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Zaner-Bloser Building Fact Fluency

Examining the longitudinal impact of Zaner-Bloser Building Fact Fluency on school-level third-grade proficiency, Spring 2021-Spring 2023

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Abstract

Math fact fluency– the ability to quickly and accurately recall basic addition, subtraction, multiplication, and division facts– is a foundational mathematical skill. *Zaner-Bloser Building Fact Fluency (BFF)* was designed to build students' conceptual understanding of arithmetic operations and increase procedural fluency among elementary school students, with the goal of strengthening math learning. LXD Research conducted a study to examine Grade 3 students' math proficiency levels on the standardized Iowa Statewide Assessment of Student Progress (ISASP) across five *Building Fact Fluency* participating schools and 20 similar Iowa comparison schools from spring 2021- spring 2023. One *Building Fact Fluency* pilot school began the program in fall 2021, and four additional schools began the program in fall of 2022. The pilot *Building Fact Fluency* school, Year 2-only *Building Fact Fluency* schools, and comparison schools had a similar percentage of students on grade level at baseline. However, Grade 3 students in *Building Fact Fluency* schools showed consistently greater improvements in the percentage of Grade 3 students on grade level in math.

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Introduction

Math fact fluency is a fundamental skill that is the bedrock for mathematical proficiency and success in a wide range of academic and real-world situations. Students who demonstrate mathematical proficiency should possess an understanding of key mathematical concepts and can automatically retrieve arithmetic facts (National Mathematics Advisory Panel, 2009). Beyond mere rote memorization, math fact fluency empowers individuals to solve more complex mathematical problems efficiently, fosters a deeper understanding of mathematical concepts, and provides a strong foundation for various STEM disciplines. In an increasingly data-driven and technologically advanced world, the importance of math fact fluency cannot be overstated, as it equips individuals with a crucial tool for problem-solving, critical thinking, and numerical literacy, enhancing their ability to successfully navigate both educational and professional landscapes.

Students often encounter difficulties in achieving math fact fluency due to a combination of factors. One primary challenge is a lack of early and consistent exposure to basic arithmetic concepts. Students who do not receive adequate foundational instruction in early grades may struggle to build on these skills as they progress through their mathematical education (Watts et al., 2014). Furthermore, individual learning differences play a significant role, as some students may require more time and varied approaches to internalize math facts (Baroody, 2006). Anxiety and negative perceptions about math can further impede progress, creating a mental block that interferes with the development of fluency. The pressure of timed tests and rote memorization can also lead to stress and hinder the natural development of number sense (Gernsbacher, Soicher, & Becker-Blease, 2020). In addition, the absence of engaging and interactive teaching methods that connect math facts to real-world applications can make the learning process less enjoyable and less likely to be retained.

To address these challenges, educators and curriculum designers must employ varied and personalized strategies to help students overcome obstacles and build essential math fact fluency. Graham Fletcher and Tracy Zager developed *Building Fact Fluency* to address this need. *Building Fact Fluency* often supplements the core math curriculum by providing students with ample opportunities to apply basic arithmetic operations in diverse real-world contexts through Lesson Strings—a series of interconnected activities, tasks, and games. When students engage in the fluent retrieval of basic facts, they build a foundation of procedural fluency. This foundation of procedural fluency allows them to apply procedures accurately, efficiently, and flexibly; to transfer procedures to different problems and contexts; to build or modify procedures from other procedures, and to

recognize when one strategy or procedure is more appropriate to apply than another (National Council of Teachers of Mathematics, 2014). The *Building Fact Fluency* approach helps students deepen their understanding of operational relationships by discussing their thinking and exploring various strategies, moving beyond rote memorization and fact drills to achieve meaningful learning and improved student outcomes.

Zaner-Bloser hired Learning Experience Design (LXD) Research to evaluate the impact of *Building Fact Fluency* on student outcomes over time. To achieve this, LXD Research evaluated and compared the Grade 3 math proficiency rate from Iowa public schools that used *Building Fact Fluency* in multiple schools over time to similar schools across the state that did not use *Building Fact Fluency*.

Program Description

Building Fact Fluency toolkits, designed for both *Addition & Subtraction* and *Multiplication & Division*, are instructional resources aimed at helping students develop a profound conceptual understanding of mathematical operations while simultaneously improving their fact fluency. Educational games play a crucial role in developing fact fluency by offering interactive and immersive experiences that reinforce mathematical concepts (Gray, 2013). These toolkits provide teachers with the means to facilitate rich tasks, strategy discussions, contextualized practice, reflection, and engaging games, all grounded in research on fact fluency.

