Digital Writing Across the Curriculum: A Look at One District over 4 years

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Abstract

This study examines the time spent digitally writing by students in grades 4-11 in an urban district from 2014-2017 to understand how much digital writing practice students are getting across the curriculum and look at the relationship between writing time and annual state assessment achievement measures. Our analyses included fixed effect regressions and structural equation models. We found that time spent writing digitally predicted increased ELA and writing scores on year-end standardized test, but we also found that the majority of students in this district were doing very little digital writing over the course of the year. Ultimately, this can be seen as an opportunity to increase students' writing skills through additional digital writing practice.

Writing is an essential skill for academic and career success, and most writing for professional and academic purposes now takes place using digital media (Brandt, 2015). Teachers report, however, that students spend less than 30 minutes a day writing and the actual observed practices are significantly less (Applebee & Langer, 2011; Graham, Capizzi, Harris, Hebert, & Morphy, 2014). This study analyzes the time spent digitally writing by students in grades 4-11 in an urban district over four school years and the relationship between writing time and annual state assessment achievement measures. We found that time spent writing digitally predicted increased ELA and writing scores on year-end standardized tests, but we also found that the majority of students in this district were doing very little digital writing.

This study draws on data gathered from 4th-11th grade students in one urban school district to address the following questions:

- How much time do students spend writing digitally?
    a. What sort of variations are found? Does the variation relate to school, grade, or access to devices?
    b. How does time spent writing digitally change over time?
- How does time spent writing digitally relate to writing achievement on standardized English language arts benchmark assessments?

Method

Population

This study focuses on students in grades 4 through 11. We were given access to data by a large urban district in the southwest United States (SUD) with predominantly Hispanic/Latino students and a large percentage of students who qualify for free or reduced lunch and are English learners. Descriptive information about the students in our sample and in the overall district are set forth in Table 1.

Data Source

Hapara (www.hapara.com), an educational technology company focused on providing instructional management tools for K-12 educators and administrators, has developed a tool that analyzes usage of Google Apps for Education and Microsoft Office Education 365. Hapara accessed students' Google school accounts using anonymous identifiers and analyzed the time stamps (not the content) for all students' written work on the school domain. Student writing and other district data was shared with researchers on a de-identified basis and in accordance with FERPA regulations, pursuant to oversight by the UC Irvine Institutional Review Board.

Variables

Variables used in the analysis were in four categories, student demographic information, access to digital technology, digital writing time, and English language arts and writing achievement on the end of the year annual state assessment.

Descriptives

We began by generating descriptive data describing students' digital writing over the course of a school year. We looked at overall data, as well as data by school and grade level, for multiple school years for trends over time.

Fixed Effect Regression Models

To determine the correlation between device access and time spent writing digitally in SUD, we used fixed effects regression. Fixed effects models, at the school level, allow us to remove school-level unidentified confounding variables. Our formula was

$$\text{WritingTime} = \boldsymbol{\beta}_1 + \boldsymbol{\beta}_2\text{DevicesPerStudent} + \boldsymbol{\beta}_3\text{dmale} + \boldsymbol{\beta}_4\text{dlep} + \boldsymbol{\beta}_5\text{dGate} + \boldsymbol{\beta}_6\text{dSPED} + \boldsymbol{\beta}_7\text{dFrl} + \boldsymbol{\beta}_8\text{dgrade} + \boldsymbol{\beta}_{8\text{-}58}\text{School} + \boldsymbol{\varepsilon}$$

Where DevicesPerStudent indicates the number of digital devices divided by student enrollment, and dummy variables for male students, students with limited English proficiency, students identified as gifted or receiving special education services, students receiving free or reduced lunch, and the current grade level of the student, and School indicates the school in which the student is enrolled during the academic year. We also checked for interactions between devices per student and male, LEP, GATE, and special education indicators.

To answer our question about the relationship between time writing and standardized achievement results, we began by again used a fixed-effect regression to model the following:

$$\text{ELA Achievement} = \boldsymbol{\beta}_1 + \boldsymbol{\beta}_2\text{WritingTime} + \boldsymbol{\beta}_3\text{dmale} + \boldsymbol{\beta}_4\text{dlep} + \boldsymbol{\beta}_5\text{dGate} + \boldsymbol{\beta}_6\text{dSPED} + \boldsymbol{\beta}_7\text{dFrl} + \boldsymbol{\beta}_8\text{dgrade} + \boldsymbol{\beta}_{8\text{-x}}\text{School} + \boldsymbol{\varepsilon}$$

Where the amount of digital writing time was substituted for devices per student to predict overall English language arts achievement on the annual state assessment. Only students in grades 4-8 and 11 had annual state assessment scores, so for this analysis our sample was limited to these grades. Once again, we checked for interactions with our demographic controls to check for heterogeneity.

