Piloting the Learning Assistant (LA) Model in a Large Lecture General Chemistry Course

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Abstract

Studies have demonstrated the positive impact of the Learning Assistant (LA) model on student learning across various disciplines, demographics, and course types. In order to investigate the effect of exposure to the LA program on student learning and success in a large Chemistry course, a pilot was launched in one of two sections of General Chemistry II at Florida Atlantic University (FAU) in spring 2020, with the addition of LAs as the sole experimental variable. The researchers hypothesized that the LA model positively impacts equity in the classroom with increased learning gains across student demographics. A t-test was used to determine the significance in differences between student exam scores in the LA and non-LA section. The researchers found that student learning was significantly higher in the LA section versus the non-LA section ($p<0.01$). Students participating in the LA section ($N=275$) had stronger outcomes than students in the non-LA section (N=290). In addition, students in the LA section were more likely to pass the course, enroll in the subsequent (Organic Chemistry) course within one year, and were more likely to be retained at the institution. These success rates held for all students, particularly for students historically underrepresented in chemistry.

Keywords: Learning Assistant, collaborative learning, active learning, equity in education, student success

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Introduction

Across higher education, student learning and success as measured by content knowledge, course grades and retention to the major is a concern for faculty and administrators alike. A major focus of higher education research has centered around persistence and graduation rates (Astin, 1993 and 1999; Bean & Metzner, 1985; Bebergal, 2003; Eimers & Pike, 1997; Pascarella & Terenzini, 2005; Tinto, 1975 & 1987). Retention and graduation in STEM disciplines has received the greatest attention as completion rates in these areas are often lower than in other academic areas of study (Chen, 2013).

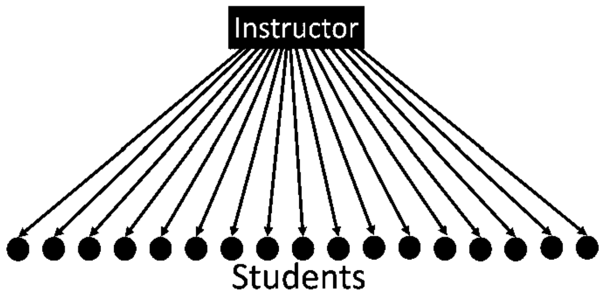
Low pass rates in gateway STEM courses, specifically chemistry, can lead to attrition or prevent students from progressing within their major (Stone, et al., 2018). This limits their ability to pursue advanced degrees and careers in medicine, research, and other vital scientific areas. The problem is exacerbated for students from historically underrepresented populations (Barbera, et al., 2020; Freeman, et al., 2015; Graham, et al., 2013; Rennar-Potacco, 2019). Academic support programs have been developed to assist students in improving content understanding and course pass rates with positive results (Arendale, 2001; Grillo & Leist, 2013; Skoglund, et al., 2018). While students utilizing peer-led programs such as tutoring and Supplemental Instruction (SI) show increased learning and course outcomes, these interventions impact students outside of the classroom, which limits the effect for students who do not or are not able to attend (Rennar-Potacco, 2019). The researchers in this study identified a more equitable intervention that impacts all students in the course through a curricular peer-led model. The study was designed to investigate the effect of exposure to the LA program on student learning, student success, and equity in a large lecture Chemistry course at Florida Atlantic University (FAU).

The Learning Assistant (LA) Model

The Learning Assistant (LA) program is an evidence-based model of embedded academic support that assists faculty in redesigning their courses to incorporate many of the best practices in teaching (Barrasso & Spilios, 2021). Undergraduate LAs, trained through a pedagogy course, work with faculty (both during class and in weekly prep sessions) to facilitate active learning and collaborative group work for all students in the course. Research shows that ideally, collaborative learning group size ranges from three to six students (Burke, 2011). In the LA model, students are grouped together as a semester-long learning team, allowing them to immediately apply concepts learned in class. The LAs and instructor move among the groups to help with the learning process as students identify and fill in gaps in knowledge related to course content. As a result, students within the course become responsible for their own learning as they engage the content with peers.

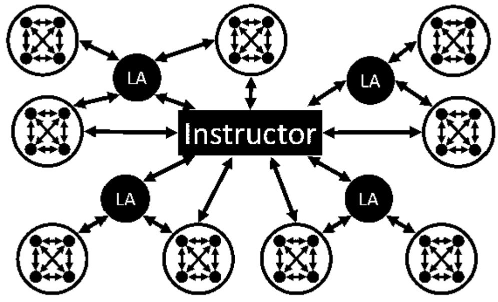
The LA model is adaptable and can evolve to meet the vision of faculty and needs of students in any college classroom environment. In traditional large lecture classrooms, the communication between students is limited and much of the faculty interaction is one-way (Figure 1). It is challenging for the students to be connected to both the faculty member and the course content, which can lead to attrition from the course, the discipline, and even the institution.

Figure 1
Traditional Lecture Course (Image from Learning Assistant Alliance, 2018)



In the LA model, the student-centered redesign (Figure 2) encourages communication between students, and curricular involvement by everyone in the course. This engagement leads to feelings of belonging and support, which can increase course completion as well as persistence within the major and institution.

Figure 2
Course with LA Model (Image from Learning Assistant Alliance, 2018)



Purpose of the Study

The purpose of this study was to investigate the effect of exposure to the LA program on student learning and student success in a large lecture Chemistry course at Florida Atlantic University (FAU). The research questions guiding this study were:

1. Does use of the LA model correlate with student learning and success in a large lecture chemistry course?
2. Does use of the LA model correlate with equity in the classroom resulting in stronger student outcomes for historically underrepresented groups?
3. Does the LA model correlate with continuing student enrollment at the institution overall and into subsequent chemistry courses?

