Frax

EFFICACY ANALYSIS OF FRAX SECTORS I & II

Year 3 Follow-up

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Executive Summary

The current report presents the findings from Year 3 of a longitudinal study of the impact of the ExploreLearning Frax program on the fractions knowledge and math achievement of 3rd and 4th-grade students. Results from Years 1 and 2 found that usage of Frax led to **statistically significant gains in math achievement, including for the most academically at-risk students,** and that these gains **were sustained as measured via performance on a standards achievement test in Year 2**.

In the third year of analysis, we analyzed data from 5th and 6th-grade students who completed Frax Sector 1 during the previous 2 years to test the **long-term impact of Frax usage on mathematics achievement**. In addition, in the 2023-2024 school year, the district expanded its use of Frax from Sector 1 (broadly targeting 3rd-grade fractions standards) to include Sector 2 (broadly targeting 4th-grade fractions standards). We analyzed a new cohort of 3rd and 4th-grade students to examine how advanced fractions content in the Frax program supports achievement of grade-level fractions standards on state math assessments.

Key findings include:

- Frax implementation builds a **strong conceptual foundation**, enabling students to exceed expectations in aligned fractions assessments.
  - In our sample of students with typical classroom fractions instruction, 11% of 3rd graders and 26% of 4th graders failed to meet grade-level fractions standards.
  - In comparison, 99% of 3rd-grade students and 98% of 4th-grade students who used Frax met proficiency in grade-level fractions standards.
- Frax usage leads to **long-term improvements** in both overall math and fractions performance.
  - Students who completed Frax Sector 1 in earlier grades significantly outperformed similar non-users on 5th and 6th-grade math assessments, including both fractions subscales and overall math scores.
- Frax benefits **all learners**, with strong gains for both at-risk and high-achieving students.
  - Nearly all academically underperforming 4th-grade students who completed both Frax Sectors 1 and 2 met fractions standards at the end-of-year assessment, compared to only half of similar students with no Frax usage.
  - High-performing baseline students were 2× more likely to exceed fractions standards after using Frax than similar students without Frax usage.

These results highlight the transformative potential of Frax for building strong conceptual foundations early in a student's learning journey. As districts and schools seek scalable, research-backed solutions to support equity and accelerate learning recovery, Frax stands out as a promising intervention that can not only boost immediate outcomes but also help change the course of students' mathematical success for years to come.

Introduction

Performance with fractions has been a weak point in U.S. education for decades and has not improved in recent years (Siegler, 2017). Building a strong foundation of early fractions knowledge is critical to later mathematical success. In a recent national survey of 1,000 Algebra teachers, most rated students' knowledge of fractions as "poor" and rated fractions as one of the top two barriers to students mastering algebra (Hoffer et al., 2007). Additionally, fractions knowledge in grade five uniquely predicts students' mathematics achievement in high school. This is true even after controlling for other variables like general intellectual ability, working memory, and family income and education levels (Siegler et al., 2012), making interventions to support early fractions learning an important and effective way to support later academic achievement.

Frax is a standards-aligned program designed to support fractions learning for students in grades 3-5 using research-proven instructional methods. Game-based and story-driven, Frax invites students to travel through space on engaging and standards-based missions that motivate and incentivize student-driven learning. Students earn rewards and tokens as they play, which they can use to personalize their virtual living quarters on the ship. It uses innovative adaptive technology that delivers different levels of support to different students depending on their progress, making it effective for both struggling students and those needing extra practice via a learning path that is unique to their skills and abilities. Frax also provides real-time data to show teachers when a student is struggling so that they can intervene.

The current report details the findings from the third year of a longitudinal efficacy analysis of Frax Sectors 1 and 2 as a digital complement to the existing math curriculum in a large, suburban public school district in Florida. Frax is designed as a zero-entry program, so that students with no previous knowledge of fractions can begin using the program immediately. Sector 1, broadly aligned to grade 3 fractions standards, is centered on the conceptual understanding that fractions are numbers with magnitude just like any other number and builds a foundation for learning fractions arithmetic. Frax Sector 2, aligned to 4th-grade standards, was released in March 2023 and adopted by this district in August 2023. Sector 2 builds upon the foundational knowledge gained in Sector 1, providing more in-depth treatment of topics such as equivalence, addition and subtraction, and comparison.

