Project Accelerate (3-Year Review): Closing the Access Gap to Physical Science Careers and Academic Programs

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Abstract

Project Accelerate is a National Science Foundation funded program providing access to a rigorous introductory college level College Board Advanced Placement physics course to students attending high schools where this opportunity is not part of the regular high school program of study. High schools in the United States not offering this opportunity in general are either small rural schools or high schools in districts serving a larger than average proportion of economically disadvantaged families. Students in Project Accelerate do as well on the AP exam as their peer groups enrolled in traditional AP® Physics 1 classrooms. In addition, students in Project Accelerate show a marked increase in interest in pursuing post high school academic programs in science.

I. Introduction

Economically disadvantaged and underrepresented high school students in many urban, rural, and small suburban communities don't have access to Advanced Placement® (AP®) courses either because of a lack of trained teachers, limited or no AP® program, or a school history of low participation. Physics is often a "gate keeper" course to entry into Physical Science, Technology, Engineering and Mathematics (STEM) careers and academic programs. Lacking opportunity to access rigorous physics courses in high school these demographic groups are hard pressed to compete in STEM fields and academic programs with their peers from more affluent communities. Project Accelerate is a partnership program between Boston University (BU) and the high schools combining the supportive infrastructures from the students' traditional school with a highly interactive private edX online instructional tool to bring a College Board accredited AP® Physics 1 course to schools not offering this opportunity. During the first 3-years of the program, we have had 103 students complete the program and take the College Board AP Physics 1 exam. Preliminary data shows that Project Accelerate students do as well or better on the AP exam as their peer groups enrolled in traditional AP® Physics 1 classrooms.

II. The Problem

There is a critical need to develop STEM competencies among youth from demographic groups underrepresented in the STEM workforce. While underrepresented youth make up more than 50% of today's American high school population, African-American/Black and Hispanic/Latino youth each comprise only 7% of STEM graduates and 6-7% of the STEM workforce [1]. Underserved high school graduates are just as likely as non-underserved populations to be interested in STEM – 49% in each case. However, underserved students are far less prepared for college STEM coursework than are students overall (e.g., only 25% of underserved STEM students met the ACT College Readiness Benchmark in science compared to 59% of students who are not underserved). These data indicate that a program to increase academic readiness can succeed in increasing participation in STEM baccalaureate and career pathways [2].

Evidence exists that students who score 3 or higher on AP® exams have greater success in college than students who did not take an AP® course. However, students who receive scores lower than 3 do not perform noticeably better than a comparison group of high school students who did not take a STEM AP® course [3-5]. This indicates how critically important quality curriculum, prepared teachers, and appropriate scaffolding are to student success [6].

The most recent reports indicate schools with predominately low-income students, both rural and urban, lag in AP® offerings by a 2:1 margin and underrepresented groups lag in taking these courses even when offered by a factor of 2 compared to whites and 4 compared to Asians [7,9]. There is also evidence that in schools that do offer AP® programs, there is a large gap in participation between low- and high-income students, regardless of race. What is clear is that economically disadvantaged and underrepresented student groups share an equal interest in STEM as non-underserved students, but they are too often lacking the opportunity to access these gateway courses to success in physical science college programs and STEM careers [2]. Robinson et al., has shown that "taking advanced courses in mathematics and the sciences in high school, e.g., AP® courses, is good preparation for university work in engineering and other STEM careers" [8]. More recently, the State of California and the College Board have collaborated on bringing more AP® courses to underserved students. The latest data indicate that a large fraction of underrepresented students (30% or 8,800) could potentially succeed in AP® STEM courses but are not enrolling due to lack of opportunity [9].

Boston Public Schools (BPS) in Massachusetts USA, a typical American urban school system, is a prime example of this problem. The Boston Public School system has 34 high schools serving a district student population of 53,000 students. The demographics of BPS is 74% black and/or Hispanic and 58% economically disadvantaged. Only 5 of the 34 BPS high schools offered algebra-based AP® Physics 1, the curriculum supported by Project Accelerate, during the 2017-18 academic year. A total of 220 BPS students took the AP® Physics 1 exam during the 2017-18 school year. Of the 220 students who took the AP® Physics 1 exam, in a traditional classroom environment, only 5% earned a 3 or better. The success rate (score of 3 or higher) in Massachusetts public schools for black and Hispanic students taking the AP® Physics 1 exam, 515 students, during the 2017-18 academic year was 11%. The success rate for all students in Massachusetts public schools taking the AP Physics 1 exam, 3,760 students, during the 2017-18 academic year was 40%. AP scores are reported on a 5-point scale with scores of 3, 4 and 5 defined by the College Board as qualified, well qualified and extremely well qualified [15].