The first research question involved a quantitative analysis of exam outcomes between students in LA and non-LA sections along with comparison of course outcomes based on grade and overall pass rates. The second research question focused on a quantitative analysis of course grades as it related to demographic background including race, gender, and first-generation college status. The final research question measured continuation both at the institution and in the Chemistry course sequence following participation in a course supported with the LA model.

Literature Review

Beginning in 2001 at the University of Colorado, Boulder, over 100 LA Programs have now been implemented worldwide. National research studies have shown the wide impact of these programs on learning gains, DFW rates, retention rates, and effects on underrepresented students (Barrasso & Spilios, 2021).

Increases in learning gains for students in LA courses have been described across the literature (Miller et al., 2013; Otero et al., 2006; Otero & Finkelstein, 2010; and Otero, 2015). Herrera & Van Dusen (2018) found that students in LA classes had learning gains 1.6 times greater than in traditional courses, and that coupling LA support with collaborative learning is correlated with higher learning gains than collaborative learning alone. LA usage is associated with improved concept inventory scores (White et al., 2016) and students in LA-supported courses perform better on exam questions requiring higher order cognitive skills (Sellami et al., 2017). The research by Sellami (2017) found that the learning gains were even more pronounced for underrepresented minority students in LA courses as compared to courses without LAs.

With increases in learning gains, it is not surprising that research has shown DFW rates (percent of enrolled students who earn grades of D, F, or withdraw) improve in LA supported courses (Alzen, et. al, 2017; Alzen, et. al, 2018), with even greater improvements for students of color (Van Dusen et al., 2015; Van

Dusen et al., 2016; Van Dusen & Nissen, 2019). Additional studies have shown a greater decrease in course failure among nonwhite and first-generation students as compared with majority groups when the LA program is implemented (Alzen, et. al, 2018). The program has been shown to mitigate disparities in the achievement of students based on gender and ethnicity, which leads to increases in equity and a reversal of traditional learning gaps for minoritized students. Additionally, it can reduce barriers to individual advancement in their degree program and provide students of all backgrounds with equal opportunities, (Adelmann et al., 2021).

Research has also shown that the LA program has a positive impact on retention (McQuade et al., 2020). A recent study showed students enrolled in an LA course in year one have a 3% increase in retention to year two over students not exposed to the LA program in their first year. This increase grows to 4% for students one standard deviation below the average high school GPA (Alzen & Otero, 2021). Attrition often occurs due to lack of connection in the classroom. This is largely prevalent in high enrollment courses. These large lectures, often utilized to teach gateway courses, appear at first glance to be cost-effective. However, high student-to-faculty ratio leads to high failure rates, which can result in students switching majors or leaving the institution (Crisp et al., 2009). The addition of LAs increases the ratio of support and can negate this trend.

Background Information

About FAU

The pilot program described in this study took place at Florida Atlantic University (FAU). FAU was founded in 1961 as the fifth public university in the state. Serving more than 30,000 undergraduate and graduate students across ten academic colleges, the University ranks as the most ethnically and culturally diverse in Florida's State University System. In 2017, FAU received federal designation as a Hispanic- Serving Institution (HSI) with over 25% of full-time undergraduate students being of Hispanic descent.

About Chemistry at FAU

The Department of Chemistry & Biochemistry in the Charles E. Schmidt College of Science at FAU offers a variety of undergraduate and graduate programs (FAU Chemistry department website http://chemistry.fau.edu/). Key service courses within the department enroll over 5,300 students annually. The average annual enrollment in these courses (fall, spring, summer) are: General Chemistry I (1900), General Chemistry II (1200), Organic Chemistry (1400), and Organic Chemistry II (900). The DFW rates are traditionally high in these courses. While the DFW rate for the course in the pilot study (Chemistry II) is not as high as other science courses at the institution, the three-year average DFW rate prior to spring 2020 was 22.68%, with 723 of the 3,188 students enrolled during that period failing to complete the course with a passing grade.

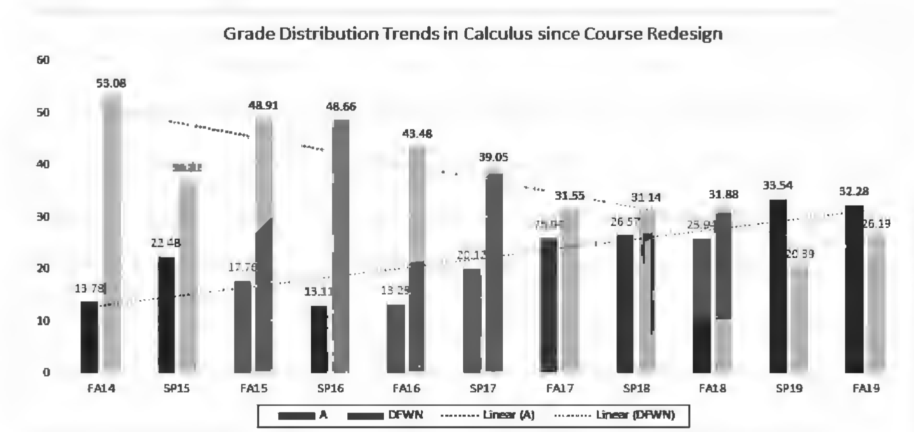
Within the Chemistry department, peer-led team learning has been provided through "Chem bonding" and "Orgo bonding" models to support students in Chemistry I and Organic Chemistry I. Additional academic support is provided through trained peer tutors and Supplemental Instruction (SI) Leaders by the Center for Teaching and Learning. Student participation in academic support has historically been strong for General Chemistry. In the spring term before the pilot (spring 2019), 399 unique students had 2,321 visits for Chemistry II tutoring (n=291) and SI (n=2,030). This has established a culture of student engagement with academic resources and peer-based support in chemistry at FAU.