Structural Equation Models

In addition to the fixed effects regression, we used structural equation models (SEM) to understand the full relationship of our digital writing and achievement variables. We used Stata to fit the SEM model in Figure 1, using maximum likelihood with missing values (MLMV). In order to understand any underlying heterogeneity in this model, we ran group contrasts for the model, comparing males/females, students with limited English proficiency/English only, grade levels, gifted students/typical students, and students in special education/typical students. We used a Wald test to determine if the variance between groups was significant. We next ran a generalized SEM (GSEM) model in Stata including dummy variables for each of the schools in our district--a fixed effects model--to reduce the likelihood of unseen confounding variables, using standardized variables for minutes and achievement scores to ensure consistent reporting across our models. Finally, we ran similar SEM and GSEM models replacing overall ELA scaled scores with the reported level of performance on the writing claim alone.

Results

Descriptive

Students are doing very little digital writing across the curriculum, but the amount is growing rapidly (Table 2). In 2014, most students in the SUD did no digital writing for school, increasing to 100.62 minutes (1.67 hours) for the 50th percentile in 2015, 194.25 minutes (3.24 hours) in 2016, and 264.60 minutes (4.41 hours) in 2017. Figures 2, 3, and 4 show the scatterplots for 2014, 2015, and 2016 minutes of digital writing (y axis) and ELA achievement scores (x access).

We find grade level differences in their digital writing time (all $p < 0.001$; Table 3). Some of the increase in minutes might simply reflect increased access to digital devices over time, as shown in Table 4.

To get a sense of the variation between schools in digital writing minutes, we looked at the 50th percentile each year for each school, separating them into elementary, middle, and high school. As Figures 5, 6, and 7 illustrate, there is a large variation between schools, even at the same level (e.g., elementary). We analyzed the school level variation in access to see if that could be responsible for any of the school-level variation in annual minutes of digital writing. Figures 8, 9, and 10 parallel the figures for minutes, showing the device/student ratio over the three years.

Fixed Effect Regression Models

Device density predicts the number of writing minutes in the first two, but not the third, years ($B = 0.29$ and 0.17; $p < 0.05$; Table 5). We also find that grade level is not predictive of writing minutes, but gender, English proficiency, and special education status predict lower scores, while identification as gifted predicts increased scores as expected. There were no significant interactions between device density and the demographic controls except for -0.08* for LEP status on 2015 minutes and -0.09* for GATE status on 2016 minutes.

In addition, digital writing minutes predicted between 0.04 and 0.06 ($p < 0.001$) of the overall annual English language arts achievement (Table 6). However, in 2014 these effects are almost erased for students with limited English proficiency or classified as GATE or in special education ($B = -0.03$, $p < 0.05$; -0.03, $p < 0.05$; and -0.04, $p <0 .001$), increased for students in special education in 2015 ($B = 0.04$, $p < 0.001$), and slightly impacted in 2016 for males ($B = 0.01$, $p < 0.001$) and students with limited English proficiency ($B = -0.01$, $p < 0.01$).

Structural Equation Models

Our first model found that the number of digital writing minutes in the preceding year predicted those in the subsequent (B = 0.29, 0.33, and 0.31, respectively, $p < 0.001$), as expected (Figure 11). In addition, annual ELA achievement scores predicted the following year's scores (B = 0.79 and 0.81, respectively; both $p < 0.001$). Even more interesting, we have verification that ELA achievement level predicts the amount of digital writing done by a student in the succeeding year (higher ELA achievement leads to more predicted writing time and vice versa), with the end of 2014 ELA score predicting 2015 digital writing time (B = 0.26, $p < 0.001$), 2015 ELA score predicting 2016 digital writing time (B = 0.28, $p < 0.001$), and 2016 ELA score predicting 2017 digital writing time (B = 0.33, $p < 0.001$). Finally, even controlling for the prior year's ELA achievement score, the amount of time spent writing digitally during the school year predicted the end of the year ELA score (B = 0.11 and 0.09, 2015 and 2016; both $p < 0.001$).

Males show significant differences in some parameters, but not in the effect of digital writing minutes on ELA scores (Figure 12). Students with limited English proficiency, on the other hand, are statistically different than students who only speak English. Students in special education are statistically significantly different (except for the path between 2014 minutes and ELA score). Students identified as gifted have some statistically significant variance from typical students, for example the effect of 2015 minutes on 2015 ELA score ($p < 0.001$), but not 2016 minutes on 2016 ELA score ($p < 0.075$). The results are not practically different for girls and boys, however, even where they are statistically significant.

