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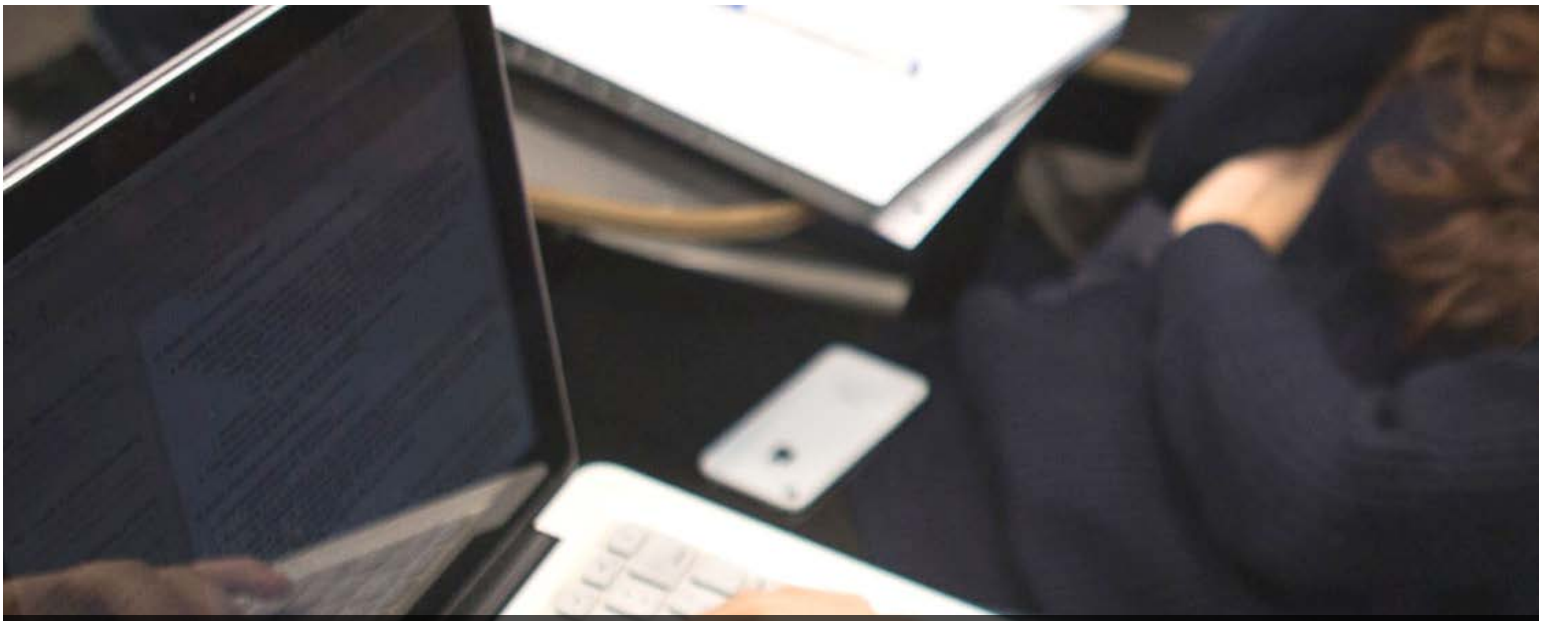

Using Personalized Learning to Improve Student Achievement: The Academic Impact of *GiftedandTalented.com's* Digital Math Program

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Metropolitan Center for Research on Equity and the Transformation of Schools
726 Broadway, 5th Floor | New York, New York 10003-6680
212 998 5100 | 212 995 4199 fax | 800 4NYU 224 | www.steinhardt.nyu.edu/metrocenter

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Using Personalized Learning to Improve Student Achievement: the Academic Impact of GiftedandTalented.com's Digital Mathematics Program

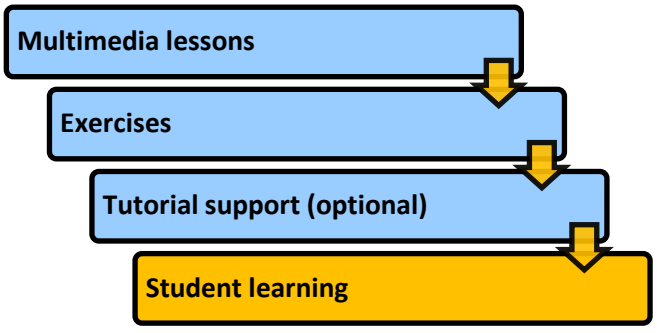
This study examines the academic growth of students at or below grade level who used the GiftedandTalented.com's *Digital Mathematics Program*. (DMP)[1] The study analyzed five years of DMP data from nearly 6,000 students, in grades 2 through 4, with a specific focus on struggling learners who began the program significantly below grade level. Our analyses revealed that all students made gains in the DMP, with struggling students achieving the greatest performance improvements. In addition, we found a positive relationship between time spent in the program and academic progress, particularly when students used the tutoring program's component.

What is the Digital Mathematics Program?

The Digital Mathematics Program (DMP) is an on-line, computer-based instructional resource which uses multimedia courses to introduce and illustrate fundamental math concepts. The DMP evolved from Stanford University's Education Program for Gifted Youth (EGPY), originally designed to help students become advanced learners through on-line resources focused on math, science and English language arts concepts. Through EPGY, Stanford researchers conducted in-depth studies on how best to advance student learning, and investigated emerging technologies that could encourage and support educational growth. This work became the foundation of EPGY's computer-based, multimedia courses in Mathematics, English, Language Arts, Science and Computer Programming, which have revolutionized the field of adaptive learning.

In 2013, Stanford University selected Redbird Advanced Learning to modernize the technology anchoring its EPGY, and to make the resulting on-line courses accessible to students around the world through GiftedandTalented.com (G&T.com). G&T.com was staffed by a team of educators, innovators and researchers from both Redbird and Stanford, who believed that helping students achieve academic excellence requires special technological resources. The design team recognized the need for an online community where students and their families could share ideas and resources and engage academic challenges.

Figure 1: Digital Mathematics Program Instructional Model



The DMP, one of the on-line, multi-media courses the design team developed, uses exercises to guide students' learning and mastery of core mathematics concepts, and incorporates built-in tutorial support for struggling learners. THE DMP offers two program components to meet the needs of students and their families: tutor supported and independent study (non-tutored) courses. Course content is more visual than in traditional classrooms, and all course sessions are purposefully short. Course exercises are designed to allow students to practice what they've learned through activities that range from answering simple knowledge-based questions to conducting virtual experiments and responding to open-ended probes. Students can pause and re-watch lessons as often as they wish.The software's diagnostic component assesses students' work and provides immediate feedback -- tutorial help designed to mimic the support an expert tutor might offer by

[1] EGPY Mathematics is an adaptive online mathematics course used by GiftedandTalented.com's (G&T.com), a division of Redbird Advanced Learning.

guiding students towards the correct answer rather than stating it, and also by providing additional exercises. This structure results in an individualized, self-paced curriculum in which students who master particular concepts can quickly proceed to more advanced material, while struggling students get the additional time and support necessary to master the initial concepts.

The DMP includes a course management and reporting system that provides detailed reports on students' progress, strengths, and weaknesses. The program also allows teachers to review specific course problems with students.

