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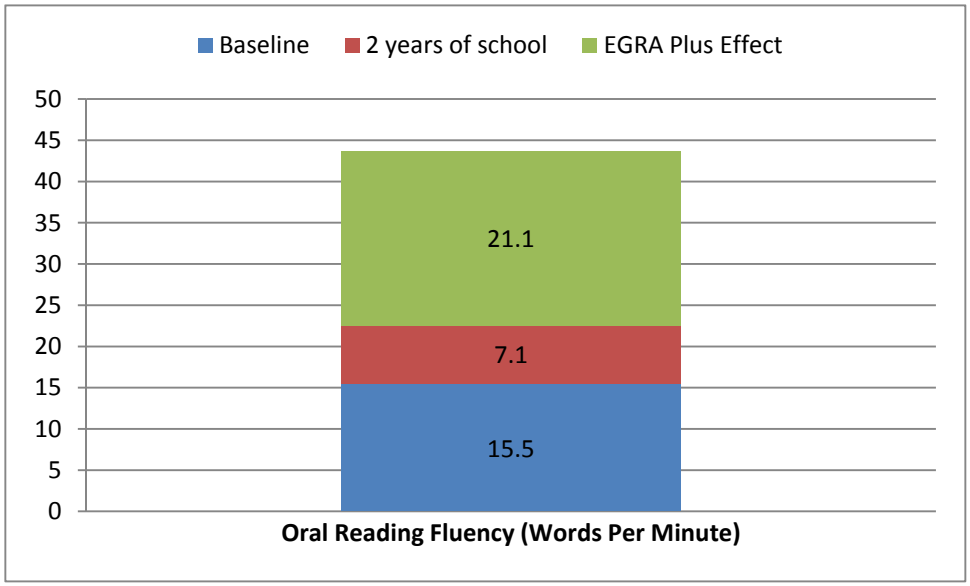
EGRA Plus: Liberia

Program Evaluation Report



Early Grade Reading Assessment (EGRA) Plus: Liberia
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USAID/Liberia

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Abbreviations

CESLY	Core Education Skills for Liberian Youth [USAID program]
CIASES	Centro de Investigación y Acción Educativa Social [Nicaraguan nongovernmenal organization]
DEO	District Education Officer
DIBELS	Dynamic Indicators of Basic Early Literacy Skills
EGMA	Early Grade Mathematics Assessment
EGRA	Early Grade Reading Assessment
GLH	General Linear Hypothesis
LC	listening comprehension
LTTP2	Liberia Teacher Training Program
MOE	Ministry of Education
NC	North Carolina
ORF	oral reading fluency
PMP	Performance Management Plan
PTA	parent-teacher association
RTI	RTI International [trade name of Research Triangle Institute]
SD	standard deviation
US	United States
USAID	United States Agency for International Development

1. Executive Summary

Building on the success of the Early Grade Reading Assessment (EGRA) as a measurement tool, many countries have begun to show interest in moving away from assessments alone and toward interventions focused on changing teacher pedagogy, and as a result, increasing student reading achievement. Liberia, for example, began an EGRA-based intervention, called EGRA Plus: Liberia, in 2008. The results from the EGRA Plus midterm evaluation showed very promising results on a variety of learning outcomes.[1] This report is an impact evaluation of the EGRA Plus program at project completion, and it presents compelling evidence that a targeted reading intervention focused on improving the quality of reading instruction in primary schools can have a remarkably large impact on student achievement in a relatively limited amount of time.

Program Design

Liberia's path toward intervention started with a World Bank-funded pilot assessment using EGRA in 2008, which was used as a system-level diagnosis. Based on the pilot results that showed that reading levels of Liberian children are low, the Ministry of Education (MOE) and USAID/Liberia decided to fund a two-year intervention program, EGRA Plus: Liberia, to improve student reading skills by implementing an evidence-based reading instruction program. EGRA Plus: Liberia was designed as a randomized controlled trial. Three groups of 60 schools were randomly selected into full treatment, light treatment, and control groups. These groups were clustered within districts, such that several nearby schools were organized together. The intervention was targeted at grades 2 and 3. The design was as follows: The control group did not receive any interventions. In the "full" treatment group, reading levels were assessed; teachers were trained on how to continually assess student performance; teachers were provided frequent school-based pedagogic support, resource materials, and books; and, in addition, parents and communities were informed of student performance. In the "light" treatment group, the community was informed about reading achievement using school report cards based on EGRA assessment results or findings and student reading report cards prepared by teachers.