In addition to looking at the relationship between digital writing time and overall ELA achievement, we also looked at the relationship between digital writing time and performance levels on the writing claim portion of the assessment (Figure 13, all $p < .001$). Once again, we found a similar trend. The prior year's writing performance level was less predictive of the following year's, perhaps due to different genres in the two years since each year multiple genres are tested at random. Digital writing minutes was a slightly stronger indication of the end of the year writing claim performance score, likely reflecting closer alignment between the measure (solely writing) and digital writing time .

Our model was robust, with the relationships retaining their significance when using school fixed effects to control for school-level confounding variables (Figure 14).

Discussion

We believe there are three important takeaways from our analyses:

1. Students write very little digitally across the curriculum. Our data will provide some baseline information to judge whether and how this changes as time goes on and technology becomes more integrated in classrooms.
2. Consistent with findings with respect to handwritten writing, more proficient students spend more time writing digitally than less proficient students.
3. Even controlling for prior performance on the annual state assessment and school-level fixed effects, increased digital writing time predicts improved achievement scores.

Although the amount of digital writing may be disheartening to some, it also represents an untapped opportunity. Even in the 2017-18 school year, there were students who did no digital writing (5th percentile) or less than half an hour during the entire year (10th percentile). Students can become better digital writers, gaining important college and career proficiency, with more practice. This practice will also reap benefits in increased annual state assessment scores, even on distal measures such as overall ELA scores.

Access to devices did predict increased minutes of digital writing in most years. We expect that as saturation of devices hits an optimal level, access will prove less predictive of use. We also have seen in other research that limited access can be overcome by creative teachers and full access can be underutilized.

These analyses have several limitations. First, they are limited to a single school district. We will be looking at similar data from a second, more affluent district to begin to identify differences between districts, but more data is needed from a variety of contexts to fully understand the limitations in our single-district outcomes. Second, we only measure time spent writing. Nonetheless, we believe this data is an important beginning to understanding what digital writing looks like for adolescents in schools today.

References

Applebee, A.N., & Langer, J.A. (2011). A snapshot of writing instruction in middle schools and high schools. *The English Journal, 100*(6), 14-27.

Brandt, D. (2015). The rise of writing: Redefining mass literacy. Cambridge University Press.

Graham, S., Capizzi, A., Harris, K. R., Hebert, M., & Morphy, P. (2014). Teaching writing to middle school students: A national survey. *Reading and Writing, 27*(6), 1015-1042.

Tables and Figures

Table 1

Southwest urban district selected demographics for all grades and analytic sample

	SUD Analytic Sample (Grades 4-11)	**SUD Population (All grades)**
Total Students	28,200	54,500
Male	50%	50%
English Learners	32%	40%
Free/reduced lunch	93%	87%
Hispanic/Latino	NA	93%

Note: District numbers rounded to preserve anonymity.

Table 2

SUD annual writing minutes, over 4 academic years, by percentile

	2014-15 Academic Year	**2015-16 Academic Year**	**2016-17 Academic Year**	**2017-18 Academic Year**
1%ile	0	0	0	0
5%ile	0	0	0	0
10%ile	0	0	0	22.82
25%ile	0	.08	55.73	108.75
50%ile	**0**	**100.62**	**194.25**	**264.60**
75%ile	61.9	282.05	404.42	547.62
90%ile	172.78	557.58	699.10	933.67
95%ile	256.13	785.43	935.57	1230.68
99%ile	460.18	1286.37	1562.83	1897.08

Table 3

SUD annual writing minutes by grade level, 50%ile. Note that grade 4 was not available in our 2017 data.

	2014-15 Academic Year	**2015-16 Academic Year**	**2016-17 Academic Year**	**2017-18 Academic Year**
Grade 4	0	45.21	143.13	NA
Grade 5	0	134.38	174.78	160.01
Grade 6	34.95	197.23	192	182.33
Grade 7	37.45	220.18	196.62	179.44
Grade 8	49.17	197.03	314.63	260.06
Grade 9	50.17	164.87	287.64	434.66
Grade 10	13.01	121.40	238.12	328.92
Grade 11	0.01	67.56	308.58	425.8

Table 4

Device density at the 50th percentile by grade level over 3 academic years

	2014-15 Academic Year	**2015-16 Academic Year**	**2016-7 Academic Year**
Grade 4	0.20	0.58	1.16
Grade 5	0.20	0.59	0.76
Grade 6	1.04	1.86	1.98
Grade 7	1.04	1.86	1.98

Grade 8	1.04	1.41	1.98
Grade 9	0.23	0.79	1.24
Grade 10	0.23	0.79	1.43
Grade 11	0.32	0.68	1.24

