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A Cost-Effective Model to Address Student Readiness Through the Lens of a College Physics Course

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ABSTRACT

Students enter college with widely varying levels of preparation. This is especially visible to faculty and administrators tasked with ensuring student success in core STEM courses and helping underrepresented students succeed. Flexible support strategies are needed. They must be timely and measurable so that limited funds can be optimally allocated. This paper reviews a program that addresses these concerns and is translatable to many higher education settings and disciplines. It is situated in a physics department at a large public research university in an urban city in the southern United States. A group of rotating faculty improved the success rate in an introductory physics course for non-physics majors. A diagnostic exam is used to assess students' preparation in order to assign some to a peer-led supplementary recitation. An overview of program implementation and results is shared, along with strategies and suggested solutions to further address gaps in success rates in order to provide all students an equitable university experience and chance of success.

KEYWORDS

At-Risk Students, General Physics, Peer-Led, STEM, Supplementary Instruction

INTRODUCTION

Students arrive at college with various levels of preparation, both in terms of content mastery and knowledge about how to succeed. This situation looms large in conjunction with the deleterious effects of the COVID-19 pandemic, which will affect students' readiness in unforeseen ways for many years. Institutions of higher education (IHEs) are facing an uncertain future in which timely identification of students in need of support is crucial. Programs that identify students based on demographics rather than actual preparation and ability fail to serve all students that need support and sometimes allocate resources to students that are likely to thrive without the additional support. While supplemental instruction programs are common, they often are underutilized by the students most in need of their

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services for a wide variety of reasons including cultural perceptions about seeking help. The program presented here is structured to both identify students who need it and build in a required participation course component which ensures that the limited resources are provided to those it will most benefit.

Early success in core courses fuels students' ongoing commitment to college, particularly when content mastery is emphasized alongside guidance in self-regulation of one's learning. An important way to achieve this is through meaningful interaction with instructors and teaching assistants. This approach to student success and retention is of particular importance in science, technology, engineering, and mathematics (STEM) fields. The ongoing challenge of graduating greater proportions of students from STEM fields—while encouraging diversity among the student body—is well documented (Hurtado et al., 2010; U.S. Department of Education, 2013; van den Hurk et al., 2019) as are the myriad of interventions aimed at improving student success, especially for students in freshmen-level STEM courses.

This paper describes an intervention developed to improve successful course completion rates in a high enrollment introductory physics lecture program. A team of faculty and administrators at a large public research university, in an urban region of the southern United States, initiated a mandatory companion supplementary instructional program (hereafter referred to as recitation) for at-risk students who were taking an introductory physics course. Several years of data indicates that the program has been instrumental in recapturing a relevant proportion of students who may have failed the course without this support. The impact of the program on different groups is also analyzed, revealing that while the program improves performance for all at-risk student groups, it is insufficient for students least prepared for the course. Based on these results, further curricular innovations are needed for highly at-risk students, the majority of whom are from historically underrepresented groups in STEM majors.

This process can be extrapolated to other fields of study, STEM or otherwise, since the essential questions that guided its development are universal. How are at-risk students identified at the earliest possible moment? What is cost-effective in terms of additional academic support? What degree of standardization is needed in course experience? For which students are different academic support created and what might that look like?

BACKGROUND AND CONTEXT

The efforts of the physics department were part of a comprehensive student success program to improve (a) successful course completion rates in high enrollment freshmen introductory biology, chemistry, physics, and math courses, and (b) persistence and graduation rates for STEM students. The theory of change was grounded in research that indicates students' early experiences with STEM coursework helps shape their future decisions with respect to persistence, and ultimately their likelihood of successful completion of a STEM degree (Brownell & Swaner, 2009).

Both general science and discipline-based science education research demonstrate that the most effective pedagogical approaches include student-centered, active learning styles (Gaffney, Richards, Kustusch, Ding, & Beichner, 2008) and constructivist and inquiry-based curriculum (Bodner et al., 2001; McDermott & Shaffner, 2002; McDermott, Heron, Shaffer & Stetzer, 2006; Sokoloff & Thornton, 2004; Aditomo & Klieme, 2020). Research has shown that these approaches in STEM courses have been successful in improving student learning, retention, and motivation (Michael, 2006; Michael & Modell, 2003). Additional research demonstrates that peer-led small groups improve student learning (Gafney & Varma-Nelson, 2008; Wilson & Varma-Nelson, 2016).