III. Project Accelerate

Project Accelerate is a *partnership* between Boston University (BU) and high schools providing a structured, supportive, and rich educational opportunity for underserved students from schools not offering AP® Physics. Project Accelerate is a potential scalable and sustainable solution to closing this access gap to STEM careers and academic programs.

Four Components to Project Accelerate: Project Accelerate combines four components to support student success: (i) An interactive edX Small Private Online Tool. (ii) The supportive infrastructures of the partner high school; (iii) The coordination and academic support of the university partner; and (iv) A hands-on laboratory option.

Online Instruction Tool: The online instructional tool is supported through the edX platform. EdX was founded by Harvard University and MIT in 2012 as an online learning destination. Today there are more than 90 global partners, including Boston University, in the edX online provider community. The Project Accelerate online instructional tool is short on "video professor segments." Instead, students are engaged throughout with interactive explorations using Direct Measurement Videos, PhETs and interactive HTML5 simulations. Videos when included are no longer than 7 minutes and are provided as an alternative learning modality reviewing instruction provided through engaging and interactive instruction. The online tool contains instructional scaffolding specific to the target population, multiple assessment tools, simulations, and a suite of virtual explorations emphasizing science process practices. The timeline for the course is authored to work seamlessly with a typical high school schedule. There are 25 graded virtual laboratories, 28 homework assignments, 24 quizzes and 4 proctored and timed simulated AP® style tests. All assignments are graded through the edX online instructional tool. Participating students pose queries and engage in discourse with the larger Project Accelerate student community through an online forum. Participants also have direct access to a paid project staff, the "university liaison," who is specifically assigned to work with a small fixed number of partner high schools. The university liaisons is also tasked with monitoring and participating in the online forum discussion board.

High School Partner: The HS appoints a professional staff member to serve as "HS liaison" (e.g., science teacher, outreach coordinator, or guidance counselor). The HS liaison facilitates communication between the school, students and the project team. The HS is provided a set of guidelines for enrolling students (i.e., maximum of 10, algebra 2 proficient, potential for independent learning, demonstrated history of submitting assignments in a timely fashion and interest in academic challenge), but is provided a good deal of latitude in vetting students into the program. The high school assigns participating students in-school time like any other major course and includes the course on the student's transcript and report card. The HS liaison does not provide formal content instruction.

University Partner: The Project team appoints a "university liaison" who coordinates the day-to-day running of the program. The university liaison monitors student performance and communicates regularly with the HS liaison. The university liaison provides weekly grade reports, midterm reports, end of term grades and end of course grades. Each university liaison is assigned to work with between 5 and 8 high school partners totaling no more than 50 students. For university replication sites offering an on-campus hands-on laboratory component, the university liaison supervises the undergraduate Teaching Assistants who facilitate the on-campus hands-on laboratory sessions.

Hands-on Laboratory Option: Students within commuting distance to Boston university are required to attend weekly small group 2 and ½ hour laboratory sessions on the university campus. Sessions give students an opportunity to explore concepts through hands-on inquiry-based laboratories, receive additional support based on individual learning needs and exposure to a university campus. Sessions are facilitated by trained undergraduate Teaching Assistants. The undergraduate Teaching Assistants take the same 2-credit education course required of our Learning Assistants. The School of

Education course is specifically designed for undergraduate Learning Assistants working in support of freshman and sophomore college physics courses. Our Teaching Assistants learn about physics pre-conceptions, learning styles, engagement strategies and general learning theory. Other university replication sites have the option to offer the same on-university program. School partners not within commuting distance or by university replication sites not offering an on-campus option are encouraged and supported in providing students with a hands-on laboratory component to complement the online instruction tools. The online instructional tool, besides offering a full suite of virtual explorations required of all students taking the course, supports a full set of hands-on explorations through a dropdown menu. The hands-on laboratories including supportive data files are accessible through the online instructional tool dropdown menu. These are the same explorations performed at the Boston University on-campus program.