Table 5

SUD fixed-effects regression of device density on annual writing minutes, standardized minutes and devices/student

	Minutes of Digital Writing					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	2014-15	**2014-15**	**2015-16**	**2015-16**	**2016-17**	**2016-17**
Devices/Student	0.22	0.29*	0.24**	0.17*	0.06	0.18
	(0.15)	(0.13)	(0.08)	(0.08)	(0.07)	(0.12)
Grade		0.09		0.03		0.13
		(0.07)		(0.08)		(0.07)
Male		-0.10***		-0.17***		-0.24***
		(0.03)		(0.04)		(0.04)
Free/Reduced Lunch		-0.01		-0.03		-0.09*
		(0.04)		(0.03)		(0.04)

Limited English Proficiency		-0.10***		-0.23***		-0.20***
		(0.03)		(0.05)		(0.03)
GATE		0.15*		0.21**		0.33***
		(0.07)		(0.08)		(0.06)
Special Education		-0.20**		-0.14**		-0.17***
		(0.07)		(0.04)		(0.04)
Constant	0.19	-0.53	0.13	0.15	0.10	-0.21
	(0.11)	(0.36)	(0.11)	(0.39)	(0.12)	(0.42)
N	19657	18635	23761	18494	24980	18383
R-sq	0.037	0.303	0.054	0.298	0.004	0.286

Standard errors in parentheses.

* p<0.05 ** p<0.01 *** p<0.001

Table 6

SUD fixed-effects regression of annual writing minutes on annual ELA assessment, standardized minutes and achievement scores

	Annual ELA Achievement					
	(1)	(2)	(3)	(4)	(5)	(6)
	2014-15	**2014-15**	**2015-16**	**2015-16**	**2016-17**	**2016-17**
Annual Minutes	0.12**	0.04**	0.11***	0.04***	0.12***	0.06***

	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Grade		11.21***		5.38**		9.48***
		(1.92)		(1.59)		(1.89)
Male		-14.34***		-16.97***		-12.93***
		(0.88)		(1.57)		(1.69)
Free/Reduced Lunch		-12.04***		-13.70***		-19.48***
		(1.95)		(2.29)		(3.09)
Limited English Proficiency		-68.04***		-67.27***		-75.31***
		(1.40)		(1.56)		(2.68)
GATE		83.32***		79.90***		83.54***
		(2.11)		(3.02)		(3.32)
Special Education		-44.44***		-47.50***		-46.21***
		(2.00)		(2.43)		(2.72)
Constant	2445.83***	2443.65***	2449.14***	2473.49***	2452.85***	2454.21***
	(0.00)	(7.19)	(6.61)	(14.50)	(6.82)	(12.79)
N	16153	15454	16789	12444	17701	12271
R-sq	0.189	0.564	0.098	0.504	0.149	0.508

Standard errors in parentheses.

* p<0.05 ** p<0.01 *** p<0.001

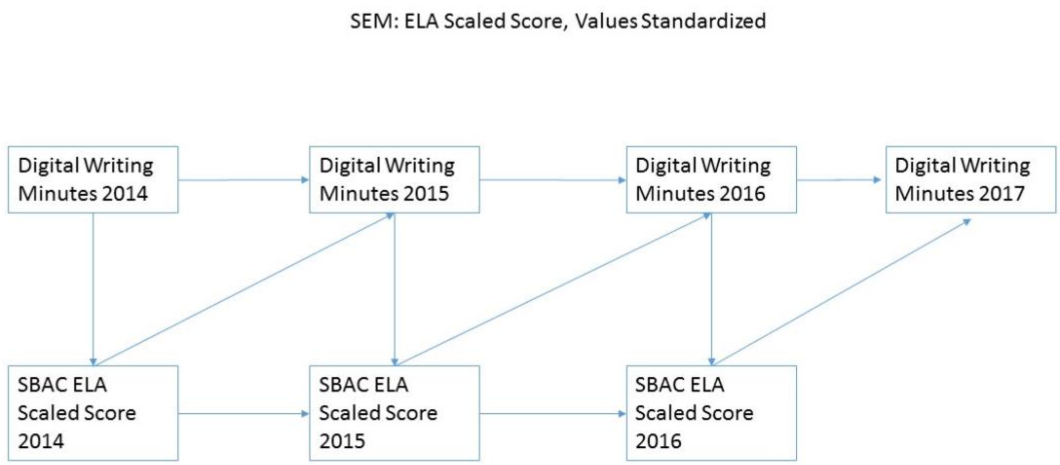
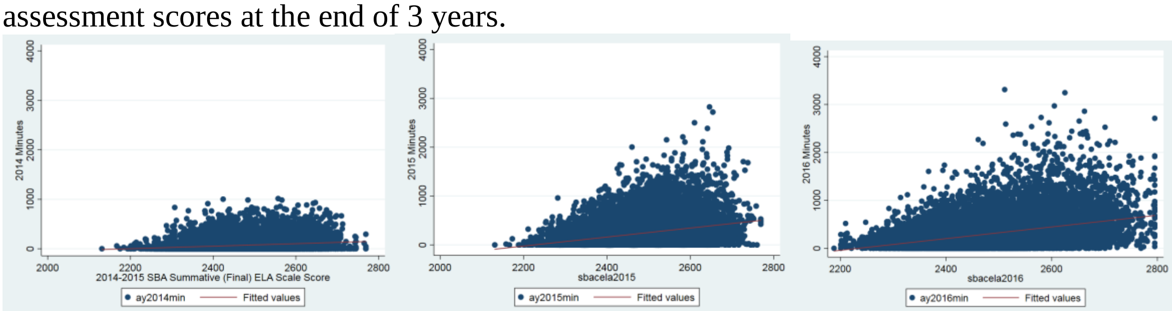