Course and Intervention

The first-semester general physics course is taken by an average of 1,480 students each academic year. The course is required by the degree plans of 12 majors; the largest number of students comes from the Department of Biology. The university is one of the most diverse in the United States; it is both an Asian Serving and Hispanic Serving Institution (U.S. Department of the Interior, 2018). The physics students are quite diverse in terms of race, ethnicity, family income, year in college, transfer status, and first-generation-in-college (FG) status, all of which are factors that correlate with student success (Duggan & Pickering, 2008; Hazari et al., 2007; Sadler & Tai, 2001).

Typically, 4 to 5 sections of the general physics course are taught each semester. The course has a pre-requisite of college pre-calculus and is taught as an algebra-based course for those not majoring in physics. It is usually taught in traditional lecture halls with a typical class size of 200 students. All sections within a semester use a common set of online homework assignments and common exams. The final course grade consists of:

- 3% diagnostic exam
- 10% teamwork/attendance
- 6% at the discretion of the instructor (e.g. reading quizzes)
- 10% homework
- 45% regular exams
- 26% cumulative final exam

For students who score below 70% on a diagnostic exam at the beginning of the term, recitation attendance composes half of their teamwork/attendance grade.

Concerns

Historically, this course has been challenging for students. Prior to implementing the recitation program, the average percentage of students who earned a final course grade between A and C- (hereafter referred to as the pass rate) had been 51%, with a standard deviation of 15%. This disappointing rate of success was accompanied by large variation between different instructors, and even among different sections for the same instructor. Many physics faculty members teach this course and have implemented several improvement strategies over the years. These include a diagnostic exam to assess preparedness (Voight, 2010) access to an online math tutorial for students with poor math skills (Forrest et al., 2017) and research-based interactive pedagogical approaches such as Peer Instruction (Mazur, 1997) and Interactive Lecture Demonstrations (Sokoloff & Thornton, 2004). These efforts have had some success in individual course sections, but did not improve the average departmental pass rate significantly.

Approach and Strategy

To standardize the experience of students across sections and to improve student engagement, beginning in Fall 2014 two interventions were implemented for all sections of the first-semester general physics course. First, active learning was to be emphasized by all faculty. Secondly, all sections would have access to standardized interactive, peer-led recitation sessions. All other aspects of the course remain as described above.

The faculty made use of the department's diagnostic exam to identify students who should attend recitations. In place since 2007, the diagnostic exam has been found to be a reliable and valid predictor of course success (Forrest et al, 2017, Voight, 2010). The exam assesses math and problem-solving skills, and all students must take it within the first 10 days of class to determine their preparedness.

- Students scoring 70% or above on the diagnostic exam are considered *Prepared*.
- Students scoring between 69% and 50% are considered *At-Risk: Moderate*. They are advised to review algebra, trigonometry, and pre-calculus using an effective online math tutorial developed by the faculty to improve their math skills (Forrest et al., 2017).

- Students scoring below 50% are considered *At-Risk: High*. They are advised to drop the course and improve their math skills, but are not required to do so.

Students scoring below 70% are “required” to attend recitations, incentivized through their course grade. The department determined that, all things considered, this benchmark of 70% would help as many students as possible while not exceeding the capacity of the recitations. Roughly half of the students were typically required to attend.

The Recitation Structure

Each recitation is led by two undergraduate Peer Facilitators (PFs). The PF program is similar to the University of Colorado Learning Assistant model (Otero et al., 2010). All PFs have excelled in a core physics class, achieving a grade of A or A-. They represent a variety of majors, including physics, engineering, and biology, and some are enrolled in the university’s STEM teacher preparation program. Peer Facilitators attend weekly meetings with faculty to discuss the material that will be covered in the upcoming week and instructional strategies. The PFs also are required to attend the physics lectures to refresh their own learning and to assist in interactive activities in the classroom; each class section has at least one PF assigned to it.

Recitations are limited to 25 students each. Students attend one 1-hour recitation per week, which are offered at a variety of times to accommodate student schedules. Students from any course section may choose any recitation.

During recitation, students are given worksheets and are encouraged to work in groups using whiteboards and markers to solve problems together. During the COVID-19 pandemic, worksheets have been adapted to be used in online recitations. The worksheets focus on both key physics concepts and problem-solving practice and were written by physics faculty and PFs. The questions emphasize key problem-solving steps following the framework of Heller and Heller (2010). Each worksheet begins with a Sample Problem that is worked by the PFs for the entire class as a brief introduction to the week’s topic. The students then work together in groups on the rest of the questions. Worksheets typically begin with conceptual questions, followed by practice problems that become increasingly challenging. The PFs are taught to *facilitate* students’ efforts. When students ask the PFs questions about how to solve a problem, the PFs are trained to guide the students by asking leading questions and prompting them towards the next step. The PFs also emphasize problem-solving skills and study habits, to improve long-term success in students’ university coursework.

