Three-Year MAP Growth at Schools Using Teach to One: Math

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MarGrady Research

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Executive Summary

Teach to One: Math (TtO) is an innovative model of teaching mathematics that re-envisions the way in which teachers, students, and curriculum interact in middle and high school classrooms to provide a more personalized learning experience for every student. Through a technology-infused mix of direct instruction, collaborative work with peers, and individualized learning, TtO seeks to introduce students to mathematics content at the right level for them.

In this study, I compare three-year math test score growth at all 14 schools that used TtO from 2015-16 to 2017-18 to a national reference group, controlling for each student's starting score. To measure growth in math test scores, I use the Northwest Evaluation Association's (NWEA) Measures of Academic Progress (MAP) test, a widely-used adaptive test that can capture growth across a variety of grade levels. I also analyze internal TtO program data to begin to explore the relationship between the content students are presented with during the year and their subsequent test score gains.

Key findings from this study include:

- From fall 2015 to spring 2018, scores on the math MAP test for consistently-enrolled TtO students improved sufficiently to raise the average school-level percentile by 20 points, corresponding to 23% more growth, on average, than a national reference group.
- A broader group of students – including those not consistently enrolled – showed average three-year gains of 13 school-level percentile points and 12% greater improvement in the average math MAP test score.
- A group of "MAP growth-aligned" schools – those subject to external accountability systems that prioritize growth on the MAP test – showed average three-year gains among consistently-enrolled students of 38 school-level percentile points, which corresponds to 53% more growth.
- There is suggestive evidence that schools with a smaller content gap – those where the math content presented better matched students' tested grade level from the beginning of the year – tended to see greater gains.

These results should be interpreted with caution. The MAP test is only one measure of math knowledge, and the fact that students at TtO schools are growing faster than a national reference group does not indicate that TtO *caused* those gains. Moreover, the national reference group may be an imperfect comparison group for students in TtO schools, who are more likely to be poor, Black, and/or Latino than the average American student. With these caveats noted, however, it does appear that TtO students experienced greater three-year gains on the NWEA MAP test than a national reference group, and these results are robust to a number of alternative specifications.

Introduction

Schools using Teach to One: Math (TtO) help students learn traditional math topics in a non-traditional way. In a traditional math classroom, a teacher might deliver instruction to an entire class and then, after several days or weeks, evaluate the students using a uniform assessment. In a TtO classroom, each student learns his or her own pace and studies topics appropriate to his or her own level. Students learn at their own pace through a combination of instructional modalities, including teacher-led instruction, collaborative learning, and virtual (online) learning. At the end of each day, students are assessed on their mastery of the material, and each student's customized lesson plan is prepared for the next day.

Founded in 2011 to expand New York City's School of One program, TtO and its parent organization, New Classrooms, had grown to partner with 36 schools in 11 states by 2017-18.[1] Of these 36 schools, 14 had used TtO for three consecutive years, providing New Classrooms the opportunity to look at test score gains for students and schools over a longer time horizon than in prior analyses. Additionally, New Classrooms has collected a wealth of internal data that can be analyzed to better understand how student success is related to their level of preparation for the content they are presented with.

The primary goal of this study is to compare math test score growth at TtO schools to national norms over a three-year period. To measure growth in math test scores, I use the Northwest Evaluation Association's (NWEA) Measures of Academic Progress (MAP) test, a widely-used computer adaptive test taken three times per year by all students participating in TtO. I focus on *growth* rather than *proficiency* because many students in TtO's partner schools are far from the traditional proficiency cut points – either below or above – and TtO seeks to meet every student where they are. I look at growth on the *MAP*, as opposed to growth on *state tests*, for two reasons. First, the MAP is administered consistently at all TtO schools, providing a common yardstick against which to compare gains across schools. Second, the MAP is an adaptive test that adjusts the difficulty of questions based on student responses. Students taking the MAP may be asked questions from a variety of grade levels, whereas students taking many state tests will be asked a large number of grade-level questions, even if those questions are too easy or too difficult for some students. As a result, the MAP test may provide a more accurate estimate of growth for students who are far below or above state standards for their grade level.

To look at three-year growth, I focus my analysis on consistently-enrolled students at the 14 schools that used TtO from 2015-16 to 2017-18. In particular, I analyze results for those students who were 6th graders in 2015-16, 7th graders in 2016-17, and 8th graders in 2017-18. I calculate the change in test scores from the fall of 2015 to the spring of 2018 and compare that change to national norms in three ways.[2] First, I assign each school a status percentile in each period

[1] As of 2017-18, 36 schools used TtO's full program, or core offering. Additional schools used TtO on a partial basis or as an after-school program. As of 2018-19, TtO's core offering is used in 39 schools.

[2] The NWEA estimates national norms for the MAP test by adjusting the actual scores of students who took the MAP test in 2011-12, 2012-13, and 2013-14 to be representative of the U.S. public school

from Fall 2015 to Spring 2018 based on its average MAP test score compared to national norms, and calculate each school's change in status percentile over the three-year period. Second, to provide more nuanced results, I perform the same exercise by student, assigning each student a status percentile in each testing period and assessing the change over three years. Finally, I also compare student test score gains over three years to estimated three-year conditional growth norms from the 2015 MAP norms study.[3] While I focus my analysis on consistently-enrolled students – those who experienced TtO for three years – I also present results for all tested students in the same cohort at the 14 three-year TtO schools (regardless of whether or not those students were consistently enrolled).

A secondary goal of the study is to better understand the relationship between the content students were presented with and their test score gains. In particular, I calculate an "effective grade level" for each student based on his or her fall MAP test score each year. I then compare this effective grade level to the grade level of the content they were exposed to during the year. I term the difference between these two grade levels a "content gap," and explore whether schools with smaller average content gaps – those where students are seeing content closer to their beginning-of-year effective grade level – are showing greater long-term gains on the MAP test.

Overall, I find evidence that TtO students are improving on the MAP math test at a faster rate than a nationally representative comparison group. From fall 2015 to spring 2018, scores on the MAP math test among consistently-enrolled TtO students improved sufficiently to raise the average school-level percentile by 20 points and the average student-level percentile by 9 points.[4] Over those three years, consistently-enrolled students at TtO schools experienced approximately 23% more growth on the math MAP test than a national reference group, which corresponded to a three-year effect size of approximately 0.16 standard deviations. While these gains are largest for consistently-enrolled students, they are positive when looking at a broader group of students at three-year TtO schools as well. Underlying these overall gains was significant heterogeneity by school. A group of "MAP growth-aligned" schools – those subject to external accountability systems that prioritize growth on the MAP test – showed average three-year gains of 38 school-level percentile points, which corresponds to 15 student-level percentile points, 53% more growth, and a 0.38 three-year effect size. I also find suggestive evidence that schools with a smaller content gap – those where the content TtO presents a student better matches his or her effective grade level – tend to see greater gains.

These results should be interpreted with caution. The MAP test is only one measure of math knowledge, and the fact that students at TtO schools grew, on average,

population. For additional details, see the 2015 MAP norming study at https://www.nwea.org/content/uploads/2018/01/2015-MAP-Norms-for-Student-and-School-Achievement-Status-and-Growth.pdf

[3] NWEA does not provide three-year conditional growth norms, but I estimate them in two ways, as discussed in detail in Appendix B.

[4] As discussed in detail later, the school-level and student-level percentile gains are simply two different benchmarks to contextualize the same improvement in test scores. Because the national school-level distribution of MAP scores is narrower than the student-level distribution, as shown in Figure A1 in the appendix, the same test score improvement leads to a greater percentile gain against the school-level distribution than the student-level distribution.

faster than a national reference group does not indicate that TtO *caused* those gains. Moreover, the national reference group may be an imperfect comparison group for students in TtO schools, who are more likely to be poor, Black, and/or Latino than the average American student.[5] With these caveats noted, however, it does appear that TtO students grew more on the NWEA MAP test than a national reference group, and these results are robust to a number of alternative specifications.

Data

This study uses a combination of student-level data from New Classrooms and publicly available data from the NWEA. New Classrooms provided student-level MAP results and demographic characteristics for all students who participated in TtO in any school between 2015-16 and 2017-18. MAP results included a student's test score (called a RIT score) and testing time for the fall, winter, and spring administrations of the test in each year. Demographic characteristics included a student's race, sex, and indicators for whether the student was an English Language Learner, received special education services, or qualified for free-or-reduced price lunch. New Classrooms also provided each student's enrolled (i.e. official) grade level in each year.[6]

There are two sources of publicly-available data from NWEA. The first is the "NWEA 2015 MAP Norms for Student and School Achievement Status and Growth" (subsequently referred to as the MAP norms).[7] These data are used as a comparison point for the MAP gains of TtO students to determine whether TtO students have improved more or less than a nationally representative group of students. The MAP norms for math are developed based on test records for over 10 million unique students who took the MAP test between the fall of 2011 and the spring of 2014, and the results are adjusted by NWEA to be nationally representative. For each RIT score in each grade in each testing term (fall, winter, or spring) the study provides both a student-level and school-level percentile for that score against the estimated national distribution of scores. The study also provides an average score for each grade and testing period, as well as growth norms that represent the average growth experienced by students between two testing periods that are at most one year apart. These norms are provided both overall (e.g. for 6th graders, on average) and conditional on a student's starting score.

The second source of publicly-available NWEA data is from the study "Linking the PARCC Assessments to the NWEA MAP Tests."[8] This study, completed by NWEA in

[5] There is some evidence that better matched comparison groups may lead to similar results. See, for example, Pane et. al. (2017)'s study of personalized learning, where results using a Virtual Control Group matched on student demographics and other factors were similar to results using Conditional Growth Norms (which is one method I use here).

[6] Prior to 2017-18, New Classrooms did not always keep separate records of a student's enrolled grade level, focusing instead on what the organization referred to as an "anchor grade," which defined the end goal of various skill progressions a student might see. In most cases, the anchor grade was equal to the enrolled grade, but in some cases the two might be different. In 2017-18, New Classrooms separated enrolled grade from anchor grade and kept records of both. The organization has worked to reconstruct the correct enrolled grade for each student in prior years from their records.