Figure 1. SEM model of digital writing minutes over 4 academic years and annual state assessment scores at the end of 3 years.



Figures 2, 3, and 4. Scatterplots showing annual ELA achievement scores and number of minutes of digital writing for each of the 2014, 2015, and 2016 academic years.

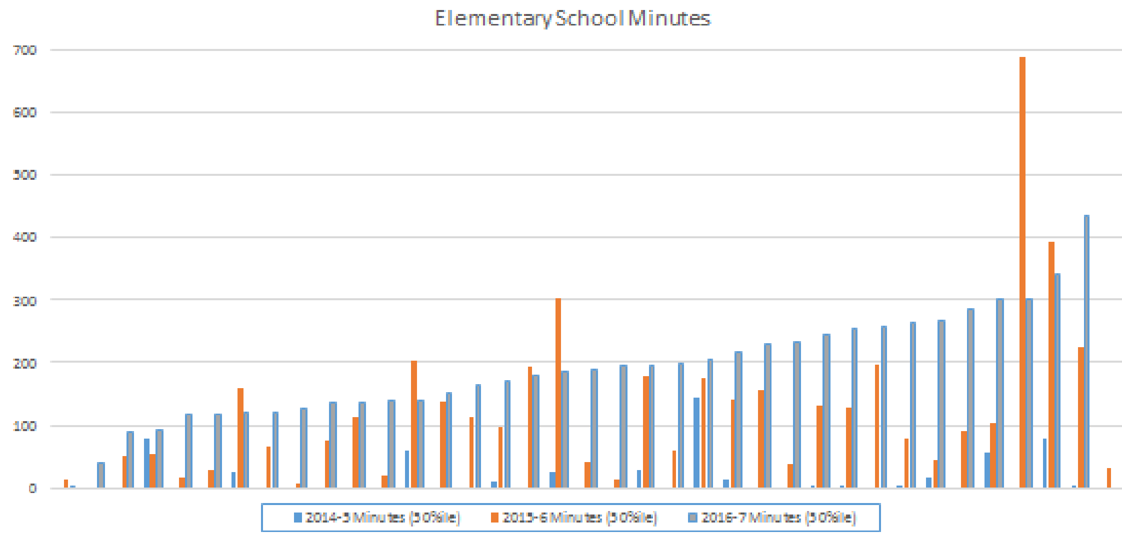


Figure 5. Elementary school annual minutes of digital writing by school at the 50th percentile over three academic years.

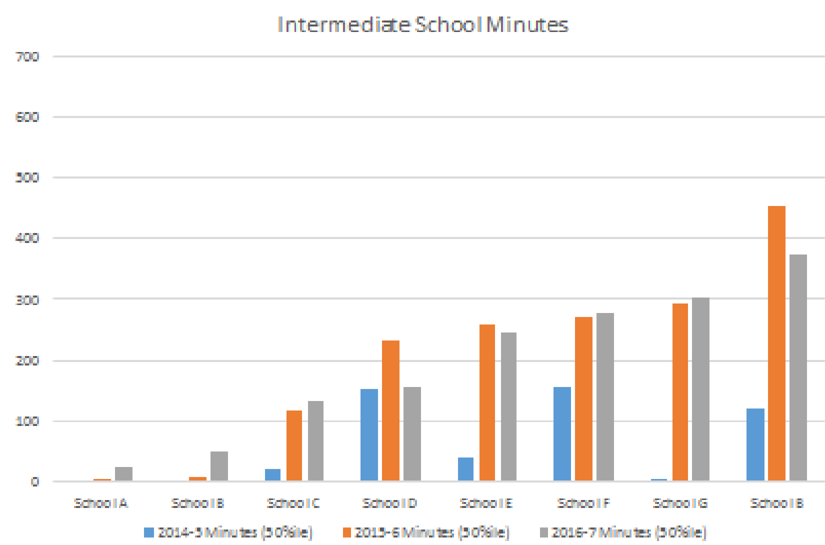


Figure 6. Intermediate school annual minutes of digital writing by school at the 50th percentile over three academic years.