METHOD

In order to assess the impact of the recitations on student success and to determine if all students were helped, an analysis was conducted based on five years of data.

Participants in the Sample

The initial data set included 3,002 students enrolled in the course over a five-year period, for whom complete demographic data existed. This number does not include students who later withdrew from the class, since final exam scores for those students were unavailable. Half of the sample (n=1,501) were at risk of not achieving a C- or better, based on the diagnostic exam.

The diagnostic exam has historically aligned with pass/fail trends among each group. The percentages of students in each diagnostic group who passed or failed the course are shown in Table 1. Consistent with earlier results, a significant difference in pass/fail rates by diagnostic group ($X^2_{2,2738} = 282.20; p<.000$) was identified. Specifically, those who were *Prepared* or *At-Risk: Moderate* were more likely to pass the course. African American students and Hispanic/Latino students were disproportionally at risk, 70% and 62% respectively. To a lesser degree, FG students were also at a disproportionate risk (55%). Additional demographic detail is given in Table 5 in the Appendix.

Table 1. Course pass / fail rates by diagnostic group, 2014-2019

	Prepared		**At-Risk: Moderate**		**At-Risk: High**	
	Number	**% of Group**	**Number**	**% of Group**	**Number**	**% of Group**
Passed	1,414	94.2%	777	80.5%	341	63.6%
Failed	87	5.8%	188	19.5%	195	36.4%
Total	1,501	100%	965	100%	536	100%

Measures

For this analysis, it was determined that the raw numerical grade on the cumulative final exam would serve as the indicator of the effect of recitation. This exam measures holistic comprehension of content over the semester, is not subject to curving by individual instructors, and is a continuous measurement. The original sample was reduced to 2,738 students for whom there was a final exam score. This did not impact the overall distribution of *Prepared / At-Risk: Moderate / At-Risk: High* students.

Descriptive statistics are used to show the course success rate over time with the advent of recitation, the demographic composition of students, and success outcomes by diagnostic group. An analysis of variance (ANOVA) is used to compare mean differences among diagnostic groups in relation to recitation dosage. Significance using Pearson's Chi Square and effect sizes are provided for all comparisons among groups.

RESULTS

In order to determine the impact of the recitation support for all students, the following were analyzed:

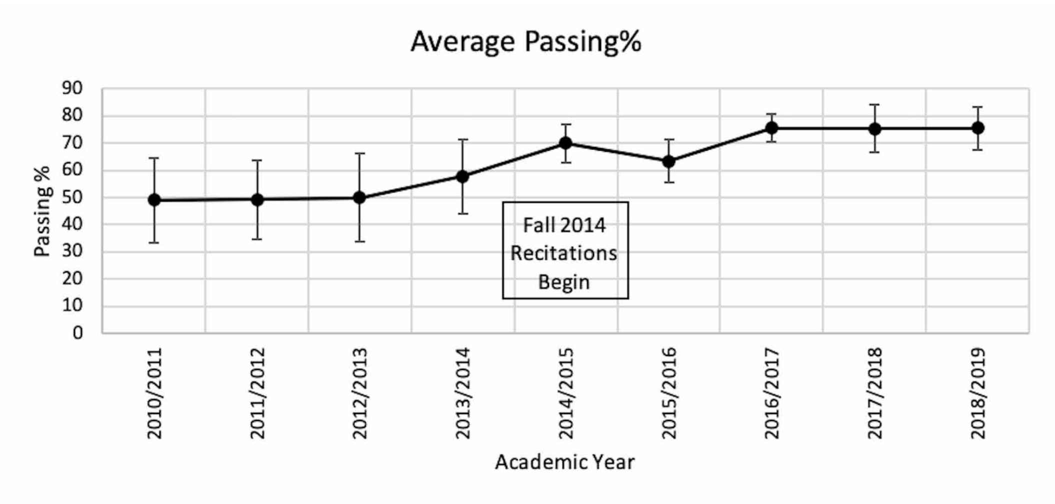
- How the overall course pass/fail rate was affected with the addition of recitation support.
- How the final exam score correlated with diagnostic group.
- How recitation attendance (dosage) affected final exam score.
- How risk status may be correlated with ethnicity and first-generation (FG) status.

Pass/Fail Rate Comparisons

The pass/fail rate for the course improved over time with continual implementation of the recitation support. Figure 1 shows the average pass rate for the physics course over an 8-year period. The average of the pass rates in all sections in the Fall and Spring semester courses (8-10 sections per year) are shown, and the error bars correspond to the standard deviation for the academic year. As discussed, a final course grade between A and C- is considered passing. Before the implementation of recitations in 2014, the average pass rate was 51% ± 15%. With the implementation of recitations, the pass rate improved to 72% ± 9%. Not only did the pass rate rise by 20 percentage points, the standard deviation decreased by 6 percentage points, indicating more consistency between course sections. This improvement across sections occurred despite the fact that many instructors taught the course. For example, seven instructors taught the course in both 2014/2015 and 2015/2016, and only three of them taught both years. This variation in instructors is typical for all years.