Comparisons at Baseline

Schools in all three groups (control, full treatment, and light treatment) were assessed three times. The baseline measurement took place in November and December 2008,[2] the

[1] Piper, B., & Korda, M. (2009). *EGRA Plus: Liberia data analytic report: EGRA Plus: Liberia mid-term assessment.* Report preared under the USAID EdData II project, Task 6, Contract No. EHC-E-06-04-00004-00. Retrieved September 21, 2010, from https://www.eddataglobal.org/documents/index.cfm?fuseaction=pubDetail&ID=200

[2] Baseline: 176 schools were assessed, including 57 control, 59 full treatment, and 60 light treatment schools, for a total of 2,988 students.

midterm in May and June 2009,[3] and the final assessment in May and June 2010.[4] Students were assessed on a variety of essential early grade reading tasks, including letter naming fluency, phonemic awareness, familiar word fluency, unfamiliar word fluency, connected-text oral reading fluency, reading comprehension, and listening comprehension. The tests used for the midterm and final assessments were equated to the baseline assessment in order to ensure comparability of data, and the reliability of the tests was calculated.[5]

Steps also were taken to ensure that the treatment groups were comparable. To illustrate, Table 1 shows the scores for each EGRA section at baseline. Note that this table presents combined scores for grade 2 and 3. The column "Comparison to Control" presents the results of *t*-tests comparing whether the outcome measures for full treatment and light treatment scores were higher or lower than they were for the control schools at the baseline. For full treatment, we found that before the intervention, the full treatment schools had higher average scores on familiar word and unfamiliar word fluency, oral reading fluency, and reading comprehension (at the .10 level). For light treatment, this table shows that light treatment schools outperformed their control school counterparts in oral reading fluency (at .10 level), reading comprehension (at .10 level) and listening comprehension.[6]

Table 1: Comparisons at Baseline and Final—Program Effects and Effect Sizes, by Treatment Group and EGRA Section

		Baseline			Final		Program Impact		
Section		Mean	Standard Deviation (SD)	Comparison to control	Mean	SD	% Increase over Baseline	Program Effect	Effect Size
Letter naming fluency (per minute)	Control	60.67	25.17		82.42	24.37	35.85%		
	Full	62.35	24.86		99.26	24.07	59.20%	14.8***	0.52 SD
	Light	60.37	25.82		88.14	24.49	46.00%	6.0***	0.21 SD
Phonemic awareness (out of 10)	Control	3.41	2.32		4.31	2.87	26.39%		
	Full	3.56	2.26		5.96	2.70	67.42%	1.5***	.55 SD
	Light	3.49	2.30		4.86	2.77	39.26%	0.4**	.18 SD
Familiar word fluency (per minute)	Control	8.51	13.54		18.83	17.41	121.27%		
	Full	10.03	14.28	Higher*	34.88	22.62	247.76%	14.3***	0.78 SD
	Light	9.24	13.86		19.73	20.19	113.53%	0.3	*No effect*

[3] Midterm: 175 schools were assessed, including 56 control, 59 full treatment, and 60 light treatment schools, for a total of 2,805 students.
[4] Final: 175 schools were assessed, including 58 control, 57 full treatment, and 60 light treatment schools, for a total of 2,688 students.
[5] Analysis of the assessment tool showed that it was reliable. The Cronbach's alpha results for baseline, midterm, and final assessments showed reliability of 0.85 or higher, which is quite good. Cronbach's alpha is a measure of how well a set of variables measure an underlying construct (in this case, early grade reading skill).
[6] Because of these slight differences at baseline, our program impact analyses account for the differences at baseline in all of the models assessed.