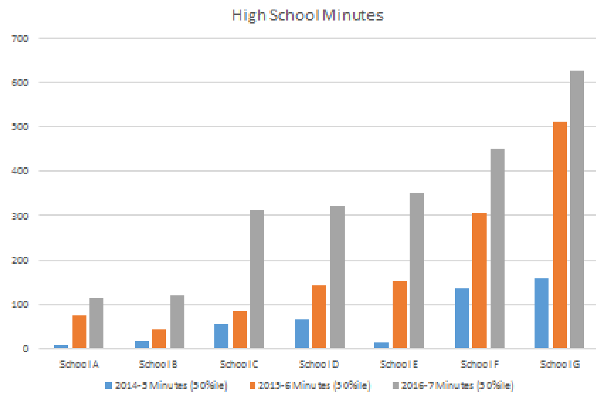


Figure 7. High school annual minutes of digital writing by school at the 50th percentile over three academic years.

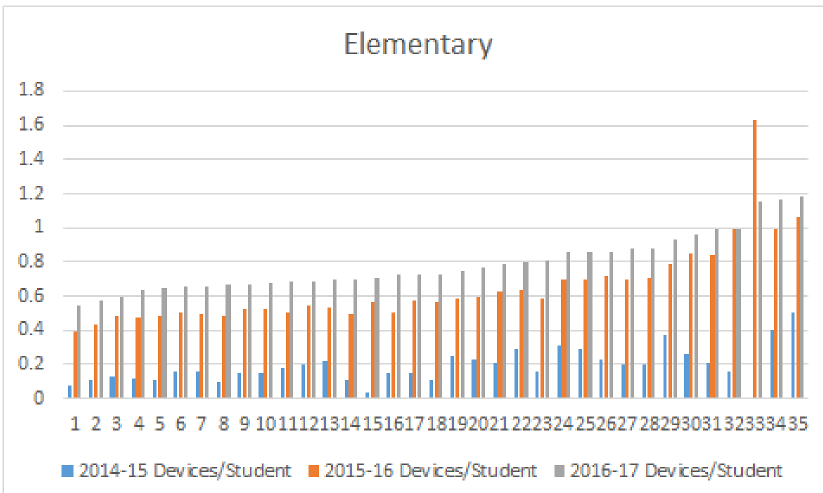


Figure 8. Number of digital devices per enrolled student at each elementary school (including K-8 and similar) over the three academic years.

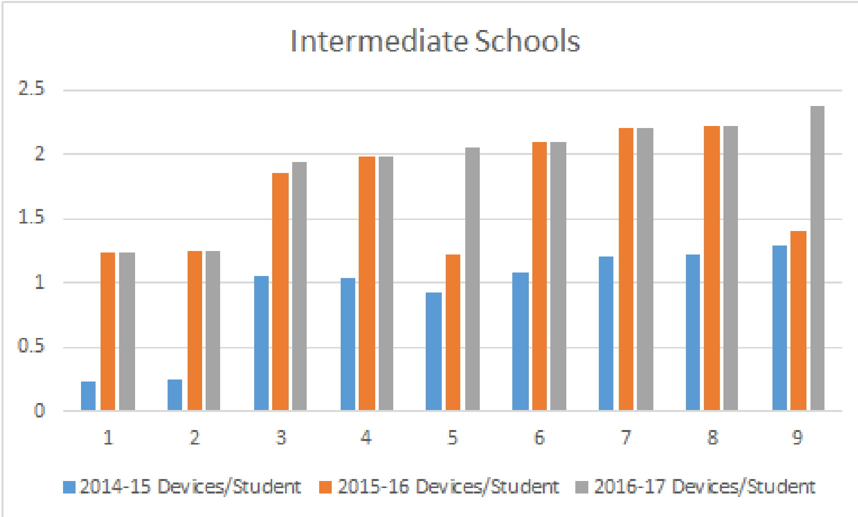


Figure 9. Number of digital devices per enrolled student at each intermediate school over the three academic years.