A smaller improvement in the pass rate is observed in the 2013/2014 academic year prior to implementation of the program. An automated prerequisite course checker was implemented that year and may have led to the observed improvement. There was no obvious cause of the decrease in 2015/2016; it appears to be unavoidable variation in section performance.

Figure 1. Average pass rate for physics course by academic year. The error bars correspond to the standard deviation in each year.



Final Exam Scores by Diagnostic Group

Mean final exam scores for each diagnostic group corresponded with expected trends, as shown in Table 2. Figure 2 shows the distribution of final exam scores for each group of students. A General Linear Model ANOVA identified significant differences in final exam scores by diagnostic group ($F_{2,2735}$=370.17; p < .000; Partial Eta^2 = .213). Post hoc analyses demonstrated significant differences between each of the three groups. Specifically, students with a diagnostic score of *Prepared* performed significantly higher on the final exam than did those in the *At-risk: Moderate* or the *At-risk: High* groups. Additionally, those in the *At-risk: Moderate* group performed significantly higher than those in the *At-risk: High* group. The average for each diagnostic group does not, of course, tell the full story. While there is a distinctive shift in the mean grade distribution toward failure as the level of academic preparation decreases, there is a broad spread of scores across the spectrum which range from 0 to 100% in every preparedness category, indicating that many conditions can affect a student's grade on the final exam irrespective of their initial preparedness.

Table 2. Mean final exam score by diagnostic group

Diagnostic Group	Mean Score	N	Std. Deviation
Prepared	75%	1,388	18
At-Risk: Moderate	60%	876	20
At-Risk: High	50%	474	19
Total		2,738	

Recitation Attendance Impact on Final Exam Score

In order to further investigate the effects of recitations on student success, students' recitation attendance versus final exam score was investigated. During the 15-week semester, students were provided with 12 weekly recitation sessions. Attendance was taken at each. Five categories were designated to describe attendance behavior, as shown in Table 3.

The mean score on the cumulative final exam was compared with attendance behavior for each diagnostic group, as shown in Table 4 and Figure 3. Additional details are provided in Table 6 in the Appendix. A General Linear Model ANOVA identified a significant interaction for final exam scores when both diagnostic group and recitation attendance levels were analyzed ($F_{8,2723}=2.47$; $p < .012$; Partial Eta$^2 = .007$). In general, the mean final exam score was higher for students who attended more frequently. Students across all diagnostic risk groups who almost always attended recitation had a mean final exam score 12 percentage points higher than those who attended rarely.

While recitation attendance had a positive effect on students' final exam score, it did not benefit all groups equally. On average, *Prepared* students passed the final exam no matter their attendance behavior. This is as expected and supports the institution's decision not to incentivize these students to attend recitations. The mean final exam scores for *At-Risk: Moderate* students ranged from 51% for those who rarely attended recitation to 63% for those who almost always attended. Along with other course components, a 50% score on the final exam was usually sufficient for a student to earn a passing course grade of at least a C-. Therefore, recitation attendance of at least 75% resulted in the *At-Risk: Moderate* group's final exam average score being 13 percentage points above a just-passing score. The largest effect in terms of passing versus failing existed for students in the *At-Risk: High* group. Those who attended at least 6 of the 12 recitation sessions managed, on average, to achieve a grade above 50% on the final exam. Of the students in the two at-risk diagnostic groups, approximately half attended recitation regularly, at least six times.

Two scenarios showed unexpected results: *Prepared* students who attended often (6-8 times), and students in all diagnostic groups who never attended recitation. The *Prepared* students who attended often had the lowest mean score of all the *Prepared* groups. The confidence of this data point is low, however, due to the small number of students in this category (n=25). The *Prepared* students who never attended recitation were actually behaving as expected as they were not required to attend. The mean final exam scores for at-risk students who never attended recitation were higher than expected. In fact, *At-risk: Moderate* students who never attended recitation scored better, on average, than those who attended 3-5 sessions. Possible reasons for this will be addressed in the Discussion section.

Ethnicity and First-Generation Status

Given that some populations of students were disproportionality represented in the at-risk groups (see Table 5 in the Appendix), the mean final exam scores were examined in relation to ethnicity, FG status, and gender. No differences were observed when accounting for gender. No interaction was noted for ethnicity and FG status together. Significant differences did exist when final exam scores were compared by ethnicity ($F_{4,2733}= 44.13$; $p < .000$; Partial Eta$^2 = .061$) and by FG status ($F_{1,2736}= 35.69$; $p < .000$; Partial Eta$^2 = .013$) separately. However, effect sizes were small for each analysis (Partial Eta$^2 < .2$). This may be explained by the variability in final exam scores by diagnostic group, which were considerable (18-20 points).

