Abstract Title Page

Title: The Impact of Achieve3000 on Elementary Literacy Outcomes: Evidence from a Two-Year Randomized Control Trial

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Abstract Body

Background / Context:
School districts are increasingly adopting technology-based resources in an attempt to improve student achievement (Knezek, 2008). Spending on educational hardware is expected to grow from $13 billion in 2013 to $19 billion in 2018, an annualized increase of eight percent, while districts spend an estimated $8 billion annually on software (Nagel, 2014; Richards & Stebbins, 2012). A growing body of research has emerged attempting to measure the causal impact of technology resources on various student achievement outcomes (Barrow, Markman, & Rouse, 2008; Campuzano, Dynarski, Agodini, & Rall, 2009; Given, Wasserman, Chari, Beattie, & Eden, 2008; James-Burdumy et al., 2009; Roschelle et al., 2007; Rouse & Krueger, 2004; R. S. Savage, Abrami, Hipps, & Deault, 2009; R. Savage et al., 2013; Wijekumar, Meyer, & Lei, 2012). Yet we still know very little about the broad impact of technology resources, as the abundance of high quality research ranges across geography, subjects, and grade levels.

This paper reports the two-year results from randomized control trial of Achieve3000 in the Wake County Public School System (WCPSS) in Raleigh, North Carolina. Achieve3000 is an early literacy program that differentiates non-fiction reading passages based on individual students' Lexile scores. The driving force behind implementing Achieve3000 in particular, and focusing on literacy in general, was the state's 2012 Read to Achieve legislation, which mandated that students failing to meet proficiency standards in grade 3 reading must attend summer camp and pass the state's Read to Achieve test before being promoted to grade 4. District staff were eager to launch a new program that could help increase reading proficiency among students receiving core instruction—as opposed to at-risk intervention—and ultimately reduce the share of children retained in grade 3 as a result of the new legislation. To our knowledge, this study constitutes the first randomized control trial of a product from the Achieve3000. According to its website, Achieve3000 has existed for more than a decade, serves more than 1 million U.S. students, and is consistently ranked by Inc. Magazine as one of the fastest growing private education companies in the United States (Magazine, 2014).

Purpose / Objective / Research Question / Focus of Study:
According to the Achieve3000 National Lexile study, use of the product "dramatically increases students' Lexile reading gains and builds the critical literacy capacities that are at the heart of the Common Core State Standards" (Achieve3000, 2012). Consequently, we address two key questions and focal areas for our research:

- Do students who use Achieve3000 outperform students who do not use Achieve3000 on a host of reading achievement measures?
- Does the performance of students who use Achieve3000 differ across student subgroups?

Setting:
The Wake County Public School System is the 15th largest local education agency (LEA) by student enrollment in the U.S. and the largest in North Carolina. The system in 2014-15 had 171 schools educating roughly 155,000 students, approximately half of whom were White, a quarter Black, and 15 percent Hispanic/Latino. Approximately one-third qualify for free- or reduced-price lunch. As a countywide district, WCPSS has suburban, urban, and rural features allowing for a diverse representation of school characteristics.

Population / Participants / Subjects:
32 elementary schools within the school system volunteered to receive Acheive3000 and implement the program with fidelity. These 32 schools were then matched on their 2012-13 elementary school End-of-Grade (EOG) reading composite score, and 16 were randomly selected to receive the treatment while the other 16 schools serve as the control group. The sample includes nearly 35,000 students in approximately 745 classrooms across grades 2-5. Figure 1, below, presents the random assignment process (Moher et al., 2010).

Intervention / Program / Practice:
The Achieve3000 suite includes six separate applications, four of which—KidBiz3000, TeenBiz3000, Empower3000, and Spark3000—the company claims are inspired by the work of R.C. Anderson on prior knowledge, Carol Ann Tomlinson on differentiation, Michael Kamil on the role of technology, and Linda Duncan on vocabulary development. Achieve3000's theory of action is that students will become college and career ready if they are able to read non-fiction texts at Lexile levels that exceed 1350. To help students reach that level, the company's applications administer an assessment that establishes a baseline Lexile level. From there, students are exposed to non-fiction adaptive reading passages that are aligned to their Lexile levels and adjust on the basis of end-of-lesson assessments. This way, reading passages are custom tailored to each student's Lexile level so that students don't spend valuable instructional time reading passages that are either too easy or too difficult (Achieve3000, 2011) .

