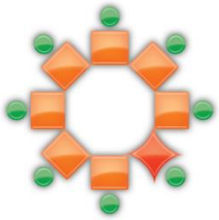

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TEN-YEAR CUMULATIVE ANALYSIS ON THE IMPLEMENTATION OF PLTL IN BIOLOGY UNDERGRADUATE EDUCATION

JOSE ALBERTE, GISELLE BARRETO, ALBERTO CRUZ, NATALY RODRIGUEZ, AND THOMAS PITZER

Abstract: Several studies have shown that students who participate in PLTL workshops perform a letter grade higher than those who do not participate in PLTL. However, no meta-analysis has been performed to show the overall effect PLTL has on student performance over a decade. Per-term analyses of the effect of PLTL on learning in biology courses at Florida International University have shown that students who participate in PLTL outperform those who do not fully participate in PLTL, which is consistent with published literature. A cumulative meta-analysis over 10 years shows that PLTL participants are approximately three times as likely to pass our gateway biology courses, versus those who do not participate in PLTL. These findings indicate that the use of Peer Leaders as facilitators is an effective learning strategy in undergraduate STEM education.

Numerous studies have demonstrated that participating in Peer-Led Team Learning (PLTL) leads to significant improvements in student course grades, retention rates, critical thinking skills, and attitudes towards their coursework compared to those who did not participate in PLTL (Tien, Roth & Kampmeier, 2002; Quitadamo, Brahler & Crouch, 2009; Wamser, 2006). Comparable improvements have also been viewed across ethnicities, including nationally underrepresented minorities, and genders (Tien et al., 2002; Horwitz & Rodger, 2009). Many current studies focus on analyzing the PLTL model over short periods of time (Mitchell, Ippolito, & Lewis, 2012; Reisel, Jablonski, & Munson, 2013; Utschig & Sweat, 2008; Sperry & Tedford, 2008). Few studies have analyzed PLTL student data within a two- to five-year time frame (Gafney & Varma-Nelson, 2012; Streitwieser, & Light, 2012; Lyle, & Robinson 2003; Mottley & Roth, 2013), while studies have yet to clearly provide a long-term perspective, over five years, on the effectiveness of the PLTL model on student success.

The PLTL model is a student-centered active learning paradigm, which uses undergraduate Peer Leaders (PLs) as facilitators. It was developed in the early 1990s, funded by grants from the National Science Foundation (NSF) to improve science education (Gosser & Roth, 1998). PLTL preserves the lecture, but enhances the student learning experience by introducing a structured learning environment, which requires the students to actively engage with the learning materials in a group setting, often referred to as workshop. The PL serves as the facilitator for discussion in

each workshop. This instructional model goes against the typical asocial nature of traditional instruction and embraces social learning. PLs are not the source of answers during workshops, but instead serve as guides or mentors to the students. The workshop provides a learning environment where students socially construct knowledge through discussion, debate, and problem solving. To accomplish this, at Florida International University (FIU) in Miami, Florida, the course instructor, learning specialists, and program staff work collaboratively to train PLs on engaging students, foster student-student interactions, and systematically solve problems in science (Alberte, Cruz, Rodriguez & Pitzer, 2013).

A meta-analysis is a statistical method focused on combining results from independent studies to identify patterns in the data. It allows for more precise estimates of the impact of established relationships. Meta-analyses on the impact of active small group learning paradigms in undergraduate STEM education have demonstrated a significant impact on student academic achievement, problem solving skills, and attitudes (Springer, Stanne & Donovan, 1999; Dochy, Segers, Van den Bossche & Gijbels, 2003). A meta-analysis was performed using exam scores over a 10 year period to analyze the effectiveness of PLTL at FIU in General Biology I, the majors' introductory biology course.

Methods

Secondary data on student exam grades in General Biology I at FIU were collected between Fall 2003 and Spring 2013. In General Biology 90% of the grade is dedicated to exams (3-5 exams) and 10% is dedicated to online quiz grades. All exam grades from each section of General Biology I taught during individual semesters were combined. This course was taught by various instructors during this ten-year period. This combination of data was possible because General Biology I instructors are required to use and follow the same syllabus, meet to discuss consistent content schedules, and use the same textbook for the course.

Only exam scores were averaged for each student, to recalculate course grades and exclude bias. The final course grade and final exam grade were not used in this study due to the impact of the PLTL participation score on these grades. An initial incentive to increase student participation in PLTL provides extra credit towards their final exam. Since most students do well in PLTL, including the final exam in the analysis would inflate the results and introduce unwanted bias. Online quiz grades were not included as they may have also inflated student course grades. As the final exam grade and the quizzes were not factored into this estimate, a full assessment of the students' performance was not considered in the analysis. Therefore, this analysis excludes grade boosters and focuses strictly on student academic performance.