Despite the variations, students who identified as Hispanic/Latino or African-American scored lower, on average, on the cumulative final. A post-hoc Tukey B analysis confirmed this result ($p<.05$). In addition, the mean final exam score for first-generation students (62) was lower than that of continuing-generation students (68). These results are depicted in Figure 4. While recitation attendance was shown to have an effect on final exam scores, it was not enough to close performance gaps among students when looked at from these two perspectives. These results are similar to those of the Learning Assistant program reported by Van Dussen and Nissen (2020).

Figure 2. Final exam score distribution (percent out of 100%) by diagnostic group

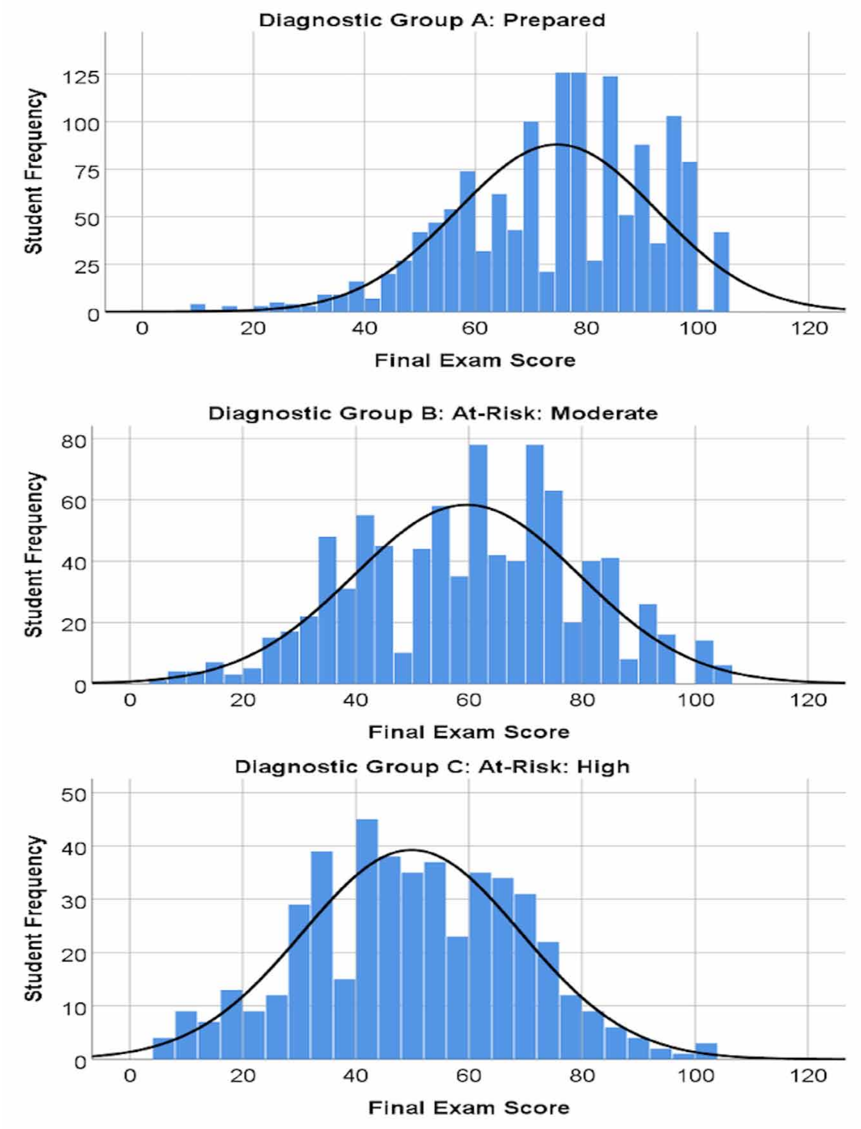


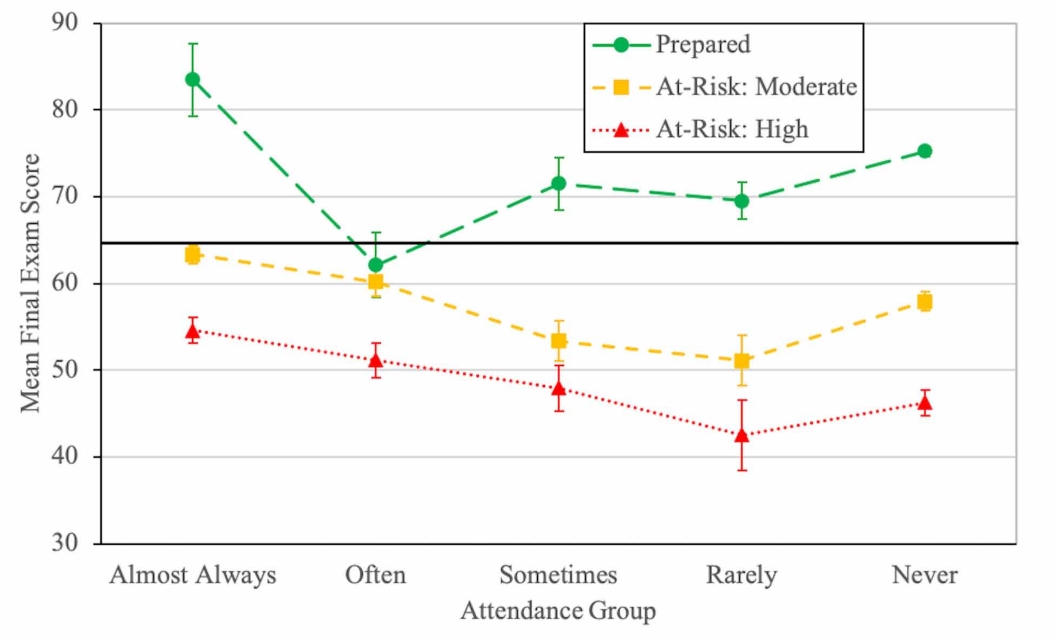
