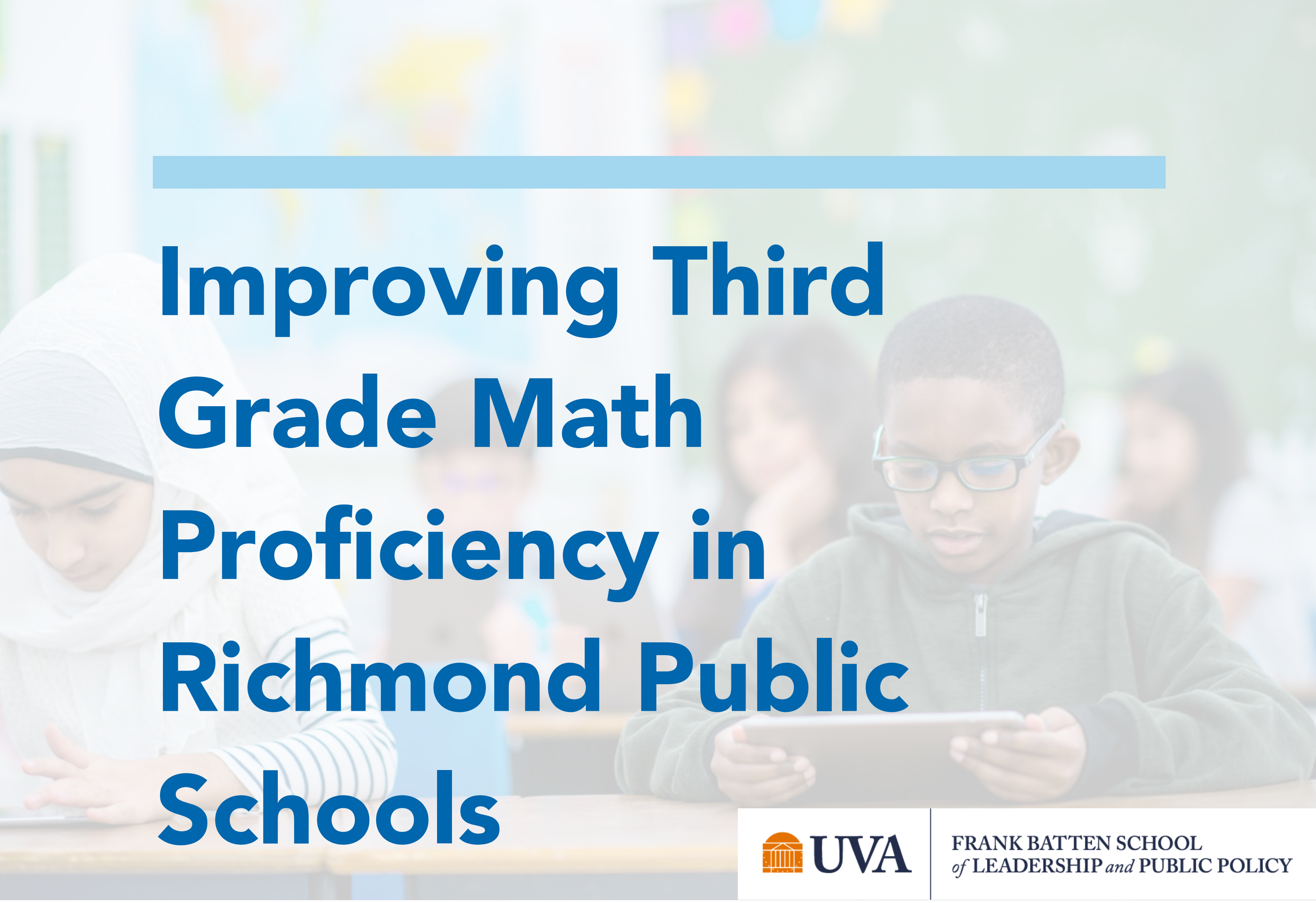

Improving Third Grade Math Proficiency in Richmond Public Schools

UVA | FRANK BATTEN SCHOOL *of* LEADERSHIP *and* PUBLIC POLICY

Prepared by Todd Hall for Richmond Public Schools | April 2022

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Honor Statement
On my honor as a student, I have neither given nor received unauthorized aid on this assignment.

Disclaimer
This research uses publicly available data from the Virginia Department of Education (VDOE) and Richmond Public Schools. The content does not reflect the views of the VDOE, the Commonwealth of Virginia, or Richmond Public Schools. The VDOE, Commonwealth of Virginia, and Richmond Public School are not responsible for the content or any loss due to the use of such content. Any mention of products, trade names, or organizations within this report is not an endorsement of those entities by the VDOE, the Commonwealth of Virginia, or Richmond Public Schools.

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Executive Summary

About 40% of the third graders in Richmond Public Schools (RPS) scored below proficient on the Virginia Standards of Learning (SOL) math exam in 2018-2019. The COVID-19 pandemic put students further behind across the state and the nation (Curriculum Associates, 2021b; Virginia Department of Education, 2022a).

Math proficiency demands attention from policymakers because math performance in the early elementary grades predicts successful transitions to adulthood. Students who are not able to reach math proficiency by third grade are less likely to do well in subsequent math courses and less likely to graduate high school (Goldhaber et al., 2021, 2021; Goldhaber & Özek, 2019).

My analysis demonstrates that **Black and Hispanic RPS third graders are more likely to be behind in third grade math—both within RPS and relative to other Black and Hispanic third graders in Virginia** (Virginia Department of Education, 2022a). This raises the stakes of addressing math proficiency from an equity perspective. Succeeding in this area relates directly to both equity as a core value of RPS and how well the division can fulfill several academic goals articulated in its 2018-2023 Strategic Plan (Richmond Public Schools, 2018).

This report identified three alternatives backed by rigorous evidence to increase math proficiency, prioritizing interventions shown to benefit struggling students most:

1. High-dosage tutoring: extend the school day with a required 35-minute tutoring block staffed by teachers and newly hired tutors.
2. ASSISTments: implement a staged rollout of a free computer-assisted learning platform that has built-in integrations with the Eureka Math curriculum.
3. Teacher recruitment incentives: offer $10,000 recruitment bonuses for teachers with an exemplary teacher evaluation who commit to filling an elementary vacancy for two years.

I evaluated each of these alternatives for equity, cost-effectiveness, and feasibility—evaluative criteria derived from the RPS core values—and recommend ASSISTments. **The staged rollout of ASSISTments would be about three times as cost-effective as the other alternatives while serving students equally and fitting seamlessly within existing curriculum.**

In light of critical funding constraints, ASSISTments could replace the math portion of the divisions' $375,000 contract for i-Ready (Kamras, 2022b), a different learning platform that is not perfectly aligned with the Eureka curriculum, is not free, and has not been evaluated as rigorously. This could help achieve both a stronger math gains and much-needed cost savings in the next round of budget negotiations.

Introduction

Math proficiency by third grade matters for future learning and successful transitions to adulthood. Although standardized tests are not the only relevant measure of academic performance, there is substantial evidence that large differences in math test scores forebode differences in life outcomes (Goldhaber & Özek, 2019). Third grade math test scores strongly predict high school math test scores, advanced math and science course enrollment, and—most importantly—high school graduation (Goldhaber et al., 2021).

Unfortunately, the COVID-19 pandemic has profoundly upended learning, especially in math, with differential impacts by student subgroups. National data on hundreds of thousands of students from Fall 2021 iReady diagnostic tests suggest that losses in math grade-readiness for majority-Black and Latinx schools were severe. The number of third graders who were two or more grades behind in math rose by 17 percentage points in majority-Black schools and 14 percentage points in majority-Hispanic schools in Fall 2021 relative to the pre-pandemic average. Reading suffered as well, but the losses in math were larger (Curriculum Associates, 2021b), perhaps because students got less exposure to math while learning remotely at home.

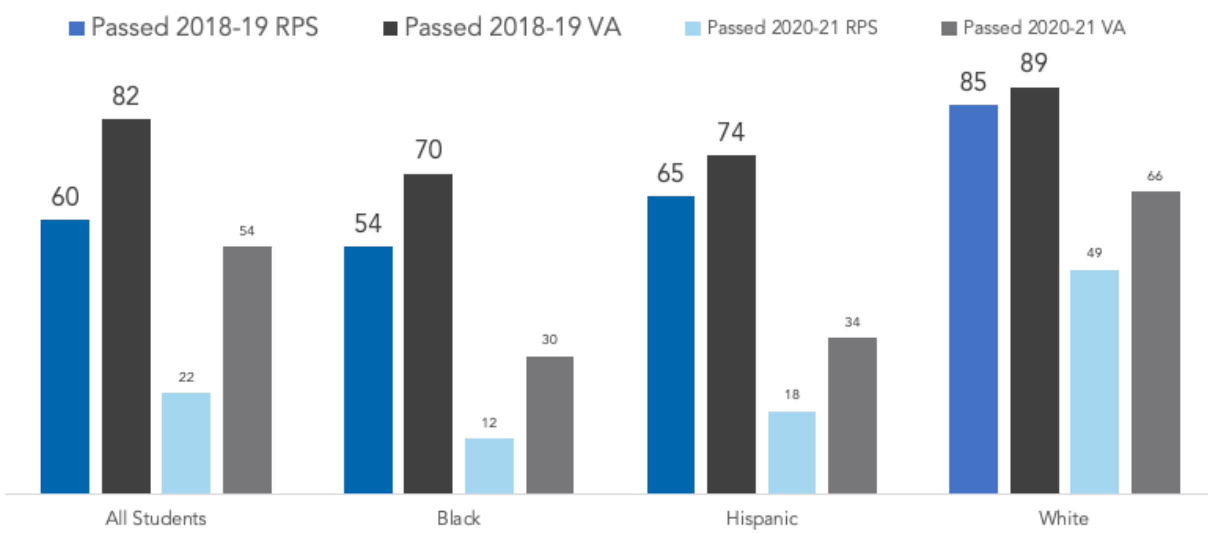
While a few points higher or lower on a test might not predict meaningful differences in life outcomes, we should be concerned that many students are below proficiency and that there are large differences in proficiency by race/ethnicity. This concern applies to the Virginia Standards of Learning (SOL) exams, which were explicitly designed to be a minimum bar for understanding of basic concepts (Ryan, 2010).