The goals of the current study are (1) to measure the long-term impact of Frax on student math achievement, building on our initial positive findings from the cohorts in Years 1 and 2, and (2) to analyze the impact of Frax Sector 2 on achievement of aligned 4th-grade fractions standards with a new cohort of students.

Analyses in Year 1 provided promising support for the use of the Frax program as an intervention program to support all students in learning fractions, and as a result, improve overall math performance. Frax was found to be 3x more effective than the average educational intervention for 3rd graders and 5x more effective than the average educational intervention for 4th graders. Students who used Frax with fidelity were significantly more likely to reach grade-level proficiency in the spring compared to matched non-users who were identical at baseline. Even academically at-risk students who used Frax were 2x more likely to reach grade level proficiency in the spring compared to matched non-users. Analyses in Year 2 showed that this benefit was sustained, with Frax users continuing to outperform matched non-users in the following year. Additionally, new students who used Frax in the second year fully caught up to the students who used Frax in Year 1, showing that Frax is beneficial both as a learning support and an intervention resource.

The following analyses include data from 5,251 3rd - 6th grade students who have both baseline and post-test math assessment data. The main analysis involves comparing comparing the overall math and fractions performance of students with fidelity usage of Frax to that of students who did not use Frax but who had scored similarly on a baseline standardized math assessment. The dependent variable used in the current study is the state-wide diagnostic math assessment, which includes a fractions subscore for grades 3-5.

Methodology and Sample

Independent Variable: Frax Sectors 1 & 2

Frax is an adaptive, game-based, online program for students in grades 3-6 to help all students learn fractions. Frax is designed as a zero-entry program so that students with no previous knowledge of fractions can begin using Frax Sector 1 immediately. Throughout the Frax experience, the program provides individualized, efficient instruction that moves each student forward on a customized path by continuously adapting and scaffolding instruction based on how they interact with the program. The Frax approach is centered on helping students understand fractions as numbers. They learn that, like whole numbers, each fraction has a magnitude and a place on the number line, allowing them to understand and reason about their size in relation to whole numbers and as well as other fractions. This ability forms the foundation for a durable understanding of fraction arithmetic that does not rely on memorized procedures and tricks.

Frax continually assesses and monitors students' progress formatively rather than using separate summative assessment activities. Thus, progress through the successive missions is the best demonstration of student growth and the metric used in the current study. Frax missions typically require 20–30 minutes to complete. Missions must be completed in order, and students are limited to completing one mission per day. Because missions are adaptive, the questions in each mission will be tailored to students' performance, which supports and maintains student engagement and motivation.

Dependent Variables: i-Ready Diagnostic and State Math Diagnostic Assessment

From fall 2021 through fall 2022, i-Ready Diagnostics were used in this district to assess students' mathematics achievement. Overall math scale scores provide a stringent test of the impact of Frax on students' overall ability to perform grade-level mathematics. Students are placed into a criterion-referenced grade-level placement based on math scale scores (e.g., current grade level or above, 1 grade level below, two grade levels below).

In spring 2023, the district switched from using i-Ready to a state-specific diagnostic math assessment tool, the Florida Assessment of Student Thinking Progress (FAST). i-Ready Diagnostics and the FAST are highly correlated, with an average spring correlation of .84 for mathematics grades 3–7. Overall math scale scores are reported, as well as percentile ranks and achievement levels for demonstrated mastery of state standards based on scale scores: below grade level performance (levels 1 and 2), on-grade level performance (level 3), and above grade level performance (levels 4 and 5). In addition, the test reports a subscale score and achievement rank related to Fractions performance in grades 3-5, which is used in the current study to quantify fractions knowledge.

In the current study, academic performance was assessed by statistically comparing the following spring 2024 test variables between similar baseline users and non-users: (1) math scale scores, (2) fractions subscale scores, and (3) relative achievement levels.

Study Sample

The students come from a large, suburban public school district in Florida. According to US News & World Report (https://www.usnews.com/education/k12), the district enrolls nearly 100,000 students across over 120 schools. The district's minority enrollment is around 70% and approximately 35% of students are economically disadvantaged.

