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Exploring the Educational and Psychological Impacts of Peer Led Team Learning and Cyber Peer Led Team Learning on Undergraduate Students in a Large-enrollment Introductory Biology Course

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Abstract

Peer Led Team Learning (PLTL) is a well-studied active learning model that is associated with improved educational outcomes for students. The introductory biology course at Syracuse University (SU) has a well-established PLTL program, and published research stemming from this program has shown that PLTL has positive impacts on the short- and long-term retention of underrepresented minority (URM) students in STEM. However, there are additional data regarding potential benefits of the PLTL program for women and first-generation college students that have yet to be published. In this thesis, I present previously unpublished data indicating that women and first-generation college students who participated in PLTL were more likely to be retained in STEM majors than their counterparts who did not participate in PLTL, and that participating in PLTL is associated with diminished feelings of imposter syndrome, which were more common among participants who identified as women.

Due to constraints imposed by the COVID-19 pandemic, the introductory biology course and its associated PLTL program transitioned to an online format during the Fall 2020 semester. This provided an opportunity to explore the impacts of the newly developed and comparatively less understood variation of PLTL, cyber Peer Led Team Learning (cPLTL), among different groups of students. We found that participating in cPLTL was associated with improved academic achievement and retention and that this trend held true when looking specifically at women, first-generation college students, and URM students.

Cumulatively, this work shows that both PLTL and cPLTL are associated with improved educational outcomes in terms of academic achievement and retention for underserved groups of students. There are several psychological benefits the program may provide to students that may be a mechanism by which PLTL improves educational outcomes, such as increased motivation,

increased sense of belonging, or reduced feelings of imposter. Together, these findings support the use of PLTL and cPLTL as active learning strategies to improve the effectiveness and equity of STEM education.

EXPLORING THE EDUCATIONAL AND PSYCHOLOGICAL IMPACTS OF PEER LED TEAM LEARNING AND CYBER PEER LED TEAM LEARNING ON UNDERGRADUATE STUDENTS IN A LARGE-ENROLLMENT INTRODUCTORY BIOLOGY COURSE

By

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Introduction

Discipline-Based Education Research (DBER) addresses questions of teaching and learning in structured, methodical ways, and it is grounded within a parent discipline. DBER began growing rapidly as a field since the early 2000s, and particularly since The National Research Council (NRC) reported in 2012 on the impact and importance of education research embedded in the culture of the discipline being studied. DBER professionals use a wide range of research methods (quantitative, qualitative, and mixed methods) to study teaching and learning while considering a discipline's priorities, worldview, knowledge, and practices (NRC, 2012).

Although DBER can be situated within any discipline and can study teaching and learning at any grade level, it is frequently associated with undergraduate Science, Technology, Engineering, and Mathematics (STEM) education because of long-standing concerns that undergraduate STEM courses are not consistently providing students with high quality learning experiences, nor are they supporting the retention of students in STEM majors to the degree that they should (President's Council of Advisors on Science and Technology [PCAST], 2012). As such, some of the main goals of DBER include determining the best methods for teaching and learning the content, practices, and ways of thinking in STEM; contributing to the knowledge base in a way that new findings can be incorporated into the classroom; and identifying approaches to make STEM education more equitable and inclusive (NRC, 2012).

A large and growing body of evidence resulting from DBER has repeatedly confirmed that active learning is a more effective and equitable teaching method than the traditional lecture, regardless of STEM discipline or class size (Deslauriers et al., 2019; Freeman et al., 2014a; Theobald et al., 2020). Drawing on these findings, major professional organizations and universities nationwide have called to reform traditional STEM education by shifting from

teacher-centered approaches, such as lectures where students passively listen to information, to student-centered approaches where students actively engage with course content (American Association for the Advancement of Science [AAAS], 2011; National Academy of Science, 2011; NRC, 2012).

Peer Led Team Learning (PLTL) is a well-studied active learning pedagogy that can be implemented as part of the large-enrollment gateway courses that have historically been taught (and often continue to be taught) primarily by teacher-centered lectures, or alongside other active learning pedagogies. The PLTL model involves students in a given course attending regular (usually weekly) PLTL workshops in addition to or in place of traditional lectures. During the PLTL workshop, small groups of students work collaboratively to solve a problem set related to course content that was prescribed by the course instructor. The workshops are led by a peer leader; an undergraduate student who succeeded in the course during a previous semester. In addition to the workshops, peer leaders attend weekly training sessions led by a learning specialist. During the training, peer leaders learn to facilitate discussion and problem solving within their group, so they can help their students work toward their own answers rather than "teaching" them the course content.

Research has shown that PLTL students experience improved educational outcomes compared to non-PLTL students in terms of academic achievement, retention, and understanding of course content (Wilson & Varma-Nelson, 2016). Participating in PLTL has also been associated with several psychological benefits, such as increased self-efficacy, increased sense of belonging, and decreased course anxiety (Wilson & Varma-Nelson, 2016). PLTL is thought to be effective because it provides opportunities to engage in active learning, a non-threatening

environment to ask questions and receive help, and peer support in learning content material (Dixon, 2012).

PLTL was first implemented in the introductory biology series at Syracuse University in response to an institutional curriculum revision. The revision included important programmatic improvements for biology majors, such as the addition of more lab-based courses at the upper division and a greater breadth of coverage in biology for the major overall. However, an unfortunate concession associated with these curricular shifts was that the lab component of the second course in the introductory biology series was made optional. There was concern for the academic achievement and retention of the students who would choose to opt out of the lab component because students who participate in the associated lab session tend to do better in introductory STEM courses than those who do not (Snyder, Carter, & Wiles, 2015).

PLTL was implemented as a potential stopgap measure for students who opted out of the lab component. At the beginning of the semester, students had the opportunity to enroll in the PLTL component, the lab component, both components, or neither. Regardless of prior academic achievement, students who did not enroll in lab scored on average a letter grade below those who did enroll in lab. However, students who did not enroll in lab but participated in PLTL performed at levels equivalent to those who took the lab component in terms of conceptual learning and achievement, showing that engaging in PLTL was a successful stopgap measure for those populations (Snyder et al., 2015).

Additional work at SU has further explored the impacts of the PLTL program in introductory biology, including impacts on academic achievement and retention in the course (Snyder, Sloane, Dunk, & Wiles, 2016) and retention in STEM majors (Sloane, Dunk, Snyder, Winterton, Schmid, & Wiles, 2021), particularly for students in underserved populations. Snyder

and colleagues (2016) found that for students who did not participate in PLTL, the percentage of students earning Ds, Fs, or withdrawing from the course (DFWs) was significantly higher for URM students (~40%) than for non-URM students (~15%). However, for students who did participate in PLTL, the percentage of students earning DFWs did not differ significantly between URM students and non-URM students, suggesting that PLTL contributed to reducing achievement gaps in introductory STEM courses.

To examine the impacts of PLTL participation on URM student retention in STEM majors, Sloane et al. (2021) collected institutional data regarding prior achievement, declared ethnicities, and any declared majors for participants three and a half years after they enrolled in the introductory biology series. For those who did not participate in PLTL, URM students were significantly less likely to be recruited or retained in STEM majors as compared to non-URM students. However, with PLTL, there were no significant differences in recruitment or retention rates between URM and non-URM students. Together, these results suggest that participating in PLTL in an introductory biology course can have important downstream effects on the recruitment and retention of URM students in STEM majors.

Data have been collected since the PLTL program was first implemented in SU's introductory biology series. While analyses of these data have led to several reports in peer-reviewed outlets, some of it has yet to be published. This includes results which may be useful to education researchers and undergraduate STEM instructors interested in evidence-based strategies for improving the equity and efficacy of education in their classrooms. For example, data has been collected regarding the association between PLTL participation and decreased imposter feelings among students, and regarding the impact of PLTL on the recruitment and retention of women and first-generation college students in STEM majors. Chapter 1 of this

thesis presents a curation of these data to be submitted for publication as a Data Note in *BioMed Central (BMC) Research Notes*.

Over twenty years of PLTL research has confirmed that students who participate in PLTL are more successful academically than those who do not, and that PLTL addresses the learning needs of students regardless of their ethnic identity or gender. However, there are barriers that prevent many students from the opportunity to participate in PLTL. Inflexible school, work, or family schedules can make it difficult for students to find a PLTL session that fits their schedule (Mauser et al., 2011). Some institutions lack the physical space necessary to provide PLTL workshops on campus (Mauser et al., 2011). Sometimes there are not enough peer leaders to offer enough PLTL sessions to accommodate all students within a given course.