This report examines how one Virginia school division, Richmond Public Schools (RPS), might raise low levels of third grade math proficiency. It provides an overview of the problem, explains how it fits within the division's priorities and constraints, and projects the likely consequences of inaction. Next, this report reviews rigorous evidence on potential solutions and evaluates how likely various alternatives are to be equitable, cost-effective, and feasible for RPS. It concludes with a recommendation and next steps for implementation.

Problem Statement

Too many third graders in Richmond Public Schools (RPS) are below proficient in math. In 2018-2019, 40% of the third graders in Richmond scored below proficient on the Virginia Standards of Learning (SOL) math exam. Tests participation in the 2020-2021 school year was too low due to the pandemic to form reliable conclusions, but performance likely worsened. [1] The low proficiency rates are further exacerbated by persistent proficiency gaps for Black and Hispanic students and learning loss during the COVID-19 pandemic. White students in Richmond passed the Grade 3 Math SOL nearly on par with the state average in 2018-2019 (85% in RPS vs. 89% in Virginia). Meanwhile, only 54% of Black RPS third graders in 2018-2019 and 65% of Hispanic RPS 3rd graders passed the Grade 3 Math SOL in 2018-2019 (Virginia Department of Education, 2022a).

Figure 1: Third Grade Math SOL Proficiency Rates in RPS and Virginia



[1] The year 2018-2019 was the last year for RPS with a sufficient number of test takers (Virginia Department of Education, 2022a), so I rely on those proficiency rates for all subsequent analyses.

Client Overview

Richmond Public Schools (RPS) serves 22,000 students across five preschools, 25 elementary schools, seven middle schools, five high schools, and three specialty schools with an operating budget of $419 million (RPS, n.d.). RPS serves a diverse student body, a large majority of whom are students of color (79%) and a slight majority of whom are economically disadvantaged (52%) (Virginia Department of Education, 2022b). Three core values—equity, engagement, and excellence—guide the division's mission to create opportunity for all students to pursue their dreams (Richmond Public Schools, 2018, 2021a).

Ensuring academic proficiency by third grade is critical to this mission. The RPS 2018-2023 Strategic Plan names increasing proficiency rates across all subjects, overall and for subgroups as Goal #3 among its top five goals. Priority #1, "Exciting and Rigorous Teaching and Learning", explicitly named adopting a new, rigorous math curriculum as action item 1.3 (Richmond Public Schools, 2018). These priorities reflect RPS core values, approval from the School Board and Superintendent, and input from more than 3,000 community stakeholders.

In May 2020, Richmond's Office of Curriculum and Instruction delivered on action item 1.3 by adopting the Eureka Math Curriculum for K-8 instruction. Eureka aligns with Common Core Standards and the Virginia SOLs. It emphasizes consistent visual modeling, fluency with basic math facts and procedures, and deep conceptual understanding (Pauly, 2020a; Petrilli, 2017).

Any Alternative Would Require Collaboration

Multiple offices at RPS share influence over math proficiency, and the main point of contact for the policy analysis in this report has limited direct authority on this issue. This project evolved from exploring what an equity funding formula in RPS could look like to focusing on student outcomes that such a fund could target.[2] The main contact, Andrew Bishop, also changed roles within RPS. He was a Specialist in School Planning in the Superintendent Chief of Staff Office at the start of this engagement (Richmond Public Schools, n.d.b); he is now a Manager, Data and System Administration in the RPS Talent Office (Richmond Public Schools, n.d.b)

Even without these changes, raising math proficiency would necessarily require collaborative effort. The Superintendent Chief of Staff Office can influence proposals for the local school division budget and thus this project focused on budget inputs that could boost math proficiency. Yet any budget proposal that would affect instruction would require significant buy in from the Academics Office. The RPS Academics Office oversees math curriculum, teaching, and instruction to promote rigorous and engaged learning (RPS, 2018). Any budget proposal that would affect teacher labor markets would require buy in from the Office of Talent Acquisition. Of course, any proposal would require buy in from schools and principals. These key players factor strongly into the feasibility analyses detailed later in this report.

[2] Simulations of different equity funding formulas that RPS might consider are documented in a separate deliverable.

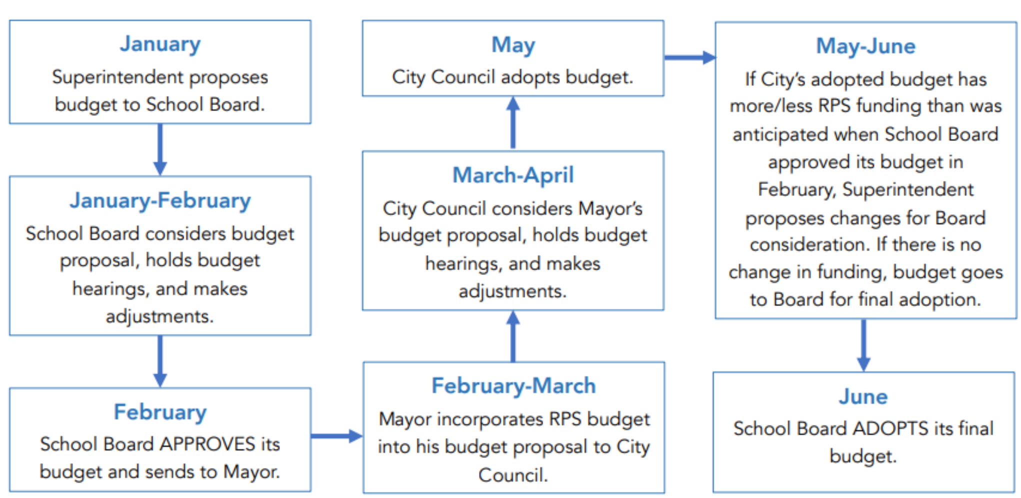
RPS Faces Constrained Capacity and a Budget Deficit

RPS faces exhaustion from the pandemic. When teachers sought mental health days in fall 2021, Superintendent Kamras not only approved the request, but also announced a moratorium on any new programming in the 2021-2022 school year (Wallace, 2021). In January 2022, the administration also withdrew plans to extend the school year to make up for pandemic-related learning loss after a November 2021 survey found a majority of students, families, and teachers preferred to keep the calendar year as-is (Kamras, 2022a).

RPS also faces tight funding constraints at both the state and local level. Virginia allocates funding to school divisions according to guidelines called the Standards of Quality, minimum requirements of free public education (Lou et al., 2018). Unfortunately, the state adjusted its funding calculation, resulting in a net decrease of $6.9 million in state funds for RPS in FY23 (Richmond Public Schools, 2022a). In February 2022, Superintendent Kamras and the School Board approved a FY23 RPS budget, but the Board still needs to identify $6 million in currently "undefined" budget cuts before the City Council can consider it. Figure 1 below outlines the local funding process. The Superintendent iterates on a budget with the Board. If approved by the Board, the tentative budget goes to the mayor for incorporation into their budget. It then goes to City Council for adjustment before returning to the Superintendent for proposed changes and finally returns to the Board for adoption. Mayor Levar Stoney has criticized budget gridlock on the Board; he recently proposed keeping the RPS budget flat but adding a $15 million contingency fund for RPS controlled by the City Council (Graff, 2022).

Given these challenges, it is unlikely that RPS can find funding for an expensive new program to raise math proficiency. Alternatives that build on existing infrastructure and that are low-cost or even cost-saving would likely have better prospects.

Figure 2: RPS Budget Process



Source: Kamras, Jason. (January 19, 2021). [FY22 Superintendent's Budget Proposal to the Richmond City School Board.]