Section		Baseline			Final		Program Impact		
		Mean	Standard Deviation (SD)	Comparison to control	Mean	SD	% Increase over Baseline	Program Effect	Effect Size
Unfamiliar word fluency (per minute)	Control	1.91	5.55		2.85	8.73	49.21%		
	Full	2.51	6.22	Higher*	14.70	17.31	485.66%	11.2***	1.23 SD
	Light	2.30	6.22		3.27	7.98	42.17%	1.1*	*No effect*
Oral reading fluency (per minute)	Control	18.14	19.42		25.21	25.52	38.97%		
	Full	20.83	20.26	Higher**	49.61	33.86	138.17%	21.1***	0.80 SD
	Light	19.77	20.37	Higher~	27.93	29.38	41.27%	1.1	*No effect*
Reading comprehension (% correct)	Control	23.70	23.86		31.50	33.27	32.91%		
	Full	25.81	24.37	Higher~	59.38	35.49	130.07%	25.2***	0.82 SD
	Light	25.74	24.44	Higher~	34.34	35.61	33.41%	0.7	*No effect*
Listening comprehension (% correct)	Control	32.64	21.56		69.43	32.33	112.71%		
	Full	33.58	20.11		83.53	24.44	148.75%	13.1***	0.39 SD
	Light	34.51	19.84	Higher*	71.79	31.22	108.03%	0.7	*No effect*

Legend: *** <.001, **<.01, *<.05, ~<.10

Program Impact

Table 1 also shows the increase in scores over the baseline for each group. Note that these estimates come from a simple tabulation of the data.

- *Letter naming fluency.* At the baseline, Liberian children were capable of identifying the names of letters, with the average control child identifying 60.7 letters in a minute. At the baseline, the letter naming scores were good, which suggests that program impacts were not likely to be very large. At the final assessment, students in full treatment schools showed a 59.2% increase in letters read, while light treatment schools increased in letter fluency by 46.0%. Control schools also increased their scores, by 35.9%. This is evidence of the learning effect, since the final assessment was held at the end of the academic year while the baseline was at the beginning of the year. These were larger impacts on letter naming than we expected, and with respect to program impact, the increases for full treatment were 0.52 standard deviations (SD) and 0.21 SD for light treatment.[7]
- *Phonemic awareness.* Program impact on phonemic awareness was also large. The combined scores for grades 2 and 3 show that the number of sounds identified increased by 67.4% and 39.3% in full and light treatment schools respectively, compared to 26.4% for control schools. This equates to an effect size of 0.55 SD in full treatment schools and 0.18 SD in light treatment schools. This

[7] Note that the effect sizes reported here are Cohen's *d* from the differences-in-differences analyses presented in sections below. Small effect sizes are from 0 to .40, moderate from .40 to .75, and large higher than .75.

represented a substantive increase of 2.4 words correct (out of 10) for full intervention schools and 1.4 for light intervention schools.

- *Familiar word fluency.* For familiar words, children in full treatment schools increased by 247.8% and light treatment schools by 113.5%. Since control schools increased their skills as well, the effect size was 0.78 SD for full treatment and was statistically insignificant for light treatment. This is because control-school children increased their scores by 121.2%. This represents an increase of 24.9 and 10.5 words per minute.
- *Unfamiliar word fluency.* For unfamiliar words, control and light treatment schools had very limited changes in outcomes. Control schools increased by 0.9 words (49.2%), while light treatment schools increased by 1.0 word per minute (42.2%). For full treatment schools the increase was 485.7% (from 2.5 words per minute to 17.3 words per minute). The effect size was a very large 1.23 SD for full treatment and insignificant for light treatment.
- *Oral reading fluency.* The impact was also quite large for fluency in oral reading of connected text. Compared against baseline, full treatment children increased the number of words read correctly by 138.2%, light treatment schools increased by 41.3%, and control schools by 39.0%. Substantively, this means that full treatment schools increased their number of words read from 20.8 to 49.6 words per minute, while light treatment increased from 19.8 to 27.9. Compared against the gains for control schools, these effect sizes are positive for full treatment (at 0.80 SD) and insignificant for light treatment. This means that at the final assessment, children in full treatment schools were reading nearly two and a half times as fluently as they were at the baseline.
- *Reading comprehension.* Comparing the final and baseline assessment scores in reading comprehension, we find that full treatment schools increased their scores by 130.1% over baseline, while light treatment scores increased by 33.4% and control schools by 32.9%. This means that, at the final assessment, children in full treatment schools scored 33.6 percentage points higher than control-school children scored at the baseline, with students in light treatment schools scoring 8.8 percentage points higher. The program's effect size was 0.82 SD and the effect was statistically significant for full, but insignificant for light treatment schools. This is more than a doubling of the reading comprehension percentage rates for full treatment children.
- *Listening comprehension.* For listening comprehension, the increases for full and light treatment schools were 148.8% and 108.0%, respectively. It should be noted that control schools increased their scores by 112.7%, so only by taking into account the baseline scores can a true program effect be estimated. Substantively, full treatment schools increased by 49.9% and light treatment schools by 37.3% over baseline, an effect size of 0.39 SD and no effect, respectively.