[7] https://www.nwea.org/content/uploads/2018/01/2015-MAP-Norms-for-Student-and-School-Achievement-Status-and-Growth.pdf

[8] https://www.nwea.org/content/uploads/2016/12/PARCC-MAP-Linking-Study-NOV2016.pdf

2016, estimates a student's probability of meeting grade-level standards on the PARCC assessment at the end of the year based on his or her fall or winter MAP score. Historically, New Classrooms has used this study to calculate a student's effective grade for internal analysis and programming purposes. Following a similar methodology, I calculate effective grade cut points based on the fall MAP score required to have a roughly 50% chance of meeting grade-level standards on the end-of-year PARCC exam for that grade. The effective grade cut point for fifth grade, for example, would be the fall MAP score that corresponds to a 50% probability of passing the fifth grade PARCC test at the end of the year. Once the cut points are established, each student is assigned an effective grade level based on where their fall MAP score falls relative to the grade level cut points. Fractional grade levels are allowed, so a student whose fall test score puts him or her 75% of the way from the grade 6 cut point to the grade 7 cut point would be given a grade level of 6.75, for example

Figure 1 shows demographic characteristics of the TtO students included in this study and compares them to national data. The first column includes the 739 students who were consistently enrolled in one of the 14 three-year TtO schools from the fall of 2015 to the spring of 2018. To be considered consistently enrolled, a student had to be a 6th grader in 2015-16, a 7th grader in 2016-17, and 8th grade in 2017-18. They also had to be enrolled in the same school for all

Figure 1 – Demographic Profile of TtO Students Compared to the Nation

	(1) TtO: Consistently Enrolled Students in 3-Year TtO Schools	(2) TtO: All Students in 3-Year TtO Schools	(3) Nation: All Public School Students
Race / Ethnicity			
% American Indian / Alaska Native	0%	0%	1%
% Asian / Pacific Islander	1%	1%	5%
% Black	51%	57%	16%
% Hispanic	40%	35%	26%
% White	8%	6%	49%
% Two or more races	0%	1%	3%
% Free Lunch	85%	84%	51%
% Special Education	12%	12%	13%
% English Language Learners	4%	9%	10%
Number of Students	739	1,675	50,438,000

Source: TtO enrollment breakdown comes from New Classrooms. Note: the TtO enrollment numbers for consistently-enrolled students include only students in the 14 3-Year MAP schools who were 6th graders in 2015-16, 7th graders in 2016-17, 8th graders in 2017-18, where enrolled in the same school for all three years, and had both a fall 2015 and a spring 2018 MAP score. The TtO enrollment numbers for all students in 3-Year TtO schools include any student with a 6th grade MAP score in 2015-16, a 7th grade MAP score in 2016-17, or an 8th grade MAP score in 2017-18. The national public school enrollment breakdown comes from the NCES *Digest of Education Statistics* Tables 203.70, 204.10, 204.20, and 204.60 (http://nces.ed.gov/programs/digest/current_tables.asp) as of fall 2015.

three years and have a MAP test score in both the fall of 2015 and the spring of 2018. The second column includes a broader group of students in the same 14 three-year TtO schools. This group includes all those students in the first column, as well as any other students with a MAP test score in any period between the fall of 2015 and the spring of 2018. The final column – taken from the federal *Digest of Education Statistics* – contains a demographic breakdown of public school enrollment for the nation.

The demographic breakdown is quite similar when comparing consistently-enrolled students (column 1) to all enrolled students (column 2) at three-year TtO schools. English Language Learners are an exception, with ELLs representing 4% of the consistently-enrolled sample and 9% of the wider sample of TtO students. Consistently-enrolled students are also somewhat less likely to be Black and more likely to be Hispanic than all students. The differences are more substantial when comparing TtO students to the national average. TtO students in this study are more likely to be Black, Hispanic, and/or eligible for free or reduced-price lunch than public school students nationally. The share of students requiring special education services and the share who are English Language Learners are similar when comparing all TtO students in the 14 three-year schools to the national average, though as noted earlier, the % ELL decreases when restricting the sample to consistently-enrolled students.

Methodology

To compare MAP gains at TtO schools to national norms, I use three methods: change in school-level percentile, change in student-level percentile, and test score change vs. estimated three-year conditional growth norms.

Change in School-Level Percentile

To calculate the change in school-level percentile, I first calculate the average MAP score for the group under review: all consistently-enrolled students in any of the 14 schools, all tested students in any of the 14 schools, or consistently-enrolled students in a specific school. I then look up the corresponding school-level percentile for that score, grade, and testing season in Table C.2 of the 2015 MAP norms study. The change in school-level percentile is simply the difference between the school percentile in the spring of 2018 and the school percentile in the fall of 2015.

Change in Student-Level Percentile

To calculate the change in student-level percentile, I first assign a percentile to each tested student in each season by comparing his or her score to Table C.1 in the 2015 MAP norms study. I then calculate the average student-level percentile for whichever group I am considering: consistently-enrolled students in any of the 14 schools, all students in any of the 14 schools, or consistently-enrolled students in a specific school. The change in the student-level percentile is the difference between the average student percentile in the spring of 2018 and the average student percentile in the fall of 2015.

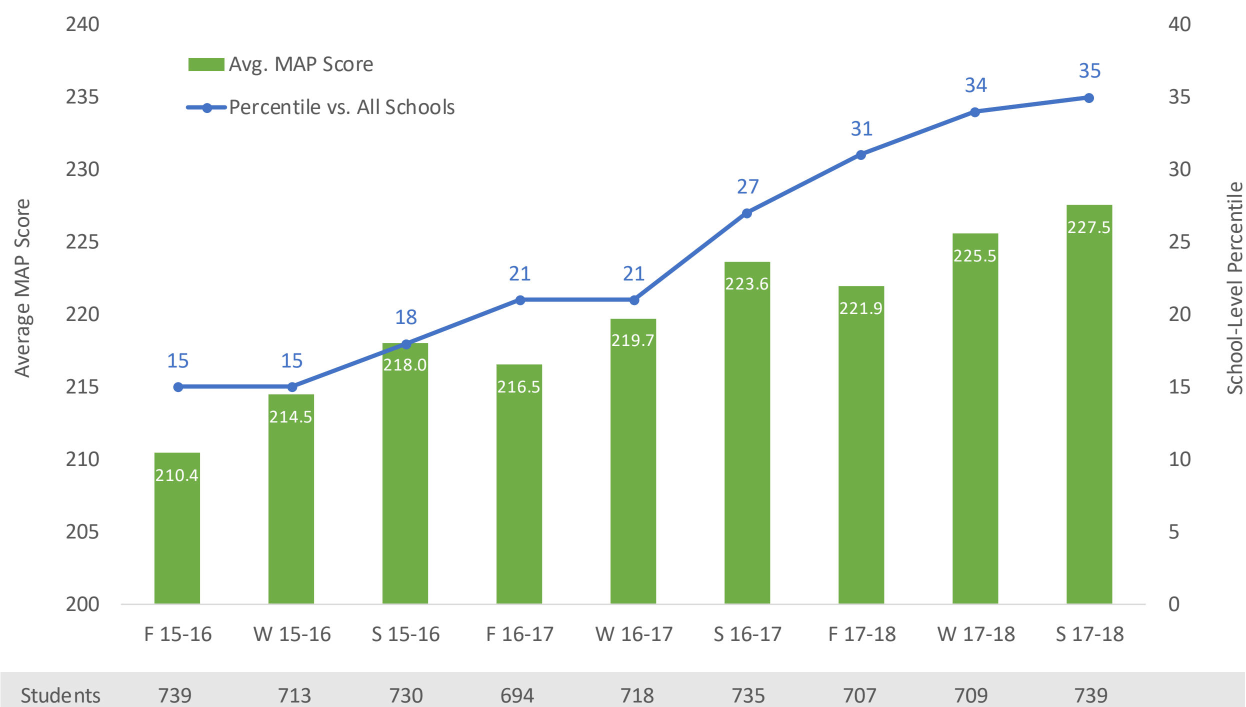
Test Score Change vs. Estimated Three-Year Conditional Growth Norm

NWEA does not provide *multi-year* growth norms in the 2015 norms study, so any comparison of TtO gains to three-year growth norms is necessarily speculative. The simplest way to estimate three-year growth norms is to calculate the difference between the national average MAP score in the spring of 6th grade (217.6) and the national average MAP score in the fall of 8th grade (230.9) from Table A in the 2015 MAP norms study. This difference of 13.3 points provides the unconditional growth norm. To make this growth norm a *conditional* growth norm – one that varies based on starting score – I multiply it by the "adjustment factor" from Table D in the 2015 MAP norms study, where I define the adjustment factor to be the ratio between the conditional growth norm for a given starting percentile and the unconditional, average growth norm for the grade and growth period. Because the adjustment factor varies by growth period, I multiply the unconditional growth norm by the average adjustment factor for three growth periods: fall 6th grade to fall 7th grade, fall 7th grade to spring 7th grade, and spring 7th grade to spring 8th grade. In addition to this method, I explore an alternative way to calculate conditional growth norms, described in detail in Appendix B. However, the method described above is preferred because it is simple, reasonable, and provides results that are consistent with the school-level and student-level percentile analyses, which are methods that require fewer assumptions.

Overall Results

Across all three methods, students in TtO schools show greater MAP math gains than the national reference group. Figure 2 shows the average MAP score and school-level percentile for the 739 consistently-enrolled students in all 14 schools that participated in TtO between 2015-16 and 2017-18. As shown in the figure, the average MAP score

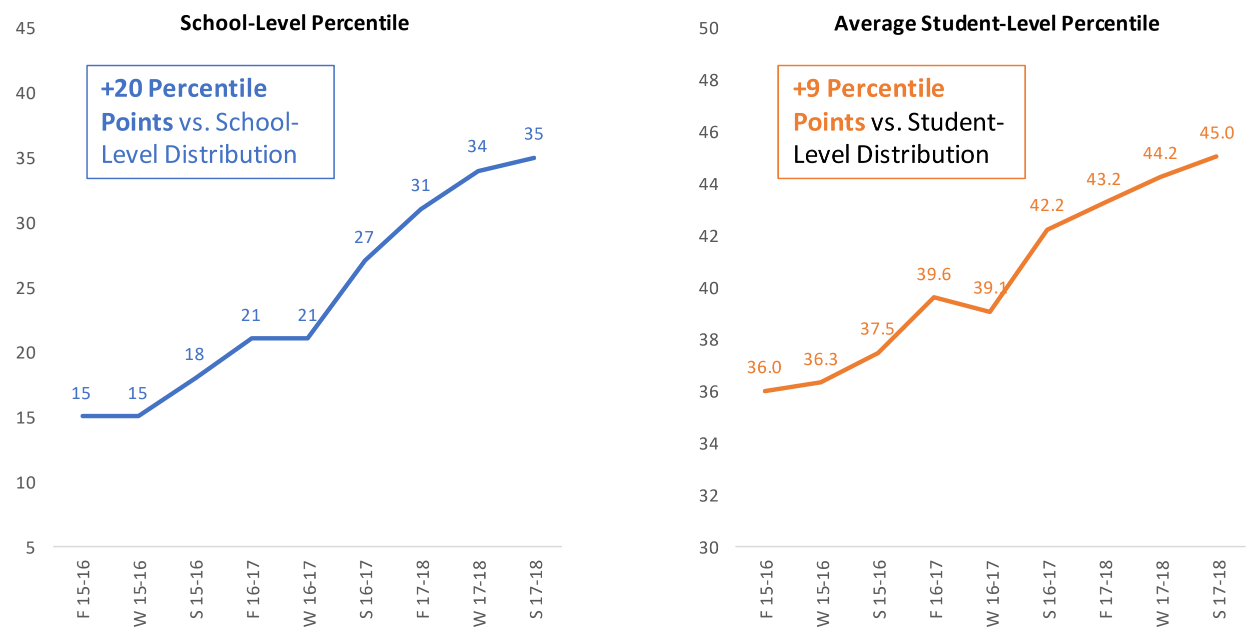
Figure 2 – Average MAP Score and School-Level Percentile (Consistently-Enrolled Students)



Note: includes only students who were 6th graders in 2015-16, 7th graders in 2016-17, 8th graders in 2017-18, enrolled in the same school for all three years, and had both a fall 2015 and a spring 2018 MAP score. Students are not required to have a test score in every period to be included.

increased from 210.4 in the fall of 2015-16, when these students were 6th graders, to 227.5 in the spring of 2017-18, when these students were 8th graders. This test score increase was consistent with a 20-point increase in the school-level percentile, from the 15th percentile in the fall of 6th grade to the 35th percentile in the spring of 8th grade.[9] The increase in the student-level percentile shows a similar pattern. Figure 3 shows the school-level percentile by period on the left and the average student-level percentile by period on the right. Over three years, the average student-level percentile for consistently-enrolled students increased by nine points, from 36 to 45.[10] When comparing test scores to the *student-level* reference group, TtO students start at a higher percentile and go up fewer percentile points than they do when against the *school-level* distribution. This is simply because the distribution of student-level scores is substantially wider than the distribution of school-level scores, as shown in Figure A1 in the appendix. Once you are well within the bounds of the school-level distribution – as most schools or groups of schools are – an identical test score increase leads to a greater percentile gain against the school-level distribution than the student-level distribution. Both methods are valid and entirely consistent with one another – they simply provide different yardsticks against which to contextualize the size of the observed gains at TtO schools.

