer leaders will experience intellectual growth as they collaborate with faculty members and lead the Workshop sessions. More importantly, PLTL sessions will open new dimensions of teaching for faculty, freeing them from the limitations of traditional lectures. David Grosser rightly labels PLTL as an untapped resource (2). Through this model, the daunting task of succeeding in college can be reached by more students.

Acknowledgements

Acknowledgements

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Southern Scholars Honors Program
Senior Project

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A significant scholarly project, involving research, writing, or special performance, appropriate to the major in question, is ordinarily completed the senior year. The project is expected to be of sufficiently high quality to warrant a grade of A and to justify public presentation.

Under the guidance of a faculty advisor, the Senior Project should be an original work, should use primary sources when applicable, should have a table of contents and works cited page, should give convincing evidence to support a strong thesis, and should use the methods and writing style appropriate to the discipline.

The completed project, to be turned in in duplicate, must be approved by the Honors Committee in consultation with the student's supervising professor three weeks prior to graduation. Please include the advisor's name on the title page. The 23 hours of credit for this project is done as directed study or in a research class.

Keeping in mind the above Senior Project description, please describe in as much detail as you can the project you will undertake. You may attach a separate sheet if you wish:

Designing and setting up a Peer-Led Team Learning (PLTL) workshop at SAU. PLTL is a Chemistry Education effort to improve learning in undergraduate courses. This project will involve leading and monitoring a PLTL group and determining its effectiveness in Organic chemistry @ SAU.

Signature of faculty advisor _____ Expected date of completion _____

This project has been completed as planned (date) Apr. 9

This is an "A" project ✓ This project is worth 2-3 hours of credit ✓

Advisor's Final Signature _____

Chair, Honors Committee _____ Date Approved _____

Dear Advisor, please write your final evaluation of the project on the reverse side of this page. Comment on the characteristics that make this A "quality work.

Dear Southern Scholars Committee,

Stephen Manu diligently performed work on his research project over the Fall '05 – Winter '06 semesters. Both Dr. Scott (who taught him in Introduction to Research) and I consider his project to be 'A' quality work. He successfully designed and implanted a Peer-Led Team Learning (PLTL) Workshop that I can use in Organic Chemistry in future years.

Stephen took the idea of creating a PLTL Workshop and ran with it, carrying out exhaustive research in the chemical journals concerning PLTL theory. Once theoretical validity of his project was established, he then took the responsibility of dealing with the 'volunteer' students for his project. I was not once approached by his students regarding PLTL throughout the entire semester, which is a strong indication to me of Stephen's excellent communication with them as well as his competence during their PLTL meetings. Each week before he met with the students, Stephen and I worked together to create a meaningful worksheets that would correlate with the materials being covered in class. Stephen then would take the material and turn the PLTL meetings into an interactive experience. The ability to effectively present material and then initiate learning based on student-student interaction is not easy, and is something that Stephen mastered by the end of the first semester.

The time Stephen spent on his project easily correlates to 2-3 hour credits. Beyond the literature research and preparation of his paper, Stephen had to plan each weekly meeting (including designing/reviewing the chemistry problems), and then meet with his students every week for 1.5-2 hours. He was meticulous in his preparation and committed to helping his students succeed.

While not a 'classical' chemistry project, Stephen's PLTL Workshop design is much more useful to me because I now have the materials prepared that I can pass on to future PLTL leaders. Research projects using so few students cannot hope to yield meaningful numbers, but trends and qualitative observations can be very useful in 'tweaking' future versions of the study. Stephen has made a Workshop that I can use in the future, has shown data that indicates it was a success in the minds of the students, and qualitatively it appears that the students in the PLTL group were successful in learning Organic Chemistry, which is what PLTL is all about.

I recommend that you accept Stephen's Southern Scholars project as a worthy demonstration of scholarly ability, commitment to excellence, and caring about serving the needs of others.

Sincerely,

Loren Barnhurst

Loren Barnhurst