Comparing across EGRA sections, we find that the EGRA Plus full treatment program had moderate impacts on listening comprehension, large impacts on phonemic awareness, letter fluency, familiar word fluency, oral reading fluency, and reading comprehension. We found very large impacts for unfamiliar word fluency, indicating that the EGRA Plus program had particularly large impacts on improving children's ability to manipulate sounds to make words.

Sex and Grade Differences

On all EGRA sections, grade 3 students scored statistically significantly higher than grade 2 students, with more than 11 additional words read correctly per minute on the oral reading fluency section. This is a measure of standard intergrade improvement, which we note for the sake of comparison: The project impact was much bigger than the standard intergrade improvement. In other words, the project was able to boost children's learning by much more than one grade. On the other hand, there were no differences between boys' and girls' achievement, except for unfamiliar word fluency, where girls outperformed boys. This appears to be largely because the EGRA Plus program had a slightly larger impact for girls than for boys, partly because scores were lower for girls at the baseline. This suggests that more work is necessary so that the program, when it is folded into other efforts in Liberia, increases the skills of boys in the more complex portions of reading, and careful attention must be given to ways to ensure that boys and girls benefit equally from the program.

Overall Program Impact

This report presents the effect sizes from a more sophisticated analysis using differences-in-differences analyses.[8] These are presented in Table 1 above, in the effect size column. *These analyses show that the full treatment group increased student achievement for every section of the EGRA, often with quite large impacts on student achievement.* In fact, the overall EGRA Plus effect size was 0.79 standard deviations, which is enormous in social science. When the program impacts are expressed in terms of grade effects, the full treatment increased letter naming fluency by 1.2 times the effect of being in school for one year. Amazingly, this was the *smallest* effect size for any of the skills assessed. The EGRA Plus full treatment effect was the equivalent of 1.9 school years in phonemic awareness, 1.8 school years in familiar word reading, a remarkable 8.0 years in

[8] Differences-in-differences is an identification strategy that attempts to make causal inference about a treatment effect by removing the secular trend using a pre and post treatment-and-control design. It is preferable to use three waves of data, if possible, as this particular data set allows. See Skoufias, E., & Shapiro, J. (2006). *The pitfalls of evaluating a school grants program using non-experimental data.* Working paper. Washington, DC: World Bank. Retrieved September 30, 2010, from http://www.webmeets.com/files/papers/LACEA-LAMES/2006/390/pec_eval.pdf

unfamiliar word fluency,[9] 1.9 years in oral reading fluency, 2.0 years in reading comprehension, and 1.8 years in listening comprehension. The light treatment group also increased student achievement in letter fluency and phonemic awareness.

This report shows that full treatment schools dramatically accelerated children's rates of learning. Our regression estimates show that full treatment children increased their word naming fluency by 2.1 words per minute per month, while the associated rate for control schools was an increase of 0.8 words per minute per month. The rate, then, in full treatment schools, was 2.6 times as fast. For unfamiliar word fluency, we find that the increase in fluency scores was 12.4 times faster in full treatment schools than in control schools, which suggests that a primary entry point for improving reading outcomes for students was through improved decoding skills. The relationship between full treatment and control schools for oral reading fluency of connected text was 4.1 times faster, and 4.0 times faster for reading comprehension. **This shows that the EGRA Plus program did not simply increase the learning outcomes for children; it dramatically accelerated children's learning to an extent seldom found in educational or social science research.**

In summary, given the existing literature on effect sizes in literacy interventions, EGRA Plus: Liberia far exceeded expectations with respect to impact on student achievement, particularly in the full treatment schools. Note that the effects were most often large in full treatment schools, with some moderate effect sizes. The range of effect sizes for full treatment was from 0.39 to 1.23 SD. Impacts were largest in unfamiliar word fluency, and smallest in listening comprehension.