Figure 3 – School-Level and Avg. Student-Level Percentile (Consistently-Enrolled Students)



Note: includes only students who were 6th graders in 2015-16, 7th graders in 2016-17, 8th graders in 2017-18, enrolled in the same school for all three years, and had both a fall 2015 and a spring 2018 MAP score. Students are not required to have a test score in every period to be included.

[9] A similar analysis for a more recent cohort of students suggests a slightly steeper increase over their first two years (see Appendix C).

[10] All student subgroups tested – special education, ELL, free-or-reduced price lunch, Black, Latino, White, male, and female students – show improvements in their average student-level percentile, and none of the differences between them are statistically significant.

Figure 4 – Score Change vs. Estimated Three-Year Conditional Growth Norm

	Results
Average Three-Year Change in RIT Score	+17.1 points
Average Estimated Three-Year Conditional Growth Norm	+13.9 points
Incremental Gains	+3.1 points
Gains / Estimated Conditional Growth Norms	1.23*
Estimated Effect Size (Three-Year)	0.16 (three-year)
Sample Size	739 students / 14 schools

Note: numbers may not add due to rounding. The three-year conditional growth norm is estimated by taking the average spring 8th grade score and subtracting the average fall 6th grade score, then adjusting by the average adjustment factor over three growth periods (see methodology section for details). The estimated effect size divides the incremental gain by 19.1, which represents the student-level standard deviation of spring 8th grade MAP math scores. ** $p < 0.01$ * $p < 0.05$.

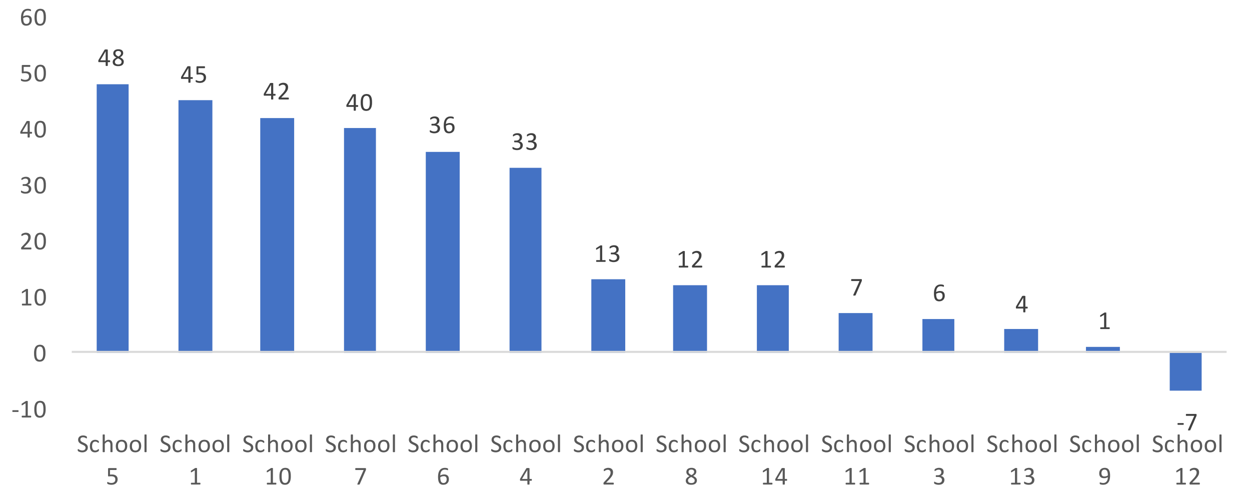
The gains described earlier are restricted to consistently-enrolled students to provide insight into growth among students who were exposed to the TtO program over three years. We also see gains, though somewhat smaller, when expanding the sample to include all students tested in any time period. As shown in Appendix D, the school-level percentile for all students increased by 13 points over three-years, from 15 in the fall of 2015 to 28 in the spring of 2018, and the average student-level percentile increased by five points over the same time period. Between the fall of 6th grade and the spring of 8th grade, the average test score for all students at the 14 three-year TtO schools increased by 14.9 points, 12% more than the national increase of 13.3 points.

Figure 4 shows how the average three-year change in the RIT score on the MAP test in TtO schools compared to the estimated three-year conditional growth norm. As shown earlier in Figure 2, the average score among consistently-enrolled students at TtO schools increased by 17.1 points on the MAP math test over three years. Each student was assigned a separate estimated three-year growth norm, conditional on his or her starting score in the fall of 6th grade. On average, students' gains exceeded their estimated three-year conditional growth norms by approximately 3.1 points, which represents 23% more growth in math test scores over three years than the national comparison group, a difference that is statistically significant at the 0.05 level.[11] Compared to the average 8th grade standard deviation of 19.1 points, this improvement represents a three-year effect size of 0.16 standard deviations.

In the appendix, I test the sensitivity of the percentile increase and conditional growth norm results to a variety of alternative assumptions. I weight schools equally rather than based on the number of tested students, I apply MAP filters recommended for high-stakes testing environments, and I test an alternative method of estimating three-year

[11] Statistical significance calculated based on a one-sample t-test with 739 student-level observations comparing the null hypothesis that the mean gains/norms is equal to one versus the alternative hypothesis that the mean gains/norms is not equal to one. The standard error is robust and clustered at the school level.

Figure 5 – Change in School-Level Percentile by School (Consistently-Enrolled Students)



	School 5	School 1	School 10	School 7	School 6	School 4	School 2	School 8	School 14	School 11	School 3	School 13	School 9	School 12
N =	20	39	23	69	54	65	136	30	33	33	96	52	40	49

Note: figure shows the change in the school-level percentile for consistently-enrolled students from the fall of grade 6 to the spring of grade 8. N represents the number of consistently-enrolled students at the school.

conditional growth norms.[12] Under these scenarios, the percentile gains are always equal to or higher than those reported in the main text. The school percentile gains range from 20 to 28 for consistently-enrolled students and from 13 to 22 for all students. The student percentile gains range from 9 to 11 for consistently-enrolled students and from 5 to 9 for all students. The gains vs. conditional growth norms range from 0.97 to 1.40, with the preferred estimate of 1.23 roughly in between the high and low estimates.

As shown in Figure 5, there was considerable heterogeneity in gains by school. Six schools saw their school-level percentile increase by between 33 and 48 percentile points, seven schools saw more modest increases, ranging from one to 13 percentile points, and one school saw a decline in its school-level percentile. School-by-school results for average student-level percentiles and gains vs. conditional growth norms show a similar pattern.

Exploratory Analysis

There are many reasons why some schools may see greater growth over three years than others. Perhaps the simplest is random chance. Over any three-year period, students in some schools are likely to grow more than others, on average, simply by chance. In Figure 5, the standard deviation in the change in school-level percentiles among

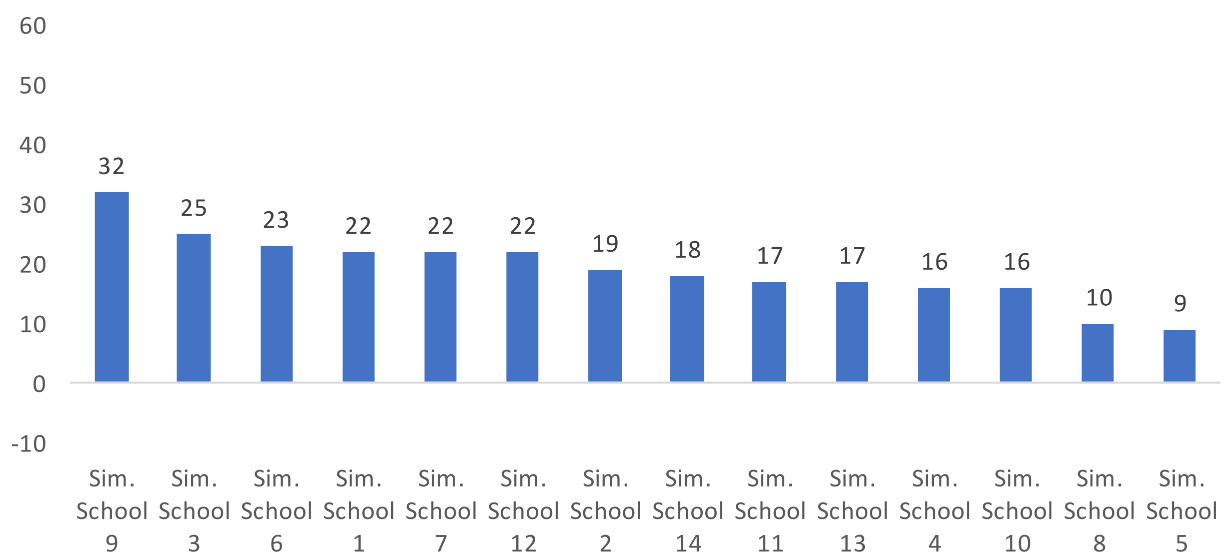
[12] In the sensitivity analysis, I apply New Classrooms' standard filters for high-stakes testing, which include removing scores that are a drop of ten or more points from the score in the immediately prior testing period and removing scores where a student's testing time was 30 minutes lower than in an adjacent testing period. These filters are generally based on the guidance provided by the NWEA in "Guidance for Administering NWEA MAP/MPG Assessments When Results are Used for High Stakes Purposes" available at: https://www.nwea.org/content/uploads/2017/04/Guidance-for-Administering-MAP-and-MPG-Assessments-When-Results-are-Used.pdf

the 14 schools is 18.8 points. Is this more than one would expect by chance? To help answer to this question – based on one of the ways that "chance" may affect schools – I run a simulation where I assign all 739 consistently-enrolled students randomly to schools in the study, keeping each school with the same number of students.