Frax Sector 1 contains 27 missions, and Frax Sector 2 contains 30 missions. Based on the findings from Year 1 (i.e., significant differences only for high Frax completion group), fidelity usage is defined here as the completion of 90% or more of the relevant Sector (24-27 missions in Sector 1; 27-30 missions in Sector 2). Non-usage is defined as students with less than 5 completed missions in Frax Sector 1.

The sample for the longitudinal analysis includes 722 5th-grade students and 384 6th-grade students who completed Frax Sector 1, as well as 476 5th-grade students and 1080 6th-grade students who did not use Frax. Table 1 provides a full breakdown of these sample demographics.

To create equivalent baseline groups, fall 2021 i-Ready scores were used to select similar groups of users and non-users. All students analyzed here scored 1 grade level below standards on their baseline math diagnostic assessment in fall 2021. This score generally indicates that the student is approaching grade-level expectations and can be ready for grade-level instruction with targeted support.

Table 1: Longitudinal Analysis Sample Characteristics

	Treatment	Control
Total N's	1,106	1,556
Grades (2023-2024 school year)		
Grade 5	722	476
Grade 6	384	1080
Demographics: n (%)		
Male	637 (57.6%)	694 (44.6%)
Female	469 (42.4%)	862 (55.4%)
Hispanic/Latino	534 (48.3%)	741 (47.6%)
Black/African American	124 (11.2%)	201 (12.9%)

The sample for the new cohort analysis includes 837 3rd-grade students who completed Frax Sector 1 and 272 4th-grade students who completed Frax Sectors 1 and 2, as well as 892 3rd-grade students and 588 4th-grade students who did not use Frax. Table 2 provides a full breakdown of sample demographics.

To create equivalent baseline groups, fall 2023 (3rd-grade cohort) or fall 2022 (4th-grade cohort) math assessment percentile ranks were used to select similar groups of users and non-users. Due to a lack of baseline equivalence in the highest and lowest performing groups, this analysis only includes students in the 21st-80th percentiles. Three groups were created for analysis: 21st - 40th percentiles, 41st - 60th percentiles, and 61st - 80th percentiles. Average baseline scores within each performance group were statistically equivalent (all p-values >.05).

Table 2: New Cohort Analysis Sample Characteristics

	Treatment	**Control**
Total N's	1,109	1,480
Grades (2023-2024 school year)		
Grade 3	837	892
Grade 4	272	588
Demographics: n (%)		
Male	656 (59.2%)	615 (41.6%)
Female	453 (40.8%)	865 (58.4%)
Hispanic/Latino	456 (41.1%)	723 (48.9%)
Black/African American	110 (9.9%)	225 (15.2%)

Results

Longitudinal Analysis: 5th- and 6th-Grade Students

Frax Sector 1 Contributes to Sustained Math Performance
Independent-samples t-tests were used to compare fractions scores and math scale scores from spring 2024 testing for the groups of users and non-users. Standardized effect sizes (Hedge's g, d_{corr}) were used to estimate the size of the difference between the treatment and the control groups.

In Years 1 and 2, we found that fidelity Frax users outperformed matched students with no Frax usage on both the overall math scale score and the fractions subscale score. Similarly, in the current analysis, we found that 5th-grade and 6th-grade students who had used Frax in prior years significantly outperformed similar students with no Frax usage on both overall math scale scores (5th and 6th grade) and fractions subscale scores (5th grade).

Independent-samples t-tests showed that Frax users significantly outperformed similar students with no Frax usage on the overall math scale score both in 5th grade, $t(1196) = 12.23$, $p < .001$, and in 6th grade, $t(1482) = 10.24$, $p < .001$ (See Table 3). To correct for baseline differences at pre-test, and to serve as the most stringent test of the effect of Frax, the overall math scale score effect size was calculated using Klauer's (2001) correction model, where dcorr is the difference between Hedge's g of the two pre- and post-test groups. This estimates the effect of the Frax intervention over and above the effect of typical classroom instruction in fractions. The effect size for grade 5 scores was .39, and for grade 6 scores was .29.