The primary objective of *Building Fact Fluency* is to move beyond rote memorization, offering students ample, varied opportunities to understand number facts and the fundamental properties of arithmetic. *Building Fact Fluency*'s scope and sequence/materials for facts are aligned with Bay-Williams & Kling's (2019) flexible learning progression, which engages students to explore and work with foundational facts before derived facts are layered in. This approach ensures that students not only accumulate number facts but also discover and understand relationships and connections within arithmetic operations. When students have a strong understanding of basic math facts, they can use what they already know to figure out new facts and understand more complex math concepts, as compared to requiring students to first memorize all their basic facts before they can start learning more advanced math (Van De Walle et al., 2019). The toolkits are structured to allow students to accumulate known number facts while simultaneously developing a deep understanding of these operations and properties.

By using *Building Fact Fluency*, designers assert that students will experience a deeper understanding of operational relationships by describing their thinking and discussing the varied ways in which to apply that knowledge. As students engage in learning through meaningful contexts rather than rote memorization or fact drills, they are given opportunities to try out strategies and ideas and have in-depth discussions about them. Teachers, in turn, are able to hear more student discourse regarding their learning of math fact fluency in the classroom. Specific program components include:

1. **Lesson Strings**
    - Interconnected activities, tasks, and games designed to apply mathematical operations in diverse real-world contexts.
    - Facilitate procedural fluency: the knowledge of procedures, their appropriate use, and skill in performing them accurately and efficiently.
    - Promote connections across mathematical ideas, supporting procedural fluency and the ability to transfer procedures to different contexts.
2. **Math Dialogue and Discussion**
    - Opportunities for students to engage in conversations about mathematical situations using both informal and mathematical language.
    - Encourages reasoning, strategy selection, and defending choices, which are especially beneficial for multilingual learners and emerging readers.
3. **Game-based Learning/Collaborative Tasks**
    - Games designed for student autonomy and mathematical decision-making, allowing for meaningful practice of number facts and strategic thinking.
    - Games provide differentiation, with variations to cater to different foundational and derived strategies.
4. **Assessment Opportunities**
    - Teachers can assess student understanding and thinking through multiple methods, including observations, interviews, work, journals, and self-assessments.
    - Focus on formative assessment approaches to gauge student progress and guide teaching strategies.

In the short term, *Building Fact Fluency* is expected to improve math fluency and strategic thinking among students while reducing math anxiety and increasing motivation to learn. Students will demonstrate flexible application of strategies, engage in meaningful math

discourse, and build both language and math understanding. Teachers will enhance their capacity in math instruction, effectively differentiating for all learners and supporting student growth.

Over time, *Building Fact Fluency* aims to increase access to rich math experiences, foster equity, and remove barriers to engagement. Students will develop relational thinking that applies to various aspects of life and higher-level mathematics. They will become creative, tenacious problem-solvers with a strengthened math self-efficacy and ownership mindset. As a result, students will feel more comfortable engaging with the math community, and their improved problem-solving skills will benefit their overall learning journey.

Methods

Participants

Pilot School and Initial Implementation

The study's pilot school (Grade 3 student N = 94), located within an urban school district in Iowa, began using the *Building Fact Fluency* program in Fall 2020. The district was 43% White, 8% Black, 3% Asian or Asian/Pacific Islander, 36% Hispanic/Latino, 3% American Indian or Alaska Native, 2% Native Hawaiian or other Pacific Islander, 6% two or more races. Across the district, 16% of students received support for learning English and 49% received free or reduced price meals. This pilot school served as the foundation for identifying comparable schools across the district and the state. The district rolled out the program to all schools the following year, four (4) of which were selected as "Year 2 Only" district *Building Fact Fluency* intervention schools for this study.

Criteria for Comparison School Selection

Twenty comparison schools across the state were of relatively similar size and had nearly the same scores as the pilot school in Spring 2021 and were thus designated as comparison group schools. The selection process for including schools in this study was designed to ensure a fair and meaningful comparison. The primary objective was to identify schools that closely resembled the pilot school in terms of size, demographics, and baseline academic performance, allowing LXD Research to accurately assess the impact of the *Building Fact Fluency* program.