Cyber PLTL (cPLTL) is a relatively new variation of PLTL that has the potential to diminish some of the barriers students face in accessing PLTL by providing more flexible scheduling and attendance options. cPLTL sessions occur in a synchronous online environment, rather than face-to-face, which eliminates the need for physical space. Flexible scheduling and attendance options can make it easier for students to find a session that fits their schedule and can increase the number of students who are willing to serve as peer leaders by reducing scheduling conflicts. However, before these benefits can be realized, more research is necessary to determine the impact of cPLTL on student educational and psychological outcomes.

Chapter 2 of this thesis explores the efficacy of cPLTL, paying special attention to its impacts on groups of students who have historically been marginalized in STEM. This chapter has been presented at the 2021 annual meeting of the Association of College and University Biology Educators (ACUBE) and the 2022 annual meeting of the National Association for Research in Science Teaching (NARST). Papers proposed for presentation at NARST are

submitted as full research reports (not mere abstracts) which are double-blind peer reviewed by at least three reviewers. This chapter has been submitted for peer review toward hopeful publication in *Bioscene: Journal of College Biology Teaching*.

The following chapter has been formatted for publication in *BMC Research Notes* using the required Data note template. *BMC Research Notes* has specific guidelines for citation styles, word limits, and section headings, which have been followed in preparation of this chapter.

Peer Led Team Learning in an Undergraduate Biology Course: Impacts on Recruitment, Retention, and Imposter Phenomenon

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Abstract

Objectives:
The data presented in this note were collected during a multi-year project conducted in the context of large-enrollment introductory biology course at a large private R-1 research institution in the Northeastern United States. The project aimed to examine the impact of Peer Led Team Learning (PLTL) on the recruitment and retention of marginalized groups in Science, Technology, Engineering, and Mathematics (STEM) majors. While several results from the project have been published, additional data of interest have yet to be reported. This data note reports on additional associations between PLTL participation and improved outcomes for students from groups that have historically been excluded in STEM. Additional data reported herein were collected to determine if students in the course experienced imposter phenomenon, and whether PLTL may be associated with reduced levels of imposter feelings.

Data description:
The data in this note includes academic information such as final course grades and academic level; socio-demographic information such as gender identity, minority status, and first-generation status; and information on student recruitment, retention, imposter feelings, and participation in Peer Led Team Learning (PLTL). These data might be useful and of value to education researchers and undergraduate STEM instructors who are interested in improving equity in STEM education.

Keywords

Peer Led Team Learning (PLTL), recruitment, retention, imposter phenomenon, women, underrepresented minority (URM), first-generation college student, biology, undergraduate, gateway course.

Objective

For over a decade, major professional organizations have called for reform in traditional Science, Technology, Engineering, and Mathematics (STEM) education by using more active learning strategies (1). These calls have been in response to a large and growing body of evidence affirming that active learning is more effective and equitable than traditional lecture (2,3).

Peer Led Team Learning (PLTL) is a well-studied active learning model wherein students meet in small groups to collaboratively solve problem sets related to course content (4). These groups are led by a peer leader who is trained in facilitating teamwork, discussion, and problem solving. Participating in PLTL can improve students' academic achievement and retention (5), especially for students who have historically been marginalized in STEM (6,7).

PLTL may improve student retention by mitigating the impostor phenomenon, which describes individuals with internal feelings that they lack talent and skill despite significant

accomplishments and achievements (8). Imposter feelings could result in attrition of well-qualified students from STEM fields.

The data in this note were collected during a large project centered on the same introductory biology course. The objective for data collection associated with Data File 1 (Data File 1) was to measure the potential impact of PLTL on the recruitment and retention of students from marginalized populations in STEM. Some results from this study were published by Sloane and colleagues (6), but Data file 1 includes additional information that may be of interest. The objectives for collection of data contained in Data File 4 (Data File 4) were to determine the degree to which students in the course may experience imposter phenomenon, and to determine if students may be less likely to struggle with imposter feelings through exposure to and interactions with potential role models (peer leaders).

Detailed methods of PLTL implementation and data collection are described along with additional descriptions of the study population in (6,7,9).

Data description

Both data files in this note were collected within the context of an introductory biology course at a large, private, research-intensive institution in the Northeastern United States. No students reported identifying beyond the binary.

Data files 1-3

The data collection methods for the data in Data file 1 can be found in the corresponding publication (6), along with results describing the impact of PLTL on the recruitment and retention of underrepresented minority (URM) students in STEM majors. Chi-square analyses were used to examine whether first-generation college students and women who participated in PLTL were more likely to be retained in STEM majors than their counterparts who did not participate in PLTL.

Retention By First Generation Status (Data file 2)

Among students who did not engage in PLTL, no difference in STEM retention rates was observed between first-generation and non-first-generation students (X^2= .340, N = 101, df = 1, p = .560). Non-first-generation students who engaged in PLTL were retained in STEM majors at a higher rate than their counterparts who did not engage in PLTL, although this difference is not significant at an alpha level of 0.05 (X^2 = 2.575, N = 127, df = 1, p = .109). First-generation students who engaged in PLTL were significantly more likely to be retained in STEM majors than first-generation students who did not engage in PLTL (X^2 = 3.969, N = 34, df = 1, p = .046).

Retention by Gender (Data file 3)

Among students who did not engage in PLTL, women were significantly less likely to be retained in STEM majors than men (X^2 = 4.998, N = 101, df = 1, p = .026). Men who engaged in PLTL were retained in STEM majors at a higher rate than their counterparts who did not engage in PLTL, although this difference is not significant at an alpha level of 0.05 (X^2 = .883, N = 57,

df = 1, p = .346). Women who engaged in PLTL were significantly more likely to be retained in STEM majors than women who did not participate in PLTL (X^2 = 6.066, N = 104, df = 1, p = .014). Among the students who engaged in PLTL, no significant differences in the retention of men and women (X^2 = .684, N = 60, df = 1, p = .408).

Data files 4-6

The information in Data file 4 was collected at the end of one semester of introductory biology. Imposter feelings were measured using Clance Imposter Phenomenon Scale (CIPS), which consists of 20 items measuring the extent to which participants experience imposter feelings (8). Participants responded on a 5-point Likert scale ranging from 1 (not at all true) to 5 (very true). The CIPS is scored by adding together the numbers of the responses to each statement, with higher scores indicating greater levels of imposter feelings. Additional student data that were collected include final course grade, gender, ethnicity, and participation in PLTL.

A main-effects general linear model was used to analyze the impacts of gender, year in school, major, race/ethnicity, course grade, and participation in PLTL on imposter score. Estimated marginal means were extracted from the model and compared between genders.

When accounting for the impact of other variables in the model, both gender ($F_{1,336}$ = 8.68, p < 0.01) and the number of PLTL sessions attended ($F_{1,336}$ = 4.1021, p <0.05) had a significant impact on imposter scores (Data file 5). The more PLTL sessions students attended, the lower their imposter scores tended to be. Estimated marginal means showed that when accounting for other variables in the model, men had an average impostor score of 57.4 ± 2.0 and women had an average impostor score of 61.9 ± 2.3 (Data file 6).

Table 1: Overview of data files/data sets.

Label	**Name of data file/data set**	**File types (file extension)**	**Data repository and identifier (DOI or accession number)**
Data file 1	Recruitment and Retention Data	Recruitment and Retention Data.xlsx	Appendix A
Data file 2	Retention by First Generation Status	Figure 1.jpg	
Data file 3	Retention by Gender	Figure 2.jpg	
Data file 4	Imposter Phenomenon Data	Imposter Phenomenon Data.xlsx	Appendix B
Data file 5	General Linear Model of Students' Imposter Scores	Table 2.jpg	
Data file 6	Imposter Score by Gender	Figure 3.jpg	

Limitations

- When examining self-reported data one must keep in mind that respondents may vary in how they ascribe values to their feelings. Self-reported data may also be subject to several types of biases, such as social desirability bias or recall bias. Additionally, self-reported data may vary with how individual participants feel during the time that they take the survey.

Abbreviations

CIPS: Clance imposter Phenomenon Scale

HHMI: Howard Hughes Medical Institute

OIR: Office of Institutional Research

PLTL: Peer Led Team Learning

STEM: Science, Technology, Engineering, and Mathematics

URM: Underrepresented Minority

Declarations

Ethics approval and consent to participate
All data were collected under IRB approved protocols. All participants gave informed consent and confirmed that they 18 years of age or older.

Consent for publication
Not applicable.

Availability of data and materials
The data described in this Data note can be freely and openly accessed. Please see table 1 and references (6) for details and links to the data.

Competing interests
None declared.