Several studies have examined the effects of EPGY courses such as the DMP on both gifted and talented youth and on struggling students from low-income families. Olzewski and Lee (2004) and Thompson (2010) analyzed the capacity of on-line distance learning programs to meet the academic needs of gifted students. A series of studies published in 1994 by Ravaglia, De Barros and Suppes, Stillman and Suppes, and Suppes and Ager demonstrated the effectiveness of computer-based math and science interventions for students taking advanced placement courses. Later research, primarily by Suppes, Holland, Hu and Vu (2009 and 2013) and Suppes, Liang, Macken and Flickinger (2014), demonstrated the positive outcomes of the DMP and other EGPY courses in schools serving Title 1 students who were struggling academically.[2] These studies, as well as others cited in the Appendix, indicate that EPGY in general and the DMP in particular are effective interventions for supporting and accelerating the academic outcomes of both gifted and talented youth and struggling students from low-income families.

Methods

This study analyzes the effects of the DMP on students who were assessed as at or below grade level by program measurements employed outside formal school settings. The study's data derive from a population of 6,216 students in grades 2 through 4 in a variety of U.S. school districts, who enrolled in the online DMP from 2009 to 2014. Students in this study used either the tutor-supported or independent study (non-tutored) components of the DMP. Students' initial program performance levels were assessed and recorded as their starting grade-level. When students finished the program, their ending grade- level was assessed and recorded. All the students in this study were identified by DMP program assessments as performing below their grade-level.

The DMP also recorded basic student demographics and assessed how much time students spent using the program, as well as measures of program engagement (i.e. sustained and careful student work). Students' grade placement and their grade-level performance were used to calculate how far behind or ahead students were relative to their grade placement, and the extent of change in grade-level performance from start to finish of their engagement with the DMP. Adjusted starting and ending grade placements were calculated by using the months in which the students started and stopped using the DMP, and then by accounting for whatever student growth might be attributable to their formal school settings. (All student participants in this study attended formal schooling daily and used the DMP during their off-school hours.)

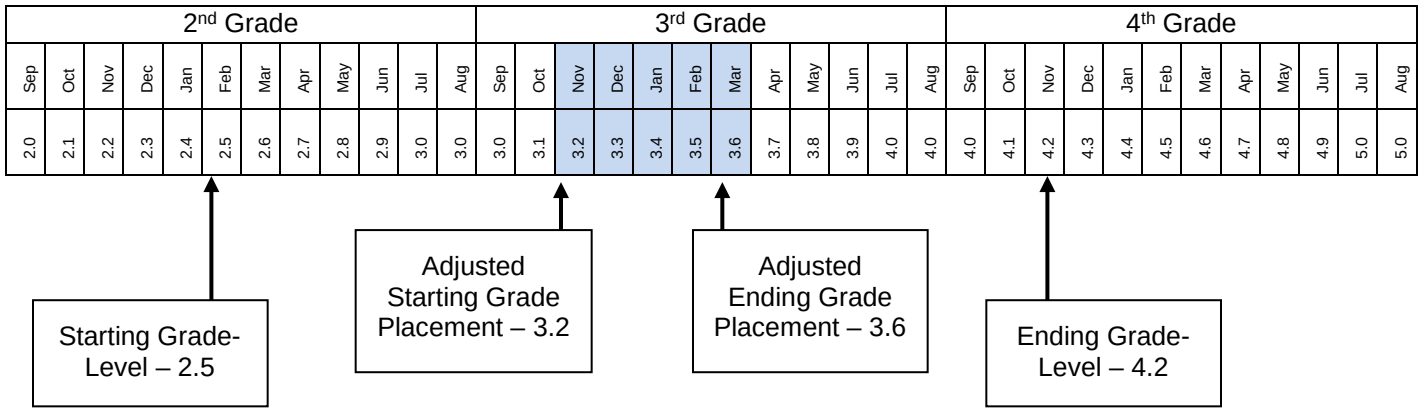
The study adjusted for the formal school settings' contributions to students' learning by adding 0.1 to their reported grade placement for each month of formal schooling attended while using the DMP, not counting

[2] Olzewski-Kubilius & Lee (2004); Ravaglia, De Barros & Suppes, (1994); Stillinger & Suppes (1994); Suppes & Ager (1994); Suppes, Holland, Hu & Vu, (2009 & 2013); Suppes, Liang, Macken & Flickinger (2014).

the summer months (see Box 1 for an example). This adjustment is a traditional research measure for estimating the extent of formal school learning, which often overstates how much that schooling actually contributes. Therefore our measures of how much progress students they make when they use the DMP may well be somewhat understated.

Box 1: Example of adjusted versus unadjusted measures of grade-level changes

A third grade student begins using DMP in November. At that time she is assessed at a starting grade-level level of 2.5. She stops using the DMP in March, and is assessed at a grade-level of 4.2.



Unadjusted	Adjusted
An unadjusted analysis shows that the student starts the DMP 0.5 grade-levels behind, and completes the DMP 1.2 grade-levels ahead – a total growth of 1.7 grade levels.	An adjusted analysis shows that the student starts the DMP two months into the regular school year, and completes the DMP six months into the regular school year. She started the DMP 0.7 grade levels behind and finished the DMP 0.6 grade levels ahead – a total growth of 1.3 grade-levels

Table 1: Key DMP variables and measures

Key Variables and Measures	Description
Sessions	The number of sessions a student completed
Time	The number of minutes students spent using the DMP as measured by the length of time they were logged on to the program
Exercises	The number of exercises completed by the student
Start Time	When the student started using the DMP
End Time	When the student stopped using the DMP
Duration	The number of days in the interval between when the student started and stopped using the DMP
Percent Correct First Attempts	The percentage of exercises in which the student provided a correct response on the first attempt. Past research has used this as a measure of sustained and careful work.
Starting Grade-Level	Assessed grade-level when student started using the DMP (as determined by program measures).
Ending Grade-Level	Assessed grade-level when student stopped using the DMP (as assessed by program measures.)
Grade-Level Change	Change in the assessed grade level (from Starting Grade-Level to Ending Grade-Level)
Grade Placement	The regular school grade the student was enrolled when starting the DMP
Adjusted Starting Grade Placement	The grade the student was enrolled in when starting the DMP, adjusted for how far along in the school year the student was.
Adjusted Ending Grade Placement	The regular school grade the student was enrolled when starting the DMP, adjusted for how far along in the school year the student was when they stopped using the DMP
Adjusted Grade-Level Change	Change in the students' assessed grade-level from the Adjusted Starting Grade-Level to the Adjusted Ending-Grade-Level
Program	Dichotomous variable indicating if the student was enrolled in the Digital Mathematics Program with tutoring support or without tutoring support (i.e., independent).

Initial descriptive statistics were run on all the above variables. Preliminary analysis revealed that 297 students used the DMP for less than one day or for only one session, and the vast majority of these students (96.3%) used the program independently, without tutor support. Since this study focuses on substantive student engagement with the DMP, these 297 essentially one-time student users were removed from the data, leaving 5,919 student cases for analysis. Further descriptive statistical analyses assessed the DMP's use by 2nd through 4th grade participants,[3] highlighting changes between students' adjusted starting and ending grade-levels. These analyses initially examined overall changes, regardless of program and grade, and then separated out changes between students participating in the tutor-supported and independent study (non-tutored) programs, in the context of their grade placements. Specific attention was paid to students who were significantly below grade-level when they started using the DMP – i.e., students who were assessed as performing more than one and one half grade-levels below their grade-placement.

Starting and ending grade-level differences were used to examine the extent of growth across all student grade-levels. Starting grade-level differences are the differences between students' grade-level as assessed by the DMP when they started the program, and the formal school grade in which they were enrolled (grade placement). Similarly, ending grade-level differences are the differences between students' grade-level

[3] Depending on how the data were disaggregated, the assumptions of some parametric tests were either upheld or violated. Therefore, both parametric and non-parametric tests were used throughout this study.

as assessed when they stopped using the DMP and their formal school grade placement. Additionally, our analyses examined the DMP's impact on students' academic achievement, based on their exposure to the program and the intensity of their participation. Students' total exposure to the program, measured in sessions completed and hours engaged, was organized into quartiles from the lowest to highest levels of program exposure. The quartiles were used as independent variables to measure changes in outcomes.