Background on the Problem

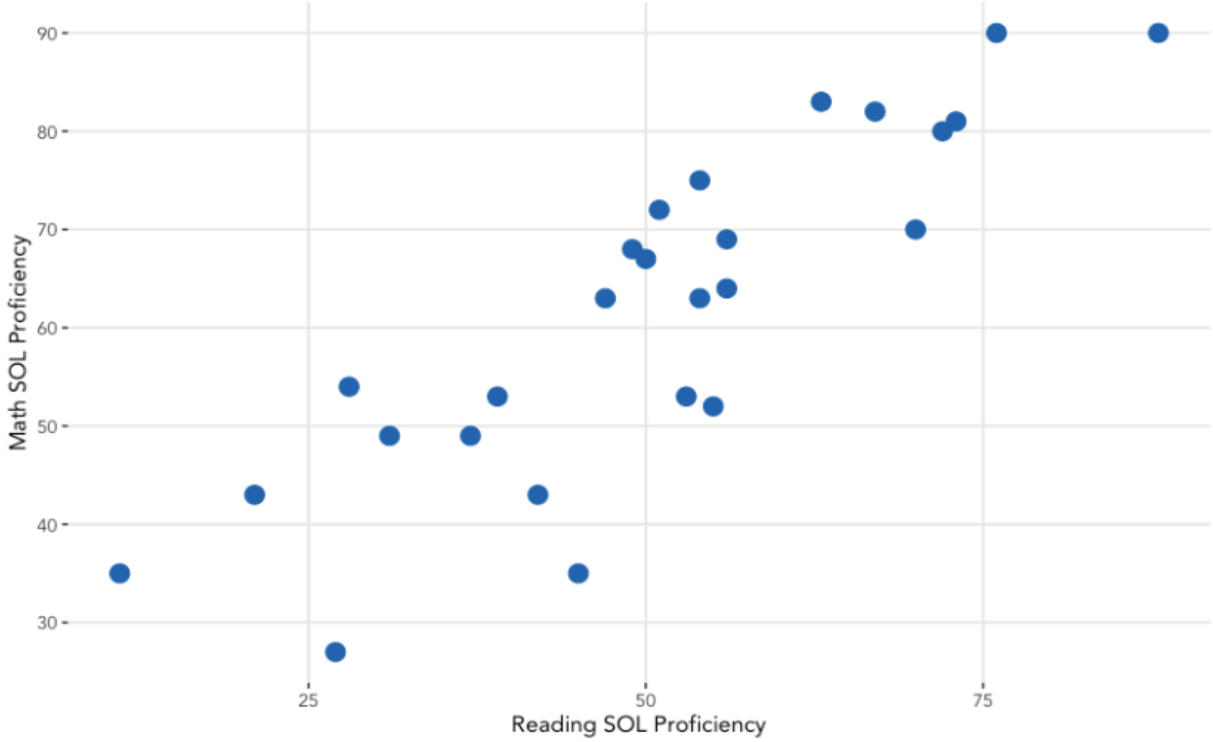
The potential causes of third grade underperformance on the Math SOL exams are complex and structural, including factors beyond RPS's direct control. Fryer and Levitt (2006) demonstrate using national data that Black students enter school behind their White counterparts. Initially, most of this gap can be explained by socioeconomic status, but Black students fall further behind through third grade such that gaps were not easily explained by socioeconomic status. Using the Richmond and neighboring Henrico school division as a case study, Ryan (2010) argues that racial and economic segregation as well as education politics that protect suburban schools have deprived students in high-poverty urban schools of the effective teachers and principals, parental engagement, high expectations and accountability they need to succeed.

Given this complexity, there is no panacea for third grade math proficiency in RPS and addressing math proficiency alone is insufficient. Instead, the alternatives analyzed in this report fit within a broader set of existing efforts. Of particular relevance, the RPS Strategic Plan explicitly prioritizes a "do whatever it takes" attitude to getting third graders to read at grade level (Richmond Public Schools, 2018). The recommendations on how to raise math proficiency in third grade are intended to complement the Division's focus on literacy, as well as the Division's core value of equity.

The three figures in this section use public data from the Virginia Department of Education (2022a) to show how intertwined math proficiency is with reading proficiency and racial equity.

Low math proficiency is clustered in schools that struggle with both math and reading by third grade. Figure 3 below shows that nine RPS schools have third grade math proficiency rates below 60% and third grade reading proficiency below 50%. Schools with low third grade reading outcomes tend to have low third grade math outcomes; the proficiency rates are strongly related (correlation = 0.86). Many early elementary students having difficulties in literacy likely also struggle in math. Addressing foundational math alongside the division's focus on literacy could mean targeting the same students who need more support overall.

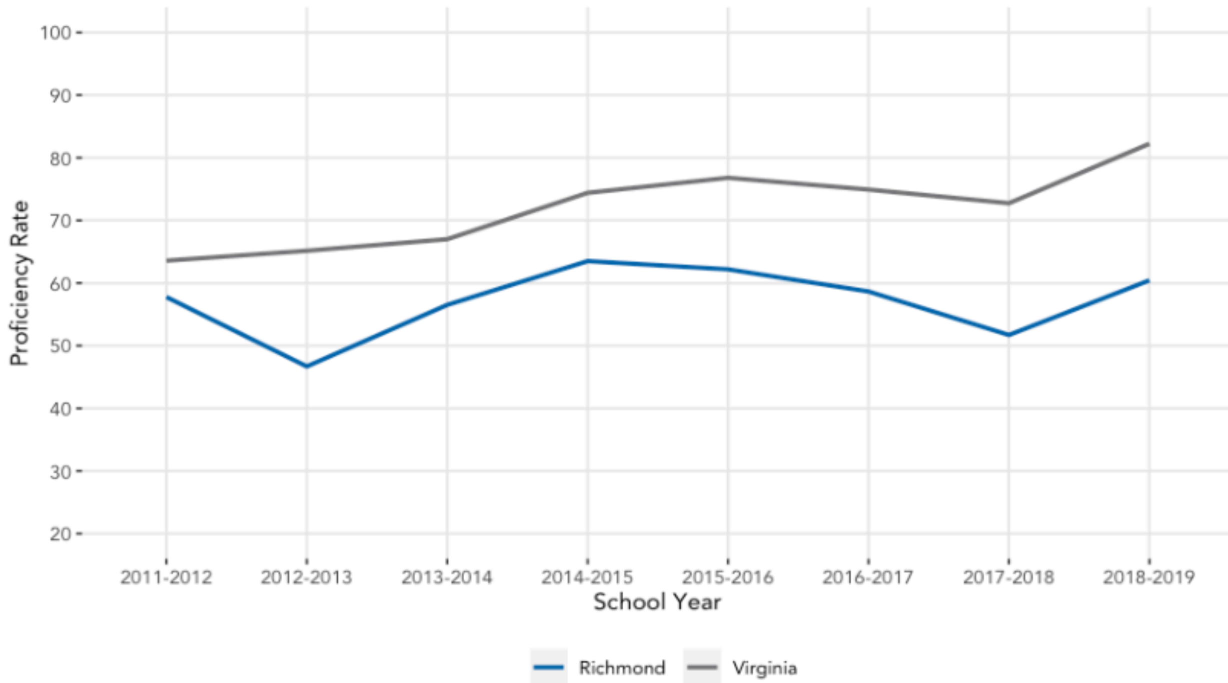
Figure 3: RPS School-level Math and Reading Third Grade Proficiency Rates (2018-2019)



Source: Virginia Department of Education Test Results: Build-A-Table, 2022. Each dot represents a school in RPS.

To put the issue of math proficiency in perspective, I compare RPS to Virginia as a whole. The division has lagged the state in third grade math proficiency over the last decade. Figure 4 below shows that proficiency in RPS declined has since oscillated around 60%. Meanwhile, Virginia had proficiency rates consistently above 60% that exceeded 80% by 2018-2019.

Figure 4: RPS and Virginia Third Grade Math SOL Proficiency Rates

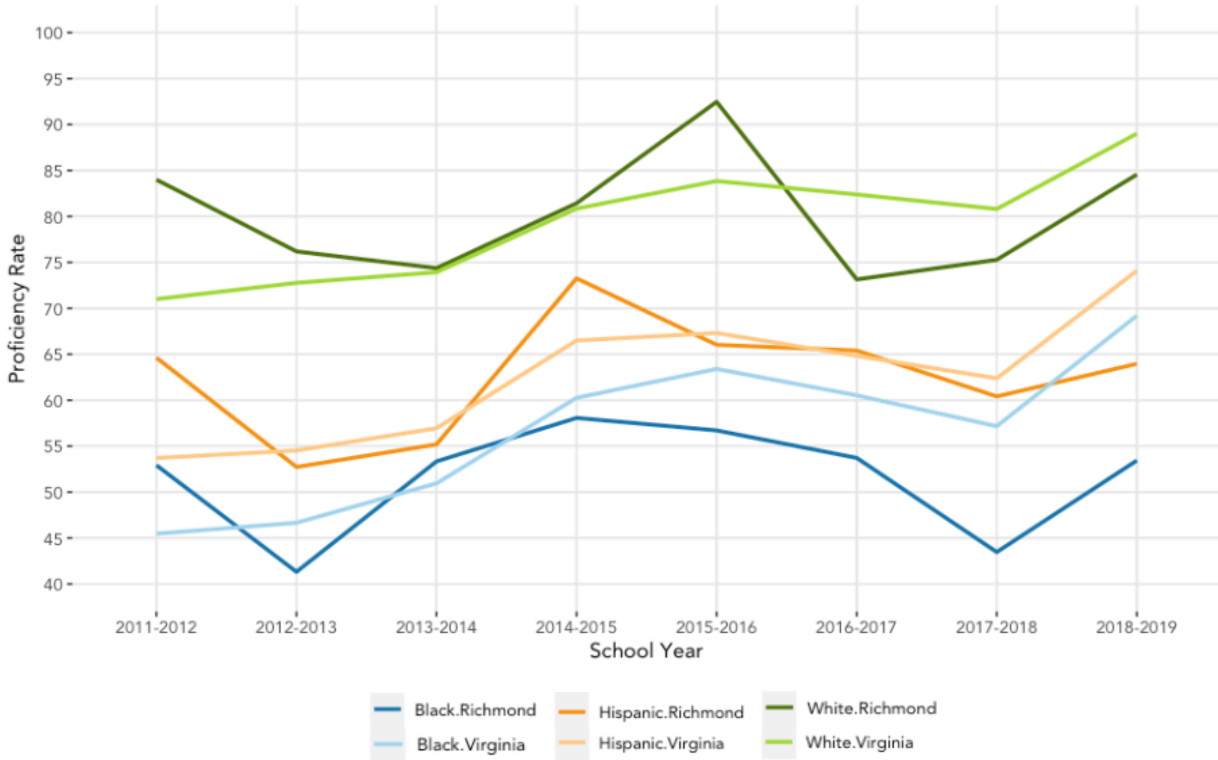


Source: Virginia Department of Education Test Results: Build-A-Table, 2022.