Table 3: Differences in spring 2024 math scale scores between Frax users (Sector 1) and similar non-users

Grade (2023-2024 school year)		Frax Usage (Sector 1 Completed)	Control (No Frax usage)	Mean Difference	Effect Size (d_{corr})
Grade 5	**Overall Math Scale Score**	233.08	221.48	11.60***	.39
Grade 6	**Overall Math Scale Score**	238.86	229.64	9.22***	.29
	**p<.05 **p<.01 ***p<.001*				

Table 3 Note: All students in this analysis scored 1 grade level below on their diagnostic testing baseline in fall 2021. This score generally indicates that the student is approaching grade-level expectations and can be ready for grade-level instruction with targeted support.

Frax Sector 1 Provides Foundation for Later Fractions Knowledge

Independent-samples t-tests showed that Frax users significantly outperformed similar students with no Frax usage on the fractions subscale, $t(297) = 4.92$, $p < .001$, Hedge's $g = .69$ (See Table 4).

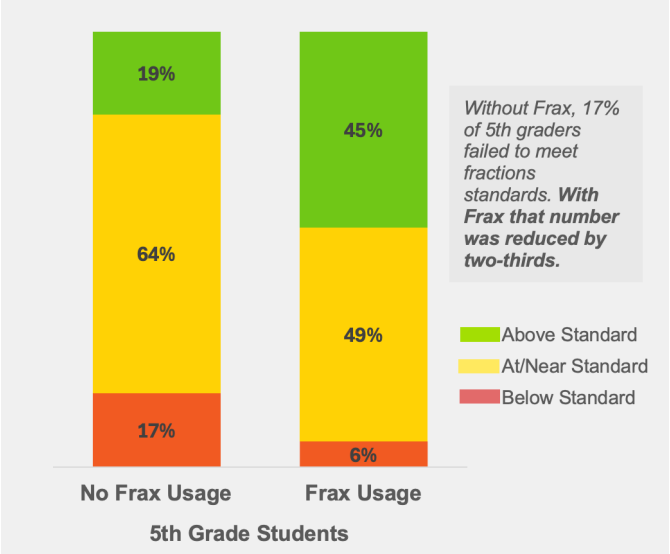
Table 4: Differences in spring 2024 fractions subscale scores between Frax users (Sector 1) and similar non-users

Grade (2023-2024 school year)		Frax Usage (Sector 1 Completed)	Control (No Frax usage)	Mean Difference	Effect Size (Hedge's g)
Grade 5	**Fractions Subscale Score**	232.87	218.07	14.80***	.69

Table 4 Note: Grade 6 post-test does not contain a fractions subscale, so fractions outcomes are only reported for 5th-grade students. All students in this analysis scored 1 grade level below on their diagnostic testing baseline in fall 2021. This score generally indicates that the student is approaching grade-level expectations and can be ready for grade-level instruction with targeted support.

Additionally, fractions performance is categorized into one of three achievement levels: below standard, at/near standard, or above standard. Only 6% of Frax users failed to meet 5th-grade fractions standards, compared to 17% of students who did not use Frax. 45% of Frax users scored above standards, while only 19% of students who did not use Frax scored above standards. Using Frax Sector 1 in earlier grades provided these students with the foundation that they needed to build more advanced fractions knowledge later, performing above expectations in fractions in 5th grade compared to the district's typical fractions instruction.

Figure 1: Spring 2024 fractions achievement levels for 5th-grade students who used Frax (Sector 1) and similar students with no Frax usage



Frax Sector 1 Improves Grade Level Proficiency

The next set of analyses looked at the relationship between Frax usage and the likelihood of meeting or exceeding grade-level proficiency. Our analyses in Years 1 and 2 found that Frax usage was related to increased performance. Similarly, in Year 3, we found that **Frax users were 1.4-1.6x more likely to meet grade-level proficiency standards in math than similar students with very low or no Frax usage**. Only half (49.6%) of 5th-grade students with no Frax usage met or exceeded grade-level proficiency math standards in spring 2024, compared to 77.4% of students with Frax usage, chi-square χ^2 (1, N = 1198) = 98.25, p < .001. For 6th-graders, 54.6% of students with no Frax usage met or exceeded grade-level proficiency math standards in spring 2024, compared to 75.5% of students with Frax usage, chi-square χ^2 (1, N = 1464) = 51.99, p < .001.