Figure 6 shows the *simulated* percentile gains by school for one simulation. While some schools improve more than others – in this case purely by chance – there is less variation between schools than in the actual results shown in Figure 5. The standard deviation of the school-level results drops from 18.8 points in Figure 5 (actual) to 5.9 points in Figure 6 (simulated). When repeating this simulation ten times, the average *simulated* standard deviation is 6.4 points with a minimum of 3.9 and a maximum of 8.5. It seems plausible therefore, that much of the school-level heterogeneity we see in the actual results is not due to chance, as least as far as chance is defined as the random assignment of students into schools.[13]

Aside from chance, there are many potential hypotheses as to why some schools using TtO grew more on the MAP math test than others. In the sections below, I present exploratory analysis related to two: the content students are exposed to and the external accountability systems schools face. While too speculative to draw definitive conclusions, these analyses point to interesting areas for further research.

Figure 6 – *Simulated* Change in School-Level Percentile by School (Consistently-Enrolled Students)



Note: figure shows the simulated change in the school-level percentile for consistently-enrolled students from the fall of grade 6 to the spring of grade 8, when students have been randomly assigned to schools (and school sizes are kept the same).

[13] The assignment of students to schools is only one way in which "chance" or luck may lead schools to have different MAP gains from one another through no clear, causal mechanism. Other ways in which chance may affect school performance include the quality of the teachers and the quality of the principal, though the magnitude of the impact these factors may have is difficult to model.

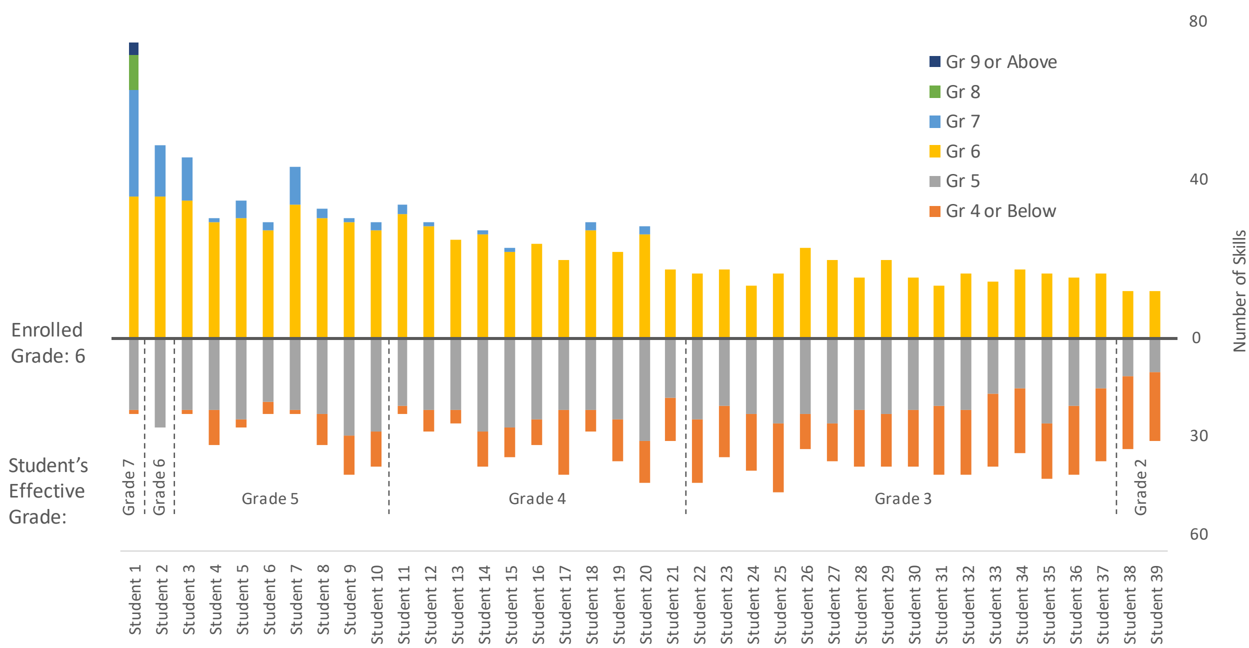
Content Gap

One hypothesis that may help explain the variation in growth patterns by school is that TtO provided a higher share of students in high-growth schools with content that was at the right level for them. While there are many ways to measure whether content is “at the right level” for a student, I look at one simple, high-level measure here: the content gap.[14] I define the content gap as the gap between a student’s effective grade level – that is, the grade level at which he or she tests at – and the average grade level of the content he or she is exposed to.

Figure 7 – Content Gap Definition

Over the time period of this study, the content presented to students varied for many reasons, with only one of them being students’ tested ability (i.e. effective grade level). Content also varied based on student performance during the year as well as many implementation decisions made by schools, districts, and New Classrooms throughout the year. Among these decisions, schools and districts could implement floors or

Figure 8 – Skills and Effective Grade Level by Student in School 1 (2015-16, Grade 6)



Note: includes only students who were 6th graders in 2015-16, 7th graders in 2016-17, 8th graders in 2017-18, enrolled in the same school for all three years, and had both a fall 2015 and a spring 2018 MAP score. Does not require a student to have a test score in every period. Effective grade level is determined based on the MAP score required to have a 50% change of scoring proficient on the PARCC test for that grade.

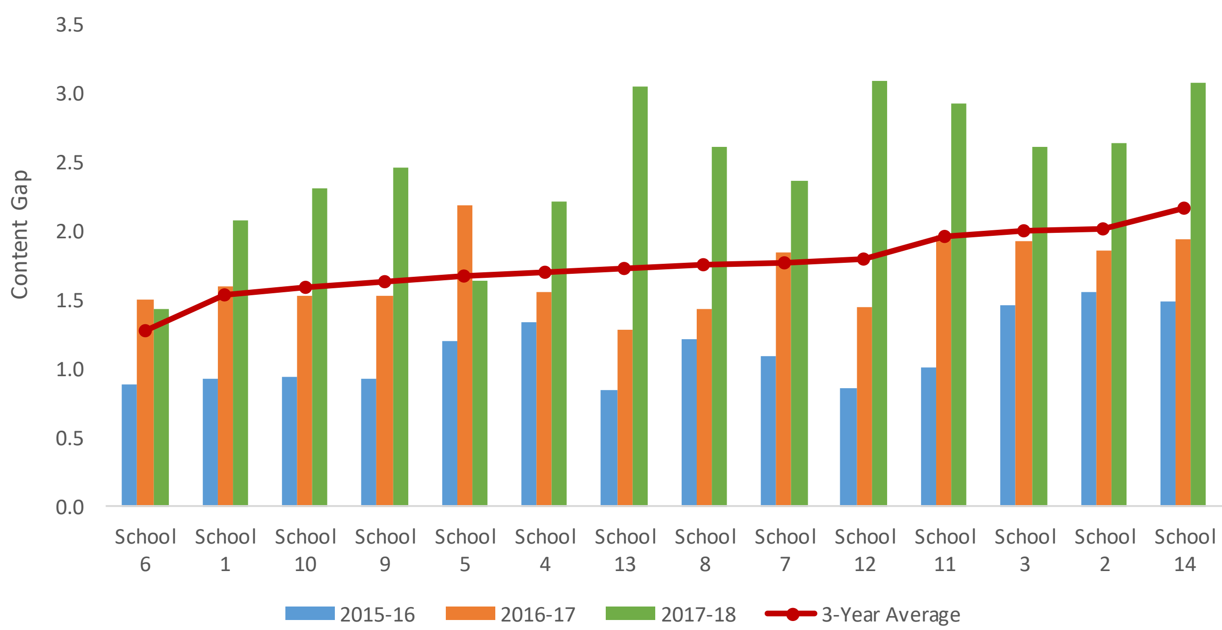
[14] This analysis explores a high-level relationship based on the data available. Future research could explore more nuanced ways to study the same question: how does student success in math relate to the content they are presented? Through TtO, New Classrooms is collecting some of the best data available to try to answer this question.

ceilings restricting the grade level of content students were exposed to and adjust the tempo of the program, increasing or decreasing the time before students were moved on to new content, even if they hadn't yet demonstrated mastery.

To estimate each student's effective grade level in each year, I use the fall MAP test, combined with the 2016 MAP-PARCC Linking Study, as described in detail in the Data section. I allow students to have fractional grade levels, so a student whose fall test score puts him or her 50% of the way from the grade 6 cut point to the grade 7 cut point would be given an effective grade level of 6.5, for example. I calculate each student's average content grade level as the average grade level of all skills a student is exposed to during a year. In grades 6-8, consistently-enrolled students were exposed to an average of 55 unique math skills per year, each of which New Classrooms has mapped to a specific grade level based on the Common Core State Standards.

In Figure 8, we see the underlying data for all consistently-enrolled 6th graders at School 1, one of the 14 schools in this study. Students are sorted into effective grade levels based on their fall 2015 MAP test, with higher scoring students on the left and lower-scoring students on the right. In this cohort, students' scores put them in effective grade levels ranging from 2nd grade to 7th grade, similar to the variation in tested ability seen in other schools. The y-axis shows the number and level of skills each student was exposed to through the TtO program during the 2015-16 school year. As one might expect, students on the left side of the chart – with higher effective grade levels – were exposed to more on or above grade level skills than students on the right side of the chart. Students on the right side of the chart – with lower effective grade levels –

Figure 9 – Average Content Gap by Year by School



Note: includes only students who were 6th graders in 2015-16, 8th graders in 2017-18, enrolled in the same school for all three years, and had a Fall 2015-16 and Spring 2017-18 MAP score. Does not require a student to have a test score in every period. Effective grade level is determined based on the MAP score required to have a 50% change of scoring proficient on the PARCC test for that grade.

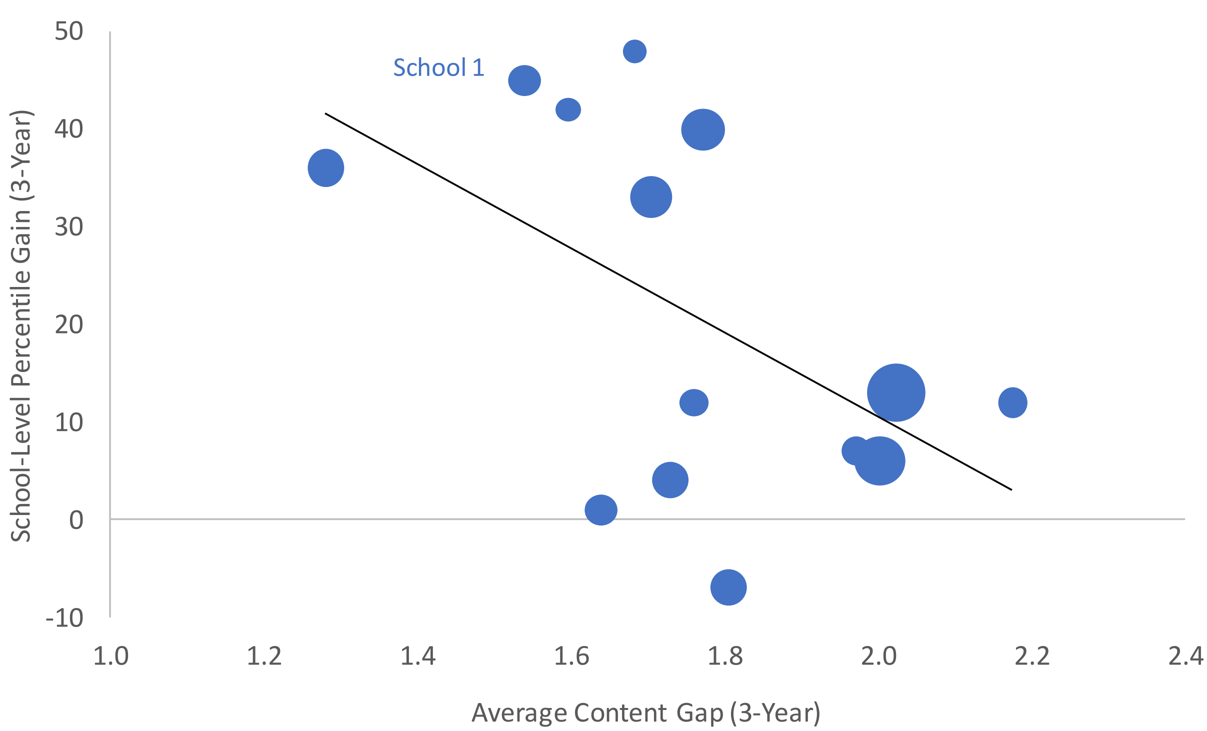
tended to be exposed to predominantly below grade-level skills.

