Peer-Led Team Learning as Educational Tool for First-Year Biology Students

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This article reports the findings of the Peer-Led Team Learning (PLTL) model intervention study in an introductory biology course at a Puerto Rican private university. PLTL introduces to the traditional class format an additional workshop session in which students interact in small groups to solve challenging exercises under the guidance of a peer leader. The questions to be answered are: (1) Does PLTL advance the understanding and learning of biology concepts? (2) Does PLTL increase the number of students passing the course? The methodology consisted of a quantitative approach comparing differences between control (non-PLTL) and experimental (PLTL) groups. Data collection included: final grades, pretests/posttests, opinion questionnaires, and postsession quizzes. The analysis showed an increase in the percent of successful final grades and quizzes, and less dropouts of PLTL over non-PLTL groups. A significant gain of learning was observed between pretest and posttest of both groups ($P \leq 0.05$), with no difference among groups. Students' questionnaires resulted in a higher percentage of positive opinion for the PLTL model. In conclusion, PLTL is a positive educational model for students who struggle to succeed in their introductory science courses.

The General Biology course (BIOL 203-204) is offered in the School of Science and Technology (SST) at a private university in Puerto Rico. To improve students' success, the researchers proposed the implementation of the Peer-Led Team Learning (PLTL) educational intervention model (Batz et al., 2015; Sarquis & Detchon, 2004; Snyder & Wiles, 2015). This PLTL model introduces active learning cooperative workshops into the traditional lecture/laboratory class format of Science, Technology, Engineer, and Mathematics (STEM) undergraduate courses (Freeman et al., 2014; Linton et al., 2014; Smith et al., 2005). In the PLTL workshop sessions, students interact in small groups to answer questions and solve course-related exercises under the guidance of a peer leader (PL). The peer leader (PL) is an upper-division undergraduate student who facilitates pupils´ interactive engagement and learning within the PLTL group. The activities carried out during PLTL meetings help stimulate the understanding of core biology concepts, the development of problem-solving skills, and critical-thinking capacities.

Methods

Setting

This research was conducted in the School of Sciences and Technology (SST) in a private urban university in the eastern region of Puerto Rico. At the time, the SST had approximately 600 students enrolled in its different programs. The participants of this study were underrepresented Hispanic students registered in the General Biology course, a requirement for scholars admitted into the bachelor's degree program in the SST.

Implementation: Pilot study

The PLTL project consisted of an implementation semester (pilot study), followed by an experimental semester (quasi-experiment). The PLTL model began its implementation phase during the first semester. Before beginning the semester, the PLs were carefully selected by means of three criteria: to have passed the courses (BIOL 203, BIOL 204) with a grade of A or B, to be recommended by a biology faculty member, and to be committed to the project. Likewise, during the implementation semester, PLs gained experience in techniques that facilitated discussion and group management under the guidance of the course's biology professors and the PLTL Center Coordinator. The PLs participated in four three-hour workshops. The main topics of these workshops were theories of learning, teaching strategies, and leadership skills.

Furthermore, in this phase (implementation), the exercises provided the faculty were tested within PLTL group sessions and edited as needed. The instruments (test, quizzes, and opinion questionnaire) were validated by experts' judgments and administrated to a pilot group with similar characteristics to those of the sample that participated in the study. An item analysis was performed on the test and quizzes in order to determine the use of the items in the study. During this phase, the researchers collected evidence for reliability from the opinion questionnaire and test by calculating Cronbach's coefficient alpha. In both cases, Cronbach's coefficient alpha was at least of 0.81. This alpha value is considered high for these instruments (Crocker & Algina, 2006).

Quasi-experiment

This study used a pre- and postintervention on intact groups (Campbell & Stanley, 1963). The experimental group relied on PLTL as the main teaching model (PLTL group); whereas the control group used traditional approaches in the teaching and learning processes (non-PLTL group). Both groups participated in 1.5-hour meetings once a week. During this time, the PLTL group conducted activities designed by the professors and guided by peer leaders. On the other hand, during the 1.5-hour weekly sessions, the students belonging to the non-PLTL group reviewed content, as a team or individually. In addition, both groups, PLTL and non-PLTL, took a quiz finalizing their meeting sessions. Furthermore, a pre- and posttest were administered to non-PLTL and PLTL groups at the beginning and end of the semester.