Program Impact Compared with Expectations

When compared against the Performance Management Plan (PMP) of February 2009, the results from the EGRA Plus program are very strong. The PMP noted that the impact over baseline two years later would be a 35% increase for oral reading fluency and reading comprehension in full treatment schools, while light treatment schools would see a 10% increase for those same tasks. For both boys and girls, for both grade 2 and grade 3, the light treatment schools made their target in oral reading fluency. By the same token, for both sexes and both grades, the full treatment schools increased by more than 30%, and for each disaggregated level, the increase was more than 100%. The results were similar for reading comprehension. The increases for both boys and girls in grades 2 and 3 in light treatment schools were more than 10%, and the impacts for all groups in full treatment schools were over 80%.[10]

[9] Note that the comparison is between the effect of moving from grade 2 to grade 3. For unfamiliar words, one must assume that the rate of learning to decode will increase as children get older; that is, the program effect is not linear. That said, children in full treatment schools benefited a significant amount in this section.

[10] Note that while these increases were quite high, the scores for control schools also increased, and at nearly the same rate as those of light treatment schools. This is why many scholars prefer reporting the impact of a program over the baseline and over control schools, to remove the "secular trend."

Table 2: Disaggregated Analysis of Percentage Increases Over Baseline, by Treatment Status, Grade, and Sex

Section	Treatment	Grade 2		Grade 3	
		Boys	Girls	Boys	Girls
Oral reading fluency	Control	4.63%	86.05%	32.71%	55.40%
	Full	**152.73%**	**244.36%**	**89.01%**	**129.36%**
	Light	**33.77%**	**71.63%**	**21.35%**	**18.81%**
Reading comprehension	Control	4.82%	51.17%	32.04%	46.93%
	Full	**149.16%**	**192.49%**	**84.76%**	**209.16%**
	Light	**17.67%**	**49.18%**	**18.81%**	**53.91%**

EGRA Plus Increased Mathematics Outcomes

Interestingly, the data show that while there was no intervention in any subject other than reading, the EGRA Plus program is likely to have increased mathematics outcomes. This was assessed by comparing the mathematics scores for children in different treatment groups. We found that for full treatment, EGRA Plus increased math scores in number identification, quantity discrimination, addition, subtraction, multiplication and fraction knowledge. For light treatment, scores increased for multiplication and fractions, but decreased in number identification. More research is necessary to determine whether the full treatment effects were due to the close relationship between reading skills and outcomes in other subjects, or whether the pedagogical techniques that the teachers obtained in EGRA Plus were also effective in other subjects. However, it does buttress the point of view that reading can be a starting place for quality improvements in other subjects, and even at higher levels in the education sector.

Recommendations

Given the success of the EGRA Plus program, we make the following recommendations:

- **Scale up the EGRA Plus program.** Given the remarkable success of EGRA Plus, there appears to be an opportunity for the Liberian Ministry of Education to scale up and expand the intervention. The Liberia Teacher Training Program (LTTP2) is a potential incubator for further interventions and offers an opportunity to determine whether the remarkable impacts of this program can be replicated at scale. For the last calendar quarter of 2010, at USAID's direction and with remaining EdData II Task 6 funds, RTI expanded the EGRA Plus: Liberia intervention to all schools—control, light, and full—for another semester.
- **Move past focus on letters and words and focus on reading comprehension.** It appears that improving the oral reading fluency and decoding skills of children is quite possible, and this is highly correlated with reading comprehension, as the

program results show. However, the effect on comprehension is not as large as it might have been if more emphasis had been placed on developing the metacognitive skills that children need in order to synthesize and understand written text. We know that children can understand a higher percentage of what they hear than what they read. Explicit instruction and modeling is necessary to match children's listening comprehension with their comprehension after they read written texts.

