Reflex

Research Summary

EXPLORELEARNING REFLEX:

A RESEARCH AND EVIDENCE-BASED SOLUTION FOR TEACHING MATH FACT FLUENCY
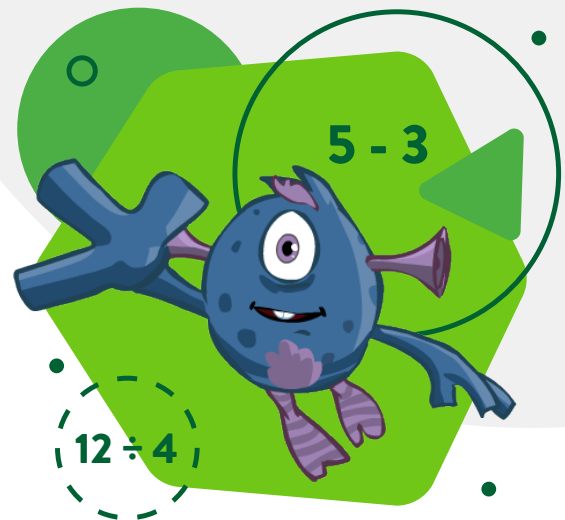
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1   Introduction to ExploreLearning's Reflex

ExploreLearning's Reflex is an adaptive, online program that helps students in grades 2–8 develop math fact fluency—the automatic (quick and effortless) recall of basic math facts. Math fact fluency is a foundational skill that predicts standardized test performance across a wide variety of assessments, so, with Reflex, every student can build the speed and accuracy with math facts they need to confidently tackle more challenging mathematics concepts.

Reflex uses fact families and delivers the right facts at the right time for each individual student, meeting students where they are. With Reflex, students learn that they can succeed in math when they put in the work. Implemented in thousands of classrooms worldwide to successfully support students at grade level, at risk, and with special needs, Reflex is the most effective digital program for all students that need to build math fact fluency.

1.1   Program Design

Reflex is an asynchronous, video game-style, online 1:1 program that can be accessed from most internet-enabled devices. Reflex can be used independently by students during small-group instruction, centers, or individual work time, in the classroom, at the library, or at home. Students typically require 10–20 minutes to complete a Reflex session. It is recommended that students use the system three or more days per week to make the best possible gains. Once an operation assignment is set by an instructor (addition-subtraction, multiplication-division), student progress is largely self-guided.

A Reflex session is comprised of the following three main components:

- A brief assessment, called Fact Fair, serves as a progress check that enables the system to determine the facts and families with which a student is not yet fluent. The assessments are administered via fun, carnival-style games.

- A coaching session with Coach Penny uses data from the Fact Fair assessment and progress shown by a student in previous sessions to determine the instructional focus for this session. Coaching varies based on the student's fluency and needs. Facts that the student might be having difficulty with are treated with more in-depth practice than those that are progressing smoothly to automaticity. Analysis of progress across all facts enables Reflex to make effective and efficient decisions about the overall objectives for the current session.

- A practice session on Reflex Island unlocks up to ten math fact games. Each game features different videogame-style play and offers students a range of fun challenges as they practice their math facts. This is where students spend the majority of their time practicing math facts.

The individualized, digital format of Reflex creates a customized path for each student by continuously adapting and scaffolding instruction based on how they interact with the program to determine the most efficient sequence. When presented with a challenging instructional concept, the program detects the student's skill gap and provides a learning path that has them practicing that discrete skill. In other words, there is no singular sequence through Reflex content, but rather infinite sequences that roll out based on previous and immediate actions students make with the program.

1.2 Meeting Curriculum Standards

As part of students' mathematics education, building fact fluency is essential as it enables students to effectively tackle the challenges of higher-level math. Many students in the United States never achieve sufficient proficiency in math facts, and those that do typically achieve fluency later than their peers in other countries. Rigorous standards and guidelines have prioritized math fact fluency as a core objective of elementary mathematics education:

- Common Core Standards for Mathematics (2010)
- National Math Advisory Panel's Core Principles of Math Instruction (2008)
- National Council of Teachers of Mathematics (NCTM) Curriculum Focal Points and Guiding Principles (2006)

For example, the following CCSS standards are addressed through *Reflex*:

2.OA.2 Fluently add and subtract within 20 using mental strategies. By the end of grade 2, know from memory all sums of two one-digit numbers.
3.OA.7 Fluently multiply and divide within 100, using strategies such as the relationship between multiplication and division. By the end of grade 3, know from memory all products of two one-digit numbers.