This study has several limitations. First, it is essentially a case study of several years of student data resulting from the use of one on-line instrument (the DMP) with two options, a tutor-supported and an independent program component. This study was not a randomized control trial, nor were there any control groups for comparison or contrast. Rather, this was a case study in which the patterned student outcomes resulting from two versions of the program (independent and tutored) were analyzed, and a set of findings were developed. While this study is useful for its initial findings and exploratory trend analyses, the study design, and its conclusions, yield less statistical validity than the results of more rigorous research.

Findings

Using the DMP

This study analyzed data from almost 6,000 students in second, third, and fourth grade classes in districts across the country who participated in the DMP from 2009 through 2014 (Table 2). Approximately one quarter of this study's participants used the DMP's tutoring support component, while the remaining students used the DMP independently. The participants were well-distributed across grade levels in both the tutoring and non-tutoring components, though there were slightly fewer 2nd grade students in the tutoring program component compared to the 3rd and 4th grade students using the same component.[4]

Table 2: Grade placement and school year of Digital Mathematics Program participants

	Grade Placement/ School-Year	2009-10	2010-11	2011-12	2012-13	2013-14	Total
Overall	2nd grade	366	371	387	287	330	1741
	3rd grade	424	426	412	350	405	2017
	4th grade	422	499	438	382	420	2161
	Total	1212	1296	1237	1019	1155	5919
Independent	Grade Placement/ School-Year	2009-10	2010-11	2011-12	2012-13	2013-14	Total
	2nd grade	288	308	301	217	250	1364
	3rd grade	300	317	297	255	301	1470
	4th grade	308	374	307	266	308	1563
	Total	896	999	905	738	859	4397
Tutor	Grade Placement/ School-Year	2009-10	2010-11	2011-12	2012-13	2013-14	Total
	2nd grade	78	63	86	70	80	377
	3rd grade	124	109	115	95	104	547
	4th grade	114	125	131	116	112	598
	Total	316	297	332	281	296	1522

[4] The DMP system recorded student grade levels based on a May 1 to April 30th calendar. Thus a student listed as starting the DMP in May is actually one regular school grade placement below their recorded grade placement in the DMP system. For example, a 4th grade student who started the DMP in May was actually enrolled in 3rd grade when she started using the program. This discrepancy was corrected for in the adjusted grade placements.

On average, DMP participants engaged in more than 50 sessions and completed more than 1,600 exercises in slightly more than 17 hours (1024.6 minutes). From start to end, DMP students were enrolled an average of 143.8 days (Table 3). Participants using the tutoring support component on average spent more time (in minutes) using the program, engaged in more sessions and completed more exercises, compared to those students who used the program's non-tutoring component independently. The non-tutored participants used the program for more days than students who used tutoring support. Both groups were nearly equal in their level of sustained and careful work in their respective programs (as measured by the percent of correct first attempts.[5])

Table 3: Overall participation and engagement

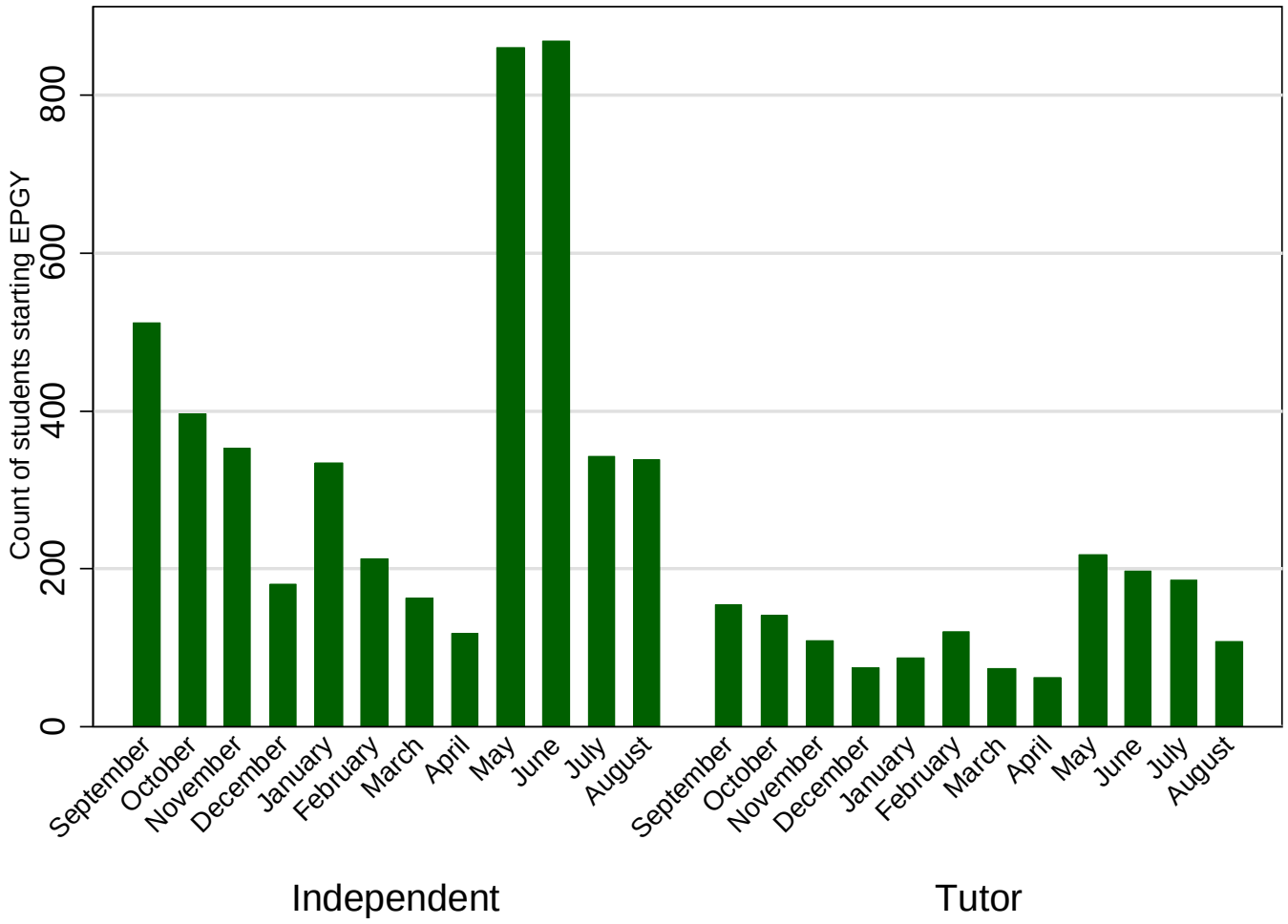
Key Participant Variables	Overall (N=5,919)			Independent (N=4,397)			Tutor (N=1,522)		
	Mdn	M	SD	Mdn	M	SD	Mdn	M	SD
Sessions	31.00	53.36	65.49	23.00	41.47	53.86	64.00	87.70	81.94
Time (in minutes)	569.98	1024.62	1279.60	407.25	765.57	990.46	1322.36	1773.00	1667.64
Duration (in days)	120.00	143.80	102.88	132.00	147.10	105.62	90.00	134.24	93.89
Completed Exercises	1062.00	1623.69	1699.20	775.00	1319.23	1508.30	2076.00	2503.27	1901.78
% Correct 1st Attempt	87.12	85.76	8.11	87.40	85.90	8.44	86.27	85.37	7.04

N = Total sample size
Mdn = Median
M = Mean
SD = Standard Deviation

Participants varied in terms of when they started the DMP, but as shown in Figure 2, the majority of users started the program in May and June, regardless of whether they used the program independently or with tutoring support. December, March, and April saw the lowest rates of new program enrollment.

