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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

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