Exploratory Analysis of Students’ Mathematics Achievement After Using Front Row
Written in partnership with WestEd
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Abstract

WestEd—a nonpartisan, nonprofit research, development, and service agency—partnered with Front Row to explore whether students who use Front Row exhibit different mathematics achievement outcomes than students who do not use Front Row. A rural school shared data on Front Row adoption and student scores on the Northwest Evaluation Association’s (NWEA) Measure of Academic Progress (MAP) in mathematics with Front Row. WestEd used these data to conduct an independent analysis to determine whether or not Front Row use was associated with higher NWEA MAP test scores. Results are consistent with the hypothesis that using Front Row in the classroom results in higher achievement in mathematics. Limitations to the study and future research directions are also discussed.
EXECUTIVE SUMMARY

Front Row is a computerized math and reading comprehension program that provides adaptive feedback and practice opportunities for K-8 students. Front Row is hypothesized to improve students’ reading and mathematics outcomes in education. In the present study, WestEd explored the potential of Front Row to support students’ mathematics achievement in Kindergarten, Grade 1, and Grade 2 classrooms.

Study participants consisted of 466 Kindergarten, Grade 1, and Grade 2 students and 25 teachers in a rural elementary school during the 2014-2015 academic year. Teachers chose to use Front Row or chose not to use Front Row during the course of the school year. Approximately half of the teachers and their associated students (14 teachers, 263 students) used Front Row in their classrooms, whereas the other half (11 teachers, 203 students) participated in business-as-usual classroom activities.

This study explores whether results are consistent with the predictions that Front Row supports student learning in mathematics. Towards this end, students’ end of year mathematics scores on the Measure of Academic Progress (MAP) assessment was collected for each student. Preliminary analyses indicated that Front Row students exhibited higher beginning of year MAP scores than the comparison students. However, an analysis that attempted to control for beginning of year MAP score differences as well as grade level indicated that students in the Front Row condition scored approximately 4.6 points higher on their end of year MAP scores relative to students who did not use Front Row, a statistically significant difference ($p < .001$).

The results of this exploratory study are consistent with the hypothesis that Front Row positively impacts students’ mathematics achievement in K-2 Grades. However, because teachers were not randomly assigned to use Front Row, the results should not be used to claim that Front Row caused higher student achievement. In addition, the study relies on a data set with limited information: Teachers chose to use Front Row or not for reasons unknown to the study team. In addition, potentially important demographic information on teachers and students are missing, thereby limiting the generalizability of the findings. Future studies can be conducted that utilize random assignment to groups and that collect information on factors that may potentially influence the effectiveness of Front Row. Such studies will increase confidence that Front Row use leads to improved mathematics outcomes.
INTRODUCTION

Front Row is an adaptive math and reading comprehension program that ensures every student receives high-quality, individualized math and reading practice. By addressing student weaknesses and building off of strengths, Front Row is designed to increase confidence and promote growth in all students, regardless of their ability level.

When starting on Front Row, students take a diagnostic to determine what they already know and areas that they could use more practice in. Then, as they continue practicing, the program adapts to provide individualized instruction tailored for each student's skill level.

Front Row is designed to be used multiple times a week in the classroom to build students’ math fluency, and provides teachers data for each student such as the report shown below:

![Sample Report Card data view](image)

**Figure 1.** Sample Report Card data view available for teachers in Front Row Math.

This study addressed the question: *Do students with teachers who used Front Row exhibit higher end of year mathematics scores than students from teachers who did not use Front Row?*

Towards this end, WestEd, a nonprofit research, development, and service organization, analyzed data that was provided by the participating school, which included end of year mathematics scores on the Measure of Academic Progress (MAP) assessment for all Kindergarten, Grade 1, and Grade 2 students at the school. The MAP assessment is administered by the Northwest Evaluation Association (NWEA) and is an adaptive measure of students' mathematics achievement. It was predicted that if Front Row supports students’ mathematics achievement, students of teachers who used Front Row would exhibit higher end of year scores on the MAP assessment relative to students of teachers who did not use Front Row.
METHOD

This study is not a randomized control trial study (i.e., students were not randomly assigned to conditions). Because of many threats to internal validity under this design, this study does not attempt to make causal claims on the impact of Front Row in student scores. Rather, it explores whether the results are consistent with the hypothesized predictions related to the impact of Front Row on student achievement.