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Authors' contributions

Mariah C. Maxwell curated the data and wrote this note along with Jason R. Wiles. Julia Snyder, Jeremy Sloane, Isabella Cannon, Julia Snyder, Ryan Dunk, and Jason R. Wiles collected the data and contributed to analyses. All authors have approved the final manuscript.

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Figure 1. Percentage of first generation college students (n=82) and non-first generation college students (n=275) retained in STEM fields by participation in PLTL. Error bars represent standard error of the percent.

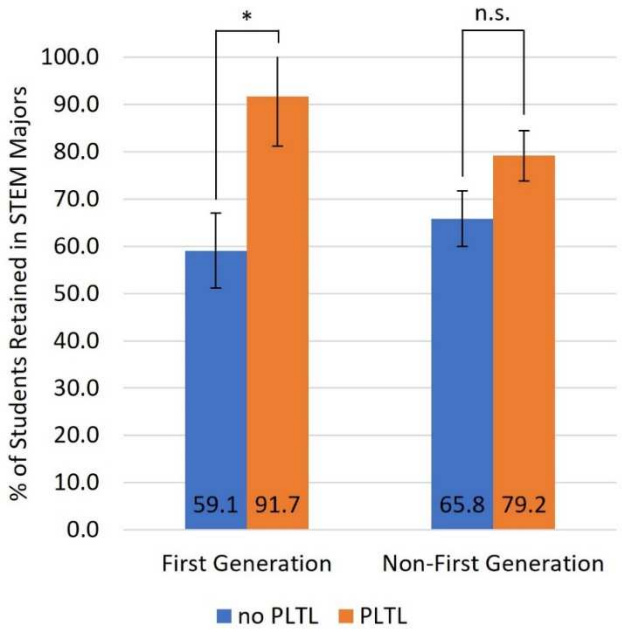


Figure 2. Percentage of women (n=229) and men (n=128) retained in STEM fields by participation in PLTL. Error bars represent standard error of the percent.

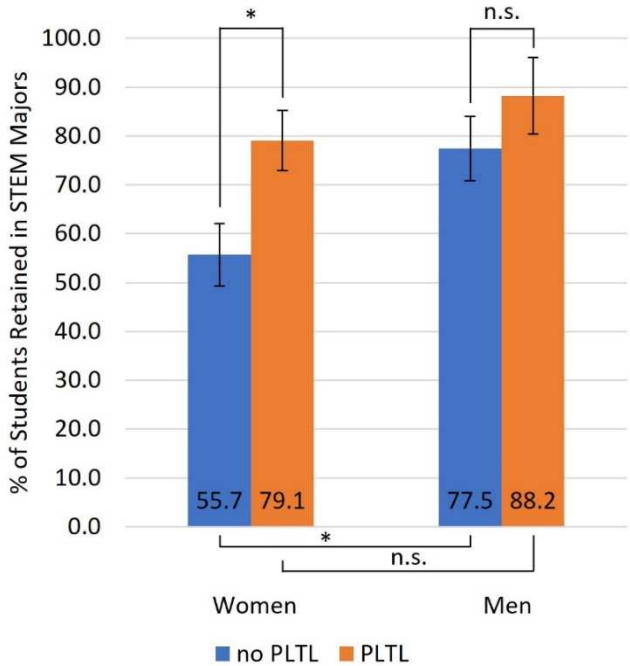
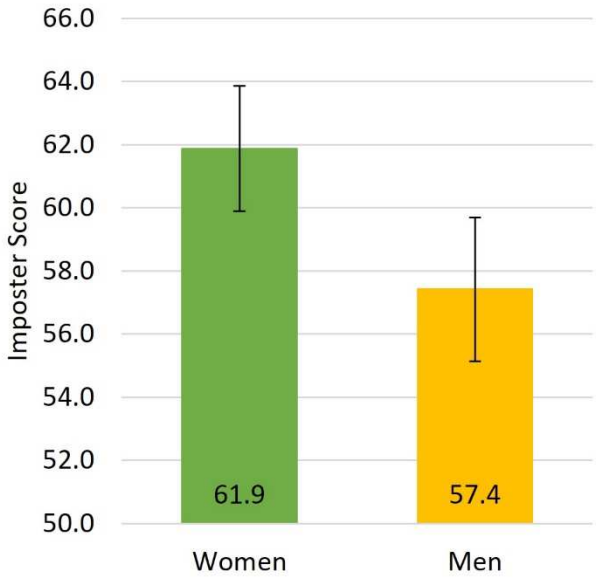


Table 2. Results of general linear model of introductory biology students' imposter scores.

Source of Variance	Sums of Squares	Df	*F*	p
Gender	1555	1	8.68	0.0034
Course Grade	26	1	0.14	0.7058
Ethnicity	34	1	0.18	0.6644
Number of PLTL sessions attended	735	1	4.10	0.0436
Academic Level	426	3	0.79	0.4990
STEM Major	166	1	0.92	0.3369
Residuals	60195	336		

Figure 3. Estimated marginal means for imposter score by gender (294 women; 105 men). Error bars represent standard error.



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Chapter 2. Cyber Peer Led Team Learning (cPLTL) Supports Marginalized Groups, Including Women, in Science Technology, Engineering, and Mathematics (STEM)

Mariah C. Maxwell, Jason R. Wiles

Abstract

Peer Led Team Learning (PLTL) is an active learning model that is particularly effective for improving the academic achievement and retention of students who have been marginalized in Science, Technology, Engineering, and Mathematics (STEM), such as women and members of underrepresented minority groups. Cyber Peer Led Team Learning (cPLTL) is a recently developed variation of PLTL that has been transitioned from a face-to-face environment to a synchronous online setting. Studies have found that PLTL and cPLTL students earned comparable educational outcomes in terms of standardized final exam scores and final course grades. Given the benefits of PLTL for marginalized students and the similarities of cPLTL to PLTL, we were interested in understanding the impact that cPLTL had on marginalized groups, including women, in an introductory biology course at a large, research-intensive institution. We found evidence that participating in cPLTL improves the retention of marginalized groups in STEM, and that student perceptions of cPLTL are generally high, especially for women. Participating in cPLTL may have several additional benefits, such as increased motivation, feelings of belonging, comfort in asking questions, and understanding of course content.

Keywords: Peer led Team Learning, cyber Peer Led Team Learning, achievement, retention, perceptions, women, first-generation college student, BHA student, STEM, introductory biology, online learning

Introduction

For over a decade, major professional organizations have called to reform traditional Science, Technology, Engineering, and Mathematics (STEM) education by using more active learning pedagogies (AAAS, 2011; NCR, 2012). These calls were based on a large and growing body of evidence that has repeatedly confirmed that active learning is a more effective and equitable teaching method than the traditional lecture, regardless of discipline, class size, or course level (Freeman et al., 2014b; Theobald et al., 2020).

Among various active learning strategies, Peer Led Team Learning (PLTL; Gosser et al., 1996) is a well-studied instructional model that is often implemented within the context of a large-enrollment gateway course. During a PLTL workshop, groups of six to eight students work collaboratively towards solving a prescribed problem set related to the conceptual content of a course they are taking together. These groups are guided by a peer leader who succeeded in the course during a previous semester by earning a final grade of A or B, and thus was recruited to be a peer leader. Their role is to facilitate teamwork, discussion, and problem solving within the group; not to lecture or tutor the group. The students meet with the same group and peer leader every week to build a sense of community and to develop as a team.

The positive effects PLTL has on undergraduate students has been well documented in a variety of contexts (Snyder et al., 2016; Wilson & Varma-Nelson, 2016). Several studies reported that PLTL students experienced higher academic achievement and improved retention in STEM courses than non-PLTL students (Wilson & Varma-Nelson, 2016). In fact, PLTL is particularly effective for improving the academic achievement and retention of groups of students who have historically been marginalized in STEM (Sloane et al., 2021; Snyder et al., 2016). For example, several studies have shown that women who participate in PLTL achieve

higher course grades; lower attrition rates; and lower frequencies of "D", "F", or withdrawal (DFW) grades than women who do not participate in the program (Drane et al., 2014; Horwitz & Rodger, 2009; Preszler, 2009; Quitadamo et al., 2009).

Student perceptions of the benefits of PLTL tend to be positive as well. Students have reported that they perceived the PLTL workshop to improve their content understanding, problem solving skills, critical thinking skills, self-efficacy, and sense of belonging within a course (Wilson & Varma-Nelson, 2016; Wilton et al., 2019). Additionally, students have reported that participating in the PLTL workshops reduced their course-related anxiety (Wilson & Varma-Nelson, 2016).