Figure 2: Spring 2024 overall math achievement levels for 5th and 6th-grade students who used Frax (Sector 1) and similar students with no Frax usage

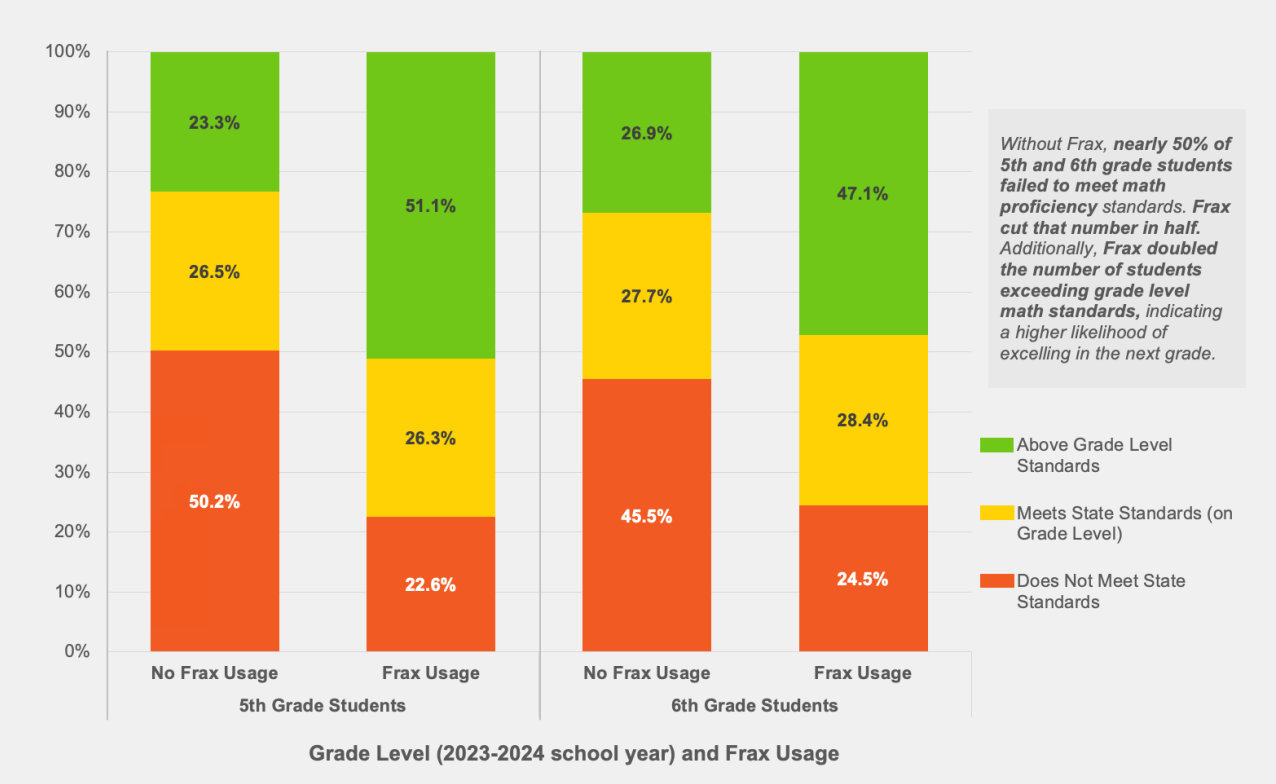


Figure 2 Note: All students in this analysis scored 1 grade level below standards on their baseline math diagnostic assessment in fall 2021. This score generally indicates that the student is approaching grade-level expectations and can be ready for grade-level instruction with targeted support.

These results demonstrate the powerful and long-term benefits of Frax. Students who completed Sector 1, which provides students with the foundational knowledge relevant to 3rd-grade fractions, were significantly more successful in meeting and exceeding more advanced math and fractions standards into grades 5 and 6. In the next set of analyses, we look at the efficacy of Frax Sector 2, which covers more advanced topics in fractions, for supporting students' performance on fractions assessments.

New Cohort: 3rd- and 4th-Grade Students

Frax Sector 1 Improves 3rd-Grade Fractions Performance
Here we present the results from a new cohort of 3rd-grade students who used Frax Sector 1, focusing specifically on the link between Frax usage and mastery of grade-level fractions standards. The results are presented separately for baseline (fall 2023 FAST) overall math percentiles to create statistically equivalent groups (see Figure 3).