PARTICIPANTS

Participants in this study were from a rural, public elementary school in the Southern United States (see Table 1). Participants consisted of 25 teachers (14 teachers in the Front Row group and 11 teachers in the Comparison group) and 466 students (263 students in the Front Row group and 203 students in the Comparison group). The 25 teachers comprised all of the teachers of Kindergarten, Grade 1, and Grade 2 at the participating school.

Some of the teachers used Front Row with their students whereas some of the teachers did not use Front Row (henceforth, these groups are referred to as the Front Row and Comparison groups, respectively). The school did not provide information on teachers’ reasons for opting to use Front Row. Students in both groups took the MAP Math assessment at the beginning and end of the 2014 - 2015 academic year (i.e., the Fall and Spring, respectively).

Attrition. Thirty-five students (16 students from the Front Row condition and 19 students from the Comparison condition) did not have complete pre and post-test data and therefore are excluded from all analyses. The complete analytic sample then consisted of 431 students (247 in the Front Row condition and 184 students in the Comparison condition) (see Table 2).

Table 1. School Demographic Information

<table>
<thead>
<tr>
<th>Type</th>
<th>% Free/Reduced Lunch</th>
<th>Enrollment</th>
<th>% White</th>
<th>% Black</th>
<th>% Hispanic</th>
<th>% Asian/Pi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public, Title 1</td>
<td>69%</td>
<td>572</td>
<td>72%</td>
<td>21%</td>
<td>2.6%</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

1 One student id appeared in two classrooms in the datasets provided and is not considered in these analyses.
Table 2. Teacher and Student Counts by Grade Included in Final Analytic Sample

<table>
<thead>
<tr>
<th>Kindergarten</th>
<th>First Grade</th>
<th>Second Grade</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>Teachers</td>
<td>Students</td>
<td>Teachers</td>
</tr>
<tr>
<td>Front Row</td>
<td>66</td>
<td>4</td>
<td>86</td>
</tr>
<tr>
<td>Comparison</td>
<td>63</td>
<td>4</td>
<td>82</td>
</tr>
<tr>
<td>Total</td>
<td>129</td>
<td>8</td>
<td>168</td>
</tr>
</tbody>
</table>

The average beginning and end of year MAP scores by grade and condition are provided in Figure 2.

![Figure 2](image)

Figure 2. Means for students’ beginning and end of year MAP scores by grade and condition.
Table 3 shows the observed and expected growth for students for each participating grade level and condition. MAP growth norms are based on the beginning to end of year growth on the MAP mathematics assessment (Northwest Evaluation Association, 2015).

**Table 3.** Growth (and standard deviations) observed in the study relative to the growth norms from the beginning to end of the academic school year on the MAP mathematics assessment for each grade level.

<table>
<thead>
<tr>
<th></th>
<th>Kindergarten</th>
<th>Grade 1</th>
<th>Grade 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Front Row Growth</strong></td>
<td>25.71 (7.51)</td>
<td>25.52 (7.73)</td>
<td>20.68 (8.19)</td>
</tr>
<tr>
<td><strong>Comparison Growth</strong></td>
<td>23.08 (7.17)</td>
<td>22.56 (7.16)</td>
<td>12.79 (5.11)</td>
</tr>
<tr>
<td><strong>MAP Growth Norms</strong></td>
<td>19.1 (7.59)</td>
<td>18.4 (7.45)</td>
<td>15.2 (7.11)</td>
</tr>
</tbody>
</table>

**DATA ANALYSIS**

Student achievement data from the MAP assessment were analyzed by WestEd. The primary analytic strategy for assessing student achievement scores involved fitting Hierarchical Linear Models (HLM). This analysis was chosen because it accounts for the nested structure of the data (i.e., students nested within teachers; Raudenbush & Bryk, 2002) (see Appendix A).

Front Row also conducted interviews with a subset of Front Row teachers to gain insight into the perceived value of Front Row (a summary of the teacher interviews is included in Appendix B).