The next figure reveals a more complex history by breaking these comparative trends down by race/ethnicity.[3] The darker shade of each color shows the trend for a specific racial/ethnic group in RPS, while the lighter shade of the same color shows the trend for that same racial/ethnic group in Virginia overall. For example, dark blue represents the proficiency rate for Black third graders in RPS and light blue represents the proficiency rate for Black third graders in Virginia. Consistent with the existence of opportunity gaps, Black and Hispanic third graders were less likely to be proficient in math than White third graders in both RPS and Virginia (both shades of the blue and orange lines are below both the green lines).

[3] Data are only shown for the three largest racial/ethnic groups (Black, Hispanic, and White) due to data suppression rules for smaller racial/ethnic groups. For some years in RPS, there were fewer than 50 Asian and American Indian/Alaska Native test-takers, and the Virginia Department of Education does not publish data on proficiency or average test scores when groups have fewer than 50 students (Virginia Department of Education, 2022a).

Figure 5: RPS and Virginia Third Grade Math SOL Proficiency Rates



Source: Virginia Department of Education Test Results: Build-A-Table, 2022.

The degree to which RPS has lagged the state varies over time within racial/ethnic subgroups. During the 2011-2012 school year, RPS students were more likely to be proficient compared to students of the same race/ethnicity statewide in Virginia. In that year, for example, 53% of Black third graders in RPS passed the math SOL compared to only 45% of Black third graders statewide. Hispanic and White third graders in RPS were also more likely to pass the math SOL than their same race/ethnicity peers in Virginia.

Unfortunately, proficiency gaps between students of color in RPS and students of color Virginia have emerged and widened in recent years. The gap between third grade math proficiency rates for Black students in RPS (dark blue) and Black students in Virginia (light blue) has widened since 2013-2014 to almost 16 percentage points in 2018-2019 (53% in RPS vs. 69% in Virginia). A gap of 10 percentage points between Hispanic students in RPS vs. Hispanic students in Virginia has also emerged. White students in RPS now lag White students in Virginia although the gap is smaller, at less than 5 percentage points. These gaps across subgroups underscore the importance of considering equity in targeting and evaluating any alternative that seeks to raise math proficiency in RPS.

Consequences of the Problem

Falling short of math proficiency in third grade imposes significant direct and indirect costs. The direct costs include remediation services provided by RPS such as summer school and grade retention. In a recent year, RPS spent $432 per student for prevention, intervention, and remediation services and 609 RPS third graders attended summer school (T. R. Epp, 2021), which cost roughly $545 per student (Richmond Public Schools, 2021c). Studies that compare students who fall just above or just below their districts' test score for assigning students to summer school provide evidence that remediation can modestly improve math proficiency (Matsudaira, 2008). Yet many students are likely to remain below proficiency despite remediation efforts under the status quo.

Prior research implies significant consequences due to negative spillovers and missed opportunities when students remain below proficiency. The salient opportunity cost—those born by society but not explicitly paid—is the anticipated reduction in students' future earnings associated with failure on the SOL math exam. According to Currie and Thomas (2001) and Dobbie and Fryer (2011), a one standard deviation increase in math test scores for a 7-year-old corresponds to 7.8 percent higher wages at age 33. Moreover, Goldhaber et al. (2021) find that students performing at the 10^{th} percentile in third grade math distribution were 12-14% less likely to graduate from high school than those in the 90^{th} percentile. Dobbie and Fryer (2011) estimate that success in helping one Black male to graduate high school rather than drop out is associated with a lifetime public benefit in present value of $256,700. The benefits stem from increased tax revenue, avoided criminal justice involvement, and reduced public health costs. Even if third grade SOL math failure explains dropout for only a tiny fraction of RPS students, not graduating high school imposes large costs on individuals and society.

Evidence on Potential Solutions to Raising Third Grade Math Proficiency

This literature review summarizes the scholarship on promising approaches to raising third grade math proficiency. It privileges evidence from randomized controlled trials (RCTs). When implemented properly, RCTs produce a valid comparison group for attributing causal effects to the intervention. I also include several studies that compare students to themselves within schools across various years. These are less rigorous than RCTs but provide reasonably strong evidence by accounting for stable differences across students or schools.

Personalized Learning to Address Prior Knowledge Gaps

High-dosage tutoring and computer-assisted learning fill knowledge gaps by targeting instruction to each student's individual level of understanding. These strategies share a theory of change whereby students' success with new math depends on mastering foundational principles such as whole numbers and basic arithmetic facts (Gersten et al., 2009). Thirteen RCTs in contexts as varied as the US, Chile, India, and Kenya have found positive effects of educational interventions focused on teaching at the student's level rather than at grade level, and six of them show larger gains for less proficient students (Abdul Latif Jameel Poverty Action Lab (J-PAL), 2019).

High-dosage tutoring in particular has delivered impressive math achievement gains across a large number of rigorous studies, including 96 RCTs and many studies in early elementary grades. Math tutoring increased test scores by 0.37 standard deviations on average for K-12 students. Effect sizes vary by the type of tutor. High-dosage tutoring delivered by teachers yielded the largest effects, while paraprofessionals delivered considerable but smaller effects. High-dosage tutoring delivered by nonprofessionals yielded effects that were about half as small but could be lower cost and more scalable (Kraft & Falken, 2021; Nickow et al., 2020).

Image Source: canva.com

Computer-assisted learning leverages similar mechanisms as tutoring but with less personal attention and lower marginal costs. Evidence from 15 RCTs shows that computer-assisted learning can significantly increase math achievement. One noteworthy program, ASSISTments, is a free homework platform that uses formative assessments to provide rapid feedback and differentiated instruction by providing teachers with feedback from the assessments. In an RCT involving 43 schools in Maine, ASSISTMents increased math test scores by 0.18 standard deviations overall and 0.29 standard deviations for students scoring below the median (Escueta et al., 2017). This larger effect for lower-performing students is particularly notable given the goal of helping students below math proficiency in Richmond. However, the ASSISTments study was conducted with 7th graders, raising questions as to whether similar effects would be seen in earlier grades (Escueta et al., 2017).

Increased Instructional Time

Increased instructional time has been found to increase average math test scores in the US, Israel, and Switzerland (Cattaneo et al., 2017; Hayes & Gershenson, 2016; Rivkin & Schiman, 2015). Evidence from quasi-randomly assigned Kindergarten testing schedules suggests that students exposed to more instructional days between tests scored higher on the MAP assessment (Hayes & Gershenson, 2016). However, Hayes and Gershensen (2016) find that the additional instructional days allowed higher-achieving students to make larger gains than lower-achieving students. Similarly, a study in Switzerland that examined within-school and within-student variation in instructional time found that students with higher initial test scores benefitted more from increased instructional time (Cattaneo et al., 2017).

Image Source: canva.com

The benefits of increased instructional time also depend crucially on classroom quality. Comparing students to themselves across different years within schools, Rivkin and Schiman (2015) estimate the effect of instructional time differences between subjects (e.g., math vs. reading) on test scores in particular subjects at the school-by-grade-by-year level. They affirm that increased instructional time modestly increases test scores, but schools with the lowest classroom quality realize much smaller gains than those of higher quality (Rivkin & Schiman, 2015). Lengthening the school year uniformly could raise average test scores but widen achievement gaps. Policymakers focused on equity may want to increase instructional time strategically in target schools or for struggling students.

Recruiting More Effective Teachers

Teacher quality matters greatly for student achievement, but struggling students tend not to have the most effective teachers (Boyd et al., 2011; Raj Chetty et al., 2011; Rivkin et al., 2005). Rivkin, Hanushek, and Kain (2005) measure the variation in teacher quality based on how achievement gains across consecutive grades and cohorts change within schools in response to the proportion of different teachers across years. Because they measure growth within students and within schools, they can distinguish teacher performance from qualities of the students or their schools that are stable over time. They estimate that a one standard deviation increase in teacher quality is associated with at least 0.11 standard deviations of growth in 4^{th}-7^{th} grade math test scores. RCT evidence affirms the value of teacher quality, with experience as a notable indicator. Kindergarteners who were randomly assigned to more experienced teachers had significantly higher kindergarten test scores and higher earnings by age 27 (Raj Chetty et al., 2011). Unfortunately, the highest performing teachers are more likely to both avoid and leave schools with the lowest performing students (Boyd et al., 2011).


Image Source: canva.com

A study spanning ten large, economically diverse school districts offers a proof of concept that low performing schools can recruit more effective teachers. The Teacher Transfer Initiative (TTI) offered $20,000 bonuses to teachers in the top quintile for test score value added to transfer to a low-performing school in their district. This incentivized some high performing teachers to transfer, although it was a small share of the potentially eligible teachers. Researchers evaluated the TTI by randomly assigning teaching teams in low-performing schools that had a vacancy to either the opportunity to hire one of these top-performing teachers or a control group. Offering teaching teams a top-performing TTI teacher increased math test scores for elementary students by about 0.18 standard deviations in year one and 0.22 standard deviations in year two for classes attached to the vacant position. This corresponds to moving a student up by about ten percentile points in their state's standardized testing. The teachers recruited through TTI left their schools at a similar rate as the other teachers in the control teaching teams (Glazerman et al., 2013).