About the LA Program at FAU

In 2014, Florida Atlantic University staff began the process of transforming the curriculum in Calculus I to implement the LA model. The LA program in Calculus has led to significant decreases in DFW rates, with the average rate in Calculus I cut in half over the past four years. Prior to the implementation of the LA model, the DFW rate averaged 48-56% each semester. In 2018-2019, the DFW rate dropped to 21-28%. Findings showed that students in FAU LA courses (Calculus I and later, Calculus II) earn higher grades across all levels of high school preparation with the effect most pronounced for students entering with lower high school GPAs.

The DFW rates in Calculus I declined while the number of students earning an A increased (Figure 3).

Figure 1
Students in Calculus courses with LAs have higher % of A's and lower DFW rates



Beyond grades, a diverse group of students commented on how the LA model helped them truly learn Calculus:

> **(Sophie, Calculus I student)** Instead of directly guiding me to the right answers or reassuring me when I had no idea what I was doing… [the LAs] would ask me what I think the first step is and why. If it was incorrect, they wouldn't tell me but would ask why… or is there a better step that can be taken. Eventually, I became better at using deductive reasoning and problem solving…by asking myself the same questions on my own.

> **(Leon, Calculus I student)** I have taken several courses with, and without, [LAs]. It is only when a learning assistant is

present that I feel most confident in my success within that course. With a learning assistant present, I can seek help from a student who successfully passed the course.

(William, Calculus I and II student) With an LA helping you as you learn, they can call you out on your mistakes as soon as they happen. Not only is this a phenomenal advantage because it helps ease the frustration of not knowing why you are having trouble, but it makes it almost impossible for bad habits to take root.

(Abigail, non-traditional FAU student in Calculus II) Any time my group was stuck on a problem, we called the LA to guide us back towards the solution. Unlike tutoring, where there is a time gap between lecture, homework, and a session, the LAs were a few steps away.

(Olivia, Calculus I student) Sometimes I felt that I had a stupid question where I was completely embarrassed to ask the professor… In those times, I would go into the breakout room with some of my classmates and finally felt comfortable asking our LA, since they are also a student… If I hadn't asked those questions, I can't say with confidence that I would have passed that course.

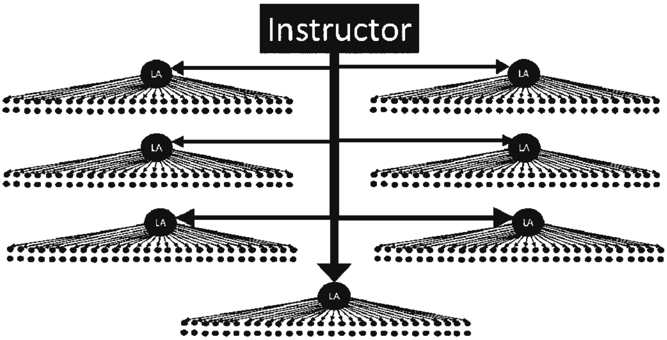
Description of the Pilot

Based on national outcomes and outcomes seen in Calculus at FAU, General Chemistry II was redesigned by faculty to include the

LA model and piloted in spring 2020. The LA program was introduced into one of two sections of this STEM gateway course, with the intent to assess the relationship between LA exposure and student performance in a high enrollment science course at FAU. During the registration period for the term, students randomly selected one of the two Chemistry sections based on section day/time and availability. Both sections were taught by the same instructor and students were unaware which section contained the LA model.

In the pilot section, seven LAs were present in the large auditorium and were assigned to designated zones within the classroom to support the 275 enrolled students. While specific groups were not assigned, each LA was responsible for working with approximately 40 students. Multiple-choice questions were asked throughout the lecture, and students were encouraged to discuss the questions with three or four nearby students and respond using I-clickers®. The LA role was to assist students in their zone during these collaborative activities by asking questions to elicit student thinking and promoting engagement and shared understanding of concepts. (Figure 4)

Figure 2
Pilot of LA in General Chemistry – class format



In the control section, LAs were not included, but other variables remained the same: instructor, content, format, and grading scale. The results from the control cohort were compared against historical institutional data results of the same course taught the previous academic year in the same format. The researchers investigated the effect of exposure to the LA program in the class by comparing the results of the first two exams in the pilot and control sections. The pilot was suspended after the first eight weeks of the semester when the move to remote instruction due to the COVID-19 pandemic occurred. Since LA support in-person was no longer possible, and the introduction of online LAs would have changed the design of the study, the decision was made to remove the LA component from the course. Although the program was only included in the first eight weeks, the researchers analyzed whether there was an impact on final course outcomes, retention to the next semester, and enrollment in Organic Chemistry.

Methodology

This study was conducted by evaluating historical data from General Chemistry II during the spring 2019 and 2020 semesters. This lower-division course is traditionally taken in the spring semester by first year students to fulfill a major requirement for baccalaureate degree programs in biology, chemistry, physics, and psychology. The focus of the study was to quantitatively correlate the use of the LA model with changes in student success rates (DFW rates, grade distribution, and institutional retention) and to compare instruction with and without the model by using an experimental/quasi experimental research design. Students were classified into two groups: LA participant or non-participant. Demographic data was provided by the institutional research department on campus. Statistical tools, including t-test, mean, and standard deviation, were used to measure group differences and statistical significance of the outcome data.

Description of Participants

In spring 2020, 565 students enrolled across two sections of General Chemistry II. This was divided into 275 students in the LA section and 290 in the non-LA section. Student demographics between the two groups were similar (Table 1), with 72.4% of students in each section classified as female and 28-29% of students identifying as Hispanic. The LA section had 21.1% of students identified as Black compared to 19.3% in the non-LA section. The outcomes were also compared to the spring 2019 Chemistry II students as a control. The two sections in the control semester had 580 total students (compared to 565 in spring 2020) with similar demographics (70.5% female; 19.5% Black; 29.7% Hispanic).