IV. Research Agenda

Our research agenda explores three aspects of the program; (i) the efficacy of the program, (ii) the scalability of the model, and (iii) the long-term sustainability of the program.

Efficacy: We explore program efficacy by measuring student outcomes through AP® exam performance, pre/post scores on the Force Motion Concept Evaluation (FMCE), course completion rate, impact on student STEM choices and longitudinal college and career choices and performance.

Scalability: We additionally explore models to scale up as a national program especially looking at the fidelity of the instructional experience as larger populations of partner schools and student participants enter the program.

Sustainability: We look at long-term sustainability through a cost analysis of delivering the program at a price point that would likely be attractive to school administrations.

V. Results Over Three Years

Student Demographics: Project Accelerate has now enrolled a total of 201 student participants with 59% black or Hispanic, 57% of all students classified as economically disadvantaged and 44% female. Behind the statistics just sited, are many anecdotal stories reflecting our success at reaching our intended audience of underserved students. Here is an email from a building liaison from a "distant" partner high school to the university liaison serving her school: "I need to talk to you about Gabriela (not the student's actual name but representative of her ethnicity) and I was hoping to chat about her on the phone. Gabriela is homeless and at the moment does not have access to the internet. She spends Saturdays, when she can, at the library to do work, and she uses her study hall to do AP Physics and other homework. She was hoping she could have an extension for some of the assignments." Another from a commuting student writing to his university liaison who also supervises the on-campus hands-on laboratory sessions: "I'm sorry to say that I can't make it to the lab today. My mom is 6 months pregnant and just got admitted to the hospital and I have to watch the kids. Is it okay if I can go on Saturday instead of my regularly assigned day?" In both cases the university liaison working with the building liaison from the partner school was able to resolve and accommodate these situations.

AP Physics 1 Exam Results: All participating students are required to take the College Board AP® Physics 1 exam. As of the 2018 testing, 103 participating students have completed the program and taken the AP® Physics 1 exam. Eleven percent of the local Boston students completing the Project Accelerate program scored a 3 or better compared to 5% for BPS students enrolled in traditional AP®

Physics 1 classrooms. Forty percent of the non-local Boston students completing the Project Accelerate program scored a 3 or better compared to 40% for non-BPS Massachusetts students enrolled in traditional AP® Physics 1 classrooms.

FMCE: We administered the Force Motion Concept Evaluation (FMCE) as a pre- and posttest. This instrument is used by many universities and colleges to gauge the learning gains of students within their own introductory college level physics courses. Students in Project Accelerate had a paired fractional gain of 0.53 which is better than the fractional gain achieved by students attending the BU introductory physics course given to non-physics non-Engineering science majors.

Overall Retention: Our overall retention rate is 77%.

Student Attendance: Local Boston area students attend a weekly 2 and ½ hour laboratory block held either during the week days from 4PM to 6:30PM or weekends from 10AM to 12:30PM on the BU campus. The attendance rate for students at these laboratory sessions is 93%.

Student STEM Interest: Seventeen of 43 Boston Public School completers through the summer of 2018 applied to participate in summer STEM programs. Sixty-five percent of these indicated in our post-course survey that participation in Project Accelerate was "important" in their decision to apply to a summer STEM program. Fifty-two percent of all students indicated on the post-course survey that they were "more likely" to pursue a STEM program in college as a result of participating in Project Accelerate. We are beginning to gather data from past cohorts to look at course selection, choices of majors and achievement in introductory physics courses. We do not have statistically meaningful data on these measures as of the writing of this paper. However, we do have anecdotal evidence. Here is a portion of an unsolicited email we received from a student from one of our distant partners: "Your class taught me something that no other had up to that point: what it felt like to really be academically challenged, and how to overcome that. I also learned to look at problems from different perspectives and find a solution that might not initially be obvious … It seems I have your class to thank for my success in both my college-level Physics course directly, and my academic success overall." This young man is currently a 2nd semester mechanical Engineering major at West Virginia University.

VI. A National Model: Scaling Up

More Parter Schools and a Replication Site: Project Accelerate is a National Science Foundation (NSF DUE 1720914) funded project. With NSF support, we are offering Project Accelerate to an expanded number of partner schools and supporting one university replication site. During our pilot year, Project Accelerate included 6 high school partners with 24 students from Massachusetts. Our current cohort, second year of our NSF award, we are working with 19 high school partners with 86 students from 3 states (MA, WV and NY). We are currently accepting additional high school partners for the 2019-20 academic year and are on track to enroll 25 high school partners with 100 students from 7 states (MA, WV, NY, CT, MN, NH and NJ).