A cut-off point of 70% or greater was established to identify students who had passed with a C average or higher. Students with averages 69.9% or lower were considered as failing the course. Students were then categorized into two groups based on whether they participated in PLTL or not. Microsoft Excel was used as a database to collect information and analyze preliminary results. The grades analysis was completed for each semester followed by an individual Odds Ratio (OR) reported for each individual semester. Odds Ratio is a statistical test which quantifies the strength of association between an exposure and an outcome. Summary

statistics were generated using a random effects model to account for any heterogeneity that may have been present in the data before analysis. Cochrane's Q and I^2 tests were used to analyze the amount of heterogeneity present in the data.

Results

Semester_ Year	N	% of Students in PLTL	% Passing who were in PLTL	% Passing who were not in PLTL	OR	95% CI
Fall_2003	268	77.99%	61.72%	35.59%	2.92	(1.59, 3.51)
Summer_2004	140	74.29%	75.00%	50.00%	3.00	(1.36, 3.79)
Fall_2004	547	61.06%	58.98%	54.46%	1.20	(0.85, 1.55)†
Summer_2005	158	72.15%	77.19%	59.09%	2.34	(1.11, 3.09)
Fall_2005	567	43.03%	72.95%	57.59%	1.99	(1.39, 2.34)
Summer_2006	153	78.43%	66.67%	45.45%	2.40	(1.10, 3.18)
Fall_2006	551	92.01%	80.67%	48.30%	2.89	(1.52, 3.53)
Summer_2007	257	74.32%	80.10%	55.00%	4.03	(2.21, 4.63)
Fall_2007	767	88.53%	78.56%	34.09%	5.83	(3.63, 6.31)
Fall_2008	576	94.27%	62.25%	27.27%	4.40	(2.00, 5.18)
Spring_2009	227	90.75%	70.39%	47.62%	2.61	(1.06, 3.52)
Fall_2009	592	74.83%	76.75%	57.05%	2.49	(1.68, 2.88)
Spring_ 2010	201	80.10%	62.11%	32.50%	3.40	(1.63, 4.14)
Summer 2010	177	86.44%	72.50%	50.00%	2.64	(1.10, 3.52)
Fall_ 2010	742	83.29%	68.28%	53.23%	1.89	(1.28, 2.28)
Spring_2011	327	91.13%	75.17%	17.24%	14.53	(5.35, 15.53)
Summer_ 2011	241	85.48%	69.42%	22.86%	7.66	(3.30, 8.50)
Fall_2011	750	83.47%	37.70%	60.13%	3.15	(1.90, 3.65)
Spring_2012	330	82.73%	58.97%	29.82%	3.38	(1.83, 4.00)
Summer_2012	256	75.39%	69.43%	47.62%	2.50	(1.40, 3.08)
Fall_ 2012	986	73.53%	69.93%	49.04%	2.42	(1.81, 2.71)
Spring_ 2013	351	81.20%	53.33%	30.76%	2.63	(1.48, 3.20)
Summary					3.11	(0.52, 18.60)†

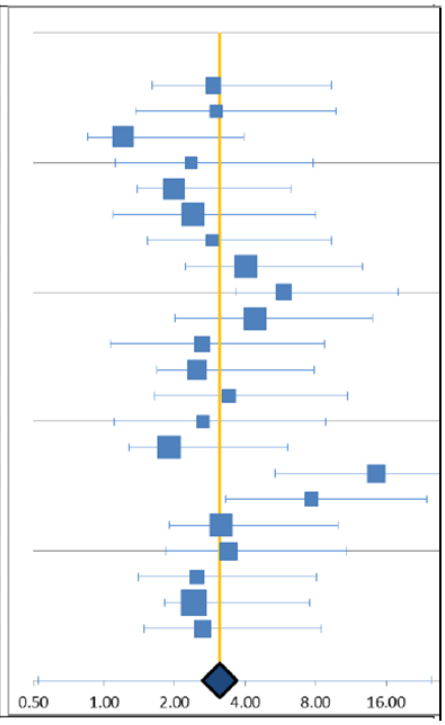

Figure 1*a*. Total number of students (*N*) in General Biology I over 10 years (22 semesters) with the percentage of students who passed the course with participation in PLTL, and passed the course without participation in PLTL. The Odds Ratio (OR) was calculated for these measures, along with the 95% confidence interval (CI). A summary OR and CI were calculated using a random effects model.

† denotes estimates considered to be insignificant at $\alpha = 0.05$ level of confidence.

Figure 1*b*. Forest Plot visually demonstrates the OR and CIs for each semester, as well as the summary estimate OR and CI.