Table 1

General Chemistry II Demographic Descriptors Spring 2019 and 2020

	Spring 2019	Spring 2020 Control (no LAs)	Spring 2020 Pilot (with LAs)
CHM 2046 Enrollment	580 total	565 total (290)	565 total (275)
Female	70.5% (409)	72.4% (210)	72.4% (199)
Black	19.5% (113)	19.3% (56)	21.1% (58)
Hispanic	29.7% (172)	29% (84)	28.4% (78)

Description of Study Design

The sections evaluated in this study were taught in the same classroom with similar enrollment sizes and demographic breakdown (see Table 1). The instructor, curriculum, and mode of instruction were the same, allowing comparison of outcomes between experimental and control sections. The only difference was the presence or absence of the Learning Assistants in the classroom.

To investigate the first research question, average grades on Exam I and II for students in the LA section were compared to students in the non-LA section. Exam means and standard deviations were calculated using Microsoft Excel. To control for a potential difference in outcomes based on time of day of the course section, exam scores from the 2020 sections were compared to the exam scores from the 2019 sections which were taught at the same day and times. Similarly, final course grades and overall pass rates were analyzed and compared between the two groups. To address the second research question, analysis of outcomes was conducted based on race, gender, and first-generation college status. To examine the third research question, retention to the next term and enrollment in subsequent Chemistry courses were measured to investigate the long-term impacts of the LA program.

Findings

Due to COVID-19, the Chemistry course moved from in-person to online instruction halfway through the semester. Based on this change, the LA model was only utilized in the first eight weeks of the sixteen-week term. Despite this limitation, outcomes for students in the LA section mirrored the positive outcomes described in the literature. Students in the LA section of the course demonstrated greater competency as they earned higher average scores on each of the first two exams (3.84 and 4.08 points higher respectively) as compared to students in the non-LA section (Tables 2 and 3). These results were statistically significant ($p<.01$). The scores were also compared to exam results from the previous academic year, before the addition of the LA model. These scores from spring 2019 aligned with the spring 2020 exam scores for the non-LA section. As the 2019 sections were taught by the same instructor, in the same classroom, and at the same time of day as the 2020 sections, it further demonstrates the likelihood that the difference in outcomes was due to the inclusion of LAs in the course. It is unlikely that there were other mitigating factors that could explain the difference in student outcomes between the control and LA groups.

Table 2

Chemistry II Exam 1 Grade Analysis

Spring 2020 General Chemistry II Exam 1 Grade Analysis

	LA Section	Non-LA Section
Mean	68.20455	64.35563
Variance	201.3344	214.6681
Standard Deviation	14.18923634	14.65155728
Observations	264	284
df	545	
t Stat	-3.12342	
P(T<=t) two-tail	0.001883	
t Critical two-tail	1.964326	

Table 3

Chemistry II Exam 2 Grade Analysis

Spring 2020 General Chemistry II Exam 2 Grade Analysis

	LA Section	Non-LA Section
Mean	66.27376	62.19485
Variance	198.1996	211.2645
Standard Deviation	14.07833713	14.53493981
Observations	263	272
df	533	
t Stat	3.297262	
P(T<=t) two-tail	0.001041	
t Critical two-tail	1.964425	

Students in the LA section passed the course with a grade of C or better at a 3.7% higher rate than in the non-LA section (Table 4), with students in the LA section earning A's at a significantly higher rate (41.5% as compared to 30.3% for the non-LA section). This 11.1% difference in A's (Figure 5) continues to show the increased capacity building provided through the LA model. Although the LAs were only included in the course during the first eight weeks of the semester, final course outcomes were significantly higher for the LA section (Table 5) by over 5% ($p<.001$).

Table 4
Student Pass rates Spring 2020 in LA as compared to non-LA section

	SPRING 2020 CHM 2046-001 With LA		SPRING 2020 CHM 2046-002 Without LA		Change
	Count	%	Count	%	
Passing (A,B,C,P)	254	92.4%	257	88.6%	3.7%
Not Passing (D,F,W)	21	7.6%	33	11.4%	
	275	100.0%	290	100.0%	

Figure 3
Grade distribution in Chemistry pilot

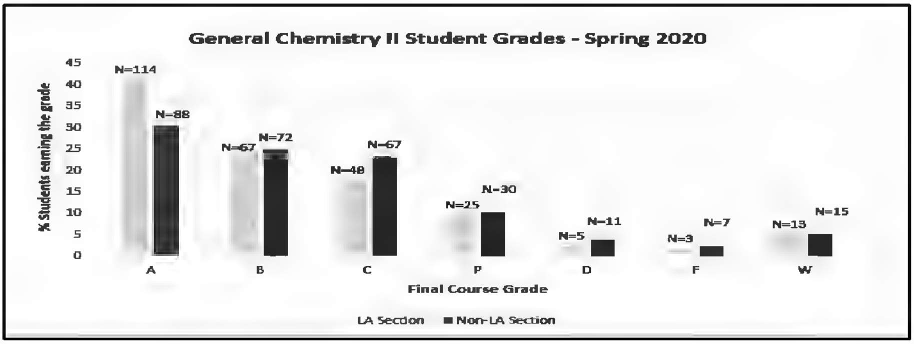


Table 5
Final course outcomes – Chemistry II Spring 2020

	LA Section	Non-LA Section
Mean	81.10479	76.09091
Standard Deviation	14.4878	16.00253
Variance	209.8962	256.081
Observations	263	276
df	536	
t Stat	3.816496	
P(T<=t) one-tail	7.56E-05	
t Critical one-tail	1.647701	
P(T<=t) two-tail	0.000151	
t Critical two-tail	1.9644	

Course Outcomes Based on Race, Gender, Ethnicity and First-Generation College Status

A number of factors impact student success in a course. Often, students who are historically underrepresented in a discipline struggle to find success. As described in the literature review, research has found that while all students benefit from the LA model, students from these underrepresented backgrounds often have greater positive gains as compared to majority students. This was found to hold in the pilot.