Staff from the district and the vendor jointly decided that in order to reach the annual goal of 80 completed activities, students would utilize KidBiz3000—the elementary school application—twice weekly for 30 minutes. On initial use, students took a 30-minute assessment to obtain a baseline Lexile score. For each activity, students would follow a five-step procedure: (1) take a poll and respond to it through the KidBiz3000 email application; (2) read a non-fiction article aligned with their current Lexile level; (3) complete a series of multiple choice questions; (4) vote in a post-reading poll; and (5) answer a "Thought Question."

Research Design:
We employ an experimental research design in the form of a cluster-randomized trial. To estimate the impact of Achieve3000 on students who are nested within schools and where schools are the unit of assignment, we fit our data to a cluster two-level model with random effects where schools were randomized within matched pairs based on a school-level prior achievement score, as noted above. We estimate impact on various summative assessments controlling for prior achievement and a host of additional student- and school-level controls. In measuring the impact of Achieve3000 on students nested in schools, we employ intent-to-treat (ITT) and treatment-on-treated (TOT) estimations. The ITT estimation represents the impact of the exogenous offer of Achieve3000 to the 16-school sample of treatment sites. This estimation represents the empirical estimate of the offer irrespective of the rate of takeup. We investigate takeup using instrumental variables estimation.

Data Collection and Analysis:
Data for this investigation come from the school system's administrative and testing records; Amplify, Inc.'s mClass reporting system; and Achieve3000's activity completion and LevelSet Lexile pre- and post-test assessments. See Tables 1 and 2, below, for school- and student-level

baseline characteristics. We linked all datasets using unique student identification numbers. Our model specification is as follows:

$$OUTCOME_{ij} = \beta_0 + \beta_1(A3KOFFER)_{ij} + Z_{ij} + \varepsilon_{ij} + u_i$$

Where OUTCOME represents our dependent variable of interest (score change or summative score for each literacy measure) for student *j* nested in school *i*; β_0 represents the constant; β_1 represents the coefficient of our A3KOFFER predictor (the offer of Achieve3000) for student *j* nested in school *i*; *Z* represents a vector of student- and school-level control variables; residual ε_{ij} represents the random effect of student *j* in school *i*; and residual u_i represents the random effect of school *i*.

To estimate the treatment-on-treated impact of *using* Achive3000 we employ a two-stage least square regression where we instrument for actual program use in the first stage. The first stage of this model is specified as:

$$A3KUSE_{ij} = \beta_0 + \beta_1(A3KOFFER)_{ij} + Z_{ijk} + \varepsilon_{ij} + u_i$$

Where A3KUSE represents our dependent variable of interest (Achieve3000 use level) for student *j* nested in school *i*; β_1 represents the coefficient of our A3KOFFER predictor (the offer of Achieve3000) for student *j* nested in school *i*. The second stage of this model is specified as:

$$OUTCOME_{ij} = \beta_0 + \beta_1(\widehat{A3KUSE})_{ij} + Z_{ij} + \varepsilon_{ij} + u_i$$

Where $\widehat{A3KUSE}$ represents the exogenous portion of the offer variable. We instrument for use using a conservative implementation level equal to students completing at least one activity.

Findings / Results:

Two-year pooled results show that Achieve3000 did not have a significant impact on student outcomes. However, both intent-to-treat (ITT) and treatment-on-treated (TOT) estimates show that in 2015, the second year of implementation, students in the treatment group outperformed their control-group counterparts by 0.13 standard deviation units (σ) on the year-end Achieve3000 Lexile test (see Tables 3 and 4, below). This effects size is consistent with mean empirical effect sizes reported by Lipsey et al. (2012). Yet in neither the pooled nor annual samples did Achieve3000 significantly impact student performance on additional Lexile outcomes (NC EOG Lexile) or various DIBELS assessments. These aggregate results, in conjunction with slightly better implementation in the second year, suggest that the treatment group may (1) benefit from improved implementation and (2) may be conditioned, by virtue of familiarity with the user interface, to outperform their control group counterparts.