1. **District Similarity**
    - LXD Research identified 20 school districts across Iowa that were similar in size to the *Building Fact Fluency* district. These districts had a comparable number of schools, specifically within a range of 10 schools, providing a similar administrative and community context within this small state with large rural areas.
2. **Academic Performance Matching**
    - Within these districts, LXD Research further refined the school selection to those with third-grade math proficiency rates from Spring 2021 within a 52% to 68% range. This range was set to match the proficiency rate of the pilot school within a 15-point margin, ensuring similar academic baselines for comparison.
    -

3. **Demographic Considerations**
    - LXD Research collected and analyzed demographic data for each school, focusing on the percentage of students from low socioeconomic status (SES) backgrounds and students receiving special education services (SPED). These data were collected for the 2022-2023 school year to provide a comprehensive understanding of each school's student population.

Although the pilot school started using the *Building Fact Fluency* program in Fall 2020, Spring 2021 was selected as the key academic performance comparison point. This decision was made because Spring 2020 testing data was unavailable due to school closures amid the pandemic. Thus, Spring 2021 provided the first post-pandemic dataset for a fair statewide comparison to examine multi-year trends.

Implementation History

By the 2022-2023 school year, the pilot school had thoroughly integrated the *Building Fact Fluency* program, with third graders using it since first grade. This ensured that students had multiple years of exposure to the program, allowing LXD Research to assess its cumulative impact over time.

Table 1. Implementation Timing of Building Fact Fluency

Group	**Implementation Year for Third Graders**		
	2020-2021	**2021-2022**	**2022-2023**
Pilot School (N=1)	First Year	Second Year	Third Year
Additional BFF Schools (N=4)		First Year	Second Year
Comparison Schools (N=20)	No Use of *Building Fact Fluency*		

Table 2. School Demographics

Group	% Proficient 3rd Grade (2021)	Average School Size Grades 3-5	Average % Low SES	Average % SPED
Pilot School	61%	293	73%	15%
District *BFF* Schools	60%	175	77%	14%
Comparison Schools	60%	157	56%	18%

Core Curriculum Used in the Building Fact Fluency District

The HMH program Into Math covers third-grade skills such as multiplication and division within 100, understanding fractions as numbers, developing strategies for solving problems involving the four operations, and analyzing two-dimensional shapes. It uses a structured approach to building conceptual knowledge and procedural skills and would pair effectively with a supplemental math fact fluency program. By integrating a fluency-focused supplement, students can simultaneously strengthen their foundational arithmetic skills, allowing them to approach more complex problems with confidence and efficiency.

Data Collection

State math assessment scores from Iowa were downloaded from the state website, Iowa School Performance, (https://www.iaschoolperformance.gov) for Spring 2021, 2022, and 2023.

Analysis Plan

For the pilot school comparison, using Iowa State math test data, LXD Research compared the pilot school with a matched comparison group of 20 schools. The analysis focused on determining whether the pilot school significantly differed in the percentage of students performing at grade level in math at baseline and for each year of program participation. LXD Research, therefore, compared the pilot and comparison schools' Spring 2021 baseline scores, Spring 2022 "Year 1" scores, and Spring 2023 "Year 2" scores, using chi-square tests at each respective year.

For district schools that began using *Building Fact Fluency* one year later (fall 2022), LXD Research compared the percentage of students on grade level in math for the Iowa State standardized test between the intervention school group with the matched comparison group of 20 schools. Therefore, LXD Research compared the intervention and comparison schools' Spring 2022 baseline scores and Spring 2023 "Year 1" scores using chi-square tests for both years.