Black students passed the LA section of the course at 91.38% as compared to the non-LA section where Black students passed at a rate of 85.71%. This provided a greater than 5.5% higher passing rate for these students if they took the course with the LA model. Additionally, this group had a higher chance to earn a course grade of A (36.2%) as compared to those Black students who took the course without LAs (19.64%). The non-LA Black students who passed were most likely to earn a final course grade of C (35.71%) as compared to only 20.7% of the Black students in the LA section who earned a C. (Table 6)

Table 6
Outcomes for Black Students

Spring 2020 General Chemistry II Outcomes for Black Students	LA Section	Non-LA Section
Final Course Grade	*% earning grade*	
A	36.20%	19.64%
B	24.10%	25.00%
C	20.70%	35.71%
P	10.34%	5.36%
TOTAL Pass (A, B, C, P)	91.38%	85.71%
D	3.44%	3.57%
F	0.00%	3.57%
W	5.17%	7.14%
TOTAL non-Pass (D, F, W)	8.62%	14.29%

Students who identify as Caucasian saw the benefit of the LA model on their course grades as white students in the LA section earned A's at a 13.24% higher rate (44.21% to 30.97%). While the overall course pass rates were equivalent between the LA and non-LA groups for white students, the students in the LA sections performed significantly better overall as measured by course grades (Table 7).

Table 7
Outcomes for White Identifying Students

Spring 2020 General Chemistry II Outcomes for White Students	LA Section	Non-LA Section
Final Course Grade	*% earning grade*	
A	44.21%	30.97%
B	24.21%	23.01%
C	16.84%	26.55%
P	8.42%	14.16%
TOTAL Pass (A, B, C, P)	93.68%	94.69%
D	1.05%	2.65%
F	2.10%	0.88%
W	3.16%	1.77%
TOTAL non-Pass (D, F, W)	6.32%	5.31%

As a Hispanic Serving Institution (HSI), outcomes for Hispanic identifying students are an institutional priority. Hispanic students in the LA pilot passed the course (89.74%) at an 8.79% higher rate than those not in the LA section (80.95%) (Table 8).

Table 8
Outcomes for Hispanic Identifying Students

Spring 2020 General Chemistry II Outcomes for Hispanic Students	LA Section	Non-LA Section
Final Course Grade	*% earning grade*	
A	28.20%	30.95%
B	30.77%	28.57%
C	24.36%	14.29%
P	6.41%	7.14%
TOTAL Pass (A, B, C, P)	89.74%	80.95%
D	1.28%	7.14%
F	1.28%	3.57%
W	7.69%	8.33%
TOTAL non-Pass (D, F, W)	10.26%	19.05%

While prior studies have shown that the LA model has a strong positive impact on first-generation students (Alzen, et. al, 2018), the pilot in this study did not show a difference in outcomes for first-generation college students (N=120). Both the LA and non-LA sections showed a pass rate of 88.33% for this population. Within this study, the institutional classification for first-generation college students was used, which is that neither of the student's parents completed college (Table 9).

Table 9
Outcomes for First-Generation College Students

Spring 2020 General Chemistry II Outcomes for First-Generation College Students	LA Section	Non-LA Section
Final Course Grade	*% earning grade*	
A	25.00%	30.00%
B	36.67%	26.67%
C	21.67%	25.00%
P	5.00%	6.67%
TOTAL Pass (A, B, C, P)	88.33%	88.33%
D	1.67%	3.33%
F	0.00%	3.33%
W	10.00%	5.00%
TOTAL non-Pass (D, F, W)	11.67%	11.67%

In terms of gender, women are often underrepresented in chemistry (Stockard, et al., 2021). The pilot showed only a modest difference in pass rates for women (91.96% to 89.05%) between the sections. The data did however show a higher percentage of women earning As in the LA section (39.70%) as compared to the non-LA section (30.48%) (Table 10).

Table 10

Outcomes for Female Student

Spring 2020 General Chemistry II Outcomes for Female Students	LA Section	Non-LA Section
Final Course Grade	*% earning grade*	
A	39.70%	30.48%
B	24.62%	24.76%
C	18.09%	23.33%
P	9.55%	10.48%
TOTAL Pass (A, B, C, P)	91.96%	89.05%
D	2.51%	4.76%
F	0.00%	1.90%
W	5.53%	4.29%
TOTAL non-Pass (D, F, W)	8.04%	10.95%

Enrollment in Organic Chemistry

Students who complete General Chemistry II often enroll in the next course in the chemistry sequence, Organic Chemistry. The researchers examined whether participation in the LA model in Chemistry II led to increased likelihood of the student enrolling in the subsequent course within one year. In the LA pilot, students who took General Chemistry II with LAs enrolled in Organic Chemistry I within one year at a rate of 61.8%. This is compared to only 53.1% for students who took the General Chemistry II course that semester without the LA model; (Table 11) a difference of 8.7%.

Table 11
Enrollment in Organic Chemistry

SPRING 2020 CHM 2046-001 With LA Enrolled in CHM 2210 within 1 year	Count	%	SPRING 2020 CHM 2046-002 Without LA Enrolled in CHM 2210 within 1 year	Count	%	Change
Enrolled	170	61.8%	Enrolled	154	53.1%	8.7%
Not Enrolled	105	38.2%	Not Enrolled	136	46.9%	
	275	100.0%		290	100.0%	

Retention to the University

Research has shown that students who take courses within the LA program have increases in retention rates (McQuade et al., 2020). This held true through the pilot. Students who took General Chemistry II with LAs in spring 2020 were retained to the fall semester at a 92% rate. Retention for the non-LA Chemistry II students was only 86.9% (Table 12). This 5.1% higher retention rate for the LA students exceeds previously published data.