Procedure

The study involved a non-PLTL and a PLTL course. Each PLTL session focused on completing four or five 10–20-minute activities in order to address the material discussed during the week in class. The activities carried out during the PLTL sessions were designed by the course's professor to stimulate the understanding of core biology concepts and to develop problem-solving skills, critical thinking, and higher-order thinking skills such as analysis and application. Each activity was completed within groups of three or four students and was later discussed with the PLs. After the PLTL session or study period, both PLTL and non-PLTL groups were administered a quiz. The quiz was identical for all students and included five or six multiple-choice questions about the content discussed by the professors in class during the week. A pretest was administered to PLTL and non-PLTL groups at the beginning of the semester. Likewise, a posttest was administered to each group at the end of the semester. Furthermore, an opinion questionnaire was also administered to the PLTL group at the end of the semester. The distribution of tasks for calculating students' final grades was as follows: 40% conference tests (four departmental tests), 25% laboratories (four departmental tests and laboratory quizzes or reports), 30% assessment activities (debates, assignments, oral reports, etc.) and 5% of PLTL or study session participation.

Subjects

The sample consisted of two groups of the undergraduate general biology course (non-PLTL and PLTL groups). During the second semester, 20 students participated in the non-PLTL group and 23 participated in the PLTL groups, respectively. All participants were Hispanic, and they consisted of both male and female students between the ages of 18 and 26. In both groups, female participation was higher than male participation (55% and 58% in PLTL and PLTL groups correspondingly). The participants in each group constituted a convenience sample (Gay et al., 2012). The nonprobabilistic sample was selected considering that the course sections were taught by professors who incorporated PLTL as the preferred model for teaching BIOL 203-204. Once the sections were identified, students in both groups were oriented and invited to complete the consent form approved by the Institutional Review Board (IRB).

Data collection

The data were gathered from four sources. First, a pre- and posttest were administered to the non-PLTL and PLTL groups. Each test consisted of 40 questions that were extracted from the three exams administered throughout the semester. A table of specifications was elaborated in which the objectives and content of the course were aligned to the learning domains suggested by Bloom´s taxonomy: knowledge, comprehension, application, analysis, synthesis, and evaluation (Marzano & Kendall, 2007). This table was used to classify the questions from the pre- and posttests. Nearly 60% of the questions were aligned to higher forms of thinking (e.g., analysis and evaluation). Second, a total of 11 short tests (quizzes) consisting of five multiple-choice questions about main topics of the course were completed by both groups. The third instrument was an opinion questionnaire completed by the PLTL group. The questionnaire consisted of 32 Likert-scale questions (ranging from "totally agree" to "totally disagree") exploring students' opinion regarding the PLTL model. The opinion questionnaire consisted of nine subscales: (1) facilities and environment; (2) activity; (3) team work in PLTL; (4) contribution and participation in activities; (5) quizzes; (6) peer leaders; (7) students' behavior and attitude toward PLTL; (8) willingness to become peer leaders; and (9) suggestions for others to enroll in PLTL. Lastly, the participants' final grades were used as a student success indicator in the course.

Analysis

The analysis included descriptive statistics, tables, and graphics to measure frequencies, percentages, and final grade distributions among the PLTL and non-PLTL groups. The results of students' opinion questionnaire, as well as the students' performance on tests, were analyzed. In addition, *t*-tests for independent samples were used to compare pre- and posttests between groups and a *t*-test for paired samples was conducted to compare pre- and posttest in both groups. A nonparametric test (U-Mann-Whitney Test) allowed the researchers to compare student performance on quizzes. In order to conduct these analyses, the data analysis software SPSS, version 21 for Windows, was used.

Results

Final grades and dropout rate

This study relied on students' final grades in the PLTL and non-PLTL course in order to establish the groups' behavior. Successful course outcomes were defined as final grades consisting of "As," "Bs," and "Cs." A 25% increase was observed in the percentage of successful outcomes in the final PLTL course grades obtained by participants as compared with participants in the non-PLTL course (77% in the PLTL group and 52% in the non-PLTL group). Concerning dropouts, the researchers observed that the withdrawal rate in the PLTL course was significantly lower than in the non-PLTL course (2% versus 21%, respectively).

Differences between groups

The score distribution on the pre- and posttests used in this study met the normality (Shapiro-Wilk's test) assumption. The homogeneity of variance was met (Levene's test) in all the comparisons made (pre- and posttests).

Differences in pretest and posttest

A two-tailed t-test shows no significant difference between students' results on the pretest in non-PLTL and PLTL groups. These results lead to disregard the selection bias as a serious threat to internal validity of the study; thus, justifying its advisement. The gain (acquisition) in learning of PLTL and non-PLTL groups was determined by the statistically significant difference between the pre- and posttests in each group ($P \leq 0.05$). Finally, this study also compared both groups' performance on posttests. These results indicated no significant difference in learning among students belonging either to the PLTL or non-PLTL groups ($p = 0.128$).