[5] Students using the program independently were statistically slightly more engaged in the program, with slightly higher percentages of correct first attempts, than students using the tutoring program.

Figure 2: Distribution of months when students starting using the Digital Mathematics Program, by program



Impact of the Digital Mathematics Program

Our analyses indicate that the DMP has a clear positive impact on student performance in both its tutoring and non-tutoring components, though the tutoring components' results are considerably stronger. We used one-sample t-tests to determine if the adjusted grade-level gains were statistically different from zero, and we employed paired-sample t-tests, Wilcoxon matched-pairs signed-ranks test, and sign tests of matched pairs to determine if the ending grade-levels were statistically different from the starting grade-levels.

Student participants experienced, on average, more than one and one-half grade-levels' growth over the course of a single school year, not adjusting for whatever growth may have occurred in their formal school settings. Moreover, the data indicates that students using the DMP added almost 1.2 grade-levels of growth beyond any growth attributed to time spent in formal schooling (Table 4 and Figure 3).

Table 4: Academic growth by program

	Overall (N=5,919)			Independent (N=4,397)			Tutor (N=1,522)		
Unadjusted	Mdn	M	SD	Mdn	M	SD	Mdn	M	SD
Starting Grade Level Difference	-0.50	-0.60	0.53	-0.50	-0.58	0.44	-0.30	-0.64	0.74
Ending Grade Level Difference	0.76	0.96	1.28	0.59	0.75	1.15	1.37	1.58	1.40
Academic Growth (in grade-levels)	1.27	1.56	1.32	1.12	1.33	1.15	2.00	2.23	1.54
Adjusted	Mdn	M	SD	Mdn	M	SD	Mdn	M	SD
Starting Grade Level Difference	-0.50	-0.68	0.56	-0.50	-0.65	0.46	-0.60	-0.76	0.77
Ending Grade Level Difference	0.30	0.50	1.17	0.11	0.28	1.04	0.98	1.14	1.29
Academic Growth (in grade-levels)	0.90	1.18	1.24	0.69	0.93	1.05	1.62	1.90	1.46

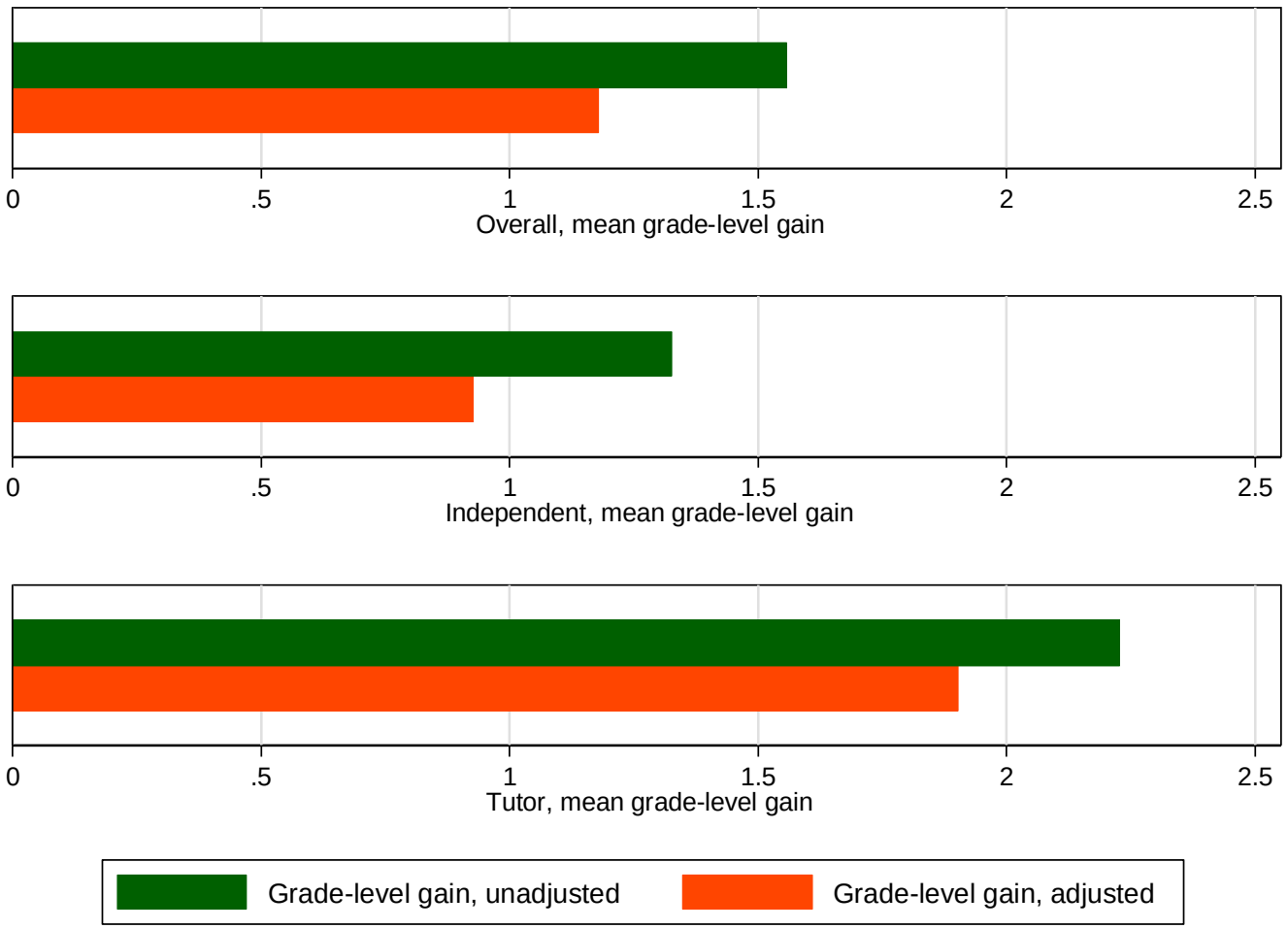
N = Total sample size
Mdn = Median
M = Mean
SD = Standard Deviation

Our analyses indicate that a large percentage of students previously performing below grade-level were able to meet and often exceed their grade-level performance by using the DMP; on average, students using the DMP made very impressive grade-level gains (Table 4 and Figure 4).[6] As noted above, although all the study's participating students were assessed at or below grade level when they began using the DMP, more than half those students advanced to above grade-level performance by their program completion.[7]

[6] Paired-sample t-tests and Wilcoxon sign-rank tests were used to compare students starting grade-level difference to their ending grade-level difference.

[7] The unadjusted data included only students who were at or below grade level. However, after adjusting grade placement data, a small number of students in the sample were slightly above grade-level.