Table 12
Retention at the University for LA as compared to non-LA participants

SPRING 2020 CHM 2046-001 With LA Retention - Enrolled FALL 2020	Count	%	SPRING 2020 CHM 2046-002 Without LA Retention - Enrolled FALL 2020	Count	%	Change
Enrolled	253	92.0%	Enrolled	252	86.9%	5.1%
Not Enrolled	22	8.0%	Not Enrolled	38	13.1%	
	275	100.0%		290	100.0%	

Qualitative Results

A student perception of teaching survey administered at the end of the semester highlighted the positive feelings that students had about the pilot program. In response to the question "What did you like most about this course," students specifically identified the assistance of the LAs:

- I really appreciated the Learning Assistants.
- The LAs were so helpful in every way… I would like to thank each and every one of them for such a great job this semester.
- The interactive iclicker questions that allowed group work
- Learning assistants and group iclickers
- I liked the lectures before quarantine. Having learning assistants around for the i-clicker questions was such a big help. There were times when I couldn't understand what the question was asking, and the learning assistants were able to help.
- I like how helpful the LAs were, especially during lecture before the stay-at-home orders.
- I enjoyed having the LAs in class. It can be intimidating to ask questions in front of a 200-person lecture, so I liked that I was able to ask an LA about things I didn't fully understand.
- The LAs were very helpful and they helped guide us through all the steps of a problem.

Discussion

Why General Chemistry II was Selected

This paper describes an adaptation of the LA Program to General Chemistry II during the first eight weeks of a sixteen-week semester and its effects on student success. This course was selected for the pilot based on a variety of factors. In addition to the culture of peer-led support established for Chemistry courses and the high number of students earning a DFW in Chemistry II as described previously, the course was also selected based on its role as a gateway course into several majors. Student failure to complete the course with a passing grade could inhibit their progression in a variety of STEM areas. A higher percent of students earning A's in the course could impact student completion of degree programs, continuation of scholarships, and matriculation into graduate and professional programs. Based on the success of the LA model in Calculus at FAU which cut the DFW rate in half and increased the percentage of students earning final course grades of A as compared to C, the decision was made to implement the LA model to improve pass rates and major completion. Chemistry II student success can also have an impact on institutional metrics which affect state funding. Finally, instructor interest was a primary motivation for selecting this course for the pilot. The faculty member attended the LA International Workshop in Boulder, Colorado in October 2019 and felt that the model was a good fit for his course. He was willing to put in the effort to transform the course and implement the model within a short timeframe, maintain the control group, and assess outcomes from the pilot.

LA Model Impact on Student Learning and Success in a Large Lecture Chemistry Course

Evaluation of data from the two exams given during the first half of the spring 2020 semester indicated that students with LA support significantly outperformed students without LA support by approximately four points on average. Even though the program was suspended after eight weeks, review of student records in the LA section indicated that students with LA support completed the course with a grade of C or better at a 3.7% higher rate compared to students without LA support. Final course outcomes were significantly higher for the LA section by over 5%. The magnitude of the reported change in final grade is large enough to be the difference between a passing grade of C and a C-, as the latter could result in graduation delays and attrition from the institution or major. These results can have implications for outcomes in future chemistry courses, overall GPA, continuation of scholarships, and acceptance to graduate and professional programs. While existing literature (Herrera & Van Dusen, 2018) describes a positive relationship between cooperative learning and student success, the results from this study highlight the effect of LAs in the classroom as more beneficial than simple cooperative learning alone. The LA impact translated to course success even in this shortened period. Therefore, the use of this pedagogical tool is highly recommended. While the results of this study are correlational, the researchers suggest there can be causational relationship between the LA model and student outcomes as controls were included in the study. Further investigations should review the effect of the LA model on specific course content, impact on students' higher-order cognitive skills, and evaluation of student perception of their learning gains.

LA Model Impact on Equity in the Classroom and Outcomes for Historically Underrepresented Groups

This report also evaluated the effects of the intervention in course outcomes based on student demographic data. Students that identified as Black in the LA section had a 5% higher passing rate compared to Black identifying students not supported by the model. Specifically, Black students were more likely to obtain A's and fewer C's if they participated in the LA-supported section. The implications from these results are far-reaching, affecting students long-term GPA, retention, financial aid, and post-graduation outcomes. Students who identify as Hispanic or Caucasian also saw the benefit of the LA model on their course grades, and women in the LA supported section had a 10% higher rate of earning A's compared to women in the control course.

These positive impacts on underrepresented populations in chemistry and the sciences can have long-lasting effects on the continuation of people identifying as female, Black and Hispanic into key science fields, including scientific research, medical and professional careers, and the teaching of science. While many diverse students at the pilot institution take chemistry courses from faculty who may not identify with the same gender, race, or ethnicity, students are exposed to near peers with demonstrated success in the chemistry curriculum who may look more like they do. This results in feelings of inclusivity and the belief that someone "like them" can do it, so they can too. The idea, "if I see it, I can be it" can promote their continuation and confidence in pursuing their dreams.

LA Model Effect on Continuing Student Enrollment at the Institution Overall and into Subsequent Chemistry Courses

This study measured the impact of the LA program on student retention to the subsequent term. The researchers found that students in the LA section continued to the fall semester at a 5.1% higher rate than students in the section without LAs. While there is a significant cost to the LA model, these data illustrate the potential Return on Investment (ROI) for an institution. Implementation of the LA model in this course cost the institution approximately $21,000 for the term. While direct causation is not implied, sixteen additional students were retained in the section of the course with the LAs as compared to the non-LA section. For each student who enrolls for another year, the University saves $3,994.80 in tuition (excluding fees) based on 2020 figures (Adelmann, et. al., 2021). If six of those students were retained because of this initiative, the institution would see positive revenue benefits and increases in state performance funding. Additionally, retention is key in helping students meet their personal and professional goals.