To address our second research question, we examined interaction effects across a range of subgroups. In the pooled sample in both ITT and TOT estimations, male students gained 0.03σ while in the ITT estimation, students with disabilities gained 0.05σ. In the second-year sample, both ITT and TOT estimates show gains of 0.05σ for male students, 0.09σ for students with disabilities, 0.05σ for gifted students, and 0.14σ for students attending year-round schools.

We also address implementation since, as the program's theory of action suggests, greater impacts should correspond with increased use of the program. The program's developers group activity completion into three main categories: completion of 1-39 activities, 40-79 activities, and 80 or more activities. The percentage of students completing activities in each of these three categories increased from 2013-14 to 2014-15. Figure 3, below, shows that the percentage of students completing 80 or more activities nearly doubled from 5.5% to 9.3%. In an extension of our implementation analysis, we plan to derive matched control groups from treatment group profiles according to implementation category and compare student achievement outcomes across these groups. Early work across the pooled sample and by year suggests that determinants of activity completion are primarily being male (2 additional activities), attending a year-round school (6-8 activities), or attending a Title I school (1-7 activities). As expected, large and significant cohort effects (5 activities) emerge in the pooled sample (see Table 5, below).

Conclusions:

Results from a two-year randomized control trial of Achieve3000 suggest that the impacts, implementation, and overall promise of a technology literacy solution fell short of expectations. This comes as niche technology solutions like Achieve3000 increasingly complement and even supplement non-digital literacy instruction in schools and classrooms across the country. Yet moderate effects may arrive with improved implementation, as our second-year results suggest. While we did not detect an impact on our primary Lexile outcome in our pooled sample, the effect size in the second year (0.13σ) was consistent with empirical averages. On the same outcome in year two, we detected treatment effects for students who are male, have a disability, are gifted, or attend year-round schools. However, we could not triangulate these results with similar outcome measures, suggesting that implementation and program familiarity (i.e., the Lexile test is embedded in the software) may explain our second-year treatment effects.

We additionally conclude that implementation remains a challenge in treatment schools. Despite the fact that our analytic sample of 32 schools all confirmed that they would implement Acheive3000 with fidelity if selected to receive the program, usage data shows that two-thirds of students in the treatment sample completed fewer than 40 activities in the second year of implementation (see Figure 3). This result stands in stark contrast to the vendor's full implementation goal of all students completing 80 or more activities.

The consequences for school districts in general and WCPSS in particular are two-fold. First, district stakeholders should adopt new instructional tools with reasonable expectations about how they might impact student achievement. Our results, along with reviews of similar RCTs (Lipsey et al., 2012), broad literacy interventions (Kim & Quinn, 2013) and technology tools (Takacs, Swart, & Bus, 2015), suggest that empirical effects are much smaller than theoretical ones. Second, districts need to develop strict implementation plans that include consistent monitoring, central office-to-school feedback loops, and accountability for weak implementation.

Study limitations are mostly implementation-based and include: limited generalizability on the basis of full implementation, select system features that did impact implementation (e.g., program start date; technology challenges), and staffing changes at the district- and vendor-level that may have impacted implementation. We will add attrition analyses to our impact and implementation findings.

Appendices

Appendix A. References

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Appendix B. Tables and Figures