Whereas TTI recruited teachers based on observed performance, very little of the within-school variation in teacher quality is explained by observable teacher characteristics. Master's degrees, for example, are not predictive of student test score gains. One exception is that teachers in their first few years tend to perform poorly relative to experienced teachers (Rivkin et al., 2005).

Training Existing Teachers

If high quality teachers are so important, why not train or coach the in-service teachers already serving low-performing students? This is a good question. Unfortunately, the rigorous evidence on ways to raise math achievement by training in-service teachers is relatively thin compared to say, the RCT evidence on math tutoring—or even the evidence on teacher coaching for reading (Kraft et al., 2018). Indeed, three fourths of the experimental or quasi-experimental studies in a comprehensive review of the teacher coaching literature by Kraft et al. (2018) were for reading interventions. The researchers only found two math-specific coaching programs to include in their meta-analysis and the effects were not statistically significant. One evaluation of a statewide, mandatory match coaching program found small, significant effects on math achievement in one of the four years it was evaluated (Kraft et al., 2018).

Image Source: canva.com

This is not to say, however, that in-service math teachers cannot benefit from instructional support. For example, an RCT of the Mathalicious curriculum showed that a high-quality off-the-shelf curriculum combined with online implementation support raised math test scores by 0.09 standard deviations. The curriculum evaluated was specifically for grades 6-12, so further research would be needed to determine whether there are similarly effective options for elementary grades (Jackson & Makarin, 2018).

Policy Alternatives

This section considers how RPS might implement alternatives raised in the literature to boost third grade math proficiency. Three options are considered: targeted high-dosage tutoring, district-wide ASSISTments implementation, and recruitment incentives to fill elementary teacher vacancies with high-performing teachers. Two options were ruled out based on recent developments in RPS. First, an extended school year was not considered viable after Superintendent Kamras' withdrew his 2022 proposals for an extended school year due to a lack of community buy-in (Kamras, 2022a). Second, an overhaul of the math curriculum and instruction was out of scope because RPS began implementing a new K-8 math curriculum in 2020 after piloting and substantial public comment (Pauly, 2020a). The three remaining alternatives were selected based on rigorous evidence and potential to benefit students with lower initial baseline test scores.

1. Small-Group, High-Dosage Tutoring

Virginia's Superintendent of Public Instruction, James Lane, suggested that RPS implement tutoring in Fall 2021 (Graff, 2021). Moreover, US Education Secretary Miguel Cardona recommended 1.5 hours of high-quality tutoring per week for all students who have fallen behind due to the pandemic in his January 2022 address (Jacobson, 2022).

High-dosage tutoring could be implemented in RPS beginning in the Fall 2022 semester preferably in all schools, or at minimum, at the nine elementary schools with below 60% third grade math SOL proficiency in 2018-2019. Schools would extend their dismissal time from 2:45 pm to 3:30 pm, allowing 5 minutes for transition, 35 minutes for a tutoring block, and 5 minutes for dismissal. This would provide a 15-minute buffer after middle school dismissal and a 30 minute buffer before high school dismissal for parents to pick up children (Richmond Public Schools, 2021b). However, this may still create school bus transportation challenges and will require additional coordination.

2. ASSISTments

The ASSISTments computer-assisted learning platform provides built-in content integrations with Engage/Eureka Math (ASSISTments, 2022c; Rochelle et al., 2017), the parent curriculum by the same provider (Great Minds) that the division is now using (Pauly, 2020). ASSISTments, includes seven modules for third grade Eureka Math. These modules contain 150 lessons for students to complete, each of which includes homework, problems, and exit tickets (ASSISTments, 2022c). Thus, implementing the platform would be an extension rather than a replacement for the curriculum being currently implemented in RPS.

ASSISTments could be implemented over four phases of professional development culminating in use of the platform in all RPS elementary schools. In phase 1, during the summer of 2022, the math instructional coaches who worked on the Eureka math curriculum rollout would have 2-3 days of professional development to understand the platform. One one-hour session during teacher professional development would be provided to briefly introduce the platform district-wide. During the summer, schools would be invited to pilot the platform with the goal of being implemented at least six schools during Fall 2022 (phase two).

The next phases would be contingent on positive feedback from the pilot schools. Pending positive reviews, implementation phase III would begin in summer 2023. The academics office would train third grade math teachers on using ASSISTments as their default math homework platform.[4] Elementary math teachers who have piloted ASSISTments could share their positive experiences with it during a professional development panel and encourage other teachers to assign ASSISTments 2-3 times per week.

3. Teacher Hiring Incentives

RPS could implement a teacher recruitment incentive to fill some of its 30+ elementary school teacher vacancies by combining aspects of the Teacher Transfer Initiative (TTI) and Virginia's former Strategic Teacher Compensation Grants (STC)[5] (Glazerman et al., 2013; Richmond Public Schools, 2022a). RPS could offer $10,000 signing bonuses for teachers in Virginia who can show proof of attaining an exemplary teacher evaluation rating in 2018-2019 (before SOL testing was disrupted) and commit two years to filling a vacancy at any elementary school with a third-grade math proficiency rate below the state average in 2018-2019. The $10,000 amount reflects a compromise between the $20,000 of the TTI and the $3,000-$5,000 of the STC and the financial constraints in RPS. Moreover, an exemplary rating is likely less distinguished that being in the top quintile for value-added under the TTI; 29% of the STC-eligible teachers earned bonuses for an exemplary rating (Shanks, 2013).

Principals and administrators at schools with vacancies would have to agree to participate in the recruitment incentive for positions starting in Fall 2022. The RPS Talent Office would need to update its job postings and advertise. The Talent Office would also need a means of verifying the proof of an exemplary rating submitted by job applicants. It might contact the teacher's principal to verify the evaluation rating, as copies of the teacher's Summative Performance Report are supposed to be retained at the school (Stronge & Caine Tonneson, 2021). Alternatively, it could try to establish an MOU with the Virginia Department of Education to provide verification if needed.

[4] The implementation section of this report details how ASSISTments stacks up to an existing learning platform in RPS.

[5] The Strategic Teacher Grant was a bipartisan performance pay pilot launched by Governor Bob McDonnell that awarded teachers in select hard-to-staff schools $3,000-$5,000 if they achieved an exemplary summative rating on the state's uniform performance evaluation system, which at the time based 40% of the teacher's rating on student academic progress (Caldwell, 2011; Shanks, 2013).

Evaluating Alternatives

This section evaluates each of the three alternatives—tutoring, ASSISTments, and hiring incentives—against three criteria: cost-effectiveness, equity, and feasibility. Appendix A describes how each criterion was measured. Appendix B explains the calculations for projecting the number of proficient students under the status quo and the alternatives in detail. Appendix C graphs the projected number of third graders proficient in math in each case.

Alternative 1: High-Dosage Tutoring

Equity

Equity Score: Equitable

I score high-dosage, small group tutoring as *Equitable* because this intervention is targeted specifically to students who are struggling in Math, and, unfortunately, students who are Black, Latinx, and Economically Disadvantaged (ED) are all overrepresented among these students who are below proficient in math (Virginia Department of Education, 2022a). Tutoring will typically serve more students of color and students who are ED so long as it is built onto the school day and attendance is required for students who are struggling within a school. Thus, we can expect the tutoring program to serve a greater proportion of students of color and economically disadvantaged students than the proportion in the division.

Effectiveness

K-12 math tutoring, typically 30-60 minutes per day, boosted math test scores by 0.37 standard deviations on average. Effects were consistently sized in studies focused on students from low socio-economic backgrounds and were slightly larger (0.44 standard deviations) in grades 2-5 (Nickow et al., 2020). Given the consistency of tutoring effects across studies, I do not scale down the effects I would expect to observe an average effect size of 0.37 in RPS.

Costs

Richmond Public School's FY22 budget specifies the hourly rate for tutors with a Bachelor's degree as $21.00 per hour. RPS also offers a supplemental pay amount of $25 per day if teachers take on an additional teaching period. Because teachers would be tutors with BAs and taking on an extra period, I estimate the hourly rate for using teachers as tutors as $21 + $25 = $46.00 per hour and non-teacher BA holders as tutors at $21 per hour. The tutor personnel costs are calculated as follows:

- 1,102 third graders below proficiency/4 students per tutor = ~276 tutors needed

- 108 school days x .5 hours of tutoring per day = 54 hours of tutoring each school year

- I assume half the tutors would be teachers (138) and half would not be teachers (138).

- 138 teacher tutors x 54 hours x $46 + (138 non-teacher tutors x 54 hours x $21) = $499,284

In addition to tutors, I would allocate a manager-level position at 0.5 FTE to develop and oversee the district's tutoring program in each year. Both "Manager Mathematics" and "Manager Student Supports" correspond to RPS salary schedule 130: $87,242. I estimate management costs in year one as half of that: $43,621.

- Personnel Costs = $43,621 + $499,284 = $542,905.

According to the RPS FY22 budget, the classroom rental usage fee is $50 per hour. I assume that a classroom can hold four groups of students and tutors on average. If there are 1,102 students and 16 per classroom, that corresponds to roughly 69 classrooms.