Cyber Peer Led Team Learning (cPLTL) is a newer and comparatively under-researched variation of PLTL in which student workshops are conducted in a synchronous online setting rather than an in-person context (Mauser et al., 2011). cPLTL was initially developed to provide active learning opportunities to a wider, more diverse student body by creating more flexible scheduling and attendance options. Studies have found that PLTL and cPLTL students earned comparable educational outcomes in terms of standardized final exam scores and final course grades (Mauser et al., 2011; Smith et al., 2014). One study found that students who participated in the PLTL workshop tended to report more positive perceptions of their workshop experiences than cPLTL students, however perceptions of both programs were very positive (Smith et al., 2014).

Further studies demonstrating that cPLTL is effective at improving students' academic achievement and retention across different campuses, disciplines, and student populations are needed to support wider adoption of the program. Special attention should be given to determining the impact of cPLTL for students from marginalized groups because these groups

are subjected to programmatic barriers. Programmatic barriers, such as competitive rather than collaborative gateway courses, can make it difficult for marginalized students to succeed in STEM because students must reach a certain level of achievement to pass through the barrier and move on to the next level.

Here, we investigate the effects of cPLTL on marginalized groups at a large, private, research-intensive (Carnegie R1 designation) university in the Northeastern United States, with a special focus on the program's impacts for women. This study aims to address the following questions:

(1) Is participation in cPLTL associated with higher achievement/retention among students in the context of a large-enrollment introductory biology course?

(2) What perceptions do women hold with regards to their cPLTL experience?

Given the previously shown benefits for marginalized students in traditional PLTL programs and given the many similarities of cPLTL to traditional PLTL, we expected that participation in cPLTL would be associated with higher achievement/retention among women, and that students would generally have positive perceptions of cPLTL.

Methods

Setting and Participants

Our study institution has a well-established PLTL program associated with its introductory biology course, which serves mostly freshman and is open to STEM and non-STEM majors (Sloane et al., 2021; Snyder et al., 2015; Snyder et al., 2016; Winterton et al., 2020). During the Fall 2020 semester, the introductory biology course and its associated PLTL program were transitioned to an online format due to constraints imposed by the COVID-19 pandemic. Unlike other cPLTL studies, we were not able to have a PLTL comparison group because of the

circumstances. Therefore, we do not attempt to evaluate whether cPLTL results in comparable student outcomes as PLTL, rather we explore the impact of the cPLTL program individually.

Student demographic information is summarized in Table 1. This information came from institutional data, so we are not able to determine if any students identified beyond the binary with regard to gender. Six hundred and fifteen students (33.1% identifying as men: 66.9% identifying as women) enrolled in introductory biology, of whom 145 (20.7% identifying as men: 79.3% identifying as women) enrolled in the cPLTL program. There were four students for whom gender data was not available. A larger proportion of women opted in to cPLTL than what was represented in the whole class, showing that women preferentially chose to participate in cPLTL, X^2 (1, N=611) = 13.1472, p = 0.0003.

Within the course, 26.8% of students identified as Black or African American, Hispanic or Latino, or American Indians or Alaska Natives (BHA). First-generation college students made up 23.9% of students in the course. There does not appear to have been a selection bias for BHA students (X^2 (1, N=601) = 0.4998, p = 0.4796) or first-generation college students (X^2 (1, N=586) = 0.2382, p = 0.6255), as similar proportions enrolled into cPLTL as was represented in the entire course. Race/ethnicity data was missing for 14 students, and parental education information was missing for 29 students.

Implementation

Recruitment for participation in cPLTL took place during class time. Students were shown the results of prior studies (Snyder et al., 2015; Snyder et al., 2016) to highlight the benefits of the PLTL pedagogy. All students had equal opportunity to opt in to the cPLTL program at the beginning of the semester, and no student groups were encouraged to participate more than others.

There were 36 cPLTL groups, each consisting of 5-8 students. Eleven sessions were offered throughout the semester that lasted 50 minutes each. cPLTL sessions occurred outside of regular class time and attendance was encouraged but not mandatory. At the end of the semester, students received a small amount of extra credit for each PLTL session they attended. Unlike other cPLTL studies, we did not provide students with microphones/headsets, webcams, or document cameras (Mauser et al., 2011; Smith et al., 2014; Wilson & Varma-Nelson, 2021). Peer leaders participated in weekly training sessions where they reviewed course content and pedagogical practices. They received course credit as compensation for being a peer leader.

Data Collection and Analysis

Student course grades, withdrawal status, and demographic data were provided by the course instructors and the Office of Institutional Research. While studies reporting on DFW rates often construe this as a measure of achievement, the W in DFW, which stands for "withdrawal", is also related to retention in the course. Thus, achievement is difficult in some cases to disassociate from retention.

The introductory biology course at our study institution may act as a programmatic barrier because students must earn a C+ or better in the course in order to declare biology as their major, and/or to meet prerequisite requirements for upper-division courses. Therefore, we decided to focus on the proportion of students earning less than C+ or withdrawing from the course (%CDFW) as a critical measure of achievement and/or retention. Students who achieved a C+ or better in the course were considered to have successfully navigated programmatic barriers, while students who earned a C or less were considered to still have "barriers remaining". A Chi-squared test was conducted, to determine if there were significant differences between cPLTL and non-cPLTL groups in this regard.

Our institution provides optional individual and group tutoring sessions for students in the study course through its Center for Learning and Student Success (CLASS). Data regarding the number of tutoring sessions attended by each student in the course was collected from CLASS so that we could consider the data in light of this potentially confounding variable. Only students who participated in three or fewer of the weekly CLASS tutoring sessions were included in statistical analyses. Of these 595 students, 394 (66.2%) were women, 158 (26.6%) were BHA students, 136 (22.9%) were first-generation college students, and 137 (23.0%) participated in cPLTL.

To explore perceptions of our cPLTL program, students were invited to participate in an online post-course survey. Students were recruited through the course Blackboard site and were awarded a small amount of extra credit for participating. The survey consisted of 15 statements that students responded to using a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree), a question asking students if they would recommend cPLTL to a friend, and an open-ended question for respondents to share any additional details about their cPLTL experience. The percentage of students who somewhat agreed, agreed, or strongly agreed with each statement was summed to determine the percent of students who agreed with each statement. Conversely, the percent of students who somewhat disagreed, disagreed, or strongly disagreed with each statement was summed to determine the percent of students who disagreed with each statement. A Chi-squared test was conducted to determine if there were statistically significant differences in the rate of agreement between men and women, BHA and non-BHA students, and first-generation and non-first-generation college students.

Results

Comparison to Previous Semesters

A chi-square test indicated that there was no significant difference in the proportion of students earning CDFW in the introductory biology course between the 2020 and 2019 iterations (X^2 (1, N=1065) = 0.8481, p = 0.3571). For students who participated in PLTL in 2019 or cPLTL in 2020, there was no significant difference in the proportion of students who earned CDFW (X^2 (1, N = 368) = 0.0234, p = 0.8785).

Academic Achievement/Retention

Participating in cPLTL was associated with a smaller proportion of students being left with remaining barriers, X^2 (1, N= 595) = 19.7501, p = 0.0001 (Figure 1). For non-cPLTL students, 17.03% (78/458) were left with remaining barriers, as compared to only to 2.19% (3/137) of cPLTL students. This trend held true when looking specifically at women (X^2 (1, N= 349) = 12.7748, p = 0.0004), BHA students (X^2 (1, N= 158) = 6.8680, p = 0.0088), and first-generation college students (X^2 (1, N= 136) = 6.5083, p = 0.0107; Table 2). For women, 14.39% (41/285) of non-cPLTL students were left with remaining programmatic barriers, as compared to only 1.83% (2/109) of cPLTL students. For BHA students, 22.58% (28/124) of non-cPLTL students were left with programmatic barriers remaining, as compared to only 2.94% (1/34) of cPLTL students. Similarly, 28.57% (30/105) of first-generation college students who did not participate in cPLTL were left with remaining programmatic barriers, as compared to only 6.45% (2/31) of cPLTL students.

Perceptions

Three-quarters (104/137, or 75.91%) of cPLTL students completed the post-course survey and overall, responses were positive. For the most part, agreement rates for each statement were around 75% while disagreement rates for most statements were around 10% or less (Table 3). About 83% of respondents agreed they were satisfied with their overall cPLTL

experience (Table 3; Figure 2), and about 76% of respondents reported that they would recommend online PLTL to a friend (Figure 3).