VII. Conclusion

Project Accelerate offers a potential solution to a significant national and international problem of too few underserved young people having access to high quality physics education, resulting in these students being ill prepared to enter STEM careers and STEM programs in college.

Project Accelerate is based upon the compelling need to provide access to AP® Physics for economically disadvantaged and other underserved groups. Research shows that providing high quality

education is critical to student's success in the future, and on the growing body of evidence that blended course structures, combining online learning with in-person sessions, can be very effective in improving student learning outcomes (see a review by Means, [10]). In addition, several studies have demonstrated that technology improves access to information, and hybrid or blended models engage students more effectively [11-14].

Thousands of high schools do not provide opportunities for underserved students to access AP® physics [9]. Project Accelerate blends together the supportive formal structures of the student's home school, immediate acceptance into school curricula through the AP® designation, a private online instructional tool designed specifically with the needs of underserved populations in mind, and small group laboratory experiences to make AP® Physics accessible to underserved students.

Finally, Project Accelerate is a scalable model of STEM success, replicable at sites across the country, and therefore setting up for success thousands of motivated but underserved students every year.

VIII. Acknowledgement

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References

1. Liana Christin Landivar, "Disparities in STEM Employment by Sex, Race, and Hispanic Origin," National Census Report (U.S. Department of Commerce, 2013), https://www.census.gov/prod/2013pubs/acs-24.pdf.
2. The Condition of STEM 2014 (ACT, 2014), https://www.act.org/content/dam/act/unsecured/documents/National-STEM-Re-port-2014.pdf.
3. Timothy P. Scott, Homer Tolson, and Yi-Hsuan Lee, "Assessment of advanced placement participation and university academic success in the first semester: Controlling for selected high school academic abilities," J. Coll. Admission 208, 26–30 (2010).
4. Kristin Klopfenstein and M. Kathleen Thomas, "The advanced placement performance advantage: Fact or fiction," Texas Christian University and Mississippi State University, American Economic Association Annual Meeting Papers, (2005).
5. Philip M. Sadler and Robert H. Tai, "Advanced placement exam scores as a predictor of performance in introductory college biology, chemistry and physics courses," Sci. Educ. 16 (2), 1–19 (2007).
6. Kristin Klopfenstein, "Recommendations for maintaining the quality of advanced placement programs," Am. Secondary Educ. 39-48 (2003).
7. P. Handwerk, N. Tognatta, R. Coley, and D. H. Gitomer. "Access to Success: Patterns of Advanced Placement Participation in U.S. High Schools" (Educational Testing Service, 2008), https://www.ets.org/Media/Research/pdf/PIC-ACCESS.pdf.
8. Mike Robinson et al., "AP mathematics and science courses as a gateway to careers in engineering," Front. Educ. IEEE (2003).

9. AP Expansion in California, College Board (2015), https://www.collegeboard.org/california-partnership/ap-expansion.
10. B. Means, Y. Toyama, R. Murphy, M. Bakia, and K. Jones, B. Means, “Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies” (U.S. Department of Education, 2010).
11. O. Delialioglu and Z. Yildirim, “Design and development of a technology-enhanced hybrid instruction based on MOLTA model: Its effectiveness in comparison to traditional instruc-tion,” Computer Educucation 51 (1), 474–483 (2008).
12. D. W. Sanders and A. I. Morrison-Shetlar, “Student attitudes toward web-enhanced instruction in an introductory biology course,” J. Res. Comput. Educ. 33 (3), 251–261 (2001).
13. G. A. Gunter, “Making a difference: Using emerging technol-ogies and teaching strategies to restructure an undergraduate technology course for pre-service teachers,” Educ. Media Int. 38 (1), 13-20 (2001).
14. B. W. Tuckman, “Evaluating ADAPT: A hybrid instructional model combining web-based and classroom concepts,” Com-put. Educ. 3, 261–269 (2002).
15. About AP Scores: What Is an AP Test Score and What Does It Mean?, College Board (2017), https://apscore.collegeboard. org/scores/about-ap-scores/.