Figure 3: Comparison of grade-level changes by program

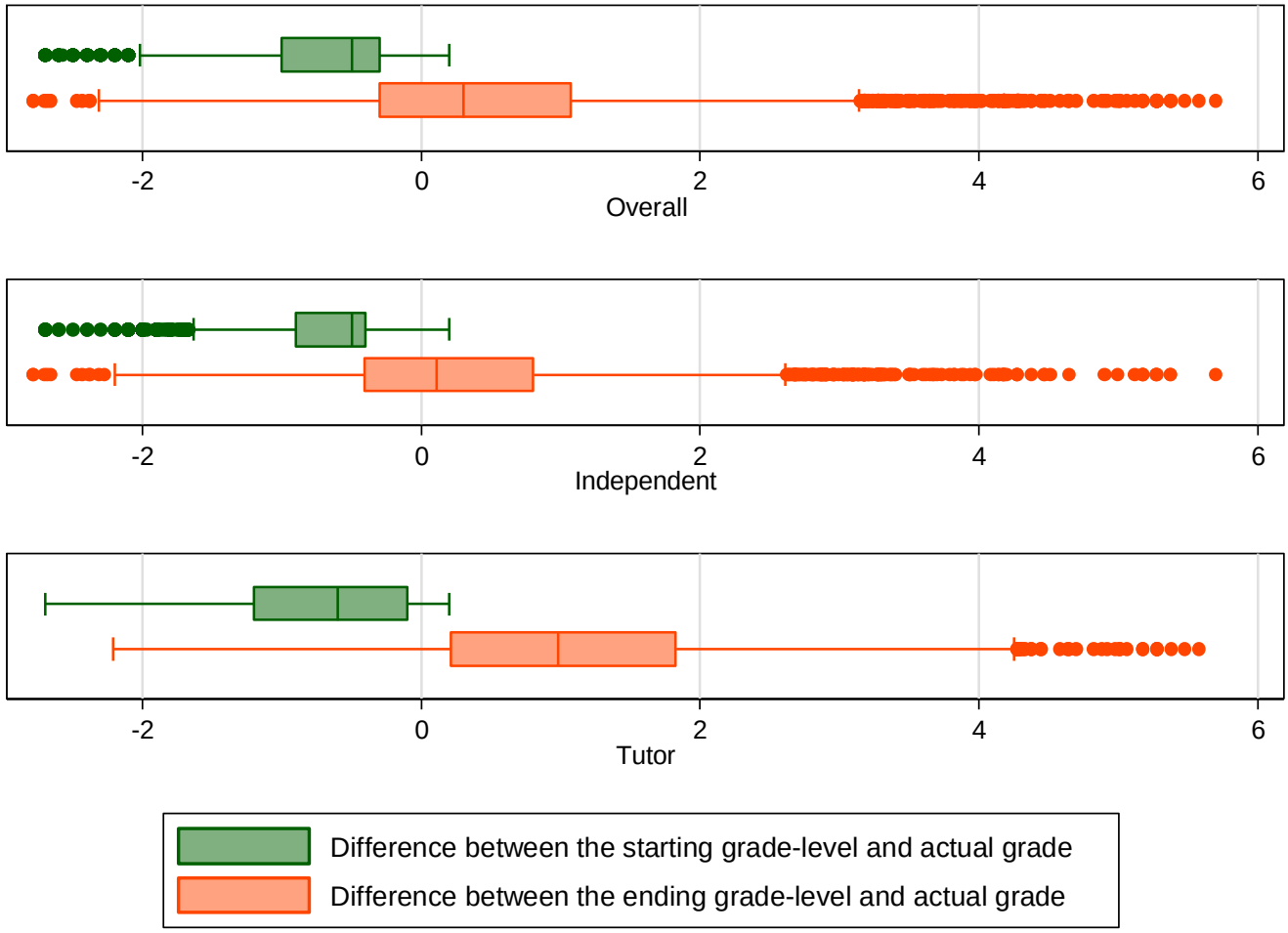


As Figure 4 below shows, there was some variation in the starting grade-level performance of students who used the DMP independently versus those who used the tutoring program component. Students using the tutoring program had slightly lower grade-level starting points compared to students using the program independently. Yet our data show that students using the tutoring program experienced significantly greater growth.[8] On average, students using the tutoring program experienced nearly two grade-levels of growth in a single school year, in addition to the growth that might be attributed to time spent in formal school settings. This result for students using the DMP's tutoring component is one grade-level more than for students using the DMP's program independently. Thus more than 75% of the students using the Digital Mathematics Program tutoring program were above grade-level by the time they completed the program.

Yet the students who used the DMP independently also benefited from the program. They experienced nearly 0.9 grade-levels of growth (or almost a full school year) in addition to growth that might be attributed to time spent in formal school settings. More than half the students using the DMP independently were above grade-level after completing the program.

[8] Two-sample t-tests, Wilcoxon rank sum tests, and nonparametric equality-of-medians test were used to examine the difference between the starting grade-level differences of students using the Digital Mathematics Program on their own (independently) and those using the tutoring program. The same tests were used to examine grade-level changes between programs.

Figure 4: Comparison of starting grade-level difference and ending grade-level differences, adjusted for when students started and stopped using the Digital Mathematics Program



Struggling Learners Becoming Advanced Learners

Our study's findings indicate that the DMP can help struggling learners perform considerably above their grade-levels, meaning they can become advanced learners. More than 1,100 study participants started the DMP at least a grade-level below their actual grade placement, and 464 began the DMP more than one and one half grade-levels behind their actual grade. Our data suggests that the DMP was particularly effective for these struggling learners; students participating in the DMP who were furthest behind their peers made the most gains in academic outcomes. (Table 5 and Figure 5 below).[9] Struggling learners in the tutoring program made particularly impressive progress. Students using tutoring who were more than one and half grade-levels behind when they started the DMP, for example, experienced almost three and one quarter years of growth in a single school-year (beyond normally expected school year growth). Similar struggling students participating

[9] Kruskal-Wallis rank tests with Wilcoxon rank-sum test as well as one-way analyses of variances (ANOVAs) suggest that the grade-level gains differed significantly between quintile groups. Post hoc estimations revealed significant differences between grade-level changes experienced for the students starting the farthest behind (1st and 2nd quintile) compared to those starting the Digital Mathematics Program closer to grade level (3rd, 4th, and 5th quintiles). One sample t-tests showed that adjusted grade-level gains were statistically different from zero, and paired-sample t-tests, Wilcoxon rank sum tests, and sign tests of matched pairs showed that the grade-level gains experienced in each quintile group were significant.