- Classroom Costs = $50/classroom x 69 classrooms x 54 hours = $186,300 per year.

Tutoring Total Costs = Personnel + Classroom = $729,205.

	Estimated Number of Proficient Students						
	2021-2022	2022-2023	2023-2024	2024-2025	2025-2026	2026-2027	
Status Quo	875	865	861	853	848	842	
Tutoring	875	1,110	1,121	1,112	1,106	1,093	Tutoring
Gain relative to status quo	0	245	260	259	258	251	**1,273**
Cost	0	$729,205	$701,159	$674,191	$648,261	$623,328	$3,376,143

<u>Cost Effectiveness = $3,376,144 /1,273 = $2,652 per proficient student</u>[6]

[6] Considering all 5,110 students who would receive tutoring over five years, regardless of whether they reach proficiency, the five year total cost per student amounts to $3,376,143 / 5,110 = $613 per student that receives tutoring. This matches a recent cost estimate of $643 per student for elementary tutoring in a national study (Kraft & Falken, 2021), which some provides additional credibility to this estimate.

Feasibility

Teacher buy-in: Medium (25 – 49%)

I project RPS teacher buy-in for an additional tutoring block based on an RPS teacher survey in November 2020 for a related policy: adding three weeks spread out during the school year for struggling students to receive small group instruction while others stay home. Teachers would have had the option of having these three weeks off or earning $5,000 for teaching the struggling students who came to class (Kamras, 2022a). Teachers having the option of working with students in small groups is conceptually similar to tutoring, and the implied teacher wage of $42 per hour ($5,000 / (3 weeks x 40 hours)) is close to the $46 an hour budgeted above for tutoring. Since 34% of teachers said they would prefer this conceptually similar policy, I assume that roughly 34% (643 out of 1,892 teachers) in RPS would also support small group tutoring after school.

Staffing Capacity: Medium

One new manager would be hired to oversee the tutoring program.

School Board Approval: Low

The Board has been skeptical of existing investments in tutoring funded by Title I, Richmond's Early Reading Initiative, and the Algebra Readiness Initiative. In February 2022 budget debates, it asked the Superintendent Kamras' Administration about the $400,000 budget for tutoring provided by Public Consulting Group: "Where is the evidence that this contract at this amount is providing dividends for our students and instructional staff? Where is the data and evidence to demonstrate the tutors are providing a benefit with these funds?" (Richmond Public Schools, 2022b, p. 16). The Board has also proposed cuts to the Academic Office staff based on the concern that the central office was too top-heavy, and this alternative would require an additional hire in central office (Richmond Public Schools, 2022b).

Administrative Capacity: Medium

Schools can use existing systems to administer the tutoring period, track attendance, etc. Besides the 0.5 FTE for a manager, this would be likely a low lift for individual people, but it would require small actions across many people to coordinate and monitor.

Alternative 2: ASSISTments

Equity

Equity Rating: Equal

Equity can be built directly into the Fall 2022 pilot with six schools. Schools invited for the pilot should serve a greater proportion of historically underserved students, which would likely coincide with the greatest need and lower proficiency rates. Westover Hills might be a good candidate school given that it piloted the Eureka Math curriculum (Pauly, 2020a). It serves about 85% students of color and about 70% Economically Disadvantaged, which exceeds the district proportions of 79% and 52% respectively (Virginia Department of Education, 2022b). Initially, then, the ASSISTments rollout would be considered equitable. However, the vision is to expand to all schools regardless of student socioeconomic status and historically underserved race/ethnicity. Ultimately, ASSISTments would serve the same shares of these subgroups that are served by the district.

Effectiveness

In an RCT involving 43 schools in Maine, ASSISTments computer assisted learning increased middle school math test scores by 0.29 standard deviations for students scoring below the median test score, which is the relevant subgroup in this analysis (Escueta et al., 2017). However, because this was outside an urban district and outside of elementary school, I scale the effect size down by 10% for each of those differences: 0.29 x 90% x 90% = ~0.23 standard deviations.

In the first year, I assume ASSISTments would be rolled out to six schools, each with a third-grade class of 25 students on average, for a total of 25 x 6 = 150 students reached in year 1. Then in the following years, I assume that all 1,702 third graders would be exposed to ASSISTments.

Costs

To project the costs of implementing ASSISTments in RPS, I draw on a cost study from the ASSISTments RCT in Maine and convert component costs to RPS based on their FY22 budget (Rochelle et al., 2017). ASSISTments itself is a "forever free" tool, so there are no software costs. As in the state of Maine, RPS already provides computers to its students so implementing ASSISTments in the division would not involve additional hardware costs.

The primary costs for RPS to adopt ASSISTments would be technical support, teacher time, and ongoing professional development. Teachers spent three days per year in professional development to learn the tool: 2.5 days for in-person trainings plus three hours ongoing for webinars. Teachers also used an average of one hour of instructional time per year to introduce the tool to their students. Finally, as part of the evaluation, the ASSISTments team provided two 1.5-hour coaching sessions each year to each participating teacher; this included a classroom observation and individual coaching time to provide feedback and answer questions (Rochelle et al., 2017).

The costs of one day of interactive professional development for all K-8 teachers to launch Eureka Math was budgeted at $32,500 (T. Epp, 2020). This professional development session consists of four hours of lessons separated by two hours of interim work, for nearly a full day (Great Minds, 2020). Thus, I assume three days of ASSISTments training for only grade 2-5 teachers would cost ($32,500 per day x 3 days) x ½ of the K-8 teachers = $48,750.

RPS budgeted $100,000 per year for ongoing technical support for its new K-8 English Language curriculum in 2019 (T. Epp, 2020). I assume 10% of that support ($10,000) would be necessary in the first year of piloting, when ASSISTments would be rolled out to about six schools. Then half that level of support would be necessary for ASSISTments in the years when all teachers in grades 2-5 could be using it; I budget $50,000 for ongoing technical support after Year 1.

Finally, I estimate 0.25 FTE of a 130-pay grade manager in the Academic Office would be needed to coordinate the rollout and hire the consultant to deliver the professional development each year. This amounts to $21,810.50. Year one would require setting up an RFP for consultants but fewer school participating while subsequent years would have a consultant contract in place but involve more schools, so I assume the management costs would be similar across years. The projected Year 1 total costs amount to $120,560.50

	Estimated Number of Proficient Students						
	2021-2022	2022-2023	2023-2024	2024-2025	2025-2026	2026-2027	
Status Quo	875	865	861	853	848	842	
ASSISTments	875	877	1,016	1,009	1,000	986	ASSISTments
Gain relative to status quo	0	12	155	156	152	144	**619**
Cost	0	$80,561	$118,706	$116,879	$115,081	$113,311	$544,538

Cost Effectiveness = $544,538/619 students = $880 per proficient student

Feasibility

Teacher buy-in: Medium (25 – 49%)

Teachers will already be familiar with the Eureka Math Curriculum that the ASSISTments platform would house. Some schools that began piloting Eureka Math in RPS in 2019 asked to halt the pilot because teachers felt overwhelmed trying to learn and teach the curriculum simultaneously. However, several expressed that they eventually got comfortable with Eureka

Math and believed it helped improve student learning (Pauly, 2020b). Learning the ASSISTments tool is a less substantial change than learning a new curriculum, and it is not expected to add to teachers' workloads beyond initial professional development. On average, teachers who implemented ASSISTments in the aforementioned Maine study did not experience a net change in planning time because the reduction in grading time from using ASSISTments was roughly offset by time spent reviewing the data reports that ASSISTments generates (Rochelle et al., 2017).

School Board Approval: High

The Board approved the Eureka Math curriculum which is built into the ASSISTments platform in an 8-1 vote, and the only dissenting opinion partly cited the $1.5 million cost of curricular materials (Richmond Free Press, 2020). There was some controversy on whether the curricular change should be postponed due to the pandemic, but this concern was allayed by offering professional development virtually and allowing teachers to delay implementation for another year—which is also possible if not built in with a staged rollout of ASSISTments (Pauly, 2020a). This may have been facilitated by the fact that many sixth-grade classrooms had already been piloting Eureka Math by the time it reached the Board vote. The staged rollout of ASSISTments for math in grades 2-5 starting with one school in Summer 2022, five in Spring 2023, and the rest in Fall 2023 may also facilitate Board buy-in.

Staffing Burden: Low

No new personnel would be needed.

Administrative Burden: Low

0.25 FTE at the manager level in the Academic Office would be needed to organize the rollout and hire a consultant to deliver the professional development in each year. There is not much administrative burden beyond that, however.

Alternative 3: Teacher Recruitment Incentives

Equity

Score: Equitable

Prior research suggests that the schools that struggle with retention and that are hard to staff are more likely to serve a larger shares of economically disadvantaged students and students of color (Boyd et al., 2005). It is likely that incentivizing high-performing teachers to fill vacancies would disproportionately benefit these groups relative to the division.

Effectiveness

Offering teaching teams a top-performing TTI teacher incentivized with a $20,000 bonus increased math test scores for elementary students by about 0.18 standard deviations in year one and 0.22 standard deviations in year two (Glazerman et al., 2013). Because the $10,000 RPS incentives is smaller and the qualification is less distinguished, I scale down the effect by 10%: 0.18 x (0.9) = 0.162 standard deviations in each teacher's first year of teaching in RPS and 0.22 x (0.9) = 0.198 in their subsequent years.