Figure 1: Assignment of Achieve3000

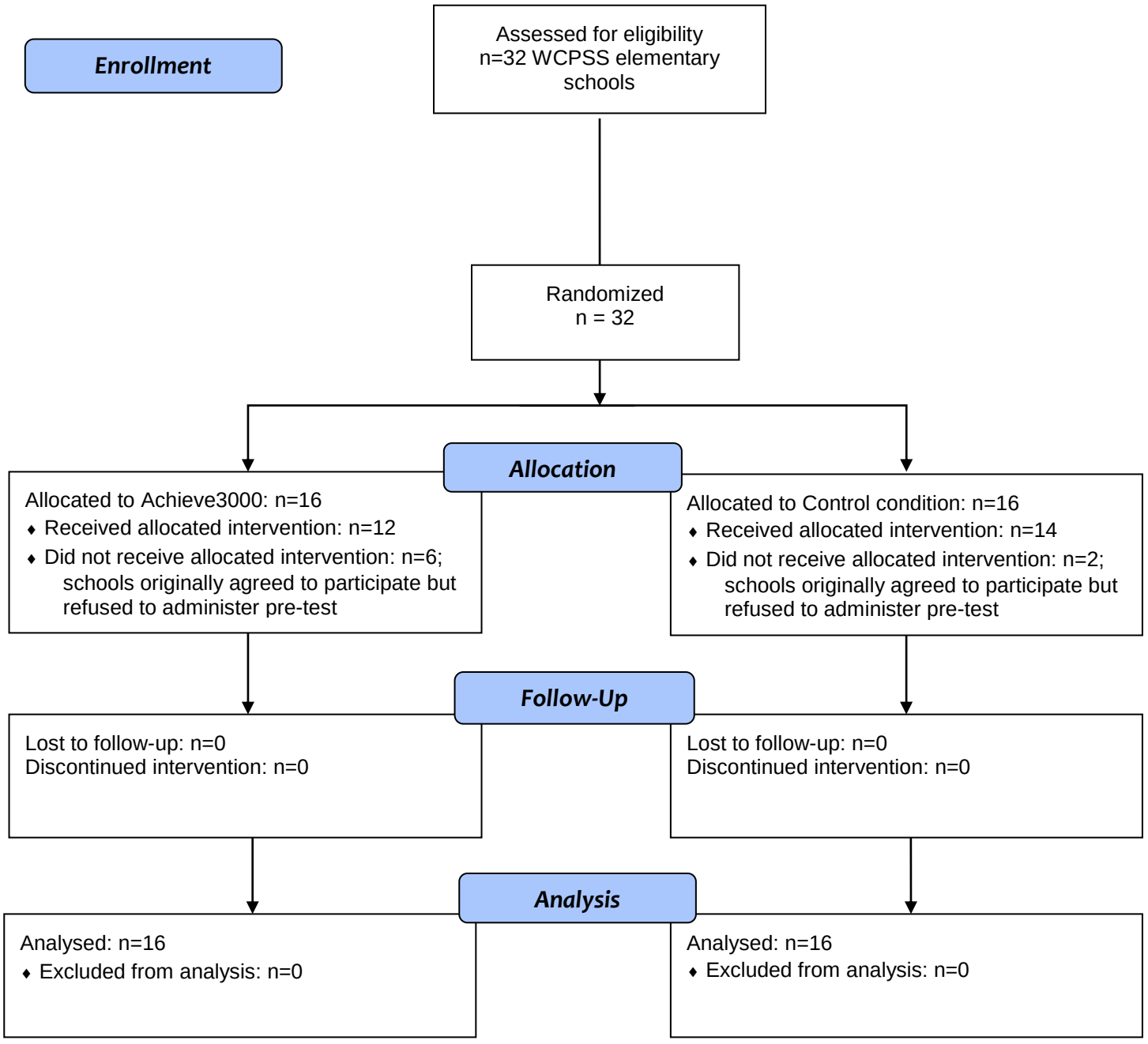

Table 1: School-Level Baseline Characteristics

	Control	Treatment	Control - Treatment	p-value from joint orthogonality test of treatment arms
School characteristics				
School % Male	0.520	0.517	0.002	0.682
	(0.004)	(0.004)	(0.006)	
School % ED	0.368	0.356	0.012	0.824
	(0.041)	(0.032)	(0.052)	
School % SWD	0.116	0.112	0.004	0.703
	(0.006)	(0.007)	(0.009)	
School % LEP	0.092	0.124	-0.032	0.122
	(0.013)	(0.016)	(0.020)	
School % AIG	0.043	0.041	0.002	0.873
	(0.009)	(0.005)	(0.010)	
School % Hispanic	0.176	0.215	-0.039	0.238
	(0.022)	(0.023)	(0.032)	
School % Black	0.309	0.203	0.106**	0.045
	(0.043)	(0.027)	(0.051)	
Prior achievement				
Achieve3000 Pretest	-0.083	0.006	-0.089	0.391
	(0.084)	(0.059)	(0.103)	
EOG Lexile Pretest	-0.012	-0.028	0.016	0.869
	(0.075)	(0.059)	(0.095)	
DIBELS Composite Pretest	-0.028	-0.008	-0.020	0.829
	(0.079)	(0.050)	(0.093)	
DIBELS Oral Reading Fluency Pretest	-0.043	-0.004	-0.038	0.681
	(0.077)	(0.052)	(0.093)	
N	16	16	32	
Proportion	0.500	0.500		