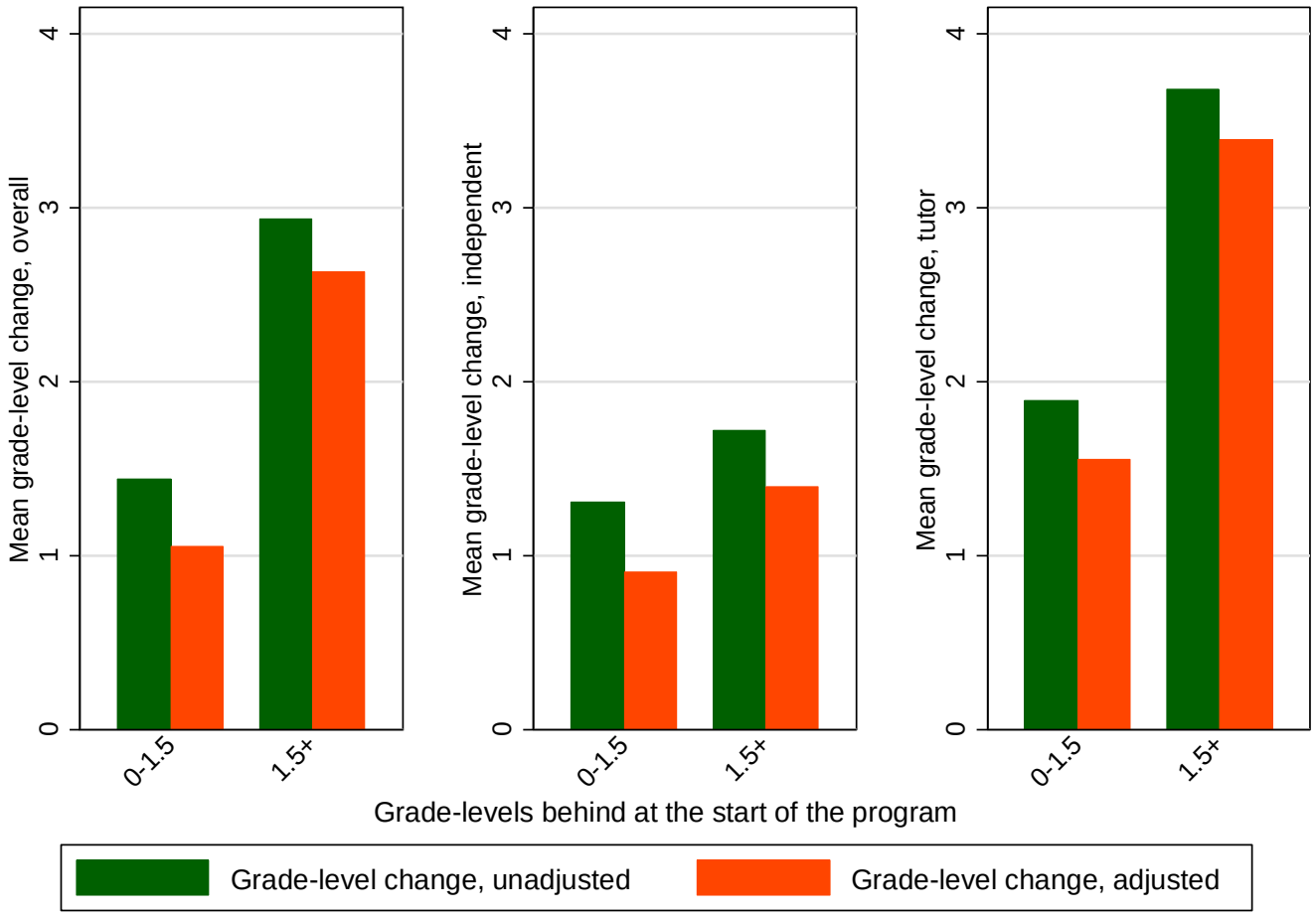
in the online program independently averaged slightly less than one and a half grade-levels of growth. Moreover, we found an inverse relationship between how far behind a student was and how much growth they made – i.e., the farther behind the student, the more progress they achieved (Table 10 in the appendix).

Table 5: Academic growth by differences between starting grade-level and adjusted starting grade placement

Grade-Levels Behind at the Start of the Program	Overall (N=5,919)			Independent (N=4,397)			Tutor (N=1,522)		
	Mdn	M	SD	Mdn	M	SD	Mdn	M	SD
0.0 to 0.5[a]	0.66	0.93	1.08	0.51	0.76	0.97	1.12	1.45	1.22
0.5 to 1.0[b]	0.92	1.13	1.07	0.80	0.97	0.98	1.49	1.75	1.18
1.0 to 1.5[c]	1.21	1.39	1.21	1.15	1.33	1.22	1.41	1.62	1.14
1.5 to 2.0[d]	2.11	2.36	1.74	1.15	1.43	1.35	2.93	3.15	1.65
2.0 to 2.5[e]	3.41	3.33	1.53	1.04	1.04	0.67	3.65	3.79	1.20
2.5+[f]	3.72	3.21	1.70	0.99	1.65	1.60	3.78	3.74	1.41

N = Total sample size
Mdn = Median
M = Mean
SD = Standard Deviation
a. At grade level through.5 grade levels behind
b. More than .5 grade-level behind through 1 grade-level behind
c. More than 1 grade-level behind through 1.5 grade-levels behind
d. More than 1.5 grade-levels behind through 2 grade-levels behind
e. More than 2 grade-levels behind through 2.5 grade-levels behind
f. More than 2.5 grade-levels behind

Figure 5: Academic growth by differences between starting grade-level and starting grade placement



Exposure and Engagement with the Digital Mathematics Program

Our findings indicate that the greater the exposure students had to the DMP, the greater their academic gains. The more DMP sessions completed by students, and the more time students spent engaged with the DMP, the greater their academic growth. Interestingly, although students experienced increased grade-level gains the longer they used the DMP, we found that students can experience considerable grade-level growth by participating in only a few program sessions.

As noted above, students using the DMP's tutoring support component on average spent more time using the program, engaged in more sessions and completed more exercises, compared to those students who used only the program's online system independently. In terms of struggling students, those who began the program more than one and half grade-levels behind, students using the tutoring program spent three times the amount of engaged time and completed nearly twice as many exercises, compared to students who worked independently in the program, even when both groups used approximately the same number of days (Table 6).

Figure 6: Academic growth by number of sessions completed and time (in minutes) spent using the Digital Mathematics Program[10]