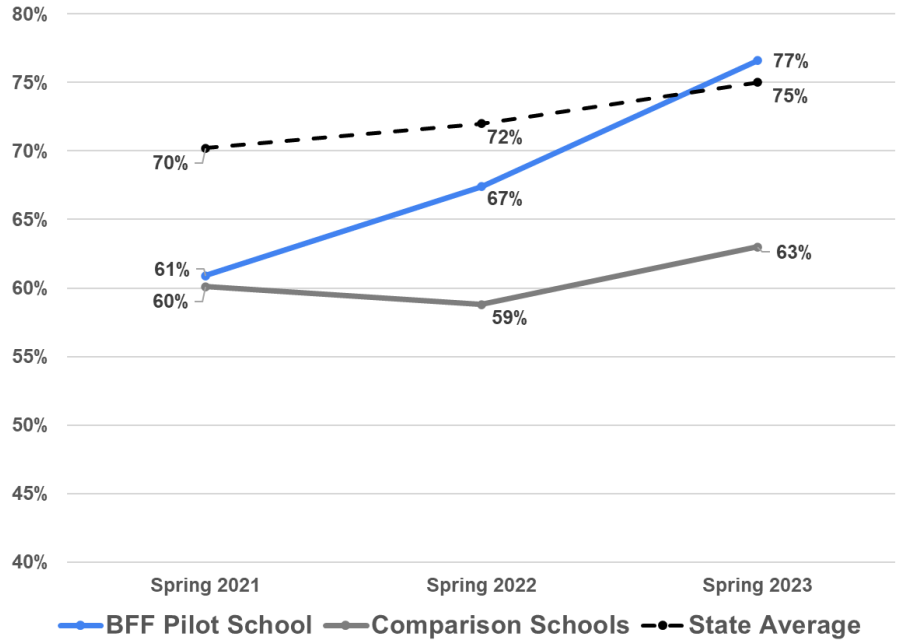
Results

This study examined the percentage of Grade 3 students' math proficiency on the Iowa Statewide Assessment of Student Progress (ISASP) test in *Building Fact Fluency* participating schools from 2021 to 2023, compared with similar Iowa schools in the comparison group.

Building Fact Fluency Pilot School and Comparison Group

Baseline end-of-year state test data in Spring 2021 indicated that the pilot and comparison schools were virtually identical in the percentage of Grade 3 students proficient in math (61% and 60%, respectively, p = .89; not significant).

Figure 1. Percentage of Grade 3 Students Proficient in Math (Building Fact Fluency Pilot School, Comparison Schools, and State Average).

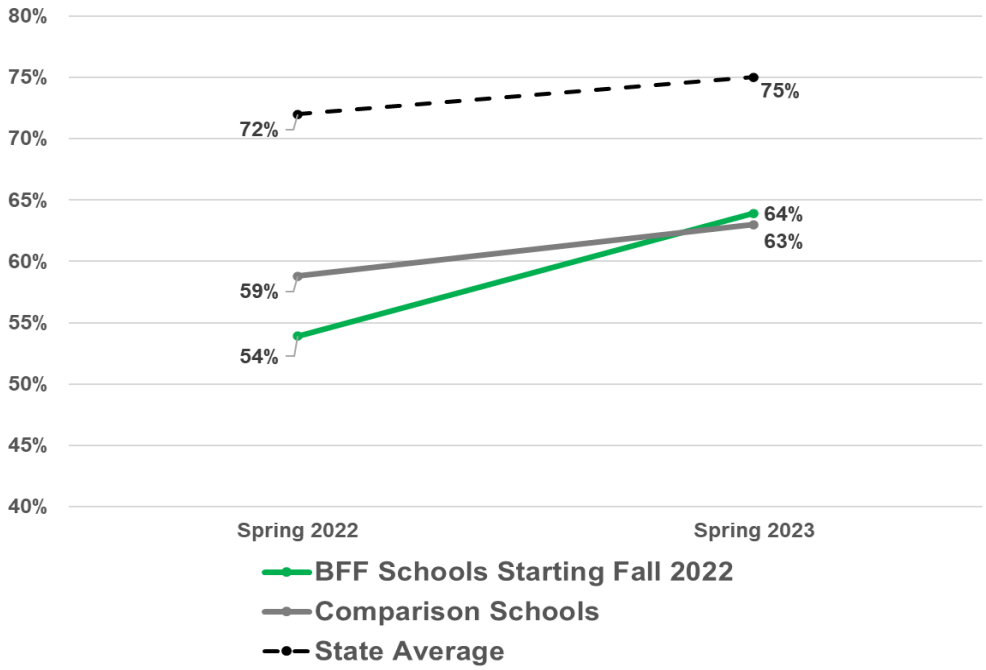


As shown in Figure 1, despite an increase in the percentage of students on grade level after 1 Year in the pilot school group, differences between the *Building Fact Fluency* pilot school (67%) and comparison group schools (59%) were not statistically significant by the spring of 2022 (p = .14; not significant). However, by the spring of 2023, a 2x2 chi-square test found that Grade 3 students in the *Building Fact Fluency* pilot school had a significantly greater percentage of students testing on grade level for math proficiency (77%) than the comparison schools (63%: $p < .01$, Phi coefficient effect size = .07).