The statements with the lowest rate of agreement ("Participating in online Peer Led Team Learning helped me form relationships with other students in the course" and "Participating in online Peer Led Team Learning helped me improve my self-confidence") were still rather positive, with 64% agreement (Table 3; Figure 4; Figure 5). Statements with the highest level of agreement were "Participating in online Peer Led Team Learning helped me learn the course material" with almost 88% agreement, "I am comfortable asking questions during online Peer Led Team Learning workshops" with 86.83% agreement, and "My Peer Leader was able to provide supportive feedback during the online Peer Led Team Learning workshops" with 85.27% agreement (Table 3; Figure 4; Figure 6).

A chi-squared test indicated that women and men differed significantly in their agreement rate for two of the perception statements (Figure 7). Women agreed more often than men that participating in cPLTL helped them engage with the course material, X^2 (1, N=104) = 4.4984, p = 0.0256, and that participating in PLTL improved their understanding of key course concepts, X^2 (1, N=104) = 4.0408, p = 0.0444. There were no significant differences in the agreement rate of BHA and non-BHA students, or first-generation and non-first generation college students.

Discussion

Academic Achievement/Retention

Overall, students performed well in the introductory biology course during the Fall 2020 semester. Without cPLTL, 17.03% (78/458) of students would not have had the option to declare a biology major and would not have met prerequisite requirements for upper-division courses (Figure 1). With cPLTL, this number was only 2.19% (3/137).

We saw similar trends when looking specifically at women, BHA students, and first-generation college students. Out of 109 women who participated in the program, only two were left with remaining barriers, and these women still earned passing grades of C (Table 2). This means that women who participated in cPLTL were 12% more likely to successfully navigate programmatic barriers than those who did not participate, and that 98% (107/109) of women who participated in cPLTL had achievement sufficient to declare a biology major and move on to upper-division courses.

Perceptions

The online format of our introductory biology course and cPLTL program may make it difficult to form relationships with other students in the course. Peer Leaders have observed that students who participate in cPLTL appear to be comfortable working together and spend time talking about topics unrelated to course content, however, the relationships they build may not translate into social connections outside of the cPLTL workshop (Smith et al., 2014). Given the difficulties students may face when forming relationships in an online setting, we are pleased that in the current study, two thirds (64.35%) of the respondents agreed that participating in cPLTL helped them form relationships with other students in the course and almost three fourths (71.31%) of the respondents agreed that participating in online PLTL made them feel included in the course (Table 3; Figure 5). These findings suggest that participating in cPLTL can have a positive impact on students' feelings of belonging and ability to form relationships within an online gateway course.

Another concern we had was that the online format may reduce students' motivation to show up and participate in class. Motivation is important because it is a critical predictor of many educational outcomes such as academic achievement and retention (Lazowski &

Hulleman, 2016; Robbins et al., 2004). Three fourths (76.54%) of our respondents agreed that participating in cPLTL improved their motivation (Table 3; Figure 6). This sentiment is echoed in the responses to the open-ended questions, as one woman wrote:

> It took a toll on my motivation not being able to go to a classroom and meet my professors in person [during the pandemic]. I feel like if I had [c]PLTL for other of my classes I would've done better in them and my motivation wouldn't have been so lost.

These findings suggest that increased motivation as a result of participating in cPLTL may be a mechanism by which cPLTL could improve educational outcomes.

Studies on gender-differences in the classroom have shown that men tend to be more comfortable asking questions and to ask more questions than women in academic settings (Daly et al., 1994; Hinsley et al., 2017). This could be because question asking is linked to self-efficacy (Daly et al., 1994). Women may experience lower self-efficacy than men, and thus have lower confidence in their ability to pose an appropriate question (Daly et al., 1994; Good, 1987; McMullin & Cairney, 2004). In the current study, about two thirds (63.56%) of the respondents agreed that participating in cPLTL improved their self-confidence, and nearly nine out of ten (86.83%) agreed that they were comfortable asking questions during cPLTL workshops (Table 3; Figure 4). These findings suggest that participating in cPLTL could facilitate women using their voices and vocally participating in an academic setting. Responses to the open-ended question reflected this idea, as one woman shared, “Overall I found [cPLTL] to be very helpful as it was a much more comfortable environment to ask questions and get help.”

In addition to hoping that the cPLTL workshops would be a comfortable place to ask questions, we hoped that the peer leaders would be able to provide supportive feedback to participating students. Receiving supportive feedback can help students form a strong science

identity (Park et al., 2018). Identifying with science is important for students in STEM majors, as studies have shown that students with a strong science identity tend to persist in their STEM major longer and experience greater interest in scientific careers than those who do have a weak science identity (Chang et al., 2011; Perez et al., 2014). However, forming a strong science identity can be difficult for women for a variety of reasons. Competitive, rather than collaborative, gateway courses can sometimes lead to women feeling less competent in their scientific knowledge or pose challenges related to stereotype threat (Ahlqvist et al., 2013; Seymour & Hewitt, 1997). In the current study, nearly nine out of ten (85.27%) respondents agreed that their Peer Leader was able to provide supportive feedback during the cPLTL workshops (Table 3; Figure 6), which suggests that cPLTL may help women identify with science.

The reason we point out that men and women differ in some of their cPLTL perceptions is not necessarily to draw comparisons between them, rather to emphasize the extent to which women perceived cPLTL to have had a positive impact on their experience in an online gateway course. As shown in Figure 7, nine out of ten women who completed the post-course survey agreed that participating in cPLTL helped them engage with the course material (91.36%) and improve their understanding of key course concepts (90.12%). One woman shared, "…the best benefit of [cPLTL] is that you really learn the material since it is reinforced during the one-hour session through engaging activities and questions." Together, these findings highlight the extent to which women feel that participating in cPLTL benefits their learning experience.

Conclusion

We contribute valuable insights and implications into teaching and learning science at the collegiate level by exploring the benefits that cPLTL has to offer for students who have

historically been marginalized in STEM. Our study is unique in that we are the first to document cPLTL in an introductory biology course. We found evidence that participating in cPLTL improved achievement/retention among women, BHA students, and first-generation college students. Student perceptions of cPLTL were generally high in our study population, especially for women. Additionally, in our population of students, women preferentially participated in cPLTL. However, we did not see this selection bias for HBA students or first-generation college students. Future work should focus on these groups and understanding how we can encourage them to opt in because cPLTL helps them, too.

In addition to improving educational outcomes of students, participating in cPLTL may have several additional benefits such as increased motivation, feelings of belonging, comfort in asking questions, and support in forming a strong science identity. Future work should use an intersectionality approach to explore the unique lived experiences of students, and to better understand how their personal identities interact with the cPLTL environment to provide these various benefits.

Acknowledgements

This work was supported by a Howard Hughes Medical Institute (HHMI) Inclusive Excellence Grant. We are grateful to the Syracuse University Office of Institutional Research and the Center for Learning and Student Success for their cooperation. We would like to express gratitude to the undergraduate students at the participating university who agreed to participate in this research. We would also like to give a special thanks to Julia Snyder for coordinating the cPLTL leadership training program, Beverly Werner for her assistance in the coordination of student activities and organization of course data, and Takunda Maisva for thoughtful comment. All data were collected under an IRB-approved protocol (IRB#: 20-241).

Table 1. Percent of students of each demographic group enrolled in introductory biology and in cPLTL.

Demographic Group	Course (n=615)	cPLTL (n=145)
Gender Identity		
Woman*	66.9	79.3
Man*	33.1	20.7
Race/Ethnicity		
BHA	26.8	24.5
Non-BHA	73.2	75.5
Generation		
First-generation college student	23.9	22.4
Non-first-generation college student	76.1	77.6

* Indicates significant differences between proportion of students enrolled in cPLTL vs. the whole course.

Table 2. Percent of cPLTL and non-cPLTL students with remaining barriers in introductory biology.

Student group	Non-cPLTL (n=458)		cPLTL (n=137)		p
	n	% with remaining barriers	n	% with remaining barriers	
Women (n=394)	41	14.39	2	1.83	0.0004
BHA (n=158)	28	22.58	1	2.94	0.0088
First-gen (n=136)	30	28.57	2	6.45	0.0107

Table 3. Percentage of respondents (N=104) who agree, neither agree nor disagree, or disagree with each statement.