Table 3. Recitation attendance groups

Attendance Group	Sessions attended
Almost always	9-12
Often	6-8
Sometimes	3-5
Rarely	1-2
Never	0

Table 4. Mean performance on final exam by diagnostic group and recitation attendance

	Prepared		At-Risk: Moderate		At-Risk: High	
Attendance Group	**N**	**Mean on final exam**	**N**	**Mean on final exam**	**N**	**Mean on final exam**
Almost always	20	83%	326	63%	153	55%
Often	25	62%	143	60%	89	51%
Sometimes	38	72%	67	53%	50	48%
Rarely	77	70%	42	51%	21	43%
Never	1,228	75%	298	58%	161	46%
Total	1,388		876		474	

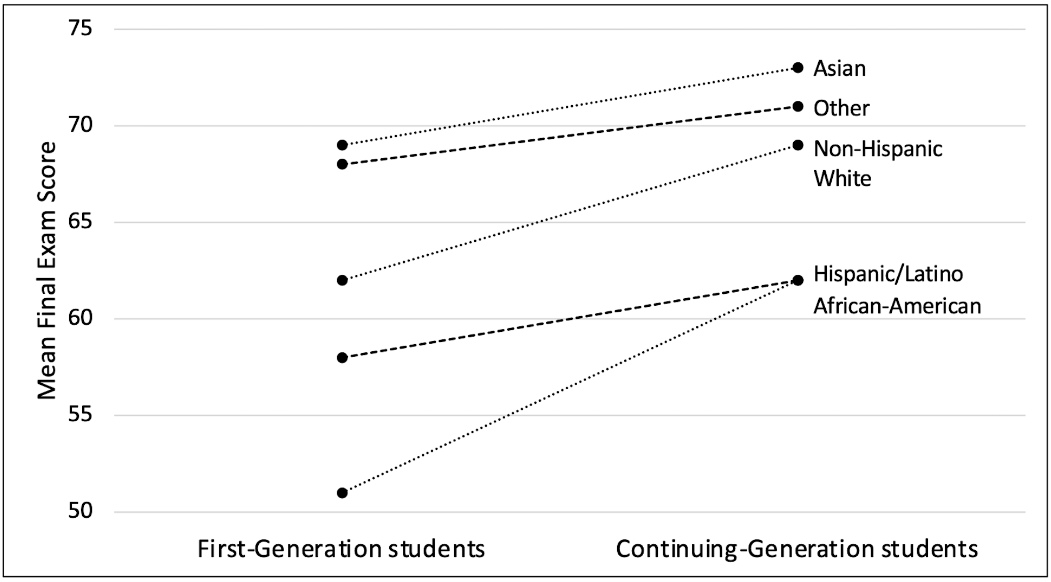
Figure 3. Mean performance on final exam by recitation attendance and diagnostic group. The error bars represent the standard deviation. The solid line marks the mean final exam score for all students, 64.6.