The study also reviewed the longitudinal effect of the intervention by evaluating the percent of the students that subsequently registered in Organic Chemistry. Based on the distribution of student majors, most students in this pilot were expected to register in organic chemistry within a year. Effectively, 61.8% of the students in the LA-supported course continued in the chemistry sequence, but only 53.1% of the students in the non-LA course did so. Delays in continuation within the chemistry sequence can be detrimental to students' overall completion of many degree programs. It is essential that students develop the content knowledge, skills, and confidence in the General Chemistry courses to be successful across the remainder of the curriculum. The factors that influenced this reduced future enrollment should be further analyzed by evaluating student decision making through a qualitative study. The researchers hypothesized that the clear application of learning and confidence students built by working with near peers in the LA section, increased the belief in their ability to succeed in the subsequent Organic Chemistry courses.

Limitations of the Study

The findings of this report are limited and preliminary because of the short period of time in which the program was instituted. Although student characteristic variables and grade distribution for them were available, the design of the study did not include student-matched characteristics and exam results to enable factor analysis at this level. Another limitation of this study was the inability to place students in more traditional LA learning teams. Due to quick implementation and the large lecture/auditorium style classroom, it was difficult to intentionally seat students with the same group for each lecture. Students were simply encouraged to work with other students around them as the LAs walked through the lecture hall during active learning sessions. Based on the high enrollment and budget limitations, the ratio of students to LAs was 40:1 with a more ideal ratio ranging between 20-30:1. A final limitation of the study that the researchers found was the impact of COVID-19. Plans had to be altered when the shift to remote learning occurred and it was decided to cease the LA pilot for General Chemistry II halfway through the semester. Because of this, there was limited formalized collection of qualitative data to describe the experience of the students in the LA section as compared to the non-LA section as was originally planned. Due to the move to remote instruction, only the first two course exams were proctored in person. Therefore, final course grades and outcomes may have been impacted by the change in testing and course structure.

Conclusion

The pilot of the LA program within a large lecture General Chemistry II course at FAU had positive outcomes and warrants the expansion of the model. Results are consistent with research that has been done previously within the LA community. This study added to the growing body of evidence that the model can have strong positive impacts on student learning, increased outcomes in terms of grades and course pass rates, particularly for those from underrepresented backgrounds in chemistry, and increases in persistence for students who take the course with LAs. The pilot demonstrated that LAs add value as compared to simply providing opportunities within the classroom for collaborative and engaged learning. While many LA programs incorporate the model within smaller labs, recitation, and small lecture courses, this study demonstrated the effectiveness of the model in a large lecture class. Additional research to match students in LA and non-LA sections across academic factors that are predictive of success in the course would further add to the literature on this model. As this study was cut short due to COVID-19, future studies can focus on the impact of the model in a large lecture course for a full semester and its effect across demographics. As the world around us changes and more courses are moving to the use of multiple teaching modalities (synchronous, asynchronous, hybrid in-person/online), future studies on the effect of the LA model across a variety of course structures could be another avenue for investigation.

References

Adelmann, B. J., Bebergal, J. L, & Mireles-James, J. (2021, April 2). Learning Reimagined: Expanding the Learning Assistant (LA) Model across the Curriculum to Transform Teaching through Student-Centered Collaborative Learning. FAU QEP Proposal.Retrieved July 7, 2021, from https://www.fau.edu/provost/qep.php.

Alzen, J. L., Langdon, L., & Otero, V. K. (2017). The Learning Assistant model and DFW rates in introductory physics courses. *Physics Education Research Conference Proceedings*, 36–39. https://doi.org/10.1119/perc.2017.pr.004.

Alzen, J. L., Langdon, L. S., & Otero, V. K. (2018). A logistic regression investigation of the relationship between the Learning Assistant model and failure rates in introductory STEM courses. *International Journal of STEM Education, 5(1)*, 1–12. https://doi.org/10.1186/s40594-018-0152-1.

Alzen, J. L. & Otero, V. K. (2021). *The Learning Assistant model in introductory STEM courses and Year 2 Persistence* [Manuscript in preparation.] School of Education, University of Colorado, Boulder.

Arendale, D. (2001). Supplemental instruction (SI): Review of the research concerning the effectiveness of SI from University of Missouri-Kansas City and other institutions from across the United States. https://files.eric.ed.gov/fulltext/ED457797.pdf.

Astin, A. W. (1993). *What matters in college: Four critical years revisited.* San Francisco: Jossey-Bass.

Astin, A. W. (1999). Student involvement: A developmental theory for higher education. *Journal of College Student Development, 40*(5), 518–537.

Barbera, S. A., Berkshire, S. D., Boronat, C. B., & Kennedy, M. H. (2020). Review of Undergraduate Student Retention and Graduation Since 2010: Patterns, Predictions, and Recommendations for 2020. *Journal of College Student Retention: Research, Theory & Practice, 22*(2), 227–250. https://doi.org/10.1177/1521025117738233.

Barrasso, A.P., & Spilios, K.E. (2021). A scoping review of literature assessing the impact of the learning assistant model. *IJ STEM Ed* 8, 12. https://doi.org/10.1186/s40594-020-00267-8.

Bean, J. P., & Metzner, B. S. (1985). A conceptual model of nontraditional undergraduate student attrition. *Review of Educational Research, 55*, 485–540.

Bebergal, J. L. (2003): Predicting retention of first-year college students. [Doctoral dissertation, Florida Atlantic University].

Burke, A. (2011). Group work: How to use groups effectively. *Journal of Effective Teaching*, 11(2), 87-95.

Chen, X. (2013). STEM Attrition: College Students' Paths Into and Out of STEM Fields (NCES 2014-001). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC. https://nces.ed.gov/pubs2014/2014001rev.pdf.

Clark, K., James, A., & Montelle, C. (2014). "We definitely wouldn't be able to solve it all by ourselves, but together…": group synergy in tertiary students' problem-solving practices. *Research in Mathematics Education*, 16(3), 306–323. https://doi.org/10.1080/14794802.2014.950687.