Building Fact Fluency Year 2 Only Group and Comparison Group

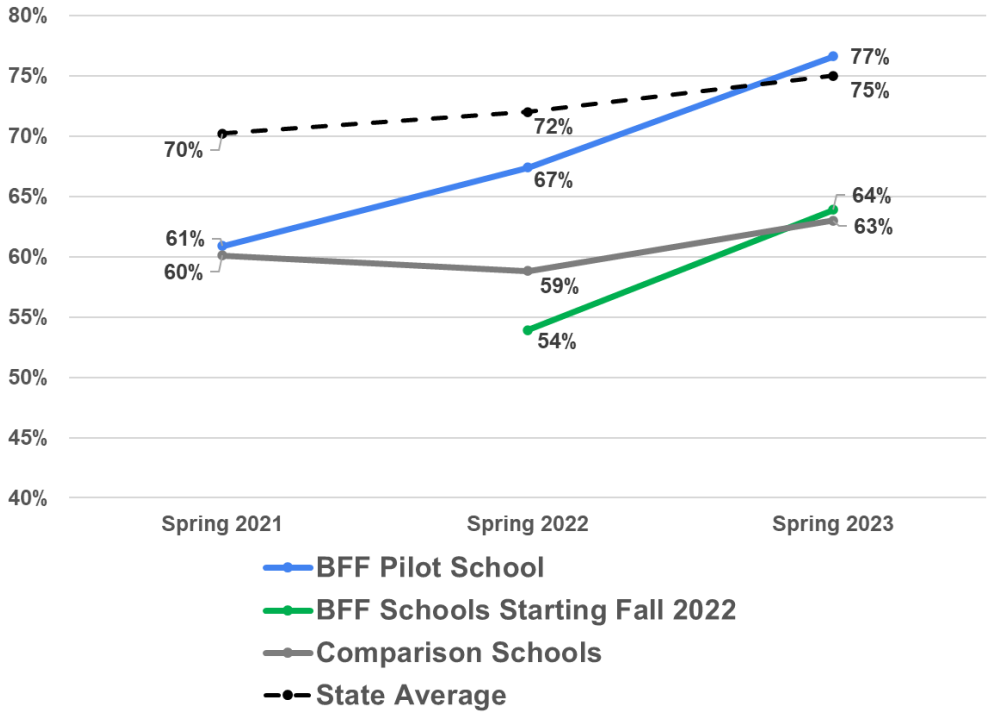
Baseline end-of-year state test data in Spring 2022 indicated that the four "Year 2 Only" schools that began *Building Fact Fluency* in Fall 2021 and comparison schools differed somewhat at baseline in the percent of Grade 3 students proficient in math, but those differences were not statistically significant (54% and 59%, respectively, p = .16).

Figure 2. Percentage of Grade 3 Students Proficient in Math (Building Fact Fluency Year 2 Only, Comparison Schools, and State Average)



As shown above in Figure 2, the four Year 2 Only *Building Fact Fluency* schools showed greater growth in percent proficiency (+10%, for a total of 64% proficient) than the comparison schools (+4%, for a total of 63% proficient) in one year. Although these results were not statistically significant, they show a promising trend, similar to that of the pilot school after a single year of *Building Fact Fluency* program implementation.

Figure 3. Percentage of Grade 3 Students Proficient in Math (All Groups)



In sum, *Building Fact Fluency* schools consistently demonstrated meaningful increases in percent proficiency in math each year, and these effects were strongest after 2 years of *Building Fact Fluency* program use. Figure 3 above showcases both intervention groups, the comparison group, and the Iowa state average for Grade 3 for context. *Building Fact Fluency* participating schools consistently showed greater improvement in proficiency than the comparison group. Though the data are supplemental to this study, there was greater growth in Grade 3 math proficiency than the state overall.

Discussion and Conclusion

Fact fluency is essential in mathematics education as it forms the bedrock for more advanced problem-solving and critical thinking. While the core curriculum provides a broad overview of mathematical concepts, it often falls short in ensuring students achieve automatic recall of basic math facts. This study highlights the importance and effectiveness of implementing a product focused on building fact fluency, such as the *Building Fact Fluency* toolkits. These toolkits, with features like Lesson Strings, Math Dialogue and Discussion, Game-based Learning, and diverse Assessment Opportunities, foster a deep understanding of mathematical operations while improving fact fluency. By engaging students in meaningful contexts rather than rote memorization, the toolkits encourage students to describe their thinking, explore various strategies, and have in-depth discussions, which enhances their ability to apply knowledge effectively.

While this study included treatment and comparison schools, only the pilot school outperformed the comparison schools, qualifying this study as Promising, ESSA Level 3. Students demonstrated improvements in standardized test scores and provided significant benefits when sustained over multiple years, underscoring the value of *Building Fact Fluency* in developing a solid mathematical foundation and boosting overall student achievement. Future research could look at the student-level, include multiple schools within the same district, and follow students over time to see how developing fact fluency supports student achievement as they engage with more complex material.

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