Opinion questionnaire: Overall categories

Table 1 illustrates a high percentage of students with positive opinions toward the PLTL model in all categories and questions.

Quizzes

The PLTL group achieved higher grades on all 11 quizzes. In this case, the researchers compared the PLTL and non-PLTL groups, considering all students who had taken at least eight out of the 11 quizzes. The U-Mann-Whitney test revealed that six out of the 11 quizzes indicated statistically significant differences between PLTL and non-PLTL groups ($P \leq 0.05$) (Figures 1 and 2).

Figure 1 illustrates the mean rank in each group. On the third and fifth quizzes, the significant differences are indicated (*) (sig $\leq$ 0.05). Figure 2 illustrates the mean rank in each group. On the sixth, eighth, ninth, and tenth quizzes, the significant differences are indicated (*) (sig $\leq$ 0.05).

Discussion

The aim of this study was to investigate whether the PLTL, an educational model, contributes to the success of students in the introductory Biology course.

Effect of Peer-Led Teaming Learning on grades, withdrawals, quizzes, and pre- and posttests

The research findings indicate that students who participated in the PLTL group achieved higher scores on quizzes and on final grades than students participating in non-PLTL group. Regarding final grades, 25% of the students in the PLTL group achieved higher final grades compared to non-PLTL peers (77% versus 52%). After comparing student performance on quizzes between the PLTL and non-PLTL groups (Figures 1 and 2), a significant statistical difference was observed in six out of 11 quizzes ($P \leq 0.05$). That is, on six quizzes, PLTL students showed improved learning than non-PLTL students. These quizzes, (corresponding to numbers 3, 5, 6, 8, 9, and 10) evaluated: structure and function of biomolecules (3), structure of the cell membrane (5), energy and metabolism (6), photosynthesis (8), Mendelian genetics (9), and cellular communication (10). The quizzes identified better performance of the students belonging to the PLTL group compared to the non-PLTL group. Hence, the results suggest that PLTL activities may foster understanding and learning of the basic concepts taught in the introductory biology course.

Furthermore, when dropout rates are compared between PLTL (2%) and non-PLTL groups (21%), the PLTL students demonstrated more resilience in completing their course than the non-PLTL. These findings support several authors' arguments indicating an improvement in student grade performance, as well as a decrease in the percentage of student withdrawal in PLTL courses (Gafney & Varma-Nelson, 2008; Preszler, 2009; Snyder et al., 2015).

Moreover, the *t*-test demonstrated a statistically significant difference ($P \leq 0.05$) between the pre- and posttests in both PLTL and non-PLTL groups. These results indicated a gain (acquisition) in learning when comparing pre- and posttests in each group. Likewise, the results of this study also indicate that, when comparing the posttest scores between the PLTL and non-PLTL groups, no statistically significant difference was identified. This result is consistent with studies that reveal no statistically significant difference between the posttests scores of PLTL and other active learning strategies when compared to traditional teaching methods (Espinosa et al., 2013; Linton et al., 2014).

Therefore, a significant difference on the posttest scores between PLTL and non-PLTL groups should not be the only assessment performed when evaluating learning improvement outcomes (Earl, 2006). Thus, the differences in learning between the two groups could be qualitative. That is, the PLTL group might benefit greatly from its learning experience as a result of being influenced by processes that seek to develop the social construction of knowledge (Vygotsky, 1979) through the engagement in course-related activities and resolution exercises, cooperative learning, and peer instruction mentorship. The latter might also explain the increase in final grades and on quiz performance, as well as the lower dropout rate of the PLTL group over

FIGURE 1

Results on quizzes (#1 –#5).