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table 2: Student-Level Baseline Characteristics

	Control	Treatment	Control - Treatment	p-value from joint orthogonality test of treatment arms
Student characteristics				
Cohort	0.521	0.516	0.005	0.390
	(0.004)	(0.004)	(0.005)	
Male	0.511	0.510	0.001	0.863
	(0.004)	(0.004)	(0.005)	
Black	0.302	0.208	0.094***	0.000
	(0.004)	(0.003)	(0.005)	
Hispanic	0.172	0.195	-0.023***	0.000
	(0.003)	(0.003)	(0.004)	
LEP	0.083	0.102	-0.019***	0.000
	(0.002)	(0.002)	(0.003)	
SWD	0.114	0.112	0.002	0.588
	(0.002)	(0.002)	(0.003)	
Economically Disadvantaged	0.359	0.348	0.011**	0.035
	(0.004)	(0.004)	(0.005)	
AIG: Reading & Math	0.071	0.065	0.006**	0.030
	(0.002)	(0.002)	(0.003)	
Magnet School	0.210	0.191	0.019***	0.000
	(0.003)	(0.003)	(0.004)	
Year-Round Calendar	0.480	0.583	-0.103***	0.000
	(0.004)	(0.004)	(0.005)	
Title I	0.604	0.643	-0.039***	0.000
	(0.004)	(0.004)	(0.005)	
Prior achievement				
Achieve3000 Pretest	-0.035	0.033	-0.067***	0.000
	(0.009)	(0.009)	(0.013)	
EOG Lexile Pretest	0.006	-0.005	0.011	0.533
	(0.013)	(0.012)	(0.018)	
DIBELS Composite Pretest	-0.006	0.006	-0.012	0.318
	(0.009)	(0.008)	(0.012)	
DIBELS Oral Reading Fluency Pretest	-0.020	0.018	-0.038***	0.001
	(0.008)	(0.008)	(0.012)	
N	16619	18013	34632	
Proportion	0.480	0.520		

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table 3: Achieve3000 ITT Impact on Achieve3000 Posttest

	2014	2015	Pooled
Achieve3000	-0.054**	0.129***	0.029
	(0.022)	(0.033)	(0.024)
Pretest	0.769***	0.866***	0.821***
	(0.006)	(0.004)	(0.003)
Cohort	0.000	0.000	0.027***
	(0.000)	(0.000)	(0.006)
Male	-0.006	0.016***	0.006
	(0.009)	(0.006)	(0.005)
Black	-0.119***	-0.084***	-0.099***
	(0.013)	(0.009)	(0.008)
Hispanic	-0.045***	-0.042***	-0.045***
	(0.015)	(0.010)	(0.009)
LEP	-0.166***	-0.068***	-0.111***
	(0.019)	(0.012)	(0.011)
SWD	-0.245***	-0.122***	-0.180***
	(0.015)	(0.011)	(0.009)
ED	-0.126***	-0.069***	-0.098***
	(0.012)	(0.008)	(0.007)
AIG	0.318***	0.158***	0.242***
	(0.017)	(0.013)	(0.010)
Magnet	0.040	0.024	0.038
	(0.031)	(0.041)	(0.029)
Year-Round	0.029	-0.010	0.001
	(0.022)	(0.033)	(0.023)
Title I	0.019	0.033	0.023
	(0.029)	(0.042)	(0.030)
School % Male	0.791	1.674*	1.282*
	(0.862)	(0.979)	(0.698)
School % ED	0.435	-0.359	-0.082
	(0.313)	(0.463)	(0.326)
School % SWD	-0.334	-0.662	-0.404
	(0.481)	(0.607)	(0.430)
School % LEP	1.044**	0.789	1.063**
	(0.492)	(0.734)	(0.518)
School % AIG	0.257	0.129	0.071
	(0.705)	(1.038)	(0.732)
School % Hispanic	-1.395***	-0.197	-0.617
	(0.411)	(0.597)	(0.421)
School % Black	-0.417**	0.099	-0.177
	(0.181)	(0.284)	(0.200)
Constant	-0.201	-0.784	-0.535
	(0.410)	(0.496)	(0.353)
μ	0.038***	0.072***	0.050***
	(0.007)	(0.009)	(0.007)
ε	0.443***	0.344***	0.397***
	(0.003)	(0.002)	(0.002)
N	9,732	12,851	22,583