DISCUSSION

The results of this study can help IHEs to determine for whom and under what circumstances additional course support should be offered. The outcomes of this study demonstrate that the implementation of required supplemental support can be beneficial to students who attend physics courses at a large public institution with a diverse student body. However, the most at-risk students need different/ additional supports. Several aspects of the program were critical to its success, are translatable to other environments, and are relevant to the next cycle of improvement.

Figure 4. Final exam average scores by ethnicity and generational status



Standardized Experiences

Since introducing the recitation program, the physics faculty have observed a positive shift of 20 percentage points in the pass rate. While other factors could not be controlled for, such as concurrent STEM initiatives on campus, the results suggest that the program has had a powerful impact over time for underprepared students. Moreover, consistency in course instruction improved; the standard deviation in the course pass rate decreased over time. The well-trained PF staff, who provided cost-effective supplemental instruction support, and mixing of PFs and students in recitations, were key to this standardized experience for students. This demonstrates that rotating faculty who are tasked with managing multiple sections of high enrollment courses can organize to create a standard experience for the student body. This is not always easy within departments of large research institutions that rely on multiple layers of faculty with different contractual arrangements.

As a result of the COVID-19 pandemic, new gaps in knowledge can be expected to emerge among students matriculating to college. This model, with its emphasis on a coordination of effort, will become even more necessary.

Reduction in Costs

While the effect sizes (Partial Eta^2 values) in this study are small to medium, it is important to consider them in regard to the cost of the intervention to the students *and* institution (Kraft, 2020). The cost to students who fail if support is unavailable is high. Either they will retake the course at their expense, or they will fail to persist and either change their major or drop out. Both decisions could impact their future earnings. For IHEs, especially those committed to improving persistence rates, the cost to the institution of program implementation may be deemed low when progress-to-degree and degree completion rates are considered. Targeting the program to students most likely to benefit further improves its cost-effectiveness.

Peer-facilitators for the studied program have been supported by stipends in the past and are currently supported with hourly wages, improving their professional development and engagement with the university while also reducing their need to find unrelated employment off campus. Furthermore, the experiences gained as members of a teaching team have been shown to strengthen engagement with STEM as a profession and, for some, to generate interest in becoming science teachers (Otero et al., 2010). Thus, there may be some indirect positive impact to society, and in the studied case, the local school districts and STEM employers.

Participation Incentives

To be effective, students must engage with the offered supports. While recitations were "required" for at-risk students, attendance counted as only 5% of their course grade. This nominal incentive wielded some influence. Approximately half of the students in the two at-risk groups attended at least six recitations. Against the context of the nationwide STEM persistence problem, the fact that half of this group participated and achieved a minimum passing grade leads us to conclude that the recitations had a positive effect on *recapturing* students who may have been lost to attrition, had they earned below a C- without this added academic support. In comparison, when recitations were offered on a purely voluntary basis for freshmen level chemistry courses, only 10% of the students attended at least one recitation. Very few attended regularly. Not surprisingly, there was no measurable impact on course passing rates in chemistry. Tying attendance in supplemental instruction to course grades had a significant impact on participation and impact.

Independent Learners

Requiring attendance impacted success for some students. On the other hand, why did some at-risk students who never attended recitation do as well as or better than those who sometimes attended? This must be addressed since it accounts for more than a third of the at-risk students in this study. Some of the students may have been "misdiagnosed", i.e. scored poorly on the diagnostic exam for reasons unknown, yet were otherwise prepared for the course. Alternatively, students may have independently found alternative help by engaging with faculty, other university tutoring programs, or peer study groups. If they participated in (un-measured) alternative supplemental instruction regularly, this would effectively shift them to the left on Figure 3, consistent with the presented results. This group is important to understand through future work as it may lead to refinements in identifying students in need of supplemental supports, improvements to the existing program, or creation of alternative supports that better match student learning preferences.

Equitable Supports

These peer-led, student-centered recitations were based on research indicating that all students, including historically underrepresented groups in STEM, benefit from more active learning and opportunities for collaborative learning (Brewe et al., 2010; Gafney & Varma-Nelson, 2008). While this intervention did help students in all diagnostic groups, those identifying as FG, Hispanic/Latino, and/or African American were more likely to be at-risk and exhibited performance gaps on their final exam scores.

If a student has not already achieved a minimum understanding of algebra and problem-solving as measured by the diagnostic exam, it is difficult to catch up during one semester. The *At-Risk: High* group did not achieve proficiency on the cumulative final exam. Extra instructional time in recitations was not enough. A separate layer of support is warranted. The authors posit that another type of algebra-based physics course should be offered—one that spreads the same content over two semesters. More time would be afforded for the learning process, shoring up foundational math skills, and the extended course could be augmented with project/service-based learning to further increase engagement and community building opportunities for students. However students are delineated in terms of pre-academic preparation and readiness, it is equally critical to match stages of support accordingly.