Statement	% Disagree	% Neither	% Agree
I am satisfied with my overall online Peer Led Team Learning Experience.	8.53	8.53	82.95
I am comfortable asking questions during online Peer Led Team Learning workshops.	7.75	5.43	86.83
My Peer Leader was able to provide supportive feedback during the online Peer Led Team Learning workshops.	5.43	9.30	85.27
Participating in online Peer Led Team Learning helped me learn the course material.	3.89	8.53	87.59
Participating in online Peer Led Team Learning improved my ability to work as a part of a team.	10.09	17.83	72.09
Participating in online Peer Led Team Learning improved my ability to communicate effectively.	10.80	18.60	71.31
Participating in online Peer Led Team Learning improved my ability to solve problems.	9.30	16.28	74.42
Participating in online Peer Led Team Learning improved my motivation to learn general biology.	11.63	13.95	74.42
Participating In online Peer Led Team Learning improved my performance in general biology.	6.99	15.50	77.52
Participating in online Peer Led Team Learning improved my self-confidence.	17.83	18.60	63.56
Participating in online Peer Led Team Learning helped me form relationships with other students in the course.	17.83	17.83	64.35
Participating in online Peer Led Team Learning made me feel included in the course.	9.31	19.38	71.31
Participating in online Peer Led Team learning made the course material more interesting.	12.40	18.60	68.99

Figure 1. Percentage of students with remaining barriers in introductory biology. Bars represent standard error of percent. ***Indicates significance of chi-square test at $p < 0.0001$.

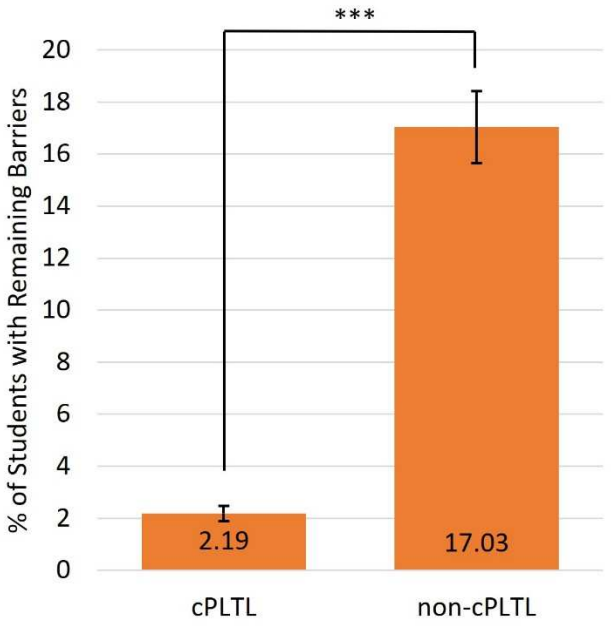


Figure 2. Student responses to the statement "I am satisfied with my overall online Peer Led Team Learning experience."

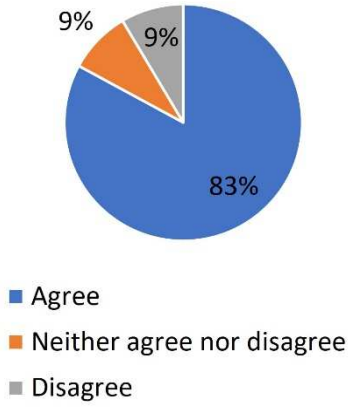


Figure 3. Student responses to the question "Would you recommend online Peer Led Team Learning to a friend?"

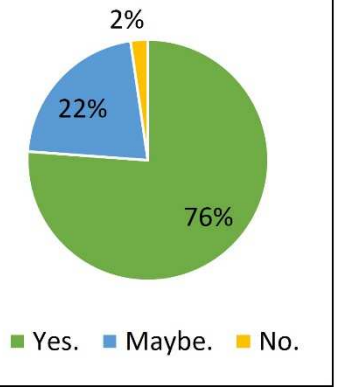


Figure 4. Responses to the statements "Participating in online Peer Led Team Learning improved my self-confidence," (left) and "I am comfortable asking questions during online Peer Led Team learning workshops," (right).

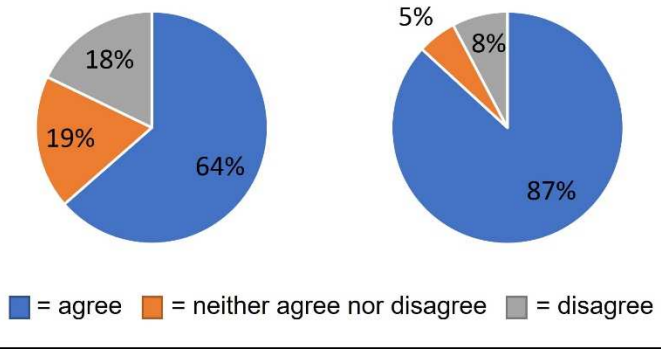


Figure 5. Responses to the statements "Participating in online Peer Led Team Learning helped me form relationships with other students in the course," (left) and "Participating in online Peer Led Team Learning made me feel included in the course," (right).

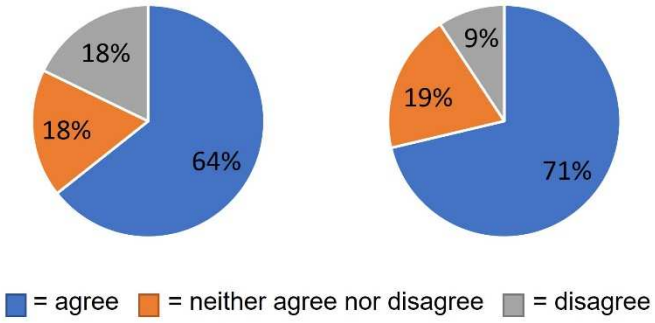


Figure 6. Responses to the statements "My Peer Leader was able to provide supportive feedback during the online Peer Led Team Learning workshops," (left) and "Participating in online Peer Led Team Learning improved my motivation to learn general biology," (right).

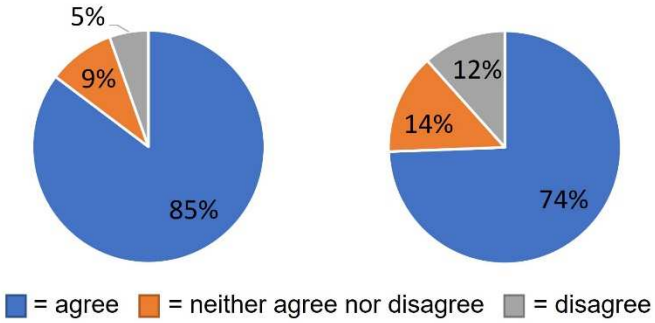
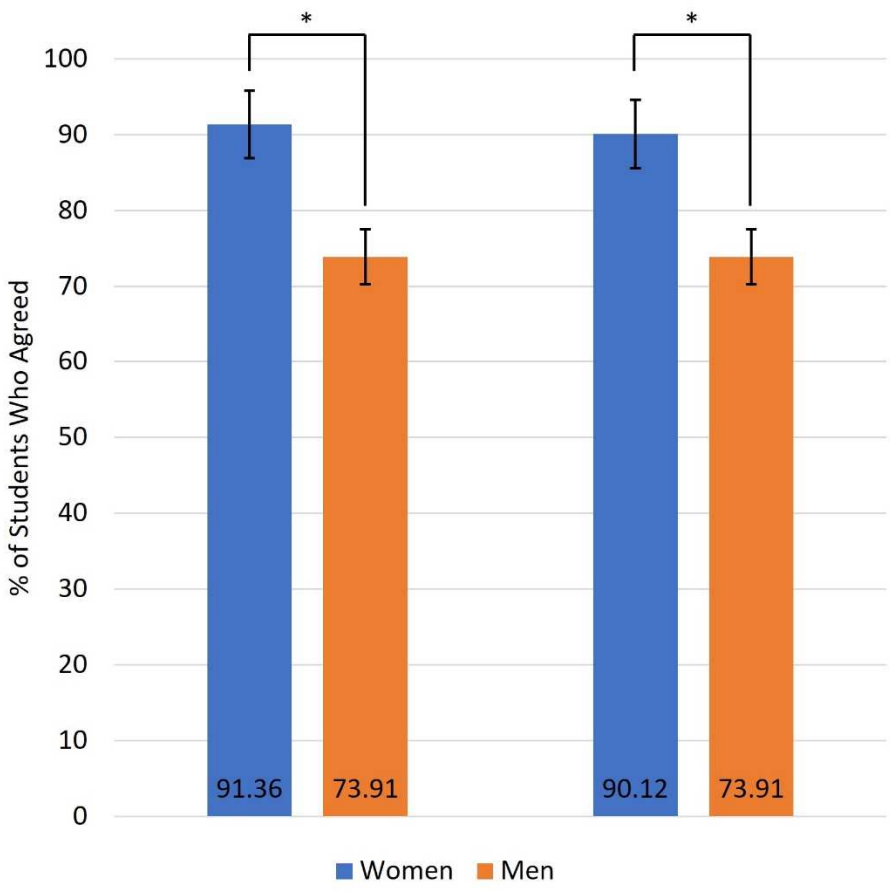


Figure 7. Percentage of men (n=23) and women (n=81) who agreed with the statements "Participating in online Peer Led Team Learning helped me engage with the course material," (left) and "Participating in online Peer Led Team Learning improved my understanding of key course concepts" (right). *Indicates significance of chi-squared tests at $p < 0.05$.