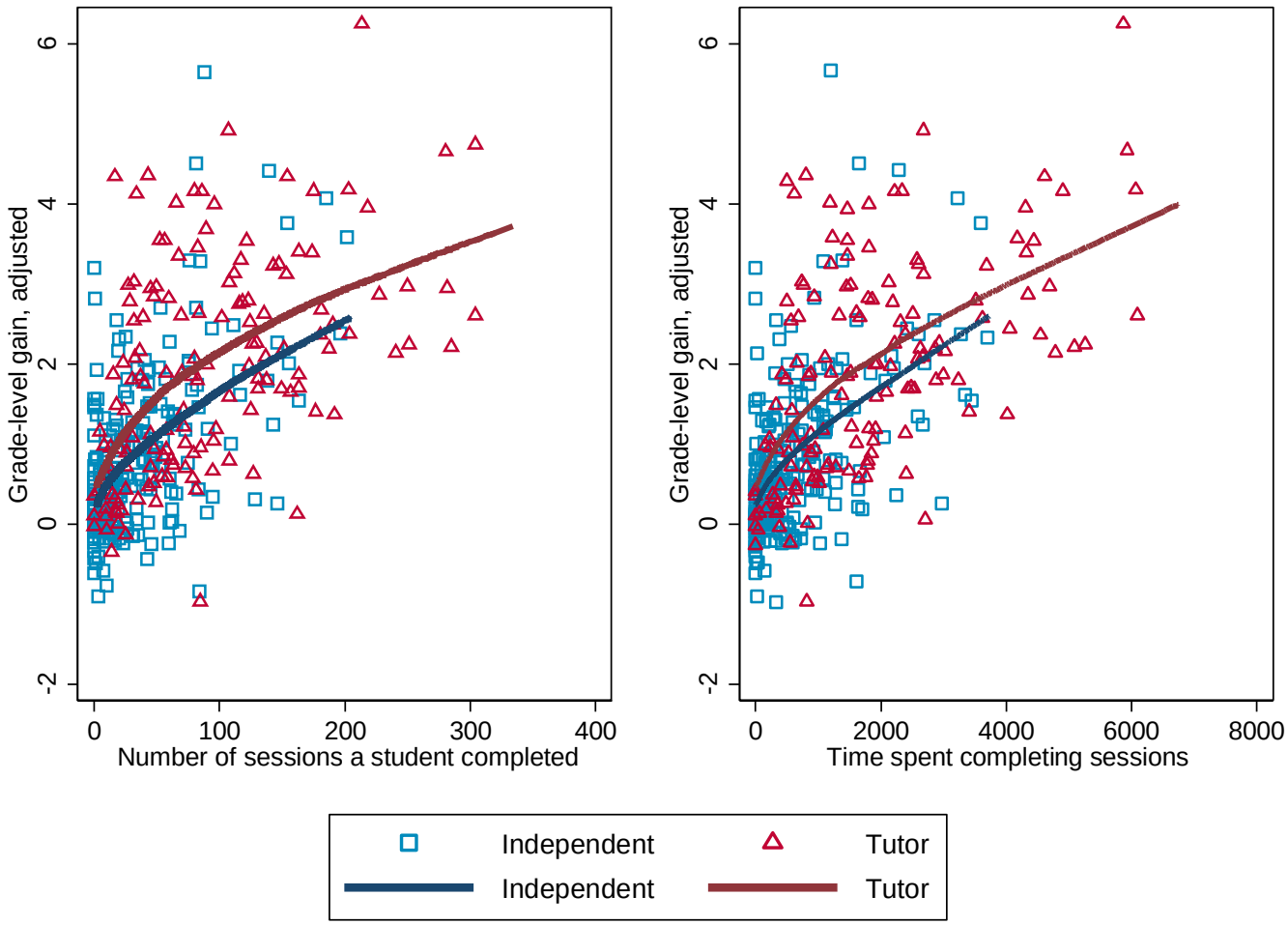


Table 6: Participation and engagement of struggling learners

Key Participant Variables	Overall (N=464)			Independent (N=4,397)			Tutor (N=1,522)		
	Mdn	M	SD	Mdn	M	SD	Mdn	M	SD
Sessions	41.00	65.42	79.94	18.00	33.34	52.93	59.00	85.21	87.12
Time (in minutes)	768.84	1235.62	1540.27	338.35	558.50	649.20	1132.63	1653.21	1767.08
Duration (in days)	88.00	118.58	90.61	100.00	115.59	93.40	87.00	120.43	88.96
Completed Exercises	1554.50	2054.69	1865.79	714.00	1147.14	1336.28	2327.00	2614.39	1926.83
% Correct 1st Attempt	89.38	88.41	6.86	88.55	87.24	8.27	89.54	89.13	5.73

N = Total sample size
Mdn = Median
M = Mean
SD = Standard Deviation

[10] To better visualize the data, this scatterplot displays only a random sample of cases from the dataset. Locally weighted scatterplot smoothing lines (or lowess lines) were generated from all of the data (excluding any univariate outliers) and have been overlaid onto the scatterplot .

To assess students' academic growth in relation to the extent of their exposure to the program, our analysis separated student participants into relatively equal groups, based on the number of sessions students completed and the amount of time students spent using the program. Since students' participation in the DMP varied in terms of which program component, tutor-supported or independent, they used, these groupings are relative to their program component.

On average, students who worked independently and were in the lowest quintile of completed program sessions had a less than one-third grade-level increase (0.32), compared to an almost two grade-levels increase (1.85) for students who worked independently and were in the highest quintile of completed program sessions. Similarly, tutoring program students who were in the lowest quartile of completed sessions had nearly a one grade-level increase (0.94), compared to an almost three (2.99) grade-levels increase for tutoring program students in the highest quintile (Table 7). We found similar patterns in relation to the amount of time (in minutes) students spent using the DMP. Students in both program components who spent more time using the program experienced greater grade-level gains, while students in the tutoring program posted the greatest grade-level gains (Table 8). We also found a relationship between the duration of time students were enrolled in the DMP and their grade-level gains, but the effect size of this relationship was relatively weaker.

Table 7: Academic growth by difference in number of sessions completed

Number of sessions by quintile		Number of sessions		Grade-level gain, adjusted		
Overall (N=5,919)	N	Min	Max	Mdn	M	SD
1st Quintile (fewest)	1284	2	9	0.12	0.38	0.72
2nd Quintile	1089	10	21	0.51	0.71	0.89
3rd Quintile	1218	22	45	0.87	1.06	1.01
4th Quintile	1161	46	85	1.23	1.45	1.13
5th Quintile	1167	86	845	2.15	2.35	1.36
Independent (N=4,397)	N	Min	Max	Mdn	M	SD
1st Quintile (fewest)	888	2	6	0.09	0.32	0.67
2nd Quintile	906	7	16	0.38	0.56	0.83
3rd Quintile	867	17	33	0.69	0.82	0.85
4th Quintile	858	34	65	0.98	1.11	0.90
5th Quintile	878	66	845	1.70	1.85	1.20
Tutor (N=1,522)	N	Min	Max	Mdn	M	SD
1st Quintile (fewest)	305	2	26	0.60	0.94	1.15
2nd Quintile	305	27	50	1.06	1.50	1.25
3rd Quintile	305	51	81	1.44	1.77	1.24
4th Quintile	306	82	135	2.04	2.32	1.28
5th Quintile	301	136	828	2.85	2.99	1.48

N = Total sample size
Mdn = Median
M = Mean
SD = Standard Deviation

Table 8: Academic growth by difference in time engaged in the Digital Mathematics Program

Time using DMP by quintile		Time (minutes)		Grade-level change		
Overall (N=5,919)	N	Min	Max	Mdn	M	SD
1st Quintile (fewest)	1184	1.58	140.38	0.10	0.37	0.75
2nd Quintile	1185	140.57	389.18	0.48	0.70	0.90
3rd Quintile	1183	389.70	834.17	0.83	1.02	0.96
4th Quintile	1184	834.25	1646.85	1.21	1.43	1.12
5th Quintile	1183	1647.67	15670.03	2.15	2.37	1.34
Independent (N=4,397)	N	Min	Max	Mdn	M	SD
1st Quintile (fewest)	880	1.58	106.75	0.09	0.34	0.71
2nd Quintile	879	106.82	284.13	0.35	0.54	0.82
3rd Quintile	880	284.22	582.98	0.68	0.81	0.84
4th Quintile	879	583.08	1231.90	0.97	1.11	0.92
5th Quintile	879	1232.30	14805.99	1.70	1.85	1.18
Tutor (N=1,522)	N	Min	Max	Mdn	M	SD
1st Quintile (fewest)	305	7.58	514.03	0.51	0.91	1.15
2nd Quintile	304	514.78	1029.58	1.06	1.48	1.21
3rd Quintile	305	1030.25	1663.27	1.37	1.82	1.31
4th Quintile	304	1664.00	2715.22	2.02	2.29	1.19
5th Quintile	304	2718.73	15670.03	2.83	3.01	1.49

N = Total sample size
Mdn = Median
M = Mean
SD = Standard Deviation

We found only a weak relationship between how far behind grade-level students were when they started the DMP, how many sessions they completed, and how much time they spent using the DMP.

Past studies of programs using varieties of technology-based on-line resources for gifted youth have used the percent of correct first attempts to answer program questions (CFA) as an effective measure of students' sustained and careful work. Our research found that for those students who used the DMP's tutoring component, the greater the percentage of students' correct first attempts, the greater their gains; those students who actively engaged in careful and sustained work in the DMP tutoring component experienced increased academic growth (Figure 7). Students in the tutoring program in the lowest quintile of percent of correct first attempts had an almost one and third (1.30) grade-level increase, compared to an almost two and a half (2.40) grade-level increase for students in the highest quartile (Table 9). This relationship did not obtain for students using the DMP independently. Once those students reached a basic level of engagement, their academic gains remained relatively flat at about a one grade-level increase.