- **Develop benchmarks for reading.** The wealth of data obtained in the three waves of assessment from EGRA Plus provide enough evidence for the Liberian Ministry of Education to determine what rates of fluency, comprehension, and word skills are necessary at each level. Such a benchmark development process will help to target resources and efforts, to invigorate the efforts to improve educational outcomes.
- **Target reading techniques using professional development.** Liberian teachers have been proven to be receptive to new pedagogical techniques and strategies. With targeted efforts, teachers can improve how well children read, quite quickly. We recommend that the evidence from this program be included in pre-service and in-service teacher professional development programs of the Liberian Ministry of Education going forward. This will require adaptation efforts, to transfer the mechanisms that were so effective in EGRA Plus to the pre-service sector.
- **Improve girls' reading achievement.** The findings here showed that while boys outperformed girls at the baseline, with instruction and investment, girls could narrow and even close the sex gap. Therefore, education officials can and should demand high achievement for girls in the classrooms under their jurisdiction, and efforts should be made to encourage teachers to have high expectations for girls.
- **Decoding skills must be emphasized.** The largest impacts of EGRA Plus were found in the tasks that measured children's ability to decode and to use the alphabetic principle. These skills were mostly lacking in nonproject schools, and it seems that these skills were crucial gateways to the rapid acceleration of learning outcomes that EGRA Plus caused.
- **Use reading improvements to increase learning in other subjects.** The findings showed that reading improvements have the potential for carryover effects in other subjects, in this case mathematics. This suggests that reading is a ripe subject for interventions, since other subjects might be improved by the simple method of increasing reading outcomes.
- **Expand the use of scripted programs for lesson delivery.** The experience of EGRA Plus makes clear that scripted lesson plans can be a part of an effective program for reading improvement. The increased rates of learning between the midterm and final assessment show that while there was some initial resistance to

such methods, the creation of and support for lesson plans for teachers has a high likelihood of continuing to be effective in Liberia.

2. Introduction

The Early Grade Reading Assessment (EGRA) Plus: Liberia program (2008–2010) was an experimental intervention. The intervention was part of a joint collaboration among the Liberian Ministry of Education, World Bank Liberia, and USAID/Liberia. Baseline, midterm, and final assessments were conducted and the results were judged against agreed-upon targets for improved student performance. The baseline assessment was conducted in November 2008, the midterm assessment was conducted in June 2009, and the final assessment took place in June 2010.

The EGRA Plus: Liberia program used empirical data from reading assessments in grades 2 and 3 to track progress toward quality improvements in early grade reading instruction. The research and intervention design allowed for the comparison of three different groups. The first was a control group that received no program interventions, but whose performance was measured (without alerting them to the fact there would be repeated measurement). The second group, the "light" intervention, was a set of schools where parents and community members were provided student achievement data in the area of literacy; they were made aware that there would be testing again. In addition, light intervention teachers were trained in the development of a student reading report card, which they issued four times a year. The final group, the "full" intervention, provided an intensive teacher-training program targeting reading instructional strategies, in addition to the same type of information on student achievement that was provided to parents and communities in light treatment schools. Note that the assignment of schools into treatment groups was random, accounting for geographic clustering.

In this report, we present the project's performance at project completion by comparison with baseline and midterm assessment results. We briefly describe the methodology used to conduct these assessments. During November 2008, a national baseline assessment of early grade literacy skills was performed in 176 schools with 2,988 students.[11] The target (and the assessment) was targeted at 60 control, 60 light, and 60 full treatment schools.[12] In each school, either 10 or 20 students were assessed, depending on the size of the school and number of teachers. The assessment itself had several sections, all of which

[11] The sample size was to have been 180 schools; the four missing schools were assessed in January and February 2009, but were not included in the baseline data analysis.

[12] The sampling procedure used in this study and in the intervention was one means of identifying the true impact of the program. Without having a counterfactual or comparison group, it would have been impossible to know whether any impacts we saw were the result of program effects, typical growth over the course of the school year, or changes that applied to all students equally. Having a control group allowed us to differentiate among those possibilities. As noted, in this case, there was one control group and two experimental groups (one having a full intervention and one a light intervention).

had been tested in a variety of other low-income countries, as well as in the June 2008 pilot assessment in Liberia.

The June 2009 midterm assessment was conducted in the same EGRA schools. A total of 175 schools and 2,882 students were included in this survey. The June 2010 final assessment was conducted in 175 schools and with 2,688 children. As was the case with the baseline and midterm assessment, either 10 or 20 students were assessed, with the target to have at minimum 10 students from grade 2 and 10 students from grade 3, depending on the size of the school. For all three assessments, students were randomly selected using a systematic sampling procedure implemented by assessors, rather than teachers, in order to prevent teachers from selecting only the best students.

Analysis of the EGRA itself showed that the assessment was reliable and that its various sections assessed different parts of the underlying early grade reading skills, in addition to tying together well as a reliable test. In fact, the final Cronbach's alpha results showed reliability of 0.87, which is quite good, and similar to what was found at the baseline and midterm.