**RESULTS**

**BASELINE EQUIVALENCE**

An analysis was first conducted to determine whether students were statistically equivalent on their beginning of year MAP scores. This analysis indicated that students in the Front Row condition scored higher ($M_{FR} = 161.44$, $SE_{FR} = 4.22$), but not statistically higher, on the pre-MAP assessment than students in the Comparison condition ($M_{Comp} = 156.05$, $SE_{Comp} = 4.77$; $p = .41$).

To measure the relative size of the baseline differences between the groups, an effect size statistic (i.e., *hedges g*) was calculated. The effect size statistic is a measure of the size of the differences between the groups in standard deviations. The effect size difference between the Front Row and Comparison groups’ baseline scores was .31, which is considered substantive (What Works Clearinghouse, 2014). The difference in beginning-of-year performance is large enough that the two groups should be considered non-equivalent (What Works Clearinghouse, 2014).
**POST-Score Analysis**

To examine student achievement for students whose teachers used Front Row relative to students who did not, we used an HLM model that attempted to control for students’ grade level and their beginning of year scores (see Appendix A).

This analysis indicated that students in the Front Row group exhibit an end of year MAP score that is an estimated 4.64 points higher than students in the Comparison group. This difference is considered significant. The effect size for this difference is .29 (see Figure 2 for means of each groups’ end of year MAP scores).

![Figure 3. Covariate-adjusted means for each Group’s end of year MAP scores. Error bars represent standard errors of the means.](image)

To interpret the effect size estimate of .29 in a more meaningful way, we converted this statistic using properties of the normal distribution. This analysis suggested that if students in the Comparison group were at the 50th percentile of a normed sample, the Front Row group students would be placed at the 59th--60th percentile of a normed sample (i.e., approximately 9.86 percentage points higher than the comparison students). We also computed an effect size for each grade level and compared this effect size to the typical expected MAP growth in mathematics (Northwest Evaluation Association, 2015). This analysis suggested that the Front Row group students are approximately two months ahead of Comparison group students in mathematics achievement (see Appendix A).

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2 Results were similar when excluding the Grade 2 students.
DISCUSSION

Students in the Front Row group exhibited higher end of year achievement scores than students in the Comparison group. This effect held when controlling for beginning of year scores and grade level. Thus, findings from this study are at least consistent with the hypothesis that using Front Row in the classroom improves student achievement outcomes.

STUDY LIMITATIONS

Because this study relied on data collected post-hoc from a naturalistic implementation, there are many issues that may limit the confidence in conclusions. First, the data set provided by the school was limited in that it contained little background information about participating students and teachers, including reasons why teachers chose to use Front Row at the school. This information would have been useful for inferring the generalizability of findings, as well as for exploring factors that may moderate the effectiveness of Front Row. Second, because this study did not utilize random assignment, it is possible that variables other than Front Row use - such as more effective teachers opting to use Front Row - contributed the increase in student scores. Third, students in the Front Row group had baseline MAP scores that were substantively higher than the Comparison group and therefore cannot be considered equivalent prior to the intervention. Finally, since the study was conducted on a relatively homogeneous and narrow population (participants within a single school), the effects may be larger than would be observed if the study were conducted on a diverse population (e.g., multiple schools in different geographic regions) (Lipsey et al. 2012).

CONCLUSIONS

This study is exploratory in nature and represents an initial step in understanding the effectiveness of Front Row on student achievement outcomes. These findings support the hypothesis that Front Row improves students’ mathematics outcomes. However, future studies can utilize random assignment to groups and collect baseline and implementation information to more conclusively determine Front Row’s impact on student outcomes.
REFERENCES


Appendix A.

Statistical and methodological details of the methods and analyses conducted.

DATA ANALYSIS

Student achievement data from the MAP assessment were analyzed by WestEd. The primary analytic strategy for assessing student achievement scores involved fitting Hierarchical Linear Models (HLM) with a random effect term for teachers (Raudenbush & Bryk 2002). This analysis was chosen as it accounts for the nested structure of the data (i.e., students nested within teachers). Models were fit using Restricted Maximum Likelihood Estimation (REML). Fixed effects in the model include treatment group, students’ baseline achievement, and grade level. We used R statistical software (R Core Team, 2015) version 3.1.2 and the lme4 package (Bates et al. 2015) version 1.1-7 to conduct the HLM analyses on student achievement.