RPS had 30 elementary teacher vacancies as of February 2022 (Richmond Public Schools, 2022a). For year one, I assume that a third of the RPS vacancies (10) are for teachers who would be teaching third grade math and they each teach a class of 25 students on average. Teachers filling these vacancies in response to the incentive would then reach an estimated 250 third graders. In years 2-5, I assume that only five vacancies are filled because, as teachers respond to the incentive, fewer teachers remain who would be incentivized by the bonus to transfer.

Finally, I assume that the recruited teachers have the same turnover rate after their two year contract ends as other teachers in RPS, which was the case for teachers recruited to districts participating in the TTI. In RPS, the average annual teacher turnover rate between 2017-2018 and 2019-2020 was 22% (Viriginia Department of Education, 2020). I thus assume two of the first ten teachers leave after two years, one teacher hired in year two leaves after year three, and one teacher hired in year three leaves after year four. The others remain for at least the five-year period.

The expected pattern of fewer teachers being recruited after year one and teacher turnover implies that the gain in proficient students rises, dips, and levels off in subsequent years even though individual teachers have larger impacts after their first year at RPS.

Cost

The largest costs are the $10,000 incentives for the vacancies. In addition, orientation and ongoing support for the new teachers who transferred through the TTI cost roughly 10% of the transfer stipend, or $1,000 per teacher in this proposal. The cost for the teachers hired is thus: 10 x $11,000 = $110,000 in year one and 5 x $11,000 = $55,000 in years 2-5. Cost data from the TTI program found that recruitment, interview support, and principal engagement used about half of a manager's time in each district for 5 months (Glazerman et al., 2013). I thus allocate 0.25 FTE of a 130-pay grade manager in the Talent Office, or $21,811 per year.

	Estimated Number of Proficient Students						
	2021-2022	2022-2023	2023-2024	2024-2025	2025-2026	2026-2027	
Status Quo	875	865	861	853	848	842	
Hiring Incentives	875	894	884	881	879	876	Hiring Incentives
Gain relative to status quo	0	29	23	28	31	34	**145**
	0	$131,811	$75,629	$74,466	$73,320	$72,192	$427,418

Cost Effectiveness = $427,418/145 students = $2,948 per proficient student

Feasibility

Teacher buy-in: Low (0-25%)

My client has shared that teacher performance evaluation reform in RPS would be politically intractable today. This alternative would limit the performance-based pay aspect to new teachers filling vacancies, but it would likely still be unpopular among teachers. Former RPS Superintendent Richard C. Hunter explained that he implemented a performance-based pay system in the division in the 1980s, but it was staunchly opposed by the teachers' union. He suggested that performance pay was possible then because Virginia did not allow collective bargaining agreements with public school employees (Hunter, 2010). In December 2021, however, RPS became the first division in Virginia to allow its employees to practice collective bargaining.

School Board Approval: Medium

The Board showed concern for retaining teachers and avoiding shortages in the February 2022 budget approval debates. Although it had been split on various issues, Board members readily agreed to raising pay for teachers by 5% and offering full-time staff a $3,000 bonus in recognition of teaching during the pandemic. Moreover, the Board hinted toward concern about the teacher shortage by asking the Kamras Administration, "Are there any guarantees in place to make sure that staff who receive the bonuses stay?" (Richmond Public Schools, 2022b, p. 9). The Board might be open to this alternative which would require newly incentivized teachers to stay for two years. Several members fought to avoid teacher layoffs and cuts to any school staff, including by retaining some teachers who had been teaching in a virtual academy established during the pandemic (Kamras, 2022b; Schiffres, 2022; Suarez, 2022).

Staffing Burden: Low

I estimate that this would require 0.25 FTE of a manager in the Talent Office in order to update job descriptions, advertise, and contact the teacher's principal to verify the applying teacher's evaluation rating.

Administrative Burden: Medium

Most of the work would be concentrated in the Talent Office, however they would likely want to establish an MOU or data sharing agreement with the Virginia Department of Education to provide teacher evaluation rating verification.

Evaluation Matrix: Shading Highlights the Best Alternative for each Criteria

Overall	Cost Per Proficient Student	Equity	Feasibility
High-Dosage Tutoring ☐	$2,652	Equitable	Buy-in (higher is better) Teacher: Medium Board: Medium Burden (lower is better) Staffing: Low Admin: Medium
ASSISTments ☑	$880	Equal	Buy-in (higher is better) Teacher: Medium Board: High Burden (lower is better) Staffing: Low Admin: Low
Teacher Recruitment Incentives ☐	$2,948	Equitable	Buy-in (higher is better) Teacher: Low Board: Medium Burden (lower is better) Staffing: Low Admin: Medium

Recommendation

I recommend that RPS implement ASSISTments. It is three times as cost-effective as the other two alternatives, although tutoring and recruitment incentives may be better targeted and thus more equitable. ASSISTments would be equitable in the short term, but when scaled up to reap returns to scale it would serve students equally. It would also require less administrative and staffing capacity and builds on momentum that the division already has with its current math curriculum.

Next Steps: Implementation Considerations

The following three steps can bolster implementation during a staged rollout of the ASSISTments computer-assisted learning platform and improve long-term sustainability.

Step 1 - Spring 2022: Identify a dedicated source of funding and frame ASSISTments as a cost-saving, more effective alternative to its i-Ready computer-assisted learning program.

ASSISTments could replace the math portion of the Divisions' $375,000 i-Ready contract (Kamras, 2022b). This could help achieve both a stronger math gains and much-needed cost savings in the next round of budget negotiations. ASSISTments outperforms i-Ready, the computer assisted learning platform currently used in RPS, on costs, effectiveness, and curriculum alignment.

	i-Ready	ASSISTments
Cost per student	$30 per student, per subject (EdSurge, 2022)	Free
ESSA Effectiveness Rating	Tier 2 (Moderate evidence) (Curriculum Associates, 2021a)	Tier 1 (Strongest evidence) (ASSISTments, 2022b)
Built-in integration with Eureka Math?	No	Yes

The half of i-Ready that focuses on literacy could remain in the budget while $187,500 for math could be replaced with a $80,560 first-year budget for ASSISTments. This would yield a cost savings of about $107,000 in year one and $66,940 in subsequent years when ASSISTments is expanded. The front-loading of savings is helpful now given the current budget deficit. The RPS School Board did not question the value of computer assisted learning itself, but it has scrutinized the expenses for instructional contracts in general, and $442,000 in instructional contracts cuts have already been made (Graff, 2022).

Because the nonprofit ASSISTments platform itself is "forever free," it is more sustainable against fiscal constraints in the future. Even if the professional development budget were reduced in subsequent years, the teachers who have already learned the tool can continue to use it at no cost.

To move this proposal forward, RPS Superintendent Jason Kamras should propose a budget to contract one or more ASSISTments Certified Trainers to deliver three days of teacher professional development in Summer 2022 for math teachers from 5-6 Title 1 Elementary

Schools (ASSISTments, 2022a). Title 1 funds are the funding source for the currently proposed i-Ready contract (Kamras, 2022b).

Step 2 – Spring 2022: Secure backing from the Office of Curriculum and Instruction for robust professional and technical support to a concentrated group of early adopters in Summer 2022.

The Kamras Administration should secure support for this plan from its Office of Curriculum and Instruction, led by Tracy Epp, to provide 10% FTE from a manager. Under direction of this manager, existing math instructional coaches would complete a free ASSISTments demo and 5-6 hours of free online ASSISTments professional development so that they can provide ongoing technical support to the elementary math teachers who begin implementing ASSISTments in Fall 2022 in 5-6 Title 1 elementary schools. Starting with a smaller group would allow the coaches to provide more hands-on support and a means of building a self-reinforcing constituency of teachers who could advocate for ASSISTments more universally in subsequent years.

Step 3 - Summer and Fall 2022: Carefully frame ASSISTments as an extension of the existing Eureka Math curriculum and emphasize the low transition costs for teachers given that they have already leaned the curriculum embedded within ASSISTments.

The Kamras' administration can mitigate the status quo advantage of i-Ready through professional development for ASSISTments with careful framing for new and returning teachers. Day 2 of the three-day professional development series should branch off into two concurrent sessions: one for new teachers (e.g., those entering their first-year teaching in RPS) and those who started after Fall 2020 (who have taught in a non-pandemic year), and one for more teachers who started in Fall 2019 or earlier. The focus of this new teacher session would frame ASSISTments as a starter pack that makes lesson planning, assigning homework, and data driven instruction easier—assuming that these teachers are roughly starting from scratch. The returning teacher concurrent session would frame ASSISTments as a seamless extension of the existing Eureka math curriculum that could potentially save teachers time on grading homework and be used in class for small-group rotations as has been done using i-Ready (Kamras, 2022b).

Conclusion

Math test scores in the early elementary grades are an important predictor of future life outcomes such as graduation and earnings (Goldhaber et al., 2021, 2021; Goldhaber & Özek, 2019). Unfortunately, too many third graders in RPS are below proficiency on the state math SOL exam. The low rates of proficiency among Black and Hispanic children underscore that supporting children's math outcomes is a matter of equity. On top of existing challenges and inequities, the COVID-19 pandemic has put children further behind and disproportionately impacted children of color (Curriculum Associates, 2021b).