The beginning portions of this analytical report lay out the various sections of the assessment, and point out how they are related to important characteristics of early reading skills and proficiency. The analysis presented here focuses on a particular set of research questions designed to inform the early stages of the program intervention as well as to provide a baseline of early grade reading skills across Liberia. Note that the purpose of this report is to examine the outcomes from the three rounds of EGRA assessments to determine whether there was a program impact that could be identified. Additional work was under way during November 2010 to use a mixed-methods methodology to investigate more details of whether and how the project was successful.

This analytical report is organized as follows:

- First, we present descriptive statistics for both predictor and outcome variables. Then we compare these descriptive statistics across important characteristics, particularly student sex, treatment group, and grade level.
- Second, we assess the reliability of the assessment itself using a variety of statistical methods, and follow this by presenting correlations of relevant variables.
- Third, we use simple comparisons between treatment and control groups to estimate the impact of the program.
- Fourth, we present graphic depictions of student achievement across various metrics as well as some multiple-regression models to estimate program impact on early reading outcomes.
- Fifth, we present the results of an Early Grade Mathematics Assessment (EGMA), compared by treatment group.

- Sixth, we present recommendations for the sustainability and scale-up of the program.

3. Early Grade Intervention in Reading

The EGRA Plus: Liberia intervention, designed based on the findings of the World Bank pilot assessment of reading in 2008, was itself based on a three-stage intervention strategy. First, a baseline reading assessment was implemented in a nationally representative set of Liberian primary schools. This assessment not only served as the baseline for all the impact evaluations, but also informed the intervention itself, taking student achievement evidence as the first step in assessing teacher training needs, and developing teacher professional development courses to respond to the critical learning areas for improving student achievement.

Second, RTI, in collaboration the Ministry of Education and supported by Liberian Education Trust, implemented a teacher professional development program that included intensive, week-long capacity-building workshops. These workshops gave teachers an opportunity to learn techniques for high-quality instruction in early grade reading. Teachers also received ongoing professional development support and regular feedback regarding their teaching. The intervention was buttressed with activities designed to foster community action and stakeholder participation, particularly around the production and dissemination of EGRA findings reports at various stages in the EGRA Plus intervention. The project also encouraged meetings between school managers and community members. Light intervention schools received primarily this set of school and community action activities, while full intervention schools also received onsite professional development and supervision support for teachers in grades 2 and 3. Activities related to teacher professional development and community participation went on for the full duration of the project.

The third major intervention activity was an additional two rounds of EGRA, which allowed for a longitudinal research design. This design allowed researchers and the Ministry of Education to identify whether and how the interventions had a significant impact on student achievement, as well as which causal mechanisms were responsible for the project's success.

3.1 Year 1: Challenges and Lessons Learned

The implementation of the reading intervention in 60 full treatment schools commenced with teacher training in December 2008. At that time, the project training team gave resources to the teachers in hopes that if they were trained and given materials before the holidays, they would spend time preparing for teaching reading. However, the school academic year did not resume on January 5, 2009, as per the academic calendar, but rather on January 19, due to a volunteer-teacher strike caused by the government's dismissal of all unqualified volunteer teachers. Note that this had a significant impact on

Liberian education in general, and EGRA Plus's assessed schools in particular, since the percentage of unqualified volunteer teachers was significant. Vis-à-vis the EGRA Plus project, this delay undoubtedly had a negative effect on the momentum created in December 2008.

While some schools, mainly in Monrovia, started teaching on time (January 5), most of the schools did not open their doors to children until late January 2009. Even when classes resumed, teachers focused on wrapping up exams and reports for the previous period, and in most cases, the EGRA reading intervention did not start until mid-February 2009. This disruption also had an impact on the morale of both teachers and the master trainers, or "Coaches," since nearly 30% of EGRA teachers were volunteer teachers.

This situation presented a significant challenge to the project, for two reasons. First, the EGRA team needed to train replacement teachers, and to continue encouraging volunteer teachers to consider the EGRA Plus program as a way to improve their skills. Second, a number of volunteer teachers left their schools permanently, creating a burden for remaining teachers who had to teach more children than before. As a result, there were instances where grades 2 and 3 were combined into one class. In some schools, the principals started to teach and Coaches began helping with teaching.

The same factors and assumptions described for full treatment schools above also apply to light treatment schools. The original plan was for Coaches to visit the