Peer-Led Team Learning is Associated with an Increased Retention Rate for STEM Majors from Marginalized Groups

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Abstract

Lack of diversity in the science community is a serious concern for social justice, scientific productivity, equity and efficacy. The first year of undergraduate education is of critical importance in increasing diversity in these fields. Peer-Led Team Learning (PLTL) has previously been shown to be associated with higher student achievement in gateway courses, particularly among students from populations that have been underserved and excluded within STEM fields (often referred to as underrepresented minorities, or URMs). We sought to determine whether participation in PLTL in an undergraduate introductory biology course is associated long-term retention rates among URM students in STEM majors. We used institutional data related to student recruitment and retention rates as well as pertinent demographic information over three and a half years subsequent to the introductory biology course experience. These data were combined with data on PLTL participation from the introductory biology course. Among students who did not engage in PLTL, URM students were significantly less likely to remain in STEM fields than non-URM students. However, no significant difference in STEM retention rates between URM and non-URM students was observed among those students who engaged in PLTL. Additionally, we found that retention rates were significantly higher for URM students who engaged in PLTL versus those who did not. These findings identify PLTL as a potential strategy to improve URM student recruitment and retention in STEM majors and indicate a need for further studies to determine the important aspects of PLTL that may lead to improved outcomes for URM students.

Introduction

As a matter of social justice, we should be beyond the need to argue the fact that diversity in any field is important. However, diversity itself is not enough (Boutte, 2008) without truly equitable inclusion of underrepresented minority (URM) groups in science, technology, engineering, and math (STEM) fields, (Puritty et al., 2017), and it has been shown that STEM fields are far from equitable (Zellmer & Sherman, 2017). Aside from issues of social justice and equity— which ought to be enough of an argument to support diversity and inclusion initiatives in STEM— diversity leads to better science in a number of ways, such as increasing group problem solving performance, enhancing effectiveness of clinical studies, broadening viewpoints and questions, stimulating creativity, and producing research with a higher rate of citations (Woolley et al., 2010; Burchard, 2014; Freeman & Huang, 2014; Nielsen et al., 2017). Then, of course, there are arguments for the importance of diversity in STEM fields from economic and workforce concerns. In 2012, the President's Council of Advisors on Science and Technology (PCAST) released a report detailing the need for one million more college STEM graduates than expected in the subsequent decade (Olson & Riordan, 2012), in part because the proportion of college graduates completing a STEM degree had fallen for years (Olson & Riordan, 2012; HERI, 2010; Graham et al., 2013). Additionally, the National Academy of Sciences has identified minority participation in STEM as a national priority, as diversity among participants in STEM fields is necessary to ensure innovation, among other benefits, and to grow a strong and talented science and technology workforce (Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline, 2011). There is, and has been, a dire need to increase representation of the "underrepresented majority"—women of any ethnicity and others who are included in URM groups—who constitute 70% of all college graduates but only 45% of STEM graduates (Olson & Riordan, 2012).

The first two years of college are critical for STEM persistence. (HERI, 2010; Graham et al., 2013; Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline, 2011; Griffith, 2010). Many students who leave STEM majors do so after taking introductory courses (Ost, 2010; Rask, 2010), and even high-achieving students often cite uninspiring introductory courses as a reason for switching majors (Thiry et al., 1997, p.444). The PCAST report (Olson & Riordan, 2012) identified three main aspects of student experience that affect persistence in STEM: intellectual engagement and achievement, motivation, and identification with a STEM field. It also emphasized the need to adopt teaching strategies that promote active learning, which can improve these facets of students' experiences with STEM as well as enhance student retention and academic achievement (Braxton et al., 2000; Finn & Campisi, 2015).