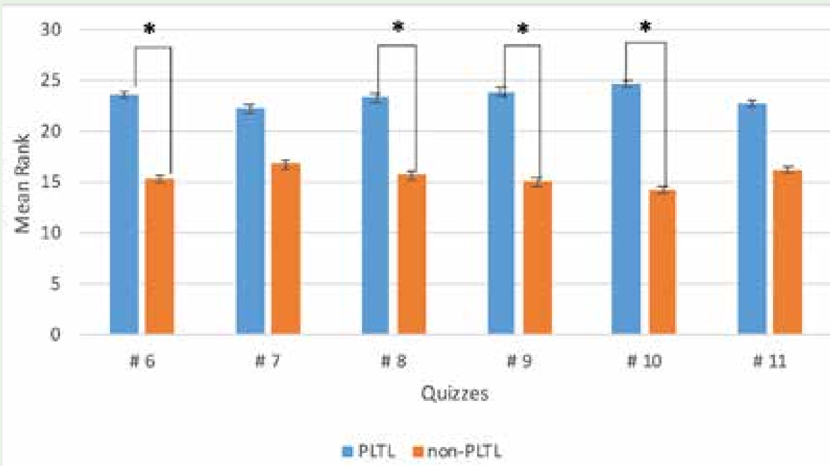
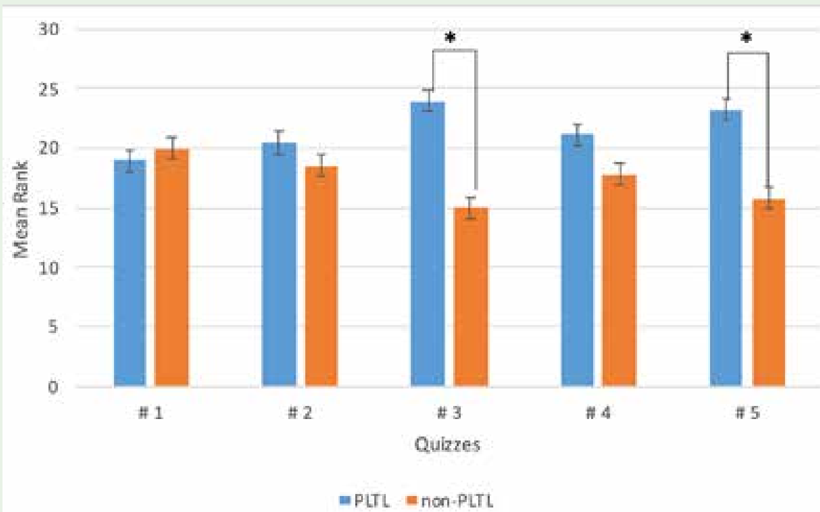


FIGURE 2

Results on quizzes (#6–#11).



the non-PLTL group, which was discussed earlier (Eberlein et al., 2008; Preszler, 2009).

Students' opinions on Peer-Led Teaming Learning influence

The data gathered from the opinion questionnaire indicated that, in general, students had a very positive opinion toward various aspects of the PLTL model (Table 1). They claimed that the PLTL sessions helped them gain a better understanding of biology concepts. In addition, the discussion with their classmates during the PLTL sessions (Category 3: Teamwork in PLTL) helped them become more successful on quizzes and tests. These data confirmed previous findings indicating that students perceived great benefits from the PLTL experience (Tien et al., 2002).

The success of the PLTL model also depends on appropriate accommodations of PLTL sessions. Students indicated that the classrooms where the PLTL sessions were held were comfortable and adequate for meeting and discussing the exercises (Table 1). Likewise, the involvement of the peer leader was considered crucial in encouraging student participation. In this study, 90% of students believed that, in general, all students on the team contributed to solving exercises, whereas only about 40% of the students stated that there were peers who acted as obstacles for completing the work to be done (Table 1). It was observed that when the students felt comfortable on a team, they became much more involved in the PLTL sessions.

In addition, the findings indicated that peer leaders must be carefully selected, trained, and very committed to their work as guides for their peers. Fortunately, leaders in this project complied with those characteristics and were very responsible. This was also perceived by participating students (Category 6: Peer Leaders). The participants also perceived that the PL's work was decisive for PLTL success and that active discussions

TABLE 1

Percentages of students' opinion by questions.

Categories	Questions	Percentages (strongly agree and agree)
Facilities and environment	(Q1) The learning center facilities are appropriate for the PLTL meetings.	100%
	(Q2) The time spent on PLTL activities is suitable.	96%
	(Q3) The noise and other distractions in the classroom made it difficult to concentrate during the discussion of the activities.	64%
Activities	(Q4) I am satisfied with the format of the PLTL activities.	91%
	(Q5) The PLTL activities are related to the material discussed in class.	100%
	(Q6) Activities were interesting.	96%
	(Q7) PLTL exercises were very difficult.	43%
Teamwork	(Q8) All students in my group participated in the solution of the exercises.	88%
	(Q9) Teamwork was usually led by one or two students.	60%
	(Q10) The group discussion, as part of the solutions for the exercises, helped me improve my capacity to think logically and critically.	100%
	(Q11) Interaction with students in my group contributed to improve my understanding of biology.	96%
	(Q12) In the group there were students who made teamwork difficult.	39%
Contribution & participation in activities	(Q13) PLTL activities helped me prepare for exams.	91%
	(Q14) Participation in PLTL helped me to get a better grade in the class.	100%
Quizzes	(Q15) The quizzes were related to PLTL exercises.	100%
	(Q16) The quizzes helped me reinforce the topics discussed in the PLTL exercises.	96%

between the PL and participating students were essential in the learning of biological concepts and in order to be successful on tests (Table 1).