Limitations

The data presented in this thesis are the result of natural experiments, in that the students were not randomly assigned to control (non-PLTL/non-cPLTL) or experimental (PLTL/ cPLTL) groups. This choice was made due to the precarious nature of conducting research on human subjects. Should the students have been randomly assigned to control and experimental groups, there would no doubt be students in the experimental group who did not want to participate in the intervention, and students in the control group who wanted to participate in the intervention. This poses two problems. First, it is unethical to withhold an educational intervention from individual students when there is reason to believe that the program may help them. Second, when conducting research on human subjects, researchers must follow the rules and regulations of the Institutional Review Board, which state that we are not allowed to coerce or force students to do something they don't want to. Therefore, student participation in any teaching intervention we are studying must be voluntary to some degree.

Because the studies presented herein were not fully randomized, it is important to make note of several potentially confounding variables. Students who participated in PLTL attended weekly hour long workshops, and therefore may have been spending more time with the course content. The differences observed could have been in part due to the extra amount of time spent with the course content.

Another potentially confounding variable is student motivation. The students who opted into the program may have had higher motivation to achieve in STEM than those who opted out. Past studies that explored the impacts of PLTL on students in the introductory biology course at SU have found that there was no significant difference in prior academic achievement between

students who opted in to PLTL and those who did not (Snyder et al., 2015; Snyder et al., 2016), however the studies presented in this thesis did not have data on students' prior achievement.

Students were provided a small amount of extra credit for attending each PLTL session, which may have contributed in part to the observed differences in academic achievement and retention. However, the points students get from doing better in the course are much larger than the small amount of extra credit that they might receive from attending PLTL sessions (students can earn up to 3 points of extra credit for each session attended, but the final course grade is out of 1,000 points).

Because the studies herein were the results of natural experiments it is important to use validation measures where possible. In the study presented in the second chapter, triangulation was used to validate the findings from the perception statements. Student responses to the open-ended question supported the positive perceptions reported on several of the perception statements.

Conclusion

This work is the product of Biology Education Research (BER) examining the impacts of the active learning models PLTL and cPLTL on different groups of students. In the first chapter I present data collected from the introductory biology course at SU that I curated for publication in *BMC Research Notes*. The data shows (1) that PLTL is associated with improved retention in STEM majors for women and first-generation college students; (2) that on average, women experience greater feelings of imposter than men; and (3) number of PLTL sessions attended has a significant impact on imposter scores, such that the more PLTL sessions attended the lower the imposter scores tend to be.

In the second chapter I present a research project where I examined the impact of a cPLTL program on undergraduate students in the introductory biology course at SU. I found (1) that participation in the program was associated with improved academic achievement and retention within the course; (2) that this trend held true when looking specifically at women, BHA students, and first-generation college students; and (3) the cPLTL program may have provided student several additional benefits, such as increased motivation and sense of belonging in the course. This work was submitted for publication in *Bioscene: Journal of College Biology Teaching.*

Cumulatively, this work contributes to the large and growing body of literature documenting the efficacy of active learning pedagogies not only for improving the educational outcomes of students, but for supporting equity, diversity, and inclusion in STEM disciplines.

Appendix A

URM, 1=yes 2=no	Gender, 1=woman 2=man	First Gen, 1=yes 2=no	PLTL, 1=yes 2=no	Recruited, 1=yes 2=no	Retained, 1=yes 2=no
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Appendix B

Clance Imposter Phenomenon Scale (CIPS) Score	Impostor Code, 1=few 2=moderate 3=frequent 4=intense	Gender, 1=woman 2=man	Final Grade (without extra credit)	URM, 1=no 2=yes	# PLTL Sessions Attended, (maximum of 12)	Academic Level, 1=Freshman 2=Sophomore 3=Junior 4= Senior	Major, 1=STEM 2=Non-STEM
70	3	1	F	2	12	2	1
84	4	1	A		8	1	2
71	3	1	A	2	6	1	1
37	1	1	C	2	4	3	2
68	3	1	B	1	0	1	1
72	3	1	B	1	2	1	2
68	3	1	B	1	10	2	2
28	1	2	C	1	0	2	1
74	3	1	B	1	1	2	2
49	2	1	B	2	11	1	2
84	4	1	C	1	9	1	1
52	2	1	C	1	10	1	2
58	2	1	A	1	7	1	1
81	4	1	D	1	0	1	2
63	3	1	D	1	7	2	2
79	3	1	C	1	3	1	1
70	3	1	B	2	4	1	1
41	2	1	A	1	6	3	1
69	3	2	A	1	12	1	1
65	3	1	B	1	10	1	2
34	1	1	B		11	1	1
69	3	2	C	1	0	1	2
65	3	1	B		12	2	2
70	3	1	C	1	0	1	2
83	4	1	C	1	0	2	2
51	2	1	B	2	0	2	2
74	3	2	B	1	12	1	1
80	3	2	C	1	0	1	2
65	3	2	B		0	1	2
74	3	1	C		12	2	2
94	4	1	C	1	0	2	1
34	1	1	B	1	10	1	1
42	2	1	D	1	9	2	2
63	3	1	D	1	11	1	2
31	1	1	B	1	12	1	2
64	3	1	B	1	0	1	2

58	2	1	C	1	1	1	1
68	3	1	C	1	0	1	1
82	4	1	B	2	12	3	1
36	1	1	A	1	12	2	1
75	3	1	B	1	11	2	1
62	3	1	B	1	0	1	1
55	2	2	A	2	0	2	1
65	3	1	B	1	11	1	2
49	2	2	D	2	0	1	1
64	3	1	C	1	1	1	2
50	2	1	A	1	11	1	1
63	3	1	A	1	12	1	2
32	1	1	B	1	7	1	2
57	2	1	C	1	5	1	2
61	3	1	B	2	0	1	2
52	2	2	B	1	6	1	2
92	4	1	B	1	12	3	1
60	2	1	C	1	4	1	1
44	2	2	B	1	10	1	1
73	3	1	B	1	7	1	2
62	3	2	B	2	11	1	1
83	4	2	C	1	0	2	2
66	3	1	A	1	7	2	2
53	2	1	C	1	12	1	2
77	3	2	B		0	1	1
45	2	2	B	1	0	1	2
53	2	2	C	1	0	2	2
56	2	2	C	1	0	1	2
65	3	1	A	1	11	1	1
60	2	2	C	1	0	1	2
56	2	1	C	2	3	1	1
85	4	1	C	1	0	2	2
73	3	1	C	1	8	1	1
57	2	1	B	1	12	2	2
67	3	1	C	1	9	3	2
70	3	1	C	1	11	1	2
45	2	1	C	1	12	1	2
67	3	1	B	1	12	1	2
17		1	A	1	12	1	1
66	3	2	C	1	0	2	1
61	3	1	C	2	0	2	2
68	3	1	A	1	11	2	1
52	2	1	C	1	11	1	2

53	2	1	D	2	0	1	1
44	2	1	C	1	0	1	2
53	2	2	A	1	0	2	1
76	3	1	A	1	0	2	1
66	3	2	C	2	0	1	2
95	4	2	C		0	1	1
51	2	1	B	2	11	2	2
61	3	1	C	2	0	1	2
71	3	2	C	1	12	1	2
51	2	1	C	2	7	1	2
69	3	1	B	1	12	2	2
64	3	2	B	1	0	2	2
50	2	2	B	2	3	1	1
76	3	2	B	1	8	1	2
73	3	2	B	1	0	2	2
59	2	1	C	1	0	2	1
45	2	1	C	2	0	1	2
43	2	2	C	2	0	1	1
49	2	2	B	1	12	1	1
58	2	2	A	1	2	1	1
83	4	1	B	1	0	1	1
59	2	2	C	2	0	2	2
29	1	1	D	2	0	4	2
55	2	2	C	2	0	3	1
69	3	2	B	1	10	1	1
60	2	2	C	1	4	1	2
57	2	1	C	2	12	2	2
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76	3	1	C	2	11	1	2
67	3	1	A	1	8	2	2
73	3	1	C	1	9	2	2
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66	3	1	C	2	0	1	2
73	3	1	B	1	0	1	2
69	3	1	A	1	9	1	2