Active learning approaches have been shown to improve student learning and reduce failure rates across all STEM disciplines and class sizes (Freeman et al., 2014). Peer-led Team Learning (PLTL) is an active learning approach that appears to provide much of what PCAST deems necessary to increase student persistence in STEM, including opportunities for intellectual engagement and achievement. PLTL employs experienced undergraduates as peer leaders who facilitate small-group workshops, which the students attend in addition to or in place of traditional lectures. During PLTL workshops, students work collaboratively on problem sets with their peers and the peer leader. The peer leaders themselves have already taken and been successful in the course, and they are trained to facilitate discussions and guide students to their own answers without "teaching" content (Tien et al., 2002). These workshops promote active learning and student engagement since the students must arrive at the answers to the problem sets themselves.

Active learning techniques like PLTL have been associated with improved achievement (Freeman et al., 2014; Gafney, 2001; Alger & Bahi, 2004; Snyder, Carter & Wiles, 2015), and achievement in "gatekeeper courses" is closely tied to persistence in STEM (Toven-Lindsey et al., 2015). Regrettably, URM students in many institutions tend to receive significantly lower grades in STEM courses than non-URM students (Rath et al., 2007). However, we have previously demonstrated that, while all groups benefit from participation in PLTL, URM students in particular earn markedly higher grades in introductory biology courses when they engage in PLTL (Snyder, Sloane, Dunk, & Wiles, 2016).

There is also evidence that active learning instructional strategies can impact students' motivation to persist in STEM. Active learning courses have positive impacts on students' motivation and intention to register for STEM courses (Esmaeili & Eydgahi, 2014). Additionally, providing students with role models in STEM – which is closely tied to motivation (Olson & Riordan, 2012; Fuesting & Diekman, 2017) – can influence both recruitment and retention in STEM (Drury, et al., 2011; Shin et al., 2016). PLTL provides opportunities for underrepresented students to interact with peers in a welcoming environment, which can increase sense of belonging (Thiry et al., 1997, p. 444), which has also been associated with motivation to persist and advance in STEM disciplines (Good et al., 2012). Given that PLTL involves active learning, group interactions, and the presence of potential role models, it may influence student motivation to persist in STEM.

The third aspect of student experience that the PCAST report asserted as an influence on persistence in STEM is identification with a STEM field (Olson & Riordan, 2012; Espinosa, 2011). Palmer, et al. found that peer group support was one of the most important factors influencing URM student retention and persistence in STEM (2011). The PLTL model provides opportunities for students to work collaboratively with one another on a regular basis under the guidance of a peer leader and to feel included in the STEM community, providing the students with opportunities to develop their STEM identity.

In summary, because PLTL is active in nature, offers role models, and encourages group interactions, it appears to satisfy what the PCAST report prescribed toward increasing student persistence in STEM. Moreover, exposure to supportive peers has been shown to contribute to the persistence of students during their first year in STEM fields (Packard et al., 2011). We therefore expected that offering PLTL in an introductory biology course could be an effective intervention at a pivotal point when many students are known to drop out of STEM majors (Snyder et al., 2015). Hence, we predicted that PLTL would have a positive influence on recruitment and retention in STEM for students overall, but also that there might be particular recruitment and retention benefits for members of URM groups who tend to drop out of STEM majors at higher-than-average rates and may have more trouble identifying with STEM in the context of traditional, lecture-based courses (Brown et al., 2016; Brown et al., 2015).

Methods

Peer-led Team Learning was offered during the second semester of the introductory biology course required for majors in the life sciences and related fields at a large, private university in the American northeast. Details on our PLTL implementation have been previously published and are freely available (Snyder et al., 2015; Snyder et al., 2016; Snyder & Wiles 2015); briefly, 90-minute PLTL sessions were offered weekly wherein students worked collaboratively, facilitated by a peer leader, on prescribed problem sets based on the course content topics. Three and a half years later, institutional data for students (N = 358, demographic details as published by Snyder, et al., 2016) were collected, including data on prior achievement, declared ethnicities, and declared majors throughout their academic careers. We compared students who participated in PLTL versus those who did not and found no statistical difference in prior achievement (measured as biology course grades from the fall semester, high school grade point average, or total SAT scores) between students who participated in PLTL versus those who did not (Snyder et al., 2015; Snyder et al., 2016). For the purposes of this study, which was funded by a National Science Foundation (NSF) S-STEM grant, majors listed by the NSF as an S-STEM-eligible discipline (2021) were considered to be STEM majors. Students were considered "recruited" into STEM if they had not declared a STEM major upon matriculation to the university and subsequently declared a STEM major between the introductory biology course experience and the time of final data collection. We considered students to have been "retained" in STEM if they ever declared a