On average, students in School 1 tested at an effective grade level of 4.3 in 2015-16 and were exposed to content at an average grade level of 5.3, for a content gap of 1.0 grade levels. This content gap increased to 1.6 grade levels in 2016-17 and 2.1 grade levels in 2017-18. On average, across all three years of this study, School 1 had a content gap of 1.5 grade levels. Figure 9 shows the content gap by year at all 14 schools in this study. On average over three years, School 1 had the second lowest content gap.

Figure 10 shows that, across all 14 schools, there is a negative relationship between the average content gap and the school-level percentile gain for consistently-enrolled students. Schools with a smaller content gap, on the left of the graph, tend to have larger three-year school percentile gains. School 1 is in the upper left of the graph, with a relatively low average content gap and a relatively high three-year percentile gain.

It seems likely that at least part of the relationship shown in Figure 10 is driven by reverse causality. As shown in Figure 8, even below grade level students are exposed to a reasonable amount of grade-level content each year, a trend that becomes more pronounced in higher grades (see Appendix F for similar charts for School 1 students in grades 7 and 8). This increasing share of grade-level content may push up the average content grade level in all schools, and schools where students experience less growth may see their content gap rise more in higher grades as a result. In other words, lower growth may cause a higher content gap, much as a higher content gap may cause lower growth.

Figure 10 – Relationship between Content Gap and School-Level Percentile Gains (3-Year)



Note: includes only consistently-enrolled students. Bubble size is proportional to the number of consistently-enrolled students.

To assess the relationship in a manner less vulnerable to this form of reverse causality, Figure 11 shows the results of a bivariate regression to predict the school-level percentile gain based on the content gap *within each year*. As shown in the figure, in both 2015-16 and 2016-17, the relationship between the annual content gap and the annual percentile gain is statistically insignificant (in 2015-16, the point estimate is positive). Only in 2017-18 is the annual relationship between the content gap and the school-level percentile gains negative and significant.[15] As Figure 9 shows, 2017-18 was also the year with the largest content gaps by school for most schools.

Figure 11 – Regression to Predict Annual School-Level Percentile Gain based on Annual Content Gap

	2015-16	2016-17	2017-18
Content Gap	8.190	-11.93	-11.66*
	(5.935)	(14.66)	(5.007)
Constant	-8.268	29.63	37.00*
	(8.084)	(27.84)	(12.87)
Observations	14	14	14
R-squared	0.081	0.050	0.185

Note: Robust standard errors in parentheses. Regressions weighted by the number of consistently-enrolled students in each school.
** p<0.01, * p<0.05, ~ p<0.1

While content gaps grew over time in nearly every school in the study, there is one factor that may have accelerated this trend in half the schools. In Schools 8 through 14, which are all part of one district, all 8th grade students studied Algebra I, which the Common Core State Standards categorizes as a 9th grade subject. Students in these schools were pushed to master not only 8th grade material, but 9th grade as well. In addition, the district and New Classrooms decided to set a higher TtO floor for 8th graders in 2017-18 than was set for other schools in this study. While Schools 1 through 7 had a floor of 5th grade in 2017-18 – meaning students could be taught skills categorized as being at a 5th grade level if appropriate – Schools 8 through 14 had a floor of 6th grade in 2017-18. This higher floor combined with a push towards 9th grade content – despite the fact that students, on average, were testing below a 6th grade level in the district – led to particularly large content gaps in many schools.

Growth-Aligned Accountability

An alternative, related hypothesis is that growth differences (and perhaps content gaps) between schools may be driven by external accountability pressures. At one end of the spectrum, some schools – such as schools 8 through 14 in this study – are subject to an accountability system that focuses primarily on performance. On its website, the district overseeing schools 8 through 14 outlines an accountability system that gives schools rewards based entirely on the proficiency rate achieved on state tests.[16] At the other end of the spectrum, schools 4

[15] Appendix G shows similar results over two years for the cohort of students who were 6th graders in 2016-17 and 7th graders in 2017-18.

[16] The state, in this case, has multiple accountability systems. One system, established by the legislature, has state test score measures that focus only on proficiency. The other system, established as a department policy, focuses on both performance and growth on state tests, though there were no explicit weights until the new ESSA approved system was released in 2018. In addition to its own performance-based accountability system, the district overseeing Schools 8 through 14 links to the state's performance-based accountability system on its web site (as of 12/1/18).

Figure 12 – Growth vs. Performance in External Accountability Systems

District	Schools	Accountability System	Growth vs. Attainment	Relative Weight on Growth	Notes
Large City A	Schools 4, 5 & 6	District-based	45% growth vs. 15% attainment	75%	• Uses the NWEA MAP test • School 5 is outside the city and does not receive an accountabilty score, but most of its charter network does
Large City B	School 7	District-based	No overall score, but growth appears first on the report	71%	• The district's previous accountability system gave 60% weight to growth and 25% weight to performance
Mid-sized City	School 1	School-based	Goal 1 of local plan targets growth and attainment equally	50%	• Accountabilty system is the charter's local plan required for renewal
Large County	Schools 2 & 3	State-based	50% performance and 40% growth	44%	• No known district-based accountability system
Small City	Schools 8-14	District-based	100% based on state proficiency rate	0%	• District also links to state's performance-based accountability system • State's new ESSA accountability gives 50% weight to growth vs. 35% to attainment (released in 2018)

Source: research by the author.

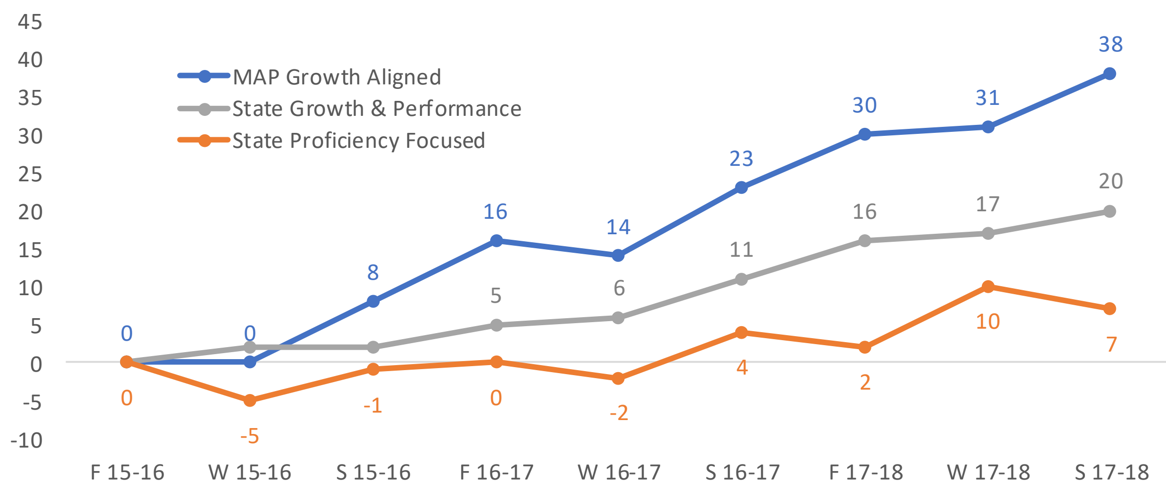
and 6 are part of a district that developed a growth-focused accountability system based on the NWEA's MAP test.[17] Of the test score-based points on the district's accountability system, 75% are based on MAP growth and 25% are based on MAP performance. None of the points in this district's accountability system are based on state test score results.

Figure 12 summarizes the accountability system that each school is subject to. At the top are those schools subject to an accountability system that places the most weight on growth. At the bottom are those schools subject to an accountability system that places the most weight on performance. When they could be identified, Figure 12 lists *district-based* accountability systems, on the assumption that those accountability systems are likely to be of greatest relevance to the school. However, in the case of schools 1, 2, and 3, I was unable to identify a formal district accountability system, so I have instead noted the school-based or statewide accountability system, respectively.

In Figure 13, I show the change in school-level percentile for schools divided into three categories. The three schools – numbers 4, 5 & 6 – in a district that uses MAP growth as the primary factor in its accountability system are categorized as "MAP Growth Aligned." The four schools – numbers 1, 2, 3 & 7 – in districts that include both state test score growth and state test score performance in their accountability systems are categorized as "State Growth & Performance". The seven

[17] I also group school 5 with this MAP growth-focused accountability group, because they are part of a charter network where most schools – including school 6 – are subject to external MAP growth accountability.

Figure 13 – Change in School-Level Percentile by School Category

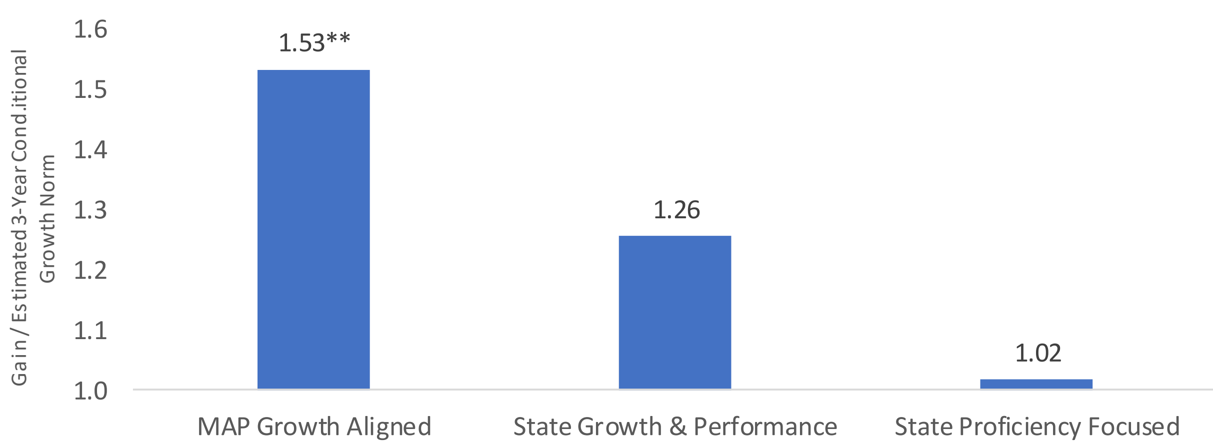


Note: figure shows percentile gain for consistently-enrolled students. The MAP Growth Aligned category includes schools 4, 5 & 6. The State Growth & Performance category includes schools 1, 2, 3 & 7. The State Proficiency Focused category includes schools 8-14.

remaining schools – schools 8-14 – are categorized as "State Proficiency Focused" because their district focuses on proficiency on the state test in its accountability system. As shown in the chart, MAP Growth Aligned schools increased their school-level percentile by 38 points over three years, State Growth & Performance schools increased their school-level percentile by 20 points, and State Proficiency Focused schools increased their school-level percentile by seven points.