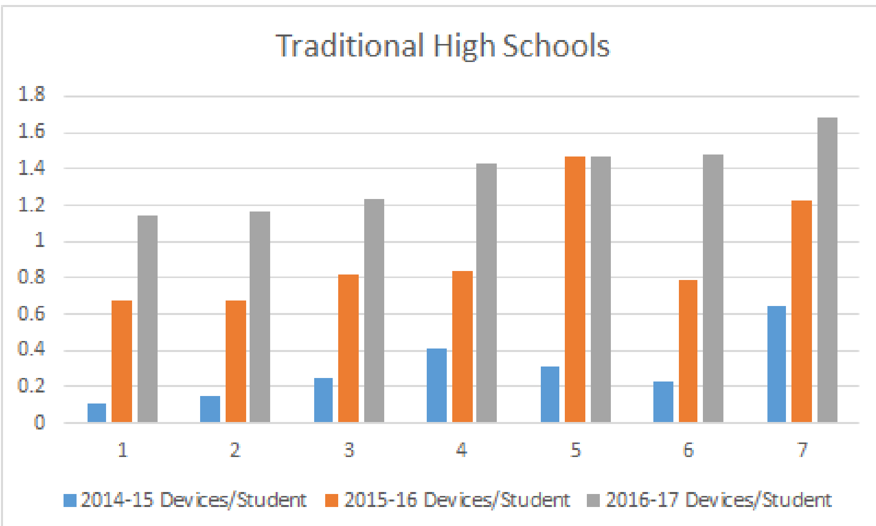


Figure 10. Number of digital devices per enrolled student at each traditional high school (continuation, other schools not shown) over the three academic years.

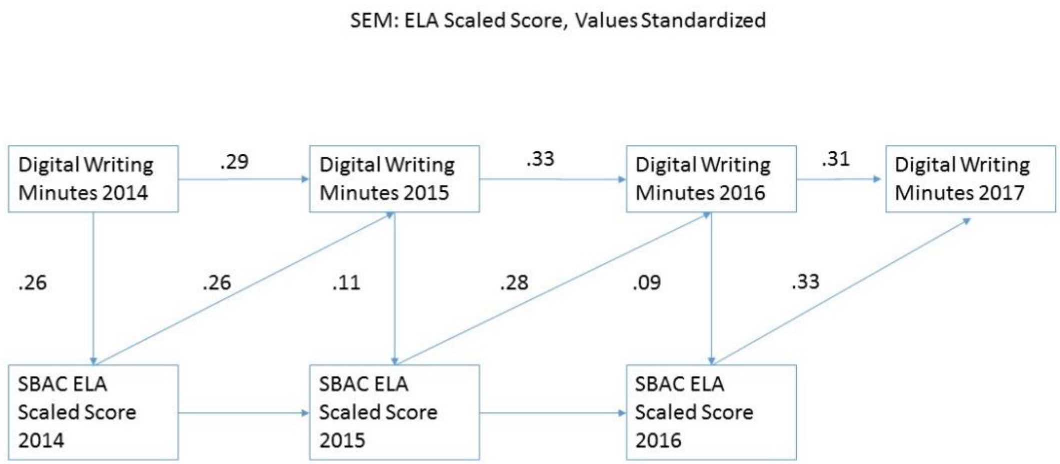


Figure 11. Results of SEM with ELA scaled score, all $p < 0.001$.