STEM major and had remained in a STEM major or had graduated with a degree in a STEM field at the time of final data collection.

Pearson's chi-square tests of independence were utilized to examine: (1) whether differences in STEM recruitment and retention rates existed between URM and non-URM students who did not participate in PLTL; (2) whether differences in STEM recruitment and retention rates existed between URM and non-URM students who participated in the PLTL model; and (3) whether participation in PLTL was associated with increased STEM recruitment and retention rates for either URM or non-URM students. We report here the uncorrected Pearson chi-square values, but when Yates' correction was applied to all tests it did not change the significance level of any of the tests.

This research was conducted according to a protocol approved by the Institutional Review Board of the Syracuse University Office of Research Integrity and Protections (IRB# 14-313).

Results

Recruitment

URM students who did not engage in PLTL were significantly less likely to be recruited into STEM fields when compared to their non-URM counterparts ($\chi^2 = 5.415$, df = 1, N = 168, p = .020). There was no significant difference in STEM recruitment rates between URM and non-URM students among those who engaged in PLTL ($\chi^2 = 1.293$, df = 1, N = 92, p = .256).

Retention

As shown in Figure 1, URM students who did not engage in PLTL were significantly less likely to remain in STEM fields than their non-URM counterparts ($\chi^2 = 6.324$, df = 1, N = 95, p = .012). There was no significant difference in STEM retention rates between URM and non-URM students among those who engaged in PLTL ($\chi^2 = .135$, df = 1, N = 53, p = .713). Additionally, URM students who engaged in PLTL were significantly more likely to remain in STEM majors than those who did not ($\chi^2 = 6.472$, df = 1, N = 32, p = .011).

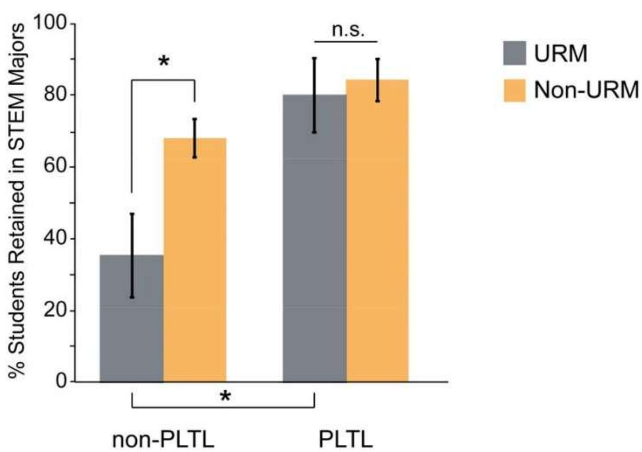

Fig 1. Retention in STEM majors for URM and non-URM students with and without PLTL. Retention in STEM majors for URM and non-URM students with and without PLTL. Percent of students retained in STEM majors. Error bars represent +/- standard error of percent. Asterisks display significance of chi-square tests at p<0.05.

Discussion

The results indicate that, without PLTL, URM students were significantly less likely than non-URM students to be recruited into STEM majors over the following three-and-a-half years or to have remained in or completed STEM majors at the end of that time. However, if the students participated in PLTL, no statistically significant differences in STEM major recruitment or retention rates were observed between URM and non-URM students. Moreover, PLTL participation was associated with a significant increase in URM student retention in STEM majors.