Figure 14 shows the same gains another way, comparing the change in MAP score by school category against the estimated three-year conditional growth norms. The

Figure 14 – Gains / Estimated 3-Year Conditional Growth Norms by School Category



Note: Effect size calculated as the incremental gain in RIT score divided by the standard deviation of 8th grade spring math scores in the 2015 MAP Norms study. Significance calculated based on one-sample t-test. ** $p < 0.01$ * $p < 0.05$.

results show a similar pattern to the school-level percentile gains in Figure 13, with schools subject to more growth-aligned accountability systems experiencing greater gains. The three schools subject to a MAP growth-aligned accountability system improved their MAP score over three years by 53% more than the estimated national growth norms. This result is statistically significant at traditional levels and corresponds to a three-year effect size of approximately 0.38 standard deviations. Schools subject to state growth & performance-focused accountability systems improved their MAP score by approximately 26% more than the estimated national growth norms, a result that is not statistically significant at traditional levels. Finally, schools subject to accountability systems that focus on proficiency on state tests showed average three-year gains nearly identical to the estimated national norms.

Conclusion

The Teach to One: Math program is a significant innovation in the way in which math is taught to middle and high school students. In an effort to provide more personalized instruction, schools using TtO reconfigure classrooms, invest in technology, and re-envision the role of the teacher. Given the investment, it is reasonable to ask whether students participating in the program learn more math than they otherwise would.

This study takes one step in that direction by asking whether students at the 14 schools that used TtO over the last three school years saw greater gains on the MAP math test than a national reference group. In large measure, the answer is yes. On average, consistently-enrolled students at schools using TtO between 2015-16 and 2017-18 saw their percentile ranking go up by 20 points against the school-level distribution of scores and nine points against the student-level distribution. These students grew an average of 23% more than the estimated three-year growth norms from a nationally representative group of students, gains which correspond to a three-year effect size of approximately 0.16 standard deviations. Gains are smaller but still positive for a broader group of students, including those who are not consistently enrolled. While this study cannot establish causality, it is encouraging to see average gains above national norms, especially with a more disadvantaged student population.

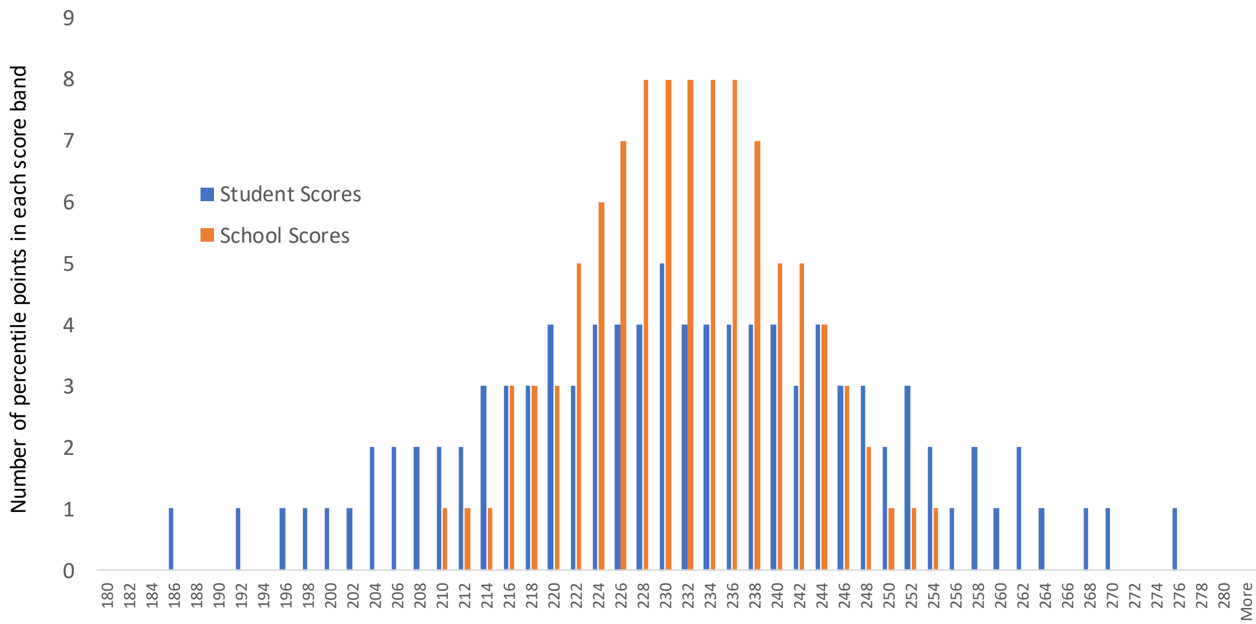
Underlying these average gains, however, was significant heterogeneity by school. Some schools grew substantially more than the TtO-wide average, while others grew less. In seeking to understand this variation, I find two relationships that merit additional exploration. First, there is some evidence that schools with a smaller content gap – the gap between students' initial test scores and the math content they were exposed to – saw greater gains on the MAP test. Second, there was a relationship between the external accountability schools faced during this period and their growth on the MAP test. Schools facing a MAP growth-aligned accountability system saw the largest gains while schools facing a performance-focused accountability system saw little, if any, growth on the MAP test. While far from conclusive, these relationships may provide an avenue for further research as New Classrooms seeks to identify why the TtO program may work better for some students, schools, and districts than others.

Appendix

Appendix A – Distribution of Student-Level vs. School-Level MAP Scores

Figure A1 shows the national student-level and school-level distribution of spring 8th grade MAP scores from the 2015 MAP norms study. As can be seen in the figure, the student-level distribution of scores is wider than the school-level distribution of scores, presumably because most schools have a mix of high and low scoring students. The difference in the shape of the distributions explains why incremental score increases that occur near the middle of the distributions lead to greater percentile increases against the school-level distribution, since the same score increase leads to a greater improvement in relative ranking (e.g. for the same score increase, a school would pass more schools against the school-level distribution).

Figure A1 – National Distribution of Spring 8th Grade MAP Scores

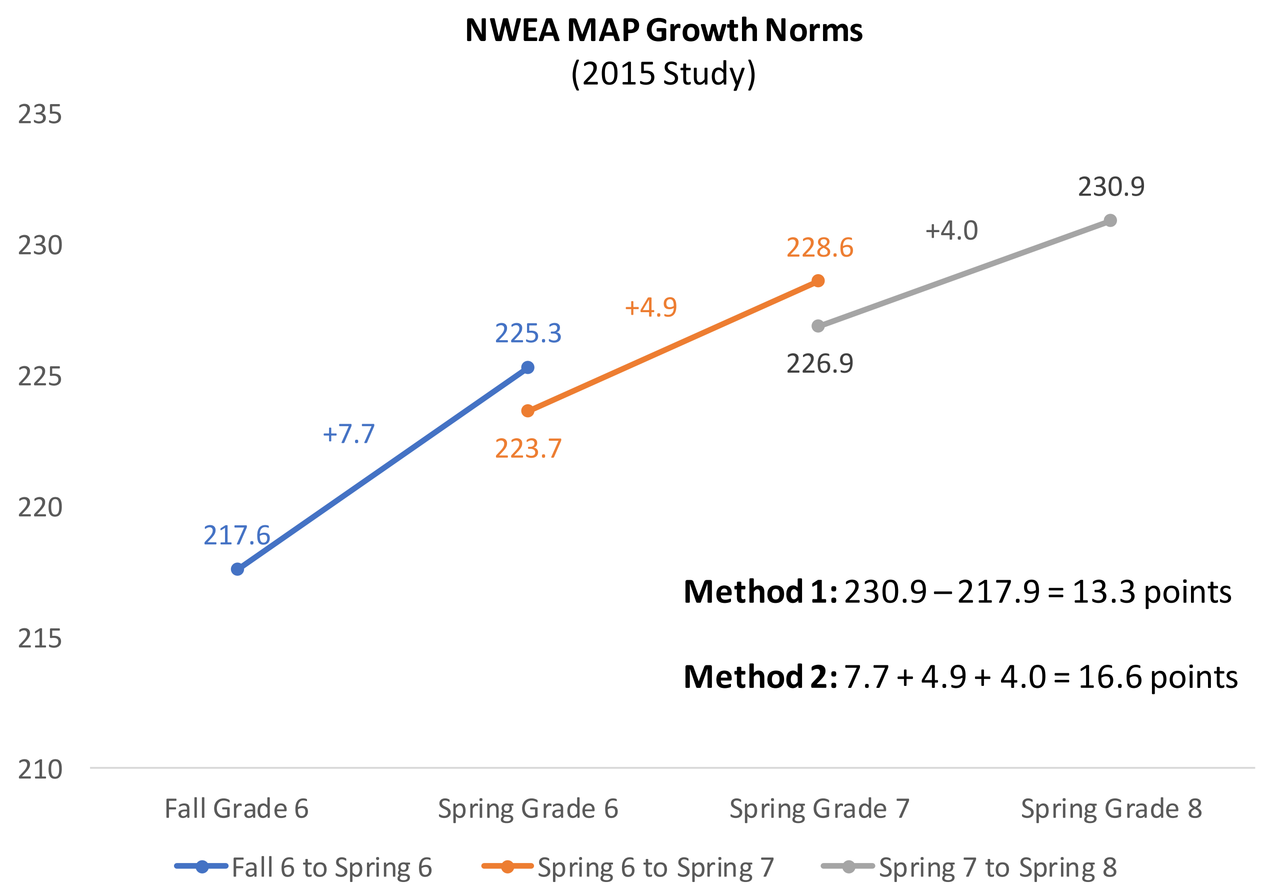


Source: 2015 MAP Growth Norms Study.

Appendix B – Estimation Methods for Three-Year Conditional Growth Norms

Figure B1 shows three one-year growth norms from Table D1 in the 2015 MAP Norms study. It shows that, for example, the national reference group of students had an average score of 217.6 in the fall of 6th grade and improved to 225.3 by the spring of 6th grade, an increase of 7.7 points. The chart shows smaller one-year growth for students from the spring of 6th grade to the spring of 7th grade, and from the spring of 7th grade to the spring of 8th grade. Interestingly, the average score at the starting point for each one-year growth period is lower than the average score for the ending period of the previous one-year time period (e.g. the average score in the spring of 6th grade is 225.3 when it is the end-point of a growth period, but 223.7 when it is the starting point). This is presumably because a different group of students are used to develop the fall grade 6 to spring grade 6 norm than are used to develop the spring grade 6 to spring grade 7 norm.