In addition, CCSS identifies several standards that provide a strong foundation for math fact fluency. Reflex supports these as well:

1.OA.3 Apply properties of operations as strategies to add and subtract.
1.OA.4 Understand subtraction as an unknown-added problem.
3.OA.4 Determine the unknown whole number in a multiplication or division equation relating three whole numbers.
3.OA.5 Apply properties of operations as strategies to multiply and divide.
3.OA.6 Understand division as an unknown factor problem.

Additionally, CCSS' Standards for Mathematical Practice (SMP) rest on important "processes and proficiencies" with long-standing support from leading mathematics education organizations and researchers. Students use the following SMPs during a typical *Reflex* session:

- Make sense of problems and persevere in solving them
- Attend to precision
- Look for and make use of structure
- Look for and express regularity in repeated reasoning

1.3 Supporting All Learners

Reflex automatically serves up different levels of support to different students depending on what they need. Students enter the program by doing an initial placement activity, and then as they progress through Reflex, the program efficiently and intentionally moves each student forward on a customized path by continuously adapting and scaffolding instruction based on how they interact with the program. This means every student is on a personalized learning path that is 100 percent unique to his or her skills and abilities (i.e., no two students have the same Reflex experience), thereby creating the optimal learning experience for each student (i.e., more celebration and accomplishment, less frustration and defeat). The individualized, digital format of Reflex adapts to what they do not know yet, reinforces skills where needed, and does all this through asynchronous, game-based technology that fits seamlessly into a hybrid, remote/virtual, or in-person teaching model.

In recognition of our commitment to identifying and supporting the individualized needs of every student, Reflex was awarded Digital Promise's Learner Variability Product Certification. This certification is awarded to products that are deemed to support the whole learner: their personal background, social and emotional learning, cognition, and content area skills.
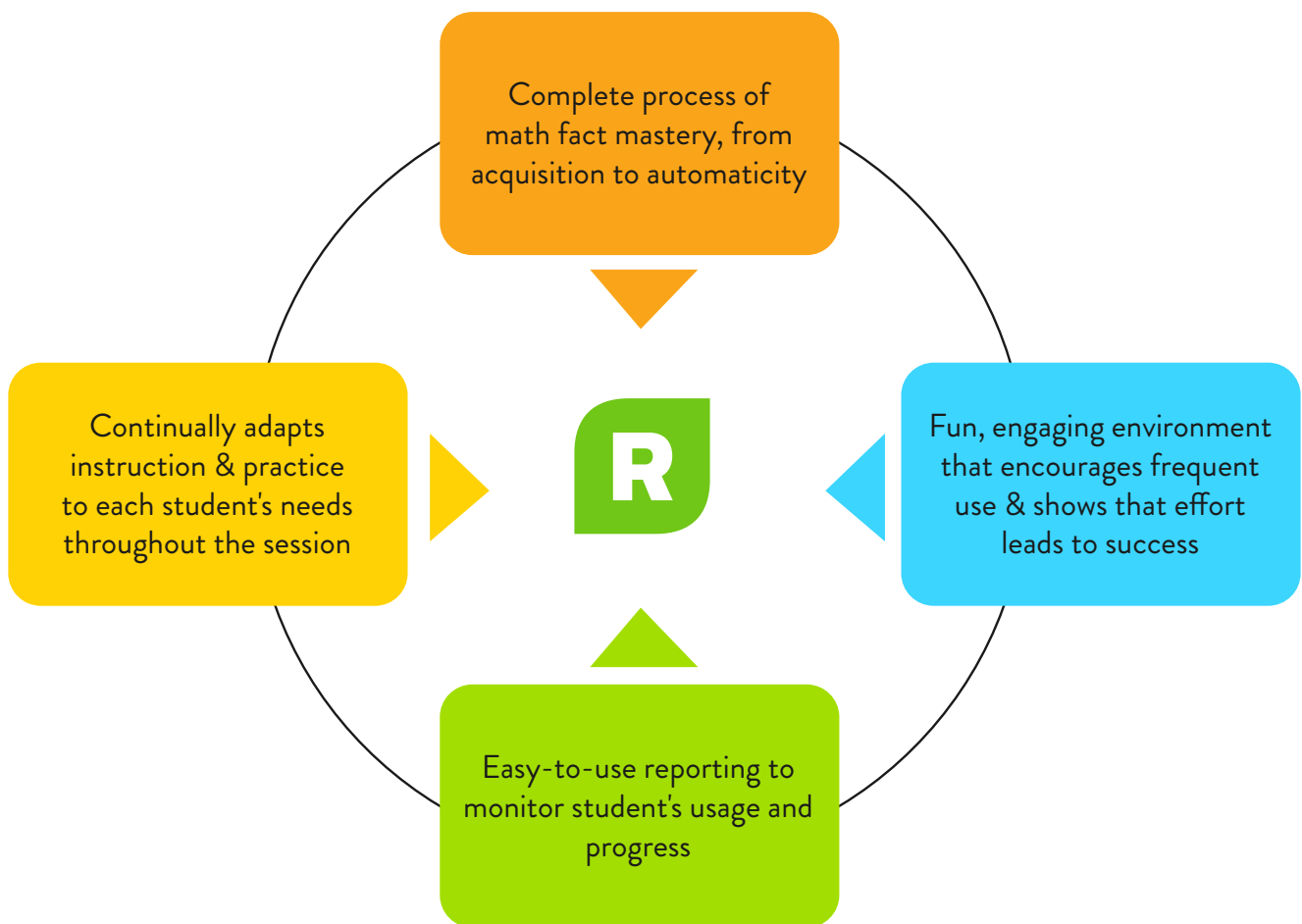
Reflex has been successful with a broad range of students and can be a vital part of any Response to Intervention (RtI) mathematics program: As part of students' mathematics education, building fact fluency is essential as it enables students to effectively tackle the challenges of higher-level math. Many students in the United States never achieve sufficient proficiency in math facts, and those that do typically achieve fluency later than their peers in other countries. Rigorous standards and guidelines have prioritized math fact fluency as a core objective of elementary mathematics education:

- **Tier I: Core instructional interventions**—Reflex can be implemented school-wide for all students to develop and maintain automaticity with basic math facts.
- **Tier II: Targeted group interventions**—Reflex can be used for targeted interventions with students who lack fluency skills already developed by peers. The program offers explicit instruction and coaching, a practice environment to maximize understanding, and specialized, fast-paced games for retention.
- **Tier III: Intensive individual interventions**—Reflex can be used to supplement intensive interventions for students behind by two or more grade levels. The program offers an adaptive experience with explicit instruction and coaching to maximize understanding. It also provides intuitive reports for educators to monitor and support student progress.

2.   Our Research Base: Why Reflex Works

Math fact fluency poses a significant challenge for educators – on the one hand, research shows that it plays a critical role in students' success in elementary mathematics and beyond. For example, differences in addition fact retrieval measured as early as Grade 1 have been shown to predict membership in high versus low achieving groups in subsequent years (Geary, 2009). On the other hand, research also reveals the limitations of traditional fluency development methods such as flashcards and worksheets to satisfactorily address the fluency deficit impeding struggling students. The Reflex system uses research-proven methods and innovative technology to provide an effective and efficient solution for developing students' math fact fluency to full automaticity.

Complete process of math fact mastery, from acquisition to automaticity

Continually adapts instruction & practice to each student's needs throughout the session

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Fun, engaging environment that encourages frequent use & shows that effort leads to success

Easy-to-use reporting to monitor student's usage and progress

2.1   Math Fact Mastery: From Acquisition to Automaticity

Reflex covers the complete process of math fact mastery, including:

- **Systematic introduction of small sets of new facts using appropriate strategies.** Reflex teaches new facts with a variety of strategies, including the commutative property, fact families and rule-based patterns (e.g., multiplication by ten). The most appropriate strategy for that student is selected by Reflex based on the type of fact and the student's demonstrated ability.

- **Development of the student's preliminary ability to recall these new facts from memory.** In the next phase of fluency development, the student completes different forms of "open sentences" (Groen & Poll, 1973; Weaver, 1973). Working with open sentences in various formats also helps to develop students' competencies in several of the Common Core's mathematics standards for Operations & Algebraic Thinking and helps them transition between preliminary stages in fluency development.

- **Progression to timed retrieval once the student has demonstrated readiness.** Coaching Practice Activities with Coach Penny are where retrieval speed is first introduced as a performance requirement. During this stage, Reflex continuously adjusts the difficulty of the retrieval process to keep the difficulty level just within the limit of the student's current ability, decreasing frustration and increasing motivation.