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

Table 4: Achieve3000 TOT Impact on Achieve3000 Posttest

	2014	2015	Pooled
Achieve3000	-0.064*	0.131***	0.031
	(0.037)	(0.045)	(0.035)
Pretest	0.769***	0.866***	0.821***
	(0.006)	(0.004)	(0.003)
Cohort	0.000	0.000	0.029***
	(0.000)	(0.000)	(0.006)
Male	-0.006	0.016***	0.006
	(0.009)	(0.006)	(0.005)
Black	-0.119***	-0.084***	-0.099***
	(0.013)	(0.009)	(0.008)
Hispanic	-0.045***	-0.041***	-0.045***
	(0.015)	(0.010)	(0.009)
LEP	-0.167***	-0.067***	-0.111***
	(0.019)	(0.012)	(0.011)
SWD	-0.246***	-0.121***	-0.180***
	(0.015)	(0.011)	(0.009)
ED	-0.125***	-0.069***	-0.098***
	(0.012)	(0.008)	(0.007)
AIG	0.318***	0.158***	0.242***
	(0.017)	(0.013)	(0.011)
Magnet	0.043	0.031	0.039
	(0.045)	(0.053)	(0.040)
Year-Round	0.031	-0.010	0.000
	(0.032)	(0.043)	(0.032)
Title I	0.028	0.033	0.022
	(0.042)	(0.055)	(0.041)
School % Male	0.573	1.633	1.308
	(1.232)	(1.276)	(0.964)
School % ED	0.374	-0.353	-0.094
	(0.448)	(0.606)	(0.453)
School % SWD	-0.202	-0.641	-0.405
	(0.692)	(0.793)	(0.596)
School % LEP	1.078	0.778	1.077
	(0.693)	(0.963)	(0.718)
School % AIG	0.037	0.164	0.086
	(1.028)	(1.360)	(1.026)
School % Hispanic	-1.408**	-0.163	-0.600
	(0.579)	(0.784)	(0.588)
School % Black	-0.432*	0.090	-0.167
	(0.262)	(0.370)	(0.280)
Constant	-0.072	-0.775	-0.554
	(0.592)	(0.646)	(0.490)
N	9,732	12,851	22,583