Figure B1 – Methods for Estimating Three-Year NWEA MAP Growth Norms



Source: 2015 MAP Growth Norms Study.

Because the 2015 MAP Norms study does not provide three-year growth norms, they must be estimated. One simple method, referred to as Method 1 in Figure B1, is to subtract the fall 6th grade score from the spring 8th grade score. This gives an unconditional three-year growth norm of 13.3 points. An alternative method, referred to as Method 2 in Figure B1, is to add together the three one-year growth norms shown in the figure. This gives an unconditional three-year growth norm of 16.6 points. It is not immediately obvious which method is likely to be a better estimate of the actual three-year growth norms, were NWEA to calculate them.

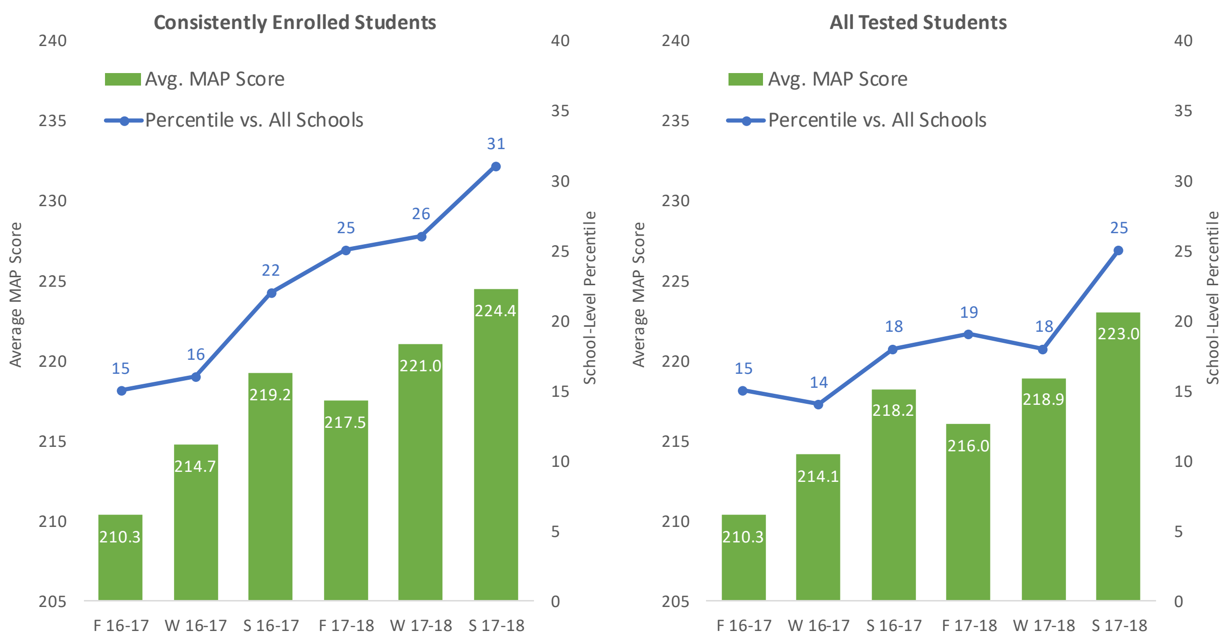
In the body of the study, I calculate gains vs. estimated three-year conditional norms based on Method 1. Method 1 is preferred because it leads to gains that are consistent with the student percentile gains shown elsewhere in the study. Method 1 implies a student-level percentile gain of approximately 6 to 9 points, which is close to the actual gain of 9 points. Method 2, by contrast, implies a student-level percentile decline of between 0 and 2 points. The actual student percentile gain of 9 points is likely to be fairly accurate – and therefore a good reference point – because it is based on data that are directly provided in the 2015 MAP norms study and requires few assumptions to calculate. I provide results for Method 2 in Appendix D, which shows the sensitivity of the overall results to various assumptions.

Appendix C – School-level Percentile Gains Over Two Years for a More Recent Cohort of Students

Figure C1 below shows the average test score increase and school-level percentile gains for the cohort of students who were 6th graders in a TtO school in 2016-17 and 7th graders in a TtO school in 2017-18. This cohort of students are one year younger than the cohort of students studied in the main body of the paper and I only have two years of data on their performance. However, they show gains over their first two years that are slightly larger than the gains shown by the three-year cohort of students over their first two years.

This analysis includes all 21 schools that had 6th graders participate in TtO in 2016-17 and 7th graders participate in TtO in 2017-18. This includes the 14 schools included in the three-year analysis and seven additional schools.

Figure C1 – Average MAP Score and School-Level Percentile for Students Who Were 6th Graders in 2016-17 and 7th Graders in 2017-18

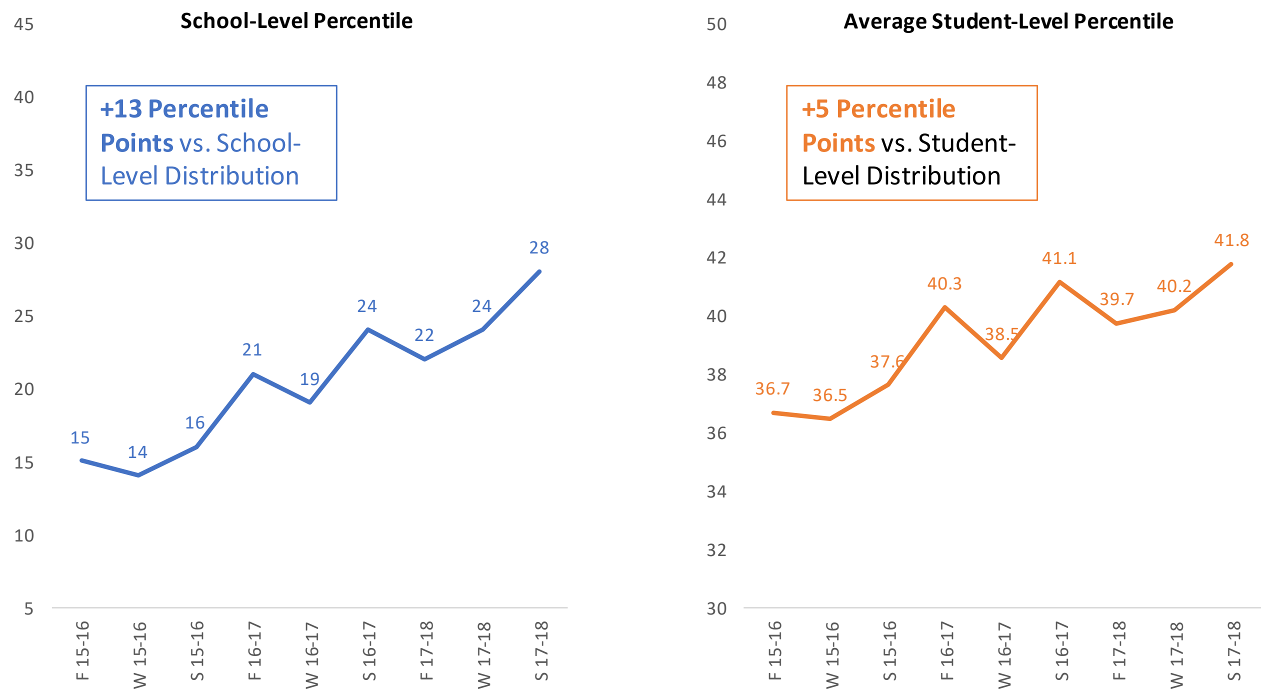


	F 16-17	W 16-17	S 16-17	F 17-18	W 17-18	S 17-18	F 16-17	W 16-17	S 16-17	F 17-18	W 17-18	S 17-18
Students	1,372	1,346	1,360	1,312	1,323	1,372	1,846	2,027	2,149	1,748	1,824	1,816

Note: the graph on the left includes only students who were 6th graders in 2016-17, 7th graders in 2017-18, enrolled in the same school for both years, and had a Fall 2016-17 and Spring 2017-18 MAP score. The graph on the right includes all tested students in 6th grade in 2016-17 or in 7th grade in 2017-18.

Appendix D – Percentile Gains for All Tested Students

Figure D1 – School-Level and Average Student-Level Percentile (All Students)



Note: includes all tested students in all periods in the 14 schools that participated in TtO for three years from 2015-16 to 2017-18.

Appendix E - Sensitivity of Overall Gain Results to Alternative Assumptions

Figure E1 shows results that appear in the body of the study highlighted in grey in column 1. Over three years, consistently-enrolled students saw test score gains consistent with a 20 percentile point gain against the school-level distribution, a 9 percentile point gain against the student-level distribution, and 23% more growth than the estimated three-year conditional growth norms. When looking at all students in the 14 three-year TtO schools – not just those who were consistently enrolled – we see percentile gains of 13 points and 5 points against the school- and student-level distributions, respectively, and a gain in average test scores that was 12% higher than the national gain.

Figure E1 – Sensitivity of Overall Gain Results to Alternative Assumptions (note: the preferred results, shaded below, are shown in the main text)

Business Rules	1. Preferred	2	3	4	5	6	7	8
Weight Students or Schools Equally	Students	Schools	Students	Schools	Students	Schools	Students	Schools
Apply MAP High Stakes Filters	No	No	Yes	Yes	No	No	Yes	Yes
Estimation Method for 3-Year MAP Growth Norms	1	1	1	1	2	2	2	2
Consistently Enrolled Students	1. Preferred	2	3	4	5	6	7	8
School Percentile Gain	20	22	25	28	20	22	25	28
Student Percentile Gain	9	9	10	11	9	9	10	11
Growth / Conditional Growth Norm	1.23	1.26	1.31	1.35	0.97	1.00	1.03	1.08
Growth / Unconditional Growth Norm	1.28	1.31	1.37	1.40	1.03	1.05	1.09	1.12
All Students	1. Preferred	2	3	4	5	6	7	8
School Percentile Gain	13	17	16	22	13	17	16	22
Student Percentile Gain	5	7	6	9	5	7	6	9
Gains / National Gains*	1.12	1.21	1.19	1.31	1.12	1.21	1.19	1.31

* Gains / National Gains shows the increase in the average test score at TtO schools from fall of 6th grade to spring of 8th grade divided by 13.3, the increase in the average MAP test score from fall of 6th grade to the spring of 8th grade in the 2015 MAP Norms study. Note: the School Percentile Gain, Student Percentile Gain, and Gains / National Gains are the same in columns 5-8 as in columns 1-4 because the estimation method for 3-Year MAP growth norms does not affect these calculations.

Columns 2 through 8 in Figure E1 test the sensitivity of those results to alternative assumptions. Columns 2, 4, 6, and 8 weight the results by school, rather than by student, when calculating average gains. Columns 3, 4, 7, and 8 remove questionable test scores by applying MAP filters recommended for high-stakes testing environments.[18] Columns 5-8 estimate three-year conditional growth norms using Method 2 – described in Appendix B – rather than Method 1.