Overall, less than 1% of 3rd-grade Frax users failed to meet grade-level fractions standards, compared to 11% of similar non-Frax users. Within every fall student placement category, Frax usage was related to increased performance on fractions standards. Frax was particularly impactful for students who were academically at-risk. For students scoring in the 21st-40th percentiles of math achievement at baseline, Frax usage led to nearly all students meeting standards, with 35% of students exceeding grade-level standards. In comparison, 21% of similar students with no Frax usage failed to meet standards, and only 10% exceeded standards.

Frax also had a strong impact on higher-achieving students (those in the 61st-80th percentile group). While nearly all of these students in both Frax usage and non-usage groups met proficiency standards, students who used Frax were 2x more likely to exceed standards (77%) compared to non-users (38%). Taken together, these results show that Frax is beneficial for students with varying levels of baseline math knowledge, helping them to master grade 3 fractions standards and preparing them for more advanced fractions instruction in grade 4 and beyond

Figure 3: Percentage of 3rd-Grade Students Meeting State Grade-Level Fractions Standards, by Frax Usage and Baseline Performance

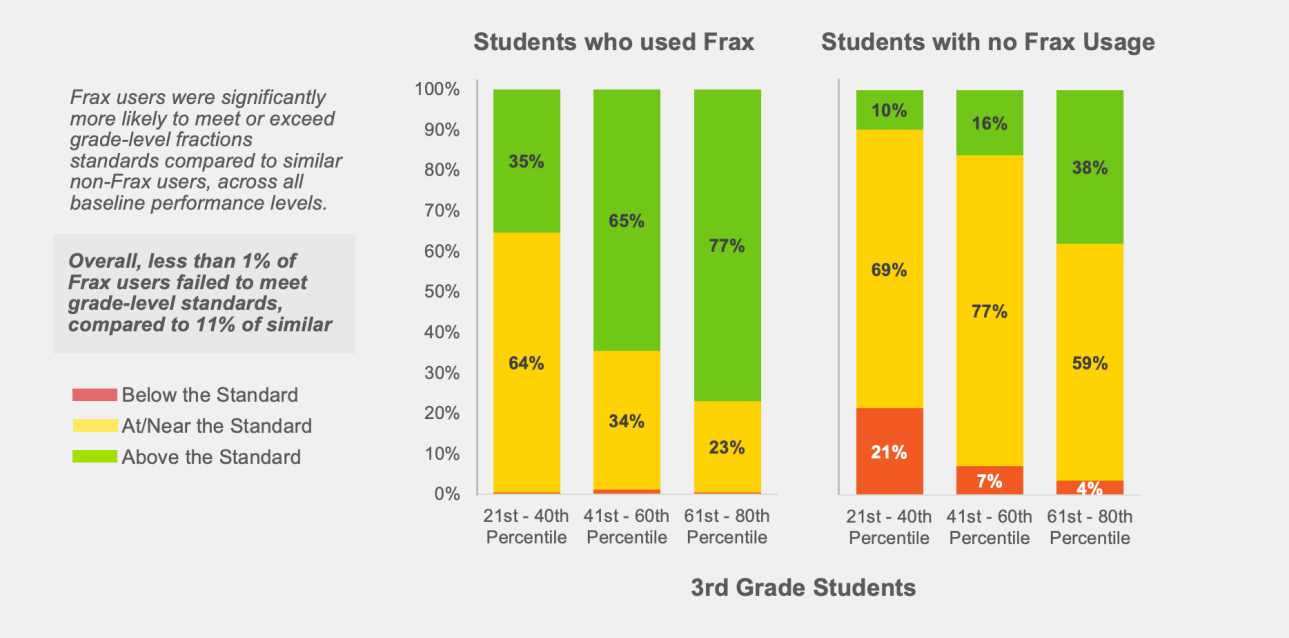


Figure 3 Note: Analyses were conducted separately based on fall 2023 FAST math percentile ranks to create equivalent groups. Baseline scores within achievement groups were statistically equivalent between users and non-users (all p values > .05).

Frax Sector 2 Improves 4th-Grade Fractions Performance
Here we present the results from a new cohort of 4th-grade students who used Frax Sectors 1 and 2, focusing specifically on the link between Frax usage and mastery of grade-level fractions standards. The results are presented separately for baseline (fall 2022 iReady Diagnostics) overall math percentiles to create statistically equivalent groups (see Figure 3).