"Local" Diagnostic Tools

In the authors' experience (Forrest et al., 2017), in contrast to other studies (Salehi et al., 2019), standardized measures of college readiness (such as the SAT), do not adequately predict success in physics. Additionally, there was no significant correlation between SAT scores and passing rates in the work presented here. Consequently, the authors recommend the use of a reliable and valid diagnostic tool that assesses each student's level of knowledge and skills relevant for the course. The development and implementation of high-quality performance-based diagnostic tools are more equitable, reach all students irrespective of background, provide instructional guidance to faculty at the beginning of a course, and could be more cost-effective for both students and institutions.

In fact, since this research was concluded, the authors' own institution has ceased requiring national testing in response to the COVID 19 pandemic. Moving forward, with a diagnostic tool already in place, this department will be able to discover not only students at risk, but also to reveal specific "gaps in knowledge" that may emerge as the pandemic continues.

CONCLUSION

Five years of data on student backgrounds, outcomes, and recitation attendance enabled a thorough study of the effect of dosage on student performance and provided valuable data about students' levels of engagement with this academic support. Not only did recitation dosage improve student success, but the recitations also standardized success across multiple sections of the course. The most salient result of this study is that a targeted intervention can help students on the margin of pass/fail to succeed in a challenging course. Furthermore, the recitations encouraged the experience of being part of a formal community of science learners that promotes the value of support networks, good study habits, and self-regulated learning. The recitation experience may provide a continued return on investment, affecting students' persistence to STEM degree completion. While the setting was physics, the approach can translate to other fields as well.

Across the United States, student populations at colleges and universities are becoming increasingly diverse in numerous ways (Coleman, 2010; Morency et al., 2017; Passel & Cohn, 2008; U.S. Department of Education, 2018;). Given the unique institutional history at the authors' university, this constructive trend has occurred rapidly and early. Building on the concepts of this program, the university is developing similar supports into other high-risk STEM courses beyond physics, as well as considering new ways to reach our least prepared and most vulnerable students.

While the landscape of higher education may have changed in relation to our physical proximity to each other in recent days, the elements that contributed to this project's success—and will inform its next cycle of improvement—remain the same.

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APPENDIX A.

Table 5. Demographic composition of students who took the diagnostic exam. The At-Risk column includes both moderate and high at-risk students. The Other category includes students who did not identify their ethnicity as well as those from groups with small populations that make statistical comparison difficult, including, for example, American Indian, Alaska native, international, or multi-racial.

		Overall population (3,002)		**At-Risk (1,501)**
		N	**% of population**	**% at risk within group**
Ethnicity	Asian	1,004	33%	37%
	Hispanic/Latino	863	29%	62%
	African American	280	9%	70%
	Non-Hispanic White	570	19%	50%
	Other	285	10%	39%
	Total	3,002	100%	
Gender	Female	1,447	48%	54%
	Male	1,555	52%	47%
	Total	3,002	100%	
Generation in College	First	1,428	48%	55%
	Continuing	1,574	52%	45%
		Total	3,002	

Table 6. Mean final exam score data for diagnostic and attendance groups

Diagnostic Groups	Attendance Group	Mean	Std. Deviation	95% Confidence Interval	
				Lower Bound	Upper Bound
Prepared	Almost Always	83.5	4.2	75.3	91.7
	Often	62.1	3.7	54.8	69.4
	Sometimes	71.5	3.0	65.6	77.4
	Rarely	69.5	2.1	65.4	73.7
	Never	75.2	0.5	74.2	76.3
At-Risk: Moderate	Almost Always	63.3	1.0	61.3	65.4
	Often	60.2	1.6	57.1	63.2
	Sometimes	53.4	2.3	48.9	57.8
	Rarely	51.1	2.9	45.5	56.8
	Never	57.9	1.1	55.8	60.1
At-Risk: High	Almost Always	54.6	1.5	51.6	57.5
	Often	51.1	2.0	47.3	55.0
	Sometimes	48.0	2.6	42.8	53.1
	Rarely	42.5	4.1	34.6	50.5
	Never	46.2	1.5	43.4	49.1

Rebecca Forrest earned her Ph.D. in Physics from the University of Houston in 1998. She did postdoctoral research at the University of California, Los Angeles and the University of Houston. She taught at the University of Houston – Downtown from 2002 – 2004, and since 2004 has been on the faculty in the Department of Physics at the University of Houston, where she is now an Instructional Professor. She is the President Elect of the Texas Section of the American Association of Physics Teachers (2021). She writes on physics education research and x-ray diffraction analysis of electronic materials.

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