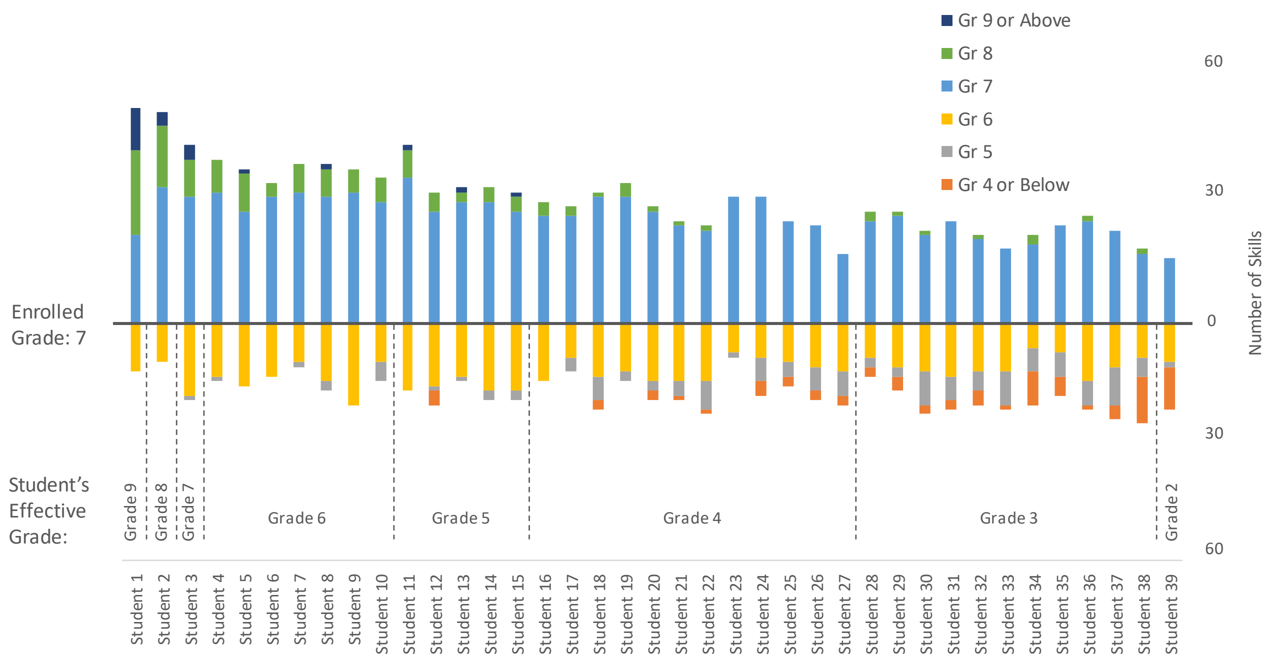
[18] These high-stakes filters, which are used by New Classrooms when reporting results, include removing scores that are a drop of ten or more points from the score in the immediately prior testing period and removing scores where a student's testing time was 30 minutes lower than in an adjacent testing period. These filters are generally based on the guidance provided by the NWEA in "Guidance for Administering NWEA MAP/MPG Assessments When

Under these scenarios, the percentile gains are always equal to or higher than those reported in the main text. The school percentile gains range from 20 to 28 for consistently-enrolled students and from 13 to 22 for all students. The student percentile gains range from 9 to 11 for consistently-enrolled students and from 5 to 9 for all students. The growth vs. conditional growth norms range from 0.97 to 1.40, with the preferred estimate of 1.23 roughly in between the high and low estimates. The simple gains vs. national gains measure – which measures the average test score increase for all students at the 14 TtO schools vs. the national average test score increase – ranges from 1.12 to 1.31.

Results are Used for High Stakes Purposes" available at: https://www.nwea.org/content/uploads/2017/04/Guidance-for-Administering-MAP-and-MPG-Assessments-When-Results-are-Used.pdf

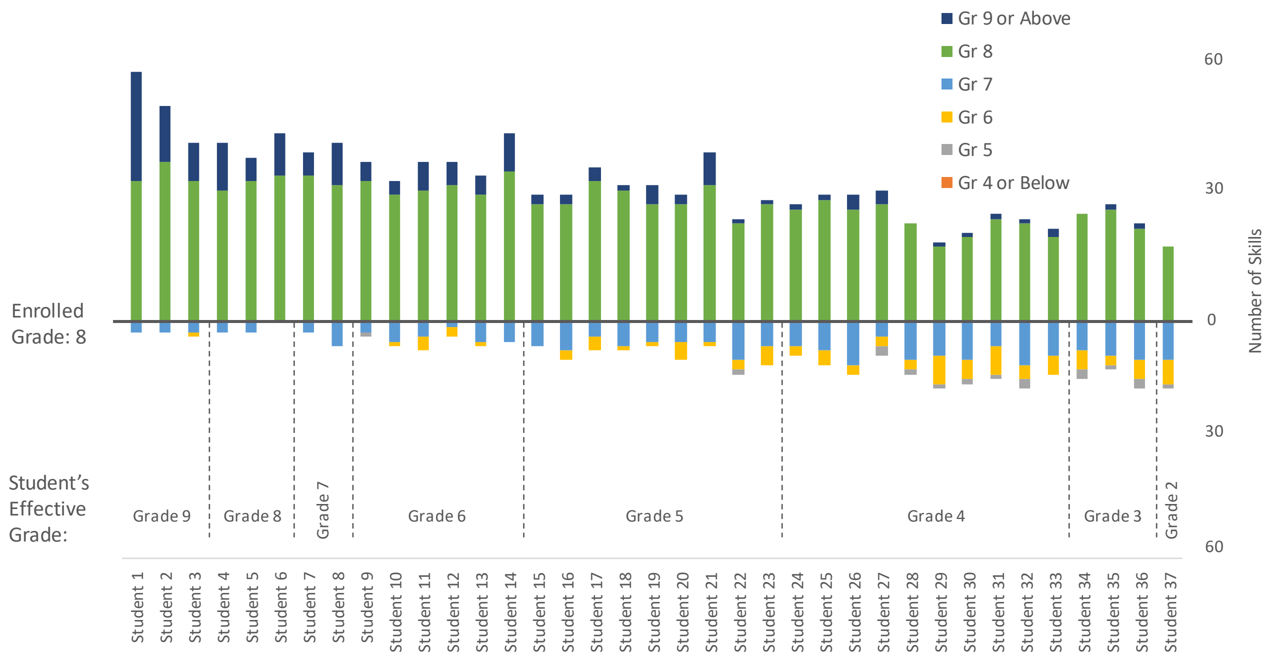
Appendix F – Content by Student at School 1 in 7th and 8th Grade

Figure F1 - Skills and Effective Grade Level by Student in School 1 (2016-17, Grade 7)



Note: includes only students who were 6th graders in 2015-16, 7th graders in 2016-17, 8th graders in 2017-18, enrolled in the same school for all three years, and had both a fall 2015 and a spring 2018 MAP score. Does not require a student to have a test score in every period. Effective grade level is determined based on the MAP score required to have a 50% change of scoring proficient on the PARCC test for that grade.

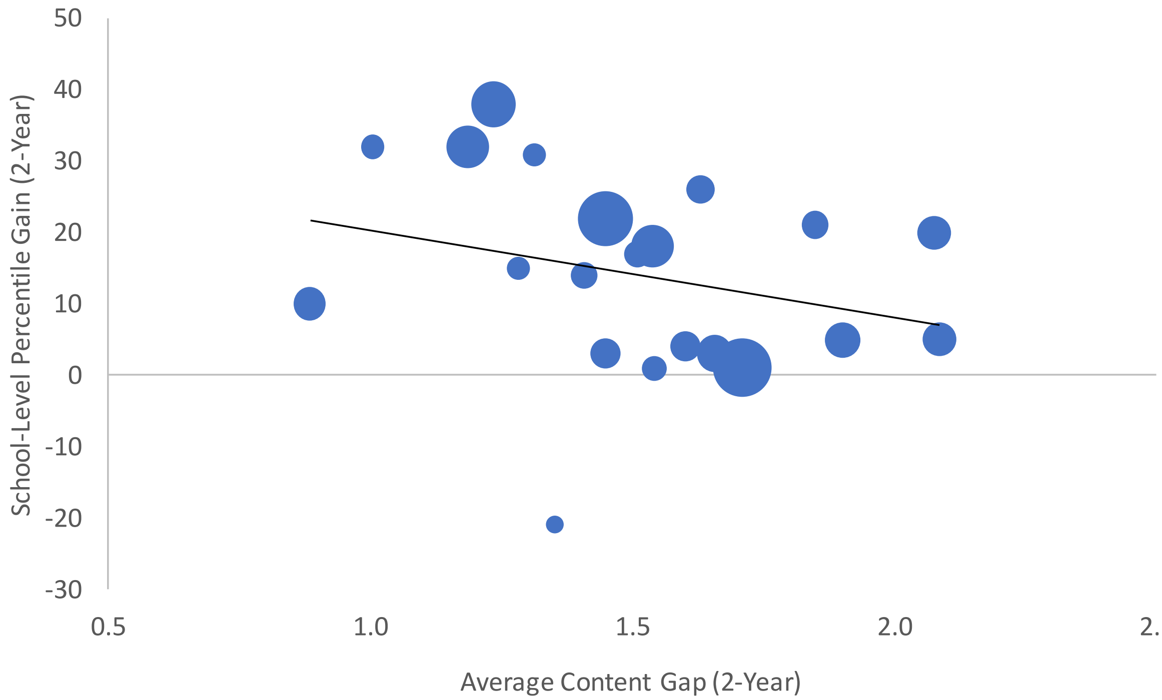
Figure F2 - Skills and Effective Grade Level by Student in School 1 (2017-18, Grade 8)



Note: includes only students who were 6th graders in 2015-16, 7th graders in 2016-17, 8th graders in 2017-18, enrolled in the same school for all three years, and had both a fall 2015 and a spring 2018 MAP score. Does not require a student to have a test score in every period. Effective grade level is determined based on the MAP score required to have a 50% change of scoring proficient on the PARCC test for that grade.

Appendix G – Two-Year Content Gap Analysis for Cohort Who Were 6th Graders in 2016-17

Figure G1 – Relationship Between Content Gap and School-Level Percentile Gains (2-Year)



Note: this figure shows the relationship between the average content gap (x-axis) and school-level percentile gain (y-axis) over two years for the cohort of students who were 6th graders in 2016-17, 7th graders in 2017-18, consistently enrolled in the same school, and had a fall 2016 and spring 2018 MAP test score. The bubble size is proportional to the number of consistently-enrolled students.

Figure G2 – Regression to Predict Annual School-Level Percentile Gain Based on Annual Content Gap

	Grade 6 2016-17	Grade 7 2017-18
Content Gap	1.480	-12.43**
	(9.434)	(3.974)
Constant	5.585	30.17**
	(12.40)	(7.087)
Observations	21	21
R-squared	0.002	0.404

Note: this figure shows the results of an Ordinary Least Squares regression to predict the annual school-level percentile gain based on the annual content gap for the 21 schools that participated in TtO with 6th graders in 2016-17 and 7th graders in 2017-18. The analysis includes only consistently-enrolled students who were 6th graders in 2016-17, 7th graders in 2017-18, consistently enrolled in the same school, and had a fall 2016 and spring 2018 MAP test score. Robust standard errors in parentheses. Regressions weighted by the number of consistently-enrolled students in each school.
** $p<0.01$, * $p<0.05$, ~ $p<0.1$