There are many reasons to expect that participation in PLTL itself could have such an impact. As a pedagogical approach that promotes active participation, PLTL provides students an opportunity to construct meaning of the course material on their own terms through social interaction with peers. This is associated with increased long-term recall of course material, which leads to higher grades in the course (Gafney, 2001). Higher grades have also been found in previous studies to be linked to improvements in students' self-efficacy (Wilkie, 2003; Ballen et al., 2017). Using traditional instructional practices, URM students have historically seen higher failure rates than non-URM students in STEM courses at many institutions (Rath et al., 2007), and PLTL has been associated with improved grades for all student groups, particularly URM students (Snyder et al., 2016). If self-efficacy is associated with student achievement in STEM, student achievement in STEM is associated with student persistence in STEM (Felder et al., 1998), and PLTL increases grades preferentially for URM students in STEM courses (Snyder et al., 2016), then differential growth in self-efficacy between URM and non-URM groups may be responsible in some part for the particular benefit of PLTL on URM STEM retention. That is, the higher grades earned by URM students who engage in PLTL, as well as subsequent increases in recruitment and retention may be related to increases in self-efficacy to levels that match or exceed their historically well-represented peers. Future research should attempt to directly measure the effects of PLTL on self-efficacy in association with these other variables to test this hypothesis.

While achievement and self-efficacy are certainly part of the recruitment and retention equation, students are not likely to choose a major or persist in a field if they have no sense of belonging in these programs and communities. Even if students are confident in their abilities and earn high marks in introductory courses, they still may not choose to join or stay in a field if they do not feel welcome, valued, and engaged in its community. This is at the root of efforts that go beyond diversity and into authentic inclusion. As Wilson et al. (2015) found in a study across several institutions, a sense of belonging is of central importance in the undergraduate STEM experience, and belonging is fostered by academic, behavioral, and emotional engagement. They conclude that highly contextualized connections to peers are of critical importance in establishing and sustaining such engagement. PLTL does provide opportunities to build connections with peers, which positions it well as a potential way to generate feelings of belonging, perhaps particularly among students who may not initially identify with STEM fields.

It has been documented that URM students often struggle with identification with STEM (Hazari et al., 2013), and that this is often a reason that they leave STEM fields (Wilson et al., 2015). African-American students who attend historically black colleges and universities are more likely to major in STEM than those at predominantly white institutions (Hurtado et al., 2010), and this may be due to the greater likelihood of instructors or other students serving as STEM role models. PLTL offers potential role models to students in the form of peer leaders, who are likely closer to them in age, experience, and other aspects of identity than a professor might be. In particular, peer leaders are thought to be effective as workshop facilitators and role models because they are closer to the students' "zones of proximal development" (Ormrod & Jones, 2018, p.216) and may have reasoning patterns more similar to the students than a typical graduate teaching assistant or professor (Gafney, 2001). Indeed research has shown that students who identify with their peer leaders and view them as role models tend to have better learning outcomes than those who do not similarly connect with their peer leaders (Winterton et al., 2020).

Conclusion

Previously, we showed that participation in Peer-Led Team Learning had a significant positive impact on URM student achievement in an introductory biology course (Esmaeili & Eydgahi, 2014). Here, perhaps more importantly, we have described the potential the downstream effects of the PLTL experience and associated higher achievement in the gateway courses. For URM students, engagement in PLTL in a first-year biology course is associated with retention in a STEM field more than three years after their PLTL experience. Further, engaging in PLTL is associated with a reduction in the recruitment gap between URM and non-URM students such. These results indicate the lasting positive impact that engagement in PLTL may have for URM students and indicate a need for further studies to determine the important aspects of PLTL that may lead to improved outcomes for URM students. Moreover, they contribute to a growing body of evidence positioning PLTL as a strategy that may help to promote inclusion and close the equity gap in STEM fields.

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