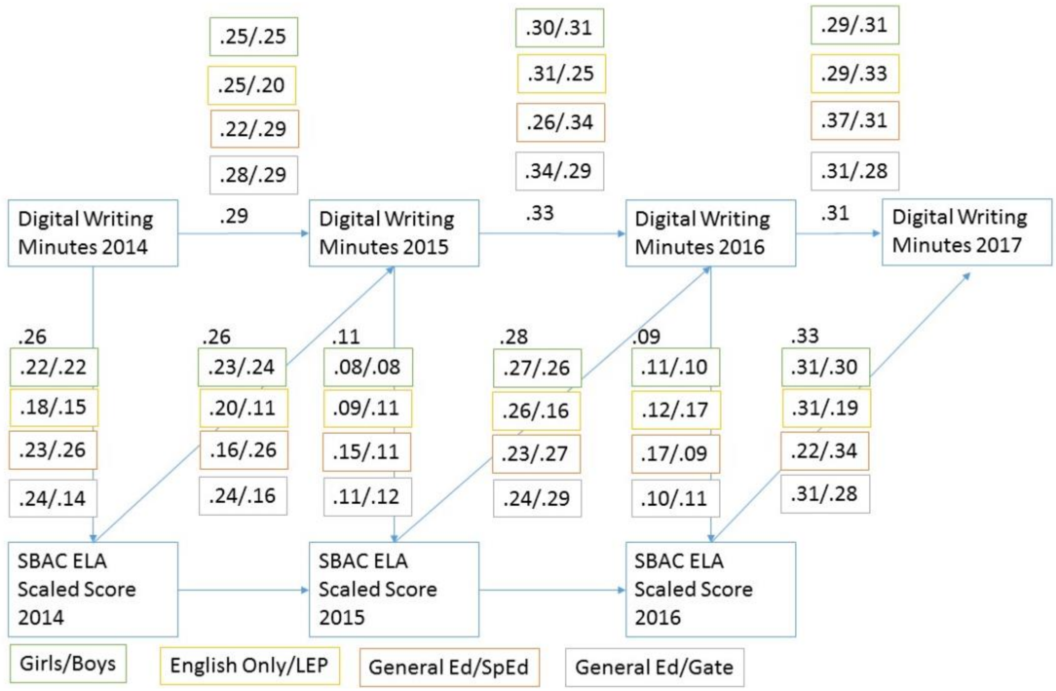


Figure 12. SEM for groups indicates the average results, plus the results for each group (men, limited English proficiency, receiving special education services, and identified as gifted) on the main paths.

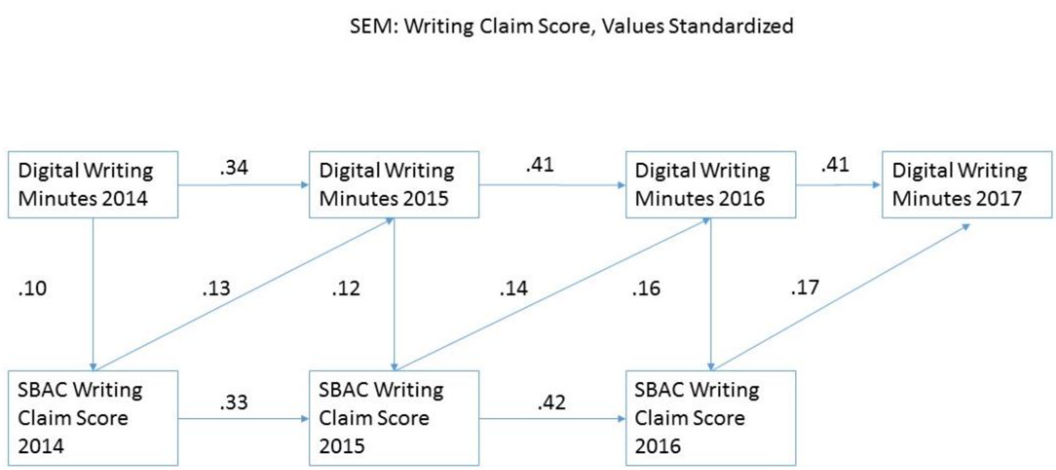


Figure 13. SEM using SBAC writing claim as achievement measure, all $p < 0.001$.

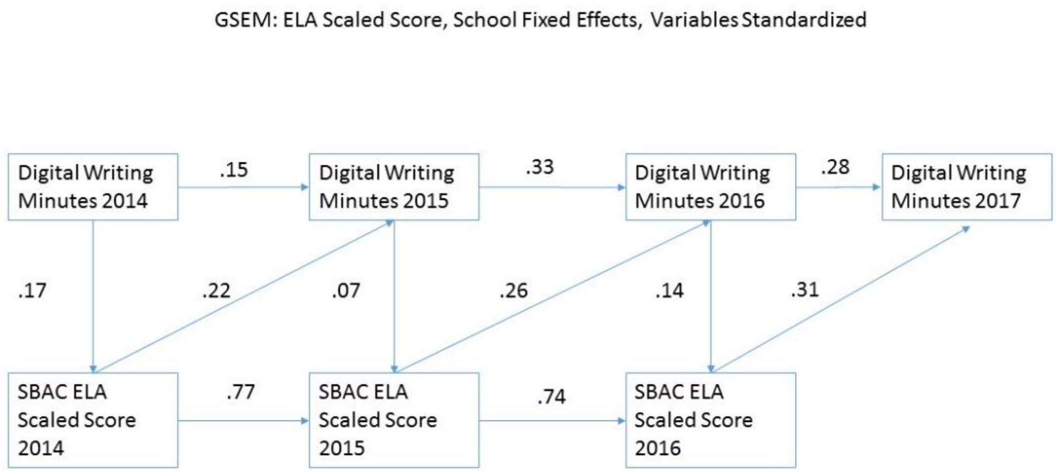


Figure 14. GSEM fixed effects model using ELA scaled score, variables standardized, all $p < 0.001$.