Figure 7: Academic growth by the percent of correct first attempts

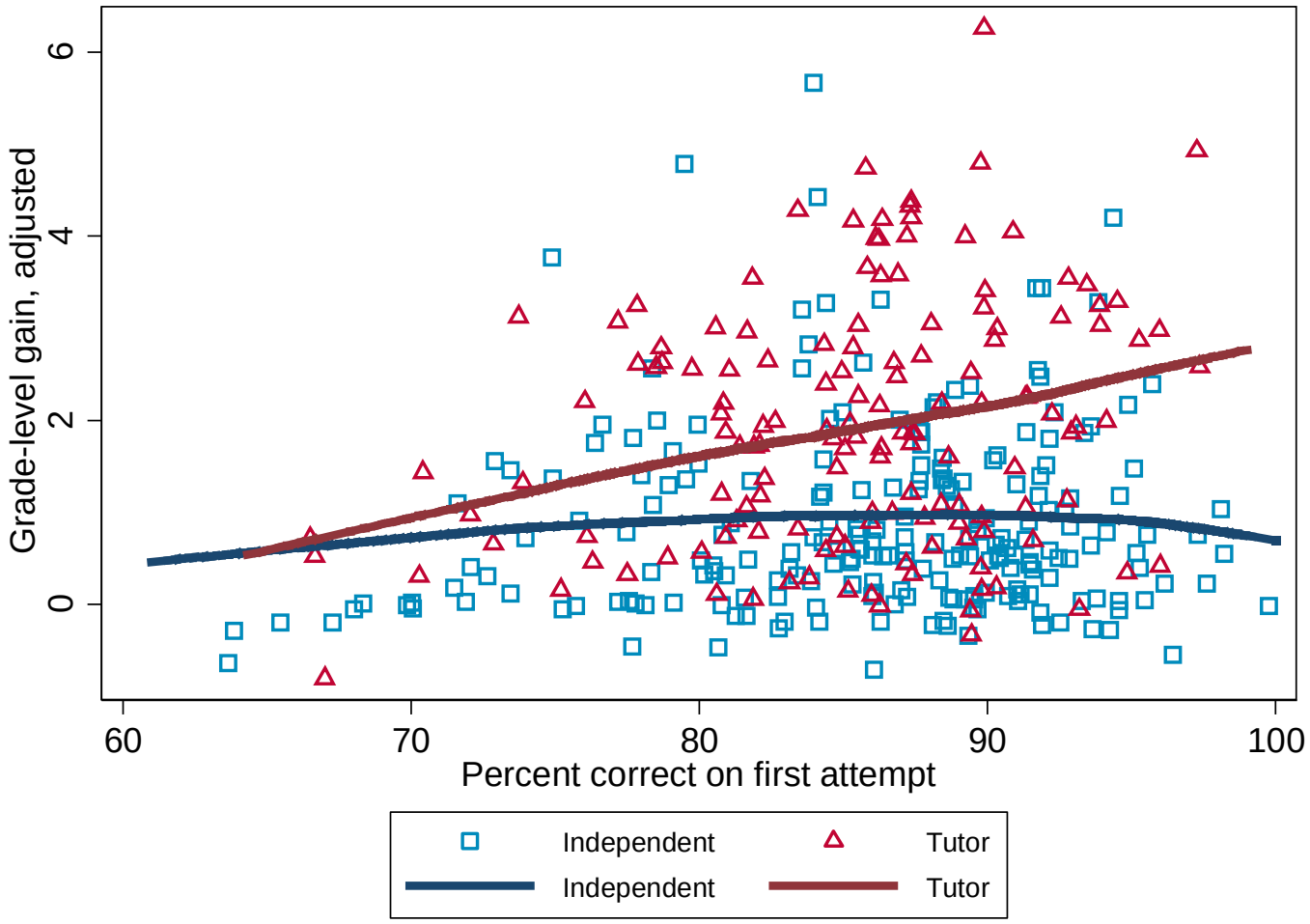


Table 9: Academic growth by percent correct first attempts

Percent of correct first attempts by quintile		Percent of correct first attempts (in %)		Grade-level gain, adjusted		
Overall (N=5,919)	N	Min	Max	Mdn	M	SD
1st Quintile (fewest)	1184	0.00	80.56	0.65	0.94	1.12
2nd Quintile	1184	80.57	85.30	0.96	1.23	1.28
3rd Quintile	1184	85.30	88.73	1.04	1.29	1.22
4th Quintile	1184	88.73	92.04	0.94	1.23	1.24
5th Quintile	1183	92.04	100.00	0.86	1.20	1.32
Independent (N=4,397)	N	Min	Max	Mdn	M	SD
1st Quintile (fewest)	880	0.00	80.62	0.53	0.81	1.06
2nd Quintile	879	80.63	85.66	0.71	0.96	1.12
3rd Quintile	880	85.66	89.06	0.87	1.02	1.04
4th Quintile	879	89.07	92.36	0.70	0.94	1.00
5th Quintile	879	92.37	100.00	0.61	0.89	1.00
Tutor (N=1,522)	N	Min	Max	Mdn	M	SD
1st Quintile (fewest)	305	40.76	80.53	0.99	1.30	1.19
2nd Quintile	304	80.53	84.55	1.52	1.80	1.42
3rd Quintile	305	84.57	87.88	1.70	1.94	1.36
4th Quintile	304	87.89	91.20	1.83	2.08	1.44
5th Quintile	304	91.22	99.03	2.20	2.40	1.64

N = Total sample size
Mdn = Median
M = Mean
SD = Standard Deviation

Conclusion

Our findings indicate that the both the independent and tutor-supported components of the DMP had quite positive effects on student performance, and were particularly effective in accelerating the learning of academically struggling students. Moreover, the DMP's tutoring component increased students' academic gains significantly more than the program's independent (non-tutoring) option. Our findings also show that students participating in the DMP who were furthest behind their peers at the start of the program made the most gains in academic outcomes. Struggling learners who opted for the tutoring program component made particularly impressive progress; those students, who were more than one and half grade-levels behind when they started the DMP, experienced almost three and one quarter years growth in a single school-year (beyond normally expected school year growth). Similar struggling students participating in the program's independent (non-tutoring) option averaged slightly less than one and a half grade-levels of growth. Moreover, our analyses show an inverse relationship between how far behind a student was and how much growth they made – i.e., the farther behind the student, the more progress they achieved (Table 10 in the appendix).

Our findings indicate that the DMP's tutoring component was particularly effective for students struggling with Mathematics because it increased their academic performance at least to grade-level and quite often helped them advance significantly beyond their grade-level. Moreover, while our analyses show that the more exposure students have to the DMP, the greater their gains, participating students still made noticeable gains in their academic achievement with only limited program exposure.

Appendix

Table 10: Correlations between academic growth (in grade-levels) and the differences between starting grade-level and actual grade by Digital Mathematics Program

	Overall (n=6,216)	Independent (n=4,683)	Tutor (n=1,533)
r^2	-0.3495	-0.2381	-0.4716
p	< 0.001	< 0.001	< 0.001

Table 11: Correlations between differences between starting grade-level and actual grade and sessions completed by Digital Mathematics Program

	Overall (n=6,216)	Independent (n=4,683)	Tutor (n=1,533)
r^2	-0.0065	-0.0167	-0.0055
p	0.6088	0.2525	0.8296

Table 12: Correlations between differences between starting grade-level and time spent using the Digital Mathematics Program by Digital Mathematics Program

	Overall (n=6,216)	Independent (n=4,683)	Tutor (n=1,533)
r^2	0.0005	-0.0228	0.0179
p	0.9687	0.1192	0.4845

Table 13: Correlations between academic growth (in grade-levels) and sessions completed by Digital Mathematics Program

	Overall (n=6,216)	Independent (n=4,683)	Tutor (n=1,533)
r^2	0.6151*	0.5942*	0.5445*
p	< 0.001	< 0.001	< 0.001

Table 14: Correlations between academic growth (in grade-levels) and time spent using the Digital Mathematics Program by Digital Mathematics Program

	Overall (n=6,216)	Independent (n=4,683)	Tutor (n=1,533)
r^2	0.6310*	0.6178*	0.5540*
p	< 0.001	< 0.001	< 0.001

Key Studies

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