* $p<0.1$; ** $p<0.05$; *** $p<0.01$

Figure 2: Achieve3000 Activity Completion, Pooled Sample

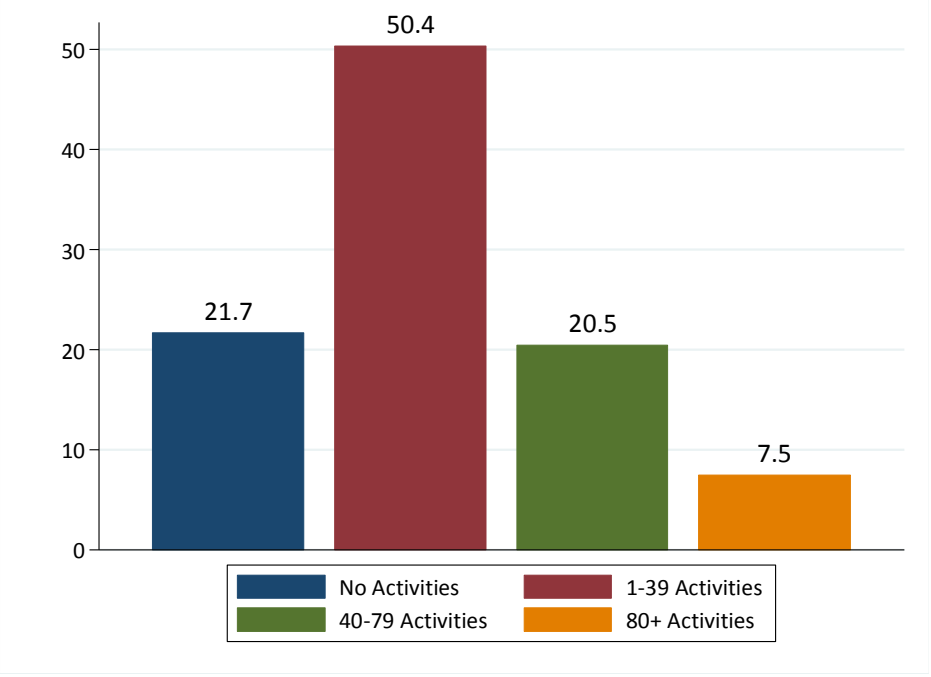

Figure 3: Achieve3000 Activity Completion, by Year

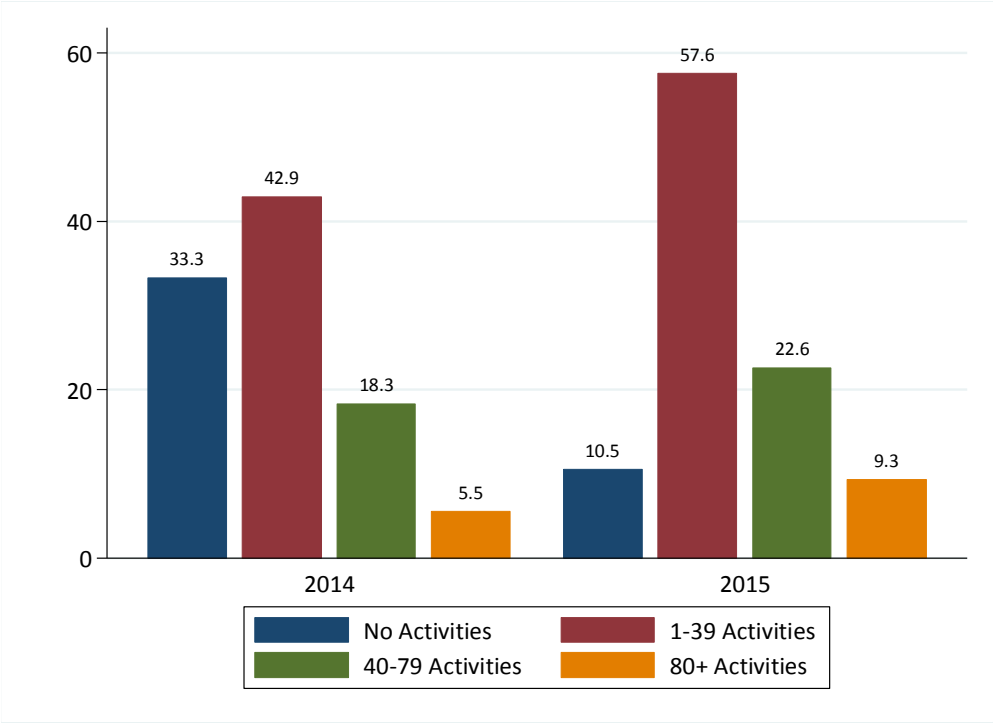

Table 5: Determinants of Achieve3000 Activities Completed

	2014	2015	Pooled
Cohort	0.000	0.000	4.709***
	(0.000)	(0.000)	(0.336)
Male	2.104***	2.214***	2.176***
	(0.428)	(0.520)	(0.339)
Black	-3.154***	-7.156***	-5.205***
	(0.575)	(0.738)	(0.472)
Hispanic	-3.552***	-5.132***	-4.320***
	(0.753)	(0.924)	(0.602)
LEP	1.712	1.514	1.532**
	(1.047)	(1.143)	(0.777)
SWD	-3.690***	-2.226***	-2.992***
	(0.581)	(0.853)	(0.512)
ED	0.553	0.628	0.613
	(0.544)	(0.691)	(0.443)
AIG	-1.789**	1.488	-0.296
	(0.757)	(1.029)	(0.629)
Magnet	-3.213***	1.629**	-0.774
	(0.598)	(0.787)	(0.496)
Year-Round	6.460***	8.145***	7.305***
	(0.509)	(0.565)	(0.381)
Title I	0.878**	7.032***	3.997***
	(0.432)	(0.547)	(0.350)
Constant	10.467***	10.317***	7.989***
	(0.526)	(0.580)	(0.438)
R^2	0.03	0.03	0.03
N	15,162	15,693	30,855

* $p<0.1$; ** $p<0.05$; *** $p<0.01$