This report identified and evaluated three evidence-based alternatives to increase math proficiency, overall and by subgroups: high-dosage tutoring, ASSISTments computer assisted learning, and teacher recruitment incentives. While tutoring holds substantial promise for improving outcomes and doing so equitably, the relatively high cost and administrative burden may make it more viable for a time when RPS has more financial and personnel capacity.

For the moment, a staged rollout of ASSISTments emerged as the best alternative to balance cost-effectiveness, equity, and feasibility. As one way forward, RPS can confront the budgetary vulnerability of iReady as an opportunity to launch ASSISTments. Amid necessary budget cuts, the Division could still implement a tool that is not only cost-saving but also integrated with Eureka math, backed by strong evidence, and "forever free."

Appendix A: Evaluative Criteria

I evaluate alternatives according to criteria derived from RPS's core values—equity, engagement, and excellence (Richmond Public Schools, 2018). Equity is itself an evaluative criteria: the extent to which each alternative engages students of color and economically disadvantaged students. Engagement informs feasibility. Excellence maps onto cost-effectiveness by quantifying the improvements in student math proficiency for a given investment. Each of these criteria are weighted equally.

1. Equity

I quantify equity as the proportion of students of color and economically disadvantaged students served by each intervention. This may change over time if interventions are implemented at select schools first, so the equity rating is based on which students each alternative would serve when fully implemented.

Alternatives will be rated on a three-point equity scale:

- Inequitable means it would serve a much lower proportion of students of color and economically disadvantaged students than the division serves overall.
- Equal means it would serve roughly the same proportion of these subgroups as the division.
- Equitable means it would serve a higher proportion of these subgroups than the division.

2. Cost Effectiveness

I follow four steps to estimate cost-effectiveness as the dollar amount spent per additional student to reach third grade math proficiency relative to the status quo.

First, I project the increase in RPS math proficiency anticipated under the status quo and under the three different policy alternatives. Appendix A explains the assumptions that enable me to estimate the number of students expected to reach proficiency under each case.

Second, I multiply that adjusted average treatment effect by the number of students served by the intervention. This is at most 1,102 based on the total number of RPS third graders below proficient in math as of 2018-2019 (Virginia Department of Education, 2022a).

Step three requires costing out each alternative. For each year of implementation over a five-year period, I calculate the total costs based on personnel, overhead, space, materials, equipment, advertising, incentives, etc. I discount future costs at a rate of 4% to account for returns RPS could make in theory by investing the tax revenue instead. I also increase future costs at a rate of 2.4% per year, which was the average annual inflation rate from 2016-2021 (Federal Reserve Bank of Minneapolis, 2022).

Fourth, for each alternative, I divide the total five-year cost by the gain in students projected to reach proficiency relative to the status quo over the same five-year period.

3. Feasibility

I quantify feasibility as follows:

- Teacher Buy-in: Relative to the status quo, roughly what proportion of teachers and principals at affected schools are likely to support this alternative (0-24%, 25-49%, 50-74%, 74% or more)? If available, I will use prior RPS teacher surveys to ballpark this.
- School Board Approval: Based on its prior voting record, how likely is the RPS School Board to approve this alternative (low, medium, high)? If School Board approval is not needed, the alternative will be scored "high."
- Staffing Capacity: Relative to the status quo, how many new personnel would RPS need to hire to implement this alternative? Count personnel twice if the need is for an already hard-to-staff position.
- Administrative Capacity: How many administrative FTE, MOUs, new data systems, and data sharing agreements does this alternative require?

Appendix B: Projecting Proficiency based on Average Treatment Effects

Projecting how various alternatives might increase the number of third graders proficient in math begins by simulating a distribution of test scores around the known data. There were 1,702 third graders enrolled in RPS in 2021-2022 (Virginia Department of Education, 2022a). The average third grade Math SOL score in RPS was 405 in 2018-2019, the last year for which there is reliable data due to the pandemic (Virginia Department of Education, 2021). The statewide standard deviation on the Math SOL exam in 2018-2019 was nearly the same magnitude as this implied gap—59.6 points (NWEA, 2020). I assume that the score distribution in RPS has the same standard deviation as the overall distribution in the state. Based on this assumption, I create a simulated distribution of 1,702 third grade student test scores by drawing randomly from a normal distribution with a mean of 405 and a standard deviation of 59.6. I do this using the Stata statistical package.

Second, I simulate the changes in test scores we would anticipate under the status quo. If RPS continues with the status quo, I expect third grade math proficiency to change by the average year-to-year change average RPS third grade Math SOL scores observed from 2011 to 2018: a decrease of 0.85 points.[7] This means I reduce each simulated test score 0.85 points per year (Virginia Department of Education, 2022a).

Third, for each alternative, I convert the average treatment effect from an RCT anticipated to an anticipated gain on the math SOL in RPS. This entails multiplying the standardized treatment effect by the standard deviation of the math SOL, which 59.6. For tutoring and ASSISTments, I scale the effect down by 10% for the first year assuming that the programs would need time to mature.

In addition, I scale the average treatment effect in standard deviations of each intervention from an RCT down by 10% for each of the following contextual differences:

- -10% if it was outside of an urban school district
- -10% if it was outside of elementary school students
- -10% if it is a substantial modification of the original intervention

Conceptually, this assumes that the effect from the RCT would be smaller the more distinct RPS is from the original setting. I assume that the effect sizes would not be larger to err toward conservative estimates and because the original RCTs may have been under more stringent implementation conditions for the study.

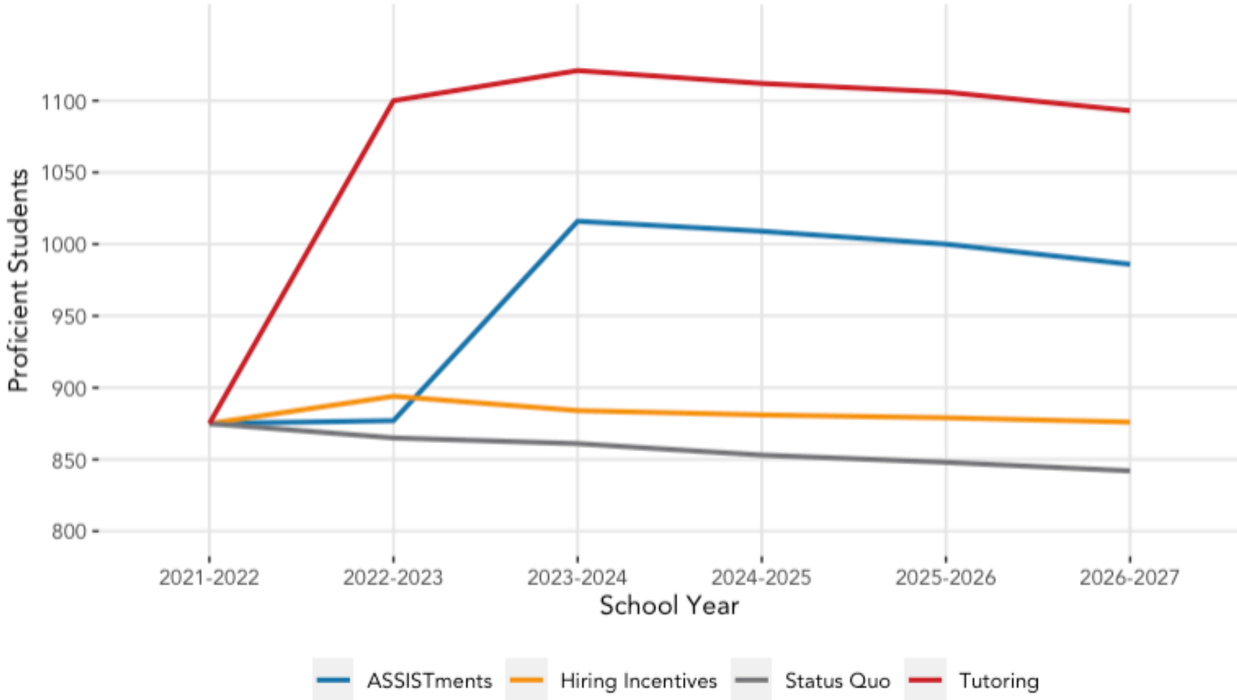
[7] The Math SOL exam was updated to new standards in 2011 that made the test harder and lowered proficiency rates statewide (Virginia Department of Education, 2013, 2022a). For consistency in proficiency changes across years, I exclude years prior to 2011. I stop at 2018-2019 due to pandemic-related disruptions; the test was not administered in 2019-2020 and participation in RPS in 2020-2021 was too low to be reliable (22% of the prior rate).

I add that adjusted average anticipated gain from each intervention to the original simulated test scores depending on how many students would be served in a given year. The rollout assumptions are as follows:

- For tutoring, I assume all students below proficiency would be served in all five years.
- For ASSISTments in year 1, I assume only 6 schools (25 students x 6) = 130 students would be served. In year 2, I assume all students below proficiency are served.
- For hiring incentives, I assume 250 students would be served in year 1 (ten teacher vacancies filled) while only five teacher vacancies would be filled in years 2-5 (an additional 75 students served per year). I also assume that due to turnover, two teachers leave after year two (50 fewer students served in year 3), one teacher leaves after year three (25 fewer students served in year 4), and one teacher leaves after year four (25 fewer students served in year 5).

Finally, for each simulated test score in each year under the status quo and each alternative, I designate the simulated student as proficient if their score is 400 or higher.

Appendix C: Projected Proficiency under the Status Quo and Alternatives



Source: Author's calculations based on Virginia Department of Education Test Results: Build-A-Table, 2022.

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