Individual semesters showed a significant difference between the passing rates of those in PLTL as compared to those who did not participate in PLTL, with the exception of Fall 2004 (OR= 1.20, 95% CI: 0.85, 1.55). The pooled estimate from the random effects model was reported as 3.11 with a 95% Confidence Interval of 0.52 to 18.60 (Figure 1*a*). After generating the Q statistic, it was found that heterogeneity within the data was significant. This was confirmed by the I^2 test, which was reported as being greater than 90%. Results are shown in Figure 1*b*, as a forest plot, which

includes the point estimate for each study, a pooled estimate, and their respective confidence intervals. In every semester, students who participated in PLTL outperformed their peers who did not participate in PLTL (Figure 2).

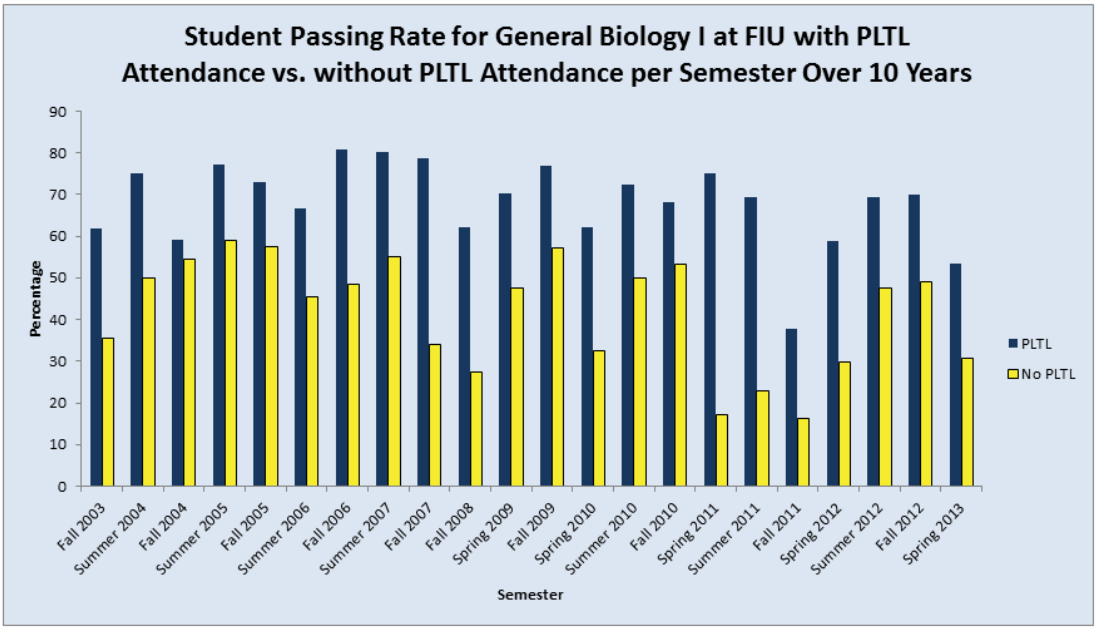

Figure 2. Passing rates for General Biology I students at FIU for 10 years (22 semesters) comparing students who participated and did not participate in PLTL.

Discussion

Studies have shown that PLTL improves student grades, not only in STEM education but in other courses and disciplines (Johnson, 2009; Murray, 2011). FIU's data provide a unique analysis of the effect of the peer-led workshops, on a campus with a diverse population of commuter, non-traditional, minority students. In our analysis, we found that the pooled effect of students who participate in PLTL is 3.11 times as likely to pass with a C or higher (≥70%), than individuals who did not take PLTL, which is congruent with past findings (Tien, et al., 2002; Sperry, et al., 2008; Quitadamo, et al., 2009; Mottley, et al., 2013; Wamser, 2006). The significance of the confidence interval also includes a negative possible correlation; however, up to now, there has been no sign from previous semesters that PLTL had a negative impact on student learning. The academic gain of students involved with PLTL was found to be significant in 21 of the 22 semesters included in this study at a 95% Confidence Interval.

Significant heterogeneity was identified in the study, which could be attributed to the nature of the pooled data used. While all instructors who teach General Biology I at FIU are required to follow the same syllabus and schedule of topics, each instructor can use different teaching techniques, which could affect student learning and can impact grades. Thus, these individual classes should be treated as individual data points, not clustered together per semester. Additionally, many factors which have not been analyzed, such as student performance in other

STEM courses, student course load, PL performance, major of study, etc., may also contribute to the heterogeneity in the data and may affect overall student performance.

Combining the data into a summary estimate shows a physical point of the findings as they interact with one another. At FIU, the program continues to demonstrate a significant difference in the passing rates between students who do and do not participate in PLTL, with about three times the difference between each group. However, there are many factors which can affect the significance of the summary statistics found.

This study demonstrates that Peer Leaders can act as a powerful and influential agent in advancing undergraduate education. The use of PLs to improve students' learning experiences is a financially realistic institutional plan with great benefits for students. Therefore, it is important to analyze the effect of PLTL on students and PLs over time, as well as to collect data on other covariates to reduce heterogeneity within the data, to identify key areas, which could increase the impact PLTL has on student learning and future success.

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