Crisp, G., Nora, A., & Taggart, A. (2009). Student characteristics, pre-college, college, and environmental factors as predictors of majoring in and earning a STEM degree: An analysis of students attending a Hispanic serving institution. *American Educational Research Journal, 46(4)*, 924–942. https://doi.org/10.3102/0002831209349460.

Eimers, M. T., & Pike, G. R. (1997). Minority and nonminority adjustment to college: Differences or similarities? *Research in Higher Education, 38*(1), 77–97.

Freeman, M. L., Martinez, M., & Gonzalez, K. P. (2015). Increasing College Completion for Latino/as in Community Colleges: Leadership and Strategy. *New Directions for Higher Education*, 2015(172), 71–80. https://doi.org/10.1002/he.20154.

Gillies, R. & Ashman, A. (2003). Co-operative learning: The social and intellectual outcomes of learning in groups.

Graham, M. J., Frederick, J., Byars-Winston, A., Hunter, A.-B., & Handelsman, J. (2013). Increasing persistence of college students in STEM. *Science, 341*(6153), 1455–1456. https://doi.org/10.1126/science.1240487.

Grillo, M. C., & Leist, C. W. (2013). Academic Support as a Predictor of Retention to Graduation: New Insights on the Role of Tutoring, Learning Assistance, and Supplemental Instruction. *Journal of College Student Retention: Research, Theory & Practice, 15*(3), 387–408. https://doi.org/10.2190/CS.15.3.e.

Herrera, X.C., Nissen, J., & Van Dusen, B. (2018). Student outcomes across collaborative-learning environments. *Physics Education Research Conference Proceedings,* 2018, 1–4. https://doi.org/10.1119/perc.2018.

Johnson, D. W., & Johnson, R. T. (2009). An Educational Psychology Success Story: Social Interdependence Theory and Cooperative Learning. Educational Researcher, 38(5), 365–379. https://doi.org/10.3102/0013189X09339057.

MacGregor, J. (1992). Collaborative Learning: Reframing the Classroom. In Collaborative Learning: A Sourcebook for Higher Education (pp. 37–40).

McQuade, A., Nissen, J.M., & Jariwala, M. (2020). Characteristics of institutions with Learning Assistant programs: An equity investigation. *American Association of Physics Teachers*, 2020 PERC Proceedings. https://doi.org/10.1119/perc.2020.pr.McQuade.

Miller, P. M., Carver, J. S., Shinde, A., Ratcliff, B., & Murphy, A. N. (2013). Initial replication results of learning assistants in university physics. AIP Conference Proceedings, 1513, 30–33. https://doi.org/10.1063/1.4789644.

Otero, V., Finkelstein, N., McCray, R., & Pollock, S. (2006). Who is responsible for preparing science teachers? Science, 313(5786), 445–446. https://doi.org/10.1126/science.1129648.

Otero, V., Pollock, S., & Finkelstein, N. (2010). A physics department's role in preparing physics teachers: The Colorado Learning Assistant model. *American Journal of Physics*, 78(11), 1218–1224. https://doi.org/10.1119/1.3471291.

Otero, V. (2015). Recruiting and educating future physics teachers: Case studies and effective practices. In C. Sandifer & E. Brewer (Eds.), Effective Practices in Preservice Teacher Education (pp. 107–116). *American Physical Society*. Accessed 5 March 2021. http://www.phystec.org/webdocs/EffectivePracticesBook.cfm.

Pascarella, E. T., & Terenzini, P. T. (2005). How college affects students: A third decade of research. Jossey-Bass.

Rennar-Potacco, D., Orellana, A., Chen, P., & Salazar, A. (2019). Rethinking Academic Support: Improving the Academic Outcomes of Students in High-Risk STEM Courses With Synchronous Videoconferencing. Journal of College Student Retention: Research, Theory & Practice, 20(4), 455–474. https://doi.org/10.1177/1521025116678854.

Sellami, N., Shaked, S., Laski, F. A., Eagan, K. M., & Sanders, E. R. (2017). Implementation of a Learning Assistant program improves student performance on higher-order assessments. *CBE Life Sciences Education, 16(4)*, 1–10. https://doi.org/10.1187/cbe.16-12-0341.

Skoglund, K., Wall, T. J., & Kiene, D. (2018). Impact of Supplemental Instruction Participation on College Freshman Retention. *The Learning Assistance Review, 23*(1), 115. https://eric.ed.gov/?id=EJ1170114.

Stockard, S., Rohlfing, C. M., & Richmond, G. L. (2021). Equity for women and underrepresented minorities in STEM: Graduate experiences and career plans in chemistry. Proceedings of the National Academy of Sciences Jan 2021, 118(4) e2020508118; https://doi.org/10.1073/pnas.2020508118.

Tinto, V. (1975). Dropout from Higher Education: A theoretical synthesis of recent research. *Review of Educational Research, 45*(1). 89-125.

Tinto, V. (1987). *Leaving College: Rethinking the causes and cures of student attrition.* Chicago: The University of Chicago Press.

Van Dusen, B., Langdon, L., & Otero, V. (2015). Learning Assistant Supported Student Outcomes (LASSO) study initial findings. *Physics Education Research Conference Proceedings*, 343-346. http://dx.doi.org/10.1119/perc.2015.pr.081.

Van Dusen, B., White, J.-S. S., & Roualdes, E. A. (2016). The impact of Learning Assistants on inequities in physics student outcomes. *Physics Education Research Conference Proceedings*, 360–363. http://dx.doi.org/10.1119/perc.2016.pr.085.

Van Dusen, B., & Nissen, J. (2019). Equity in college physics student learning: A critical quantitative intersectionality investigation. *Journal of Research in Science Teaching,* 57. http://dx.doi.org/10.1002/tea.21584.

White, J.-S. S., Van Dusen, B., & Roualdes, E. A. (2016). The impacts of Learning Assistants on student learning of physics. *Physics Education Research Conference Proceedings*, 384–387. https://doi.org/10.1119/perc.2016.pr.091.