61	3	2	C	2	0	1	2
79	3	1	D	1	12	1	2
78	3	1	A	1	12	1	2
48	2	2	B	1	12	1	1
64	3	1	B	2	12	1	1
83	4	1	B	1	0	2	1
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47	2	2	B	2	0	1	2
63	3	1	B	1	10	2	2
83	4	2	B	2	0	1	2
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57	2	1	C	2	12	1	2
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56	2	1	C	1	8	3	2

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61	3	1	B	1	1	1	2
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44	2	1	A		12	1	2
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63	3	1	B	2	12	4	2
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65	3	1	C	1	0	2	2
76	3	1	C	1	10	2	2
54	2	1	B	1	10	3	1
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78	3	1	C	1	0	1	2
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81	4	1	D	1	0	1	1
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82	4	1	D		9	2	2
27	1	1	C	2	10	1	2
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76	3	1	D	1	11	2	1
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93	4	1	F	2	0	1	1
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56	2	1	B	2	9	1	2
56	2	1	C		12	1	1
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61	3	2	A	1	11	1	1
24	1	2	D	1	12	1	2
70	3	1	B	1	0	1	1
87	4	1	D	1	8	2	1

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75	3	1	C	2	0	3	1
64	3	1	C	1	1	1	2
78	3	1	A	1	0	3	1
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56	2	2	C	1	3	1	2
68	3	1	A	1	6	2	2
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87	4	1	C	1	0	1	1
64	3	2	B		6	1	1
78	3	1	B	2	9	2	2
45	2	2	C		0	1	2
42	2	1	B	1	10	1	2
51	2	1	C	1	8	2	2
55	2	1	B	1	3	1	2
63	3	1	C	1	7	1	2
49	2	2	D	1	1	4	1
51	2	1	C	1	12	2	2
64	3	1	C	1	0	1	2
54	2	1	B	1	11	1	1
60	2	1	C	1	7	2	2
72	3	1	B	2	0	4	1
73	3	1	B	1	0	1	1
74	3	1	D	1	0	2	2
41	2	1	B	1	12	1	2
82	4	1	B	1	0	1	2
84	4	2	A	1	1	1	1
46	2	1	B	1	12	1	1
78	3	1	B	1	1	1	1
40	1	1	B	1	9	1	2
62	3	1	C		0	1	1
65	3	2	C		0	1	1
58	2	1	C	1	0	1	1
60	2	1	A	1	9	1	1
49	2	1	B	1	11	1	1
54	2	1	B	1	11	1	2
65	3	1	B	1	12	2	2

74	3	1	C	2	12	1	2
68	3	2	B		0	1	2
52	2	1	A	1	10	2	1
52	2	1	C	1	0	2	2
87	4	1	A	2	12	1	2
40	1	2	C	2	0	1	2
61	3	1	C	1	12	1	2
78	3	1	C	2	5	1	1
75	3	1	B	2	11	1	1
57	2	2	B	1	0	2	1
60	2	1	D	1	1	1	2
70	3	1	A	1	12	2	2
32	1	1	C	2	0	1	2
55	2	1	C	2	12	2	1
66	3	1	C		0	1	2
32	1	1	C	1	8	1	1
60	2	1	C	2	11	3	1
61	3	2	D		0	1	2
62	3	1	C	1	0	1	1
45	2	1	B	2	12	2	2
71	3	1	C		10	2	2
61	3	1	B	1	1	1	1
38	1	2	A	1	11	2	1
56	2	2	B	1	0	3	2
66	3	2	B	1	0	1	1
68	3	2	C		0	2	2
69	3	1	B	1	0	1	1
73	3	1	C	1	12	1	2
33	1	2	D	2	4	1	1
72	3	1	B		12	3	1
60	2	2	A	1	0	1	2
73	3	1	F	2	0	1	2
79	3	1	F		10	3	1
72	3	2	B	2	10	1	2
72	3	1	C	2	1	1	2
45	2	1	C	2	11	1	2
83	4	1	C	2	10	2	2
59	2	1	C	2	11	2	1
44	2	1	A	1	3	1	1
73	3	1	B		0	2	1
56	2	1	C	1	11	2	2
62	3	2	C	2	10	1	2
67	3	2	C		0	1	1

61	3	2	B		6	1	2
57	2	2	D	1	10	1	2
53	2	1	C		11	2	1
56	2	1	C		0	2	2
57	2	1	A	1	0	1	2
38	1	2	D	2	10	1	1
59	2	1	A		7	2	1
63	3	1	C	1	8	1	2
61	3	2	C		0	1	1

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DEGREES

Doctor of Philosophy in College Science Teaching (expected) May 2023
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Master of Science in Biology (expected) April 2022
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Graduate Certificate in University Teaching April 2022
Syracuse University. Syracuse, NY.
Department of College Science Teaching and Graduate School.

Bachelor of Science in Biology & Bachelor of Science in Animal Behavior 2017
Towson University. Towson, MD.
University Honors Scholar, Magna Cum Laude

TEACHING EXPERIENCE

Guest Lecturer, Department of Biology 2021
Syracuse University

Co-Instructor, Department of Biology 2020-2021
Syracuse University

Bricks4Kidz Teacher 2019
Syracuse, NY – Bricks4Kidz

Graduate Teaching Assistant, Department of Biology 2018
Syracuse University

SUBJECTS TAUGHT

Introductory Biology I Laboratory (TA), Introductory Biology I (Guest Lectures), Introduction to Biological Research, Peer Leader Training.

GRADUATE RESEARCH EXPERIENCE

Research Assistant, Department of Biology, Syracuse University 2019-Present
Advisor: Dr. Jason R. Wiles
Projects:

- Student Assessment of Learning Assistants in a Large-Enrollment, Introductory Chemistry Course

- Cyber Peer Led Team Learning (cPLTL) Supports Marginalized Groups, Including Women, in Science, Technology, Engineering, and Mathematics (STEM)
- Peer Led Team Learning's (PLTL) Impact on Undergraduate Students' Science Identity in a Large-Enrollment Introductory Biology Course
- The Effects of an Introduction to Biological Literature Course on Undergraduates' Science Identity and Interest in Scientific Research

PUBLICATIONS

Peer-Reviewed Manuscripts:

Johnson, L. S., **Maxwell, M. C.**, & Nash, S. (2019). What limits clutch size? A test of the incubation capacity hypothesis in a high-elevation passerine, the Mountain Bluebird. *Journal of Field Ornithology*. 0(0):1-8.

Manuscripts in Progress:

Maxwell, M. C. & Wiles, J. R. Cyber Peer Led Team Learning (cPLTL) Supports Marginalized Groups, Including Women, in Science, Technology, Engineering, and Mathematics (STEM).

Maxwell, M. C., Wiles, J. R., Snyder, J., Dunk, R., Cannon, I. & Sloane, J. Peer Led Team Learning in an Undergraduate Biology Course: Impacts on Recruitment, Retention, and Imposter Phenomenon.

PRESENTATIONS

Conference Presentations:

Maxwell, M. C. & Wiles, J. R. (2022). Cyber Peer Led Team Learning (cPLTL) Supports Marginalized Groups, Including Women, in Science, Technology, Engineering, and Mathematics (STEM). Talk at the National Association for Research in Science Teaching (NARST) annual international conference.

Maxwell, M. C. & Wiles, J. R. (2021). Cyber Peer Led Team Learning (cPLTL) Supports Women in Science, Engineering, Technology, and Mathematics (STEM). Talk at the Association of College & University Biology Educators (ACUBE) annual conference.

Departmental Presentations:

Maxwell, M. C. (2021). Lessons Learned During A Pandemic: Cyber Peer Led Team Learning (cPLTL) Supports Marginalized Groups, Including Women, in STEM. Poster presentation in Syracuse University's BIO 705 Graduate Seminar Series.

Maxwell, M. C. (2020). Examining Student Motivation in Cyber Peer Led Team Learning (cPLTL). Talk in Syracuse University's BIO 705 Graduate Seminar Series.

RELATED PROFESSIONAL DEVELOPMENT

Future Professorate Program (FPP). Syracuse University. 2019-Present
Attended professional development programming and participated in an independent teaching experience where I held primary responsibility for my own course under the guidance of a faculty teaching mentor.

Women in Science and Engineering FPP (WiSE-FPP). Syracuse University. 2021-Present
Developed peer and faculty mentoring relationships, attended professional development workshops, established road map for academic and career success, and prepared for academic employment.