Overall, less than 2% of 4th-grade Frax users failed to meet grade-level fractions standards, compared to 26% of similar non-Frax users. Within every fall student placement category, Frax usage was related to increased performance on fractions standards. Frax was particularly impactful for academically at-risk students in the analysis.

For students scoring in the 21st-40th percentiles of math achievement at baseline, Frax usage led to 92% of students meeting standards, with 36% of students exceeding standards. In comparison, nearly half (47%) of similar students with no Frax usage failed to meet standards, and only 6% exceeded standards.

Frax also had a strong impact on higher-achieving students (those in the 61st-80th percentile group). While nearly all of these students in both Frax usage and non-usage groups met proficiency standards, students who used Frax were 2x more likely to exceed standards (83%) compared to non-users (41%). This shows that Frax's treatment of 3rd and 4th-grade fractions concepts is effective for students of varying baseline achievement levels, providing them with a strong platform for continued success with fractions in grade 5.

Figure 4: Percentage of 4th-Grade Students Meeting State Grade-Level Fractions Standards, by Frax Usage and Baseline Performance

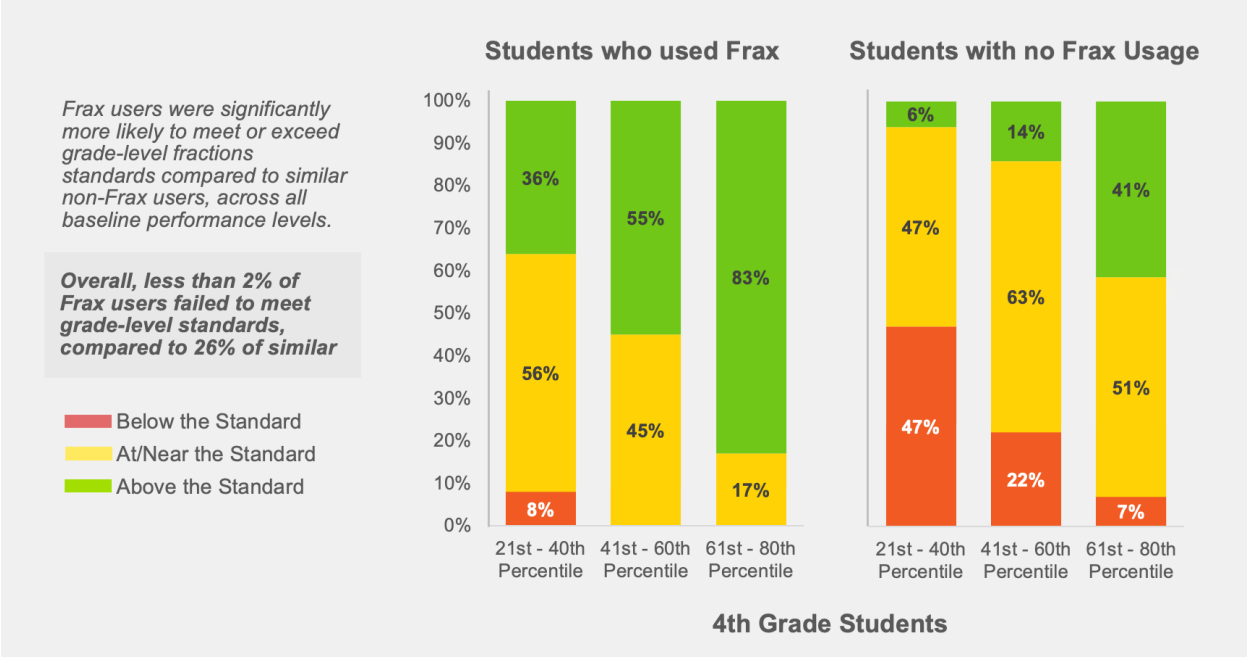


Figure 4 Note: Analyses were conducted separately based on fall 2022 iReady Diagnostic Math percentile ranks to create equivalent groups. Due to a lack of baseline equivalence in the highest and lowest performing groups, this analysis only includes students in the 21st-80th percentiles. Average baseline scores within each performance group were equivalent (all p-values >.05).