- **Automatization through game-based practice, wherein facts are recalled while the student's working memory is increasingly loaded with game-based tasks.** The student spends the remainder of each session playing Reflex's games. As the final stage of fluency development, Reflex's games provide an environment where students must continually retrieve facts from memory at a high rate while accomplishing various objectives in the game. The key progression represented by this stage is that students are now developing the ability to retrieve facts while simultaneously dealing with significant demands on their working memory.

2.2   Adaptive and Personalized Instruction

A key component of Reflex's effectiveness stems from its ability to take research-validated techniques for fluency development and customize both the content and method of these techniques for each student. The system continuously monitors students' response patterns for each fact under study and uses this data to differentiate instruction and adapt practice throughout a Reflex session. This includes:

- Selecting new facts to learn, and the optimal strategy to use to learn them

- Matching the pace of learning to the student's demonstrated abilities

- Adjusting the difficulty of each retrieval to be just within the student's current ability

- Continually assessing fluency and administering corrective actions when needed

2.3   Recognizing Effort and Accomplishments

Many children believe that success in math is dependent on an innate talent or ability, rather than being determined by the degree of effort invested in learning it – the kind of belief espoused by statements such as "I'm just not good at math." Reflex has been specifically designed to positively demonstrate how effort can lead to success in mathematics. These steady gains can be an incredibly powerful motivator for the student, supporting a "growth mindset" and

instilling confidence that builds perseverance for tackling new challenges in all subjects. Reflex is designed to provide early and positive feedback. Students are rewarded with tokens both for mastery and for correct responses within parts of the system. This rewards the effort they have invested, even in those sessions where they have not achieved full fluency in a new fact or family.

2.4 Progress Monitoring: Assessing and Managing Student Learning

In-program student usage and progress reports that teachers can access at any time are filterable by multiple data fields, including timeframe (weekly, monthly, yearly, custom) and provide important insight into student progress, including:

- Dashboard-style overviews of key information on usage and progress, as well as alerts when key individual and group milestones are reached or if usage drops below recommended minimum levels.
- Summary and detailed data on current fluency levels and daily fluency growth for both individuals and groups of students, with the ability to separate pre-existing fluency from new fluency gained within Reflex.
- Displays that relate Reflex usage to fluency gains. This also supports the identification of students not responding to a fluency-focused intervention that involves Reflex; for example, due to insufficient usage or lack of readiness, such as an inability to count.

3. Real Results: Research Evidence Shows that Reflex Works

3.1 Meeting ESSA Standards for Evidence-Based Interventions

The Every Student Succeeds Act (ESSA), the 2015 national education law that replaced No Child Left Behind, is focused on state and district decision-making. The ESSA Tiers of Evidence provide districts and schools with a framework for determining which programs, practices, strategies, and interventions work in which contexts and for which students.

Tier	Strength of Evidence	Type of Evidence
1	Strong	Supported by one or more well-designed and well-implemented **experimental studies**
2	Moderate	Supported by one or more well-designed and well-implemented **quasi-experimental studies**
3	Promising	Supported by one or more well-designed and well-implemented **correlational studies** (with statistical controls for selection bias)
4	Demonstrates a Rationale	Based on high-quality research findings or positive evaluation that the activity, strategy, or intervention is likely to improve student outcomes or other relevant outcomes

ESSA Tier 4: Demonstrates a Rationale
Reflex meets the ESSA evidence requirements for Level IV (Evidence-Building) by the following criteria:

- Detailed logic model, informed by previous, high-quality research
- Study planning and design is either completed or currently underway for ESSA Level I, II and III studies

ESSA Tier 3: Promising Evidence
Reflex has earned the Digital Promise ESSA Tier 3 Certification, which validates that Reflex positively impacts student math achievement through strong quantitative evidence. Several research studies conducted by university-affiliated researchers over the past 10+ years have demonstrated the efficacy of Reflex. ExploreLearning also works with district research partners and third-party evaluators to conduct evaluations of product efficacy, which meet criteria for ESSA levels of evidence. Together, this research demonstrates the significant, positive impacts of Reflex use on math fact accuracy, math achievement scores, and positive attitudes towards math. Across multiple grade levels, demographic groups, and assessments, students who use Reflex are scoring higher and growing faster than their peers. Below is a representative sample of research reports, with summaries and links for more details:

District Information				Research Sample			
Study	Grades	Student Enrollment	Setting	Grades	Sample Size	Student Demographics	Study Type
Broward	PK-12	256,037	Large Suburb	Grade 2–3	130	41% FRPL, 82% minority, 12% low English proficiency	Third-party study; RCT
Liberty	PK-12	3,007	Rural	Grade 6–8	89	100% Academically At-Risk	Third-party study
Tomball	PK-12	20,262	Large Suburb	Grade 2–4	108		Internal study
Houston	PK-12	194,607	Large City	Grade 3	70	81% African American	Internal study
Charlottesville City (A)	PK-12	4.255	Small City	Grade 2	90		Internal study
Charlottesville City (B)	PK-12	4.255	Small City	Grade 4	40		Internal study
Charlottesville City (C)	PK-12	4.255	Small City	Grades 2-5	568		Internal study
Albemarle	PK-12	13,714	Rural	Grade 6	34		Internal study
South Dakota	PK-12	12,847	Small City	Grade 4	10	80% Native American	Third-party study
California	KG-12	12,459	Small Suburb	Grade 4	32	25% Hispanic	Third-party study
Florida	PK-12	97,264	Large Suburb	Grades 3-4	1,556	District minority enrollment 60%; 35% of students are economically disadvantaged	Internal study
Penn State	N/A	N/A	N/A	Grade 2	112	26% FRPL, 12% special education services	Third-party study

Broward County (FL) Study (Third-Party Report): This is a collaborative work with Dr. Matt Burns, Associate Dean for Research, University of Missouri. Conducted in spring 2016, it was a single-site, randomized controlled trial (RCT) incorporating 139 students from second and third grades in a majority-minority school. The study compared students using Reflex to students learning math facts through traditional methods (e.g., timed speed tests, 10 marks, and flashcards). Students were given a pre-, interim-, and post-test to assess results. The study ran 14.5 weeks in eight classes. Users of Reflex showed statistically significant posttest gains approximately 140 percent greater than nonusers of Reflex.

- Research Report, submitted to What Works Clearinghouse: http://bit.ly/3jtvYBS_WWC-Reflex
- National Center for Intensive Intervention Evaluation: https://charts.intensiveintervention.org/aintervention

Liberty University Study (Third-Party Report): This is an independent study measuring improvement in basic math operations among 89 at-risk students in a rural middle school in Georgia. The study used a quasi-experimental design and showed statistically significant improvement on the Basic Math Operations Task (BMOT) assessment for the general population, as well as male and female subpopulations.

- Research Report: http://bit.ly/2EGUi4oLibertyUniversityStudy
- National Center for Intensive Intervention evaluation: https://charts.intensiveintervention.org/aintervention

Tomball City (TX) Study (Internal Research Report): This study replicates the Broward County study in a rural environment over an entire school year. Reflex users showed statistically significant improvements in both math fact fluency and the ability to determine missing terms in open sentences.

Houston (TX) Study (Internal Research Report): This study replicates the Broward County study in an urban environment over an entire school year. The participating school was minority-majority school, and 81 percent of the participants were African American. Reflex users in this study also showed statistically significant improvements in both math fact fluency and the ability to determine missing terms in open sentences.

- Research Brief (combining Tomball City and Houston studies): http://bit.ly/3hMxHSe_HoustonReflexStudy

Charlottesville City Schools (VA) Studies A-C (Internal Research Report): Three multi-site, correlational studies were conducted as a collaborative effort between ExploreLearning and Charlottesville City Schools. The studies found those students who used Reflex regularly significantly outperformed peers on NWEA Mathematics test (grade 2) and Virginia Standards of Learning state assessment in math (grade 4). A longitudinal study found that students (grades 2-5) who regularly used Reflex achieved substantially higher growth on the NWEA in years 2 and 3 than their peers did.

- Research Brief, Grade 2 study (A): www.reflexmath.com/casestudy2nd
- Research Brief, Grade 4 study (B): www.reflexmath.com/casestudy4th
- Research Brief, Longitudinal study (C): www.reflexmath.com/casestudy2to5

Albemarle County Schools (VA) Study (Internal Research Report): A single-site correlational study was conducted as a collaborative effort between ExploreLearning and Albemarle County Schools. The studies found those students who used Reflex regularly significantly outperformed peers on NWEA Mathematics test and Virginia Standards of Learning state assessment in math.