Regarding PLTL activities designed to develop student learning, students also felt that the exercises were very helpful (Category 4: Contribution and Participation in Activities). A high percentage of students believed that PLTL activities helped them to be successful on exams and to achieve higher scores on final grades (Table 1). The activities were designed by professors to encourage students to develop critical-thinking skills. The PLTL model places the students at the center of the discussion, where they are the protagonists of their learning process. However, adapting to this type of education is not easy if students have conceptual deficiencies or if they are shy or not committed to their learning. In addition, if students are not challenged with exercises that encourage critical thinking, then they will not recognize the value of the PLTL model.

The survey's category 7 indicated that students have a very good attitude toward the PLTL model, even though only about half of the students confessed to being prepared before attending PLTL sessions (Table 1). It is clear for participating students that small working groups provided the means for them to collaborate and share their knowledge, which strengthened their own learning. In addition, active discussions in small groups provided spaces for healthy socialization and encouraged students to develop communication skills and a shared learning community (Batz et al., 2015).

Having experienced the PLTL model also encouraged the development of a learning community that supported students who might have felt isolated. To this effect, it is well known that isolation may lead to a lack of motivation and eventual dropout of college students in the early and more

TABLE 1 (continued)

Percentages of students' opinion by questions

Categories	Questions	Percentages (strongly agree and agree)
Peer leaders	(Q17) The peer leader was well prepared to lead the group.	96%
	(Q18) The peer leader dominated the subjects of biology, which we discussed.	96%
	(Q19) The peer leader responded appropriately to the students' questions.	96%
	(Q20) The peer leader encouraged all students in the group to participate in the discussion and solution of the exercises.	100%
	(Q21) The peer leader gave us ideas of how to solve the exercises.	91%
	(Q22) Interaction with the peer leader contributed to improve my comprehension of the subject.	100%
	(Q23) The peer leader was effective in guiding us to present solutions to the exercises.	100%
Student's behavior and attitudes to PLTL	(Q24) I regularly attended PLTL activities.	91%
	(Q25) I studied the class material before going to the PLTL meeting.	57%
	(Q26) I felt comfortable interacting with the peer leader.	100%
	(Q27) I felt comfortable interacting with the students in my group.	91%
	(Q28) I felt comfortable asking questions when I did not understand the material.	96%
	(Q29) I was actively involved in my group in solving PLTL exercises.	96%
	(Q30) I liked to participate during the discussion of the exercises that were done on the board.	74%
Willingness to become "peer leader" and recommendations to others concerning PLTL	(Q31) I would like to be a PLTL leader in the future.	69%
	(Q32) I would recommend other students to take PLTL.	96%

critical years of their STEM studies (Batz et al., 2015; Watkins & Mazur, 2013). In addition, the PLTL model also provided benefits for students acting as tutors. On this matter, some findings indicate that tutors improve their mastery of course content and their perception of the study area (Otero et al., 2010).

All of the previously mentioned positive responses to the PLTL model and great motivation for student learning through discussion with peers in small groups have encouraged the researchers to further implement this educational model at the university level. It is hoped that this teaching model, focused on the student, continues to improve student learning and healthy social interactions, as well as students' cognitive development, especially in terms of their understanding of biology and their ability to communicate knowledge and acquire scientific literacy.

Conclusions

This study described the effects of the PLTL model on students' learning in an introductory biology course. The findings suggest that the PLTL model greatly contributes to students' academic success and demonstrate that the PLTL model encourages student engagement, critical thinking, and success in introductory biology courses. Likewise, the findings also support the claim that the PLTL model promotes positive attitudes among students regarding the teaching-learning process such as teamwork, group discussions, and lesson activity structures. Work sessions in small groups seem to help students develop thinking skills. Also, this study indicated that the PLTL model helps increase student retention in the PLTL group in comparison to the non-PLTL group. This evidence demonstrates that the PLTL model is useful for developing competencies in students who are mostly first-generation university students and belonging to disadvantaged socio-economic classes. Based on the results of this study, the researchers recommend the implementation of the PLTL educational model in other science and mathematics courses. ■

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