Conclusions

The current analysis provides evidence of the positive impact of the Frax program on student math achievement. Performance with fractions has been a weak point in U.S. education for decades (Siegler, 2017), and building a strong foundation of early fractions knowledge is critical to later mathematical success (Hoffer et al., 2007). The current study built upon the knowledge gained from our Year 1 and 2 analyses, which demonstrated that less than 13 hours of classroom usage of Frax led to statistically significant improvements in academic growth and that the benefits were maintained over a year later. These findings aligned with prior research, which found that supporting fractions knowledge supports numerical procedures performance more broadly, closing the achievement gap between at-risk students and typically achieving students (Fuchs et al., 2013).

In the current study, we found statistical evidence that setting a strong foundation of early fractions knowledge with Frax was related to sustained improvements in math proficiency well into 5th and 6th-grade end-of-year testing performance. Students who had high fidelity usage of Frax Sector 1 outperformed similar students up to 2 years later on both fraction knowledge and overall math proficiency. Given that Frax Sector 1 only covers grade 3 standards, this shows the importance of foundational knowledge for improving ease of learning later, more complex fraction concepts.

Additionally, a new cohort of 3rd and 4th-grade students validated and extended the findings from the previous two years of analyses, adding the impact of Sector 2 on students' fractions proficiency. Students in this sample without Frax usage showed significantly more struggle with 4th-grade fractions concepts compared to 3rd-grade, with nearly one-quarter of students in this sample failing to meet grade-level proficiency. Frax nearly eliminated this challenge, with only 2% of Frax Sectors 1 and 2 users failing to meet their 4th-grade fractions proficiency standards.

These results highlight the transformative potential of building strong conceptual foundations early in a student's learning journey. By targeting one of the most persistent stumbling blocks in elementary math—fractions—Frax offers a powerful opportunity to shift long-term trajectories in mathematics achievement. Rather than playing catch-up in middle school or facing persistent gaps that widen over time, students who engage with Frax are positioned to move forward with greater confidence, competence, and readiness for more advanced math topics like ratios, proportions, and algebra.

As districts and schools seek scalable, research-backed solutions to support equity and accelerate learning recovery, Frax stands out as a promising intervention that can not only boost immediate outcomes but also help change the course of students' mathematical success for years to come.

About ExploreLearning

ExploreLearning LLC, based in Charlottesville, VA, was founded in 1999 by educators looking for new ways to inspire students across grades K–12 and help them succeed in math and science. With a philosophy of life-long learning driving our thought leadership, a careful attention to the current needs of educators in today's rapidly-shifting educational culture, and a legacy of proven results, ExploreLearning is the best combination of proven expertise and innovative solutions over time to meet today's and tomorrow's educational challenges.

Our four digital programs (Reflex®, Frax®, Science4Us®, and Gizmos®) are currently used in classrooms in every state in the U.S. and more than 80 countries worldwide. Our programs are state- and national-standards aligned, including Next Generation Science Standards (NGSS) and the Standards for Mathematical Practice (SMP). ExploreLearning is a recognized leader in the educational software market, earning many major edtech awards.

We aim to foster student success through the use of galvanizing, age-appropriate multimedia, including interactive simulations, STEM case studies, adaptive games, instructional videos, and much more. Our development team of engineers, researchers, and instructional-design experts, most of whom are former educators, are continually innovating beyond the latest advancements in instructional pedagogy and edtech. Our programs support students in developing mastery of fundamental skills and deep conceptual understanding in math and science, while also fully engaging them in the process of internalized learning, promoting growth mindset, resiliency, productive struggle, and perseverance.

Our goal is to provide educators with captivating, best-in-class digital learning in math and science that helps students reach their full potential. We firmly believe that teachers are mission-critical, i.e., the greatest influence on student success. We also believe that data, instruction, and practice, when operating in tandem, are paramount to improving student learning and academic achievement. In support of these foundational beliefs, we deliver curricula, professional learning, and implementation and technical support services that:

- Combine research-proven instructional methods and innovative technology
- Enable equitable access to math and science learning for all students
- Build strong, lasting foundations for student success by developing procedural and conceptual understanding
- Supplement core curricula with flexible digital and blended implementation
- Create positive outcomes and results for both students and teachers

4. References

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