- Research Brief, Grade 6 study: www.reflexmath.com/casestudy6th

University of South Dakota Study (Third-Party Report): A university research study interviewed 4th grade students using Reflex over the course of a year about their experiences in a flex- blended classroom. Many of the students noted that the gamification of Reflex helped them to learn their facts better and kept them motivated and engaged with learning.

- Research Report: https://red.library.usd.edu/diss-thesis/150/

Vacaville Unified (CA) Study (Third-Party Report): A university research study found that 4th grade students who used Reflex improved in math fact fluency on both computerized and paper assessments. The average student gained 68.9 percentage points on a paper and pencil test of multiplication fact fluency from fall to spring, with an average spring fluency level of 91%. Additionally, students reported a 72.5% increase in positive attitudes towards math from fall to spring surveys.

- Research Report: https://touroscholar.touro.edu/tucgsoe/162/

Florida Study (Internal Research Report): A study of 1,556 3rd and 4th grade students in Lee County, Florida found that students who used Reflex and Frax together had statistically larger math score gains in i-Ready diagnostic assessment scores compared to non-users. Across all students, Reflex and Frax users were 60% more likely to meet or exceed typical growth goals and 2x more likely to meet or exceed aspirational stretch growth goals, with the largest gains observed in the most academically at-risk students.

- Research brief: https://explorelearning.com/resources/insights/reflex-frax-propel-growth

Pennsylvania State University Study (Third-Party Report): A university research study of 112 2nd grade students found that students gained on average almost 120 facts over the course of 10 weeks of using Reflex. Additionally, students generalized growth to paper-based assessments of both single and multi-digit addition measures. Importantly, students with disabilities gained math fact fluency at a similar rate as compared to their non-disabled peers. The students also preferred practicing on Reflex (68.5%) over paper-and-pencil practices.

- Research Report: https://etda.libraries.psu.edu/catalog/16611lej121

Additional Research Studies:

Galicia Study (Published Research Report): A university research group in Spain conducted a quasi-experimental, pretest-posttest study of the impact of Reflex on math fact fluency and math grades with 12 classes of students in levels 1-4. After using Reflex with fidelity for 9 weeks, students nearly doubled their math fact fluency test scores. Additionally, math fact fluency gains were strongly correlated with student math grades.

- Research Report: https://eric.ed.gov/?id=EJ1311454

Title I Eligible Schools Study (Internal Research Report): This study examined 20,000 students at 233 Title I eligible schools with recommended or near-recommended Reflex usage during the 2016-2017 school year. Reflex helps close the achievement gap in math for Title I elementary school students. It found that no matter what the percentage of students on free and reduced lunch at the school, students improved their fluency over 60 days.

- Research Brief: https://www.explorelearning.com/resources/insights/helping-title-students-succeed-reflex

Miami-Dade Schools National Assessment of Educational Progress (NAEP) Study (Internal Research Report) This study examined NAEP scores for fourth grade math from 2009 to 2015 and its correlation to the implementation of Reflex in the district starting in 2013. Immediately after implementation of Reflex, student math scores showed a large increase between 2013 and 2015. The study also found that student scores in the computationally intensive properties and operations strand – the area of focus for Reflex – showed the most improvement with a 7-point gain.

- Research brief: https://www.explorelearning.com/resources/insights/case-study-explorelearning-reflex-and-miami-dade-county-public-schools-naep-results

Preventing COVID-19 Learning Loss with Reflex (Internal Research Report): The majority of schools saw large declines in student mathematics achievement scores between 2019 and 2022 due to pandemic-related learning loss. In one Western region state, we looked at 5 schools that implemented Reflex between 2019 and 2022 and 5 matched control schools that did not have Reflex based on 2019 test scores. In 2022, students in grades 3 – 5 in the Reflex schools outperformed the matched peer schools on average by over 10 percentage points.

- Research brief: https://explorelearning.com/resources/insights/reflex-western-state-research

Reflex Usage and NWEA MAP Math Achievement (Internal Research Report): New research found that 2nd-grade students who used Reflex with high fidelity were significantly more likely to reach 100% fluency levels compared to students who did not use Reflex with high fidelity. Regardless of fall baseline measurements and across all achievement levels, students who used Reflex with high fidelity outscored their peers by the end of the school year. These students also showed significantly higher growth on NWEA MAP Growth assessments and a greater likelihood of meeting or exceeding growth benchmarks.

- Research Brief: https://www.explorelearning.com/resources/insights/reflex-green-light-nwea-map-achievement

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