QUANTITATIVE ANALYSES

WestEd analyzed student MAP scores using Hierarchical Linear Modeling (Raudenbush & Bryk 2002). Preliminary model testing indicated that HLM is a suitable choice, as the teacher intraclass correlation was sizeable (ICC = .69) in the unconditional model.

Baseline Equivalence. An analysis was first conducted to determine whether students were statistically equivalent at baseline on the pre MAP score. To examine whether students exhibited similar pre MAP scores, student pre MAP Scores were regressed onto the grouping variable (Front Row or Comparison) while including a random effect term for teachers. This analysis indicated that students in the Front Row condition scored higher (MFR = 161.44, SEFR = 4.22), but not statistically significantly higher, on the pre-MAP assessment than students in the Comparison condition (MComp = 156.05, SECcomp = 4.77; p = .41). The effect size for this difference was hedges g = .31, which is considered substantiv. The What Works Clearinghouse (2013) standards considers this level of baseline difference to be non-equivalent.

Post-Score Analysis. To examine student achievement for students whose teachers used Front Row relative to students who did not, we used an HLM model which included fixed effects terms for grade and beginning of year scores, as well as a random a effect term to account for the nesting of students within teachers. The HLM model that was used is presented below:

\[
PostScore_{ij} = \beta_{00} + \beta_{01}FrontRow_{ij} + \beta_{10}PreScore_{ij} + \beta_{02}FirstGrade_{ij} + \beta_{03}SecondGrade_{ij} + \xi_{0j} + \epsilon_{ij}
\]

where \(PostScore_{ij}\) is the end of year mathematics score on the MAP assessment for the \(i\)-th student of the \(j\)-th teacher, \(\beta_{00}\) is the grand mean of scores, \(\beta_{10}PreScore_{ij}\) represents students’ beginning of year MAP score, and \(\beta_{02}FirstGrade_{ij}\) and \(\beta_{03}SecondGrade_{ij}\) represent dummy variables for 1st and 2nd grade classrooms, respectively (with Kindergarten serving as the baseline). \(\xi_{0j}\) is a random
effect term for teachers and and $\epsilon_{ij}$ is a random error term. The difference between scores of students of teachers using Front Row vs. students of teachers in the Comparison group is captured by $\beta_{01} \text{FrontRow}_j$.

A summary of the random and fixed effects of this model are presented in Tables 4 and 5, respectively.

**Table 4. Random Effects Table.**

<table>
<thead>
<tr>
<th></th>
<th>Variance</th>
<th>St. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher</td>
<td>5.62</td>
<td>2.37</td>
</tr>
<tr>
<td>Residual</td>
<td>46.08</td>
<td>6.79</td>
</tr>
</tbody>
</table>

**Table 5. Fixed Effects Table.**

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Coefficient</th>
<th>St. Error</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>54.62</td>
<td>4.89</td>
<td>&lt; .001***</td>
</tr>
<tr>
<td>PreScore</td>
<td>0.77</td>
<td>0.03</td>
<td>&lt; .001***</td>
</tr>
<tr>
<td>FirstGrade</td>
<td>5.05</td>
<td>1.57</td>
<td>.003**</td>
</tr>
<tr>
<td>SecondGrade</td>
<td>0.66</td>
<td>1.86</td>
<td>0.72</td>
</tr>
<tr>
<td>FrontRow</td>
<td>4.64</td>
<td>1.19</td>
<td>&lt; .001***</td>
</tr>
</tbody>
</table>

*Note. **p < .01, ***p < .001*

If the hypothesis about Front Row improving students’ mathematics scores is correct, the output in Table 4 suggests that the students in the Front Row group would have grown an estimated 4.64 points higher than students in the Comparison group had the groups been fully equivalent prior to treatment. This difference is significant at the $\alpha < .001$ significance level. The effect size for this difference is hedge’s $g = .29$. The covariate-adjusted means for the Front Row and Comparison groups are 184.52 and 179.88, respectively, and the unadjusted standard deviations for these groups are 16.12 and 16.45, respectively.

Because Grade 2 had substantially different sample sizes in the Front Row group relative to the Control group, we reran the above model excluding Grade 2 students. The model coefficient for Front Row term using this subsetted data was still positive, and significant ($B = 3.93, \ p = .007$).
To interpret the effect size estimate of .29 in a more meaningful way, we converted this statistic using properties of the normal distribution. In the normal distribution, a 1 standard deviation increase corresponds to a 34 point percentile increase. Thus, in a normed sample, an effect size of .29 corresponds to a 9.86 point percentile increase (i.e., $34 \times .29 = 9.86$). Therefore, the results suggest that if students in the Comparison group were at the 50th percentile of the normed sample, the Front Row group students would be placed at the 59th - 60th percentile of the normed sample (i.e., $50 + 9.86 = 59.86$).

We also computed an effect size for each grade level and compared this effect size to the typical expected MAP growth in mathematics. To this end, we reran the model presented above separately for each grade level (i.e., we excluded the grade-level terms from each model). The effect sizes for the Front Row variable from these models are .29, .38, and .34 for Kindergarten, Grade 1, and Grade 2, respectively. Based on the beginning and end of year student status norms on the MAP mathematics assessment (Northwest Evaluation Association, 2015), the estimated beginning to end of year effect sizes for MAP mathematics are 1.33, 1.39, 1.14 for each of these grades. Comparing the effect sizes observed in the present study to the effect sizes of the average growth for the MAP assessment suggests that the observed effect sizes are noteworthy, corresponding to 22%, 27%, and 30% of the expected gain over the course of a school-year in Kindergarten, Grade 1, and Grade 2, respectively (e.g., for Kindergarten, $0.29/1.33 = 0.22$, etc.). Multiplying the average school-year gain for all grade-levels (.26) by 9 months (the typical number of months in a school year), we estimate that the Front Row group students are approximately two months ahead of Comparison group students in mathematics achievement.
Appendix B.

Description of teacher interviews conducted by Front Row.

**Teacher Interviews**

Teachers’ perceived value of the program was defined as the extent to which Front Row could be used effectively and efficiently by classroom teachers. To gain an understanding of the perceived value of Front Row, Front Row conducted interviews with three teachers who used Front Row about their experience with the program. The interviews were conducted over the phone in the fall of 2015, and consisted of questions about how Front Row usage impacted student engagement and outcomes in math. The teachers interviewed had used Front Row in the 2014-2015 school year and were willing to discuss their experiences with the program. Questions included how they felt Front Row impacted growth in their classroom, students’ engagement in math, and their effectiveness as teachers. Interviews lasted approximately 30 minutes each.

In general, Front Row was used in math centers with small groups of students for about 30 minutes a day, a few times a week. All the teachers interviewed said they would recommend Front Row, citing its individualized practice as the main benefit of the program. The interviewed teachers reported that they saw tremendous growth from using Front Row. For instance, one teacher said, “at the beginning of the year last year, I had kids who were significantly below grade level. By the end of the year, out of the kids I had, only 1 or 2 were not on grade level or above”.

Teachers also appreciated the way Front Row deepened students’ understanding of math concepts. One teacher remarked that “it built their confidence, because the problems were huge, and once they could break it down into its parts, they got it. They used strategies to solve the problem. I believe it exposed them to thinking outside the box”. Another teacher reported that students enjoyed it so much that they wanted to use Front Row at home.

Teachers reported that Front Row allowed them to better meet the needs of every child in their classroom, giving them the ability to focus on small groups of students at a time. One teacher stated that Front Row “allows me to see what I don’t need to waste time on. I’m able to better manage students’ instruction and manage my time better”.

Overall, the interviewed teachers viewed Front Row as an effective tool, with one saying “once I found out about it, I basically used it all the time”.

Interview responses suggest that Front Row can be a valuable classroom tool. Though only a small subset of teachers that used Front Row participated in interviews, these teachers suggested that Front Row was fluidly integrated into their classroom instruction, and that they were able to use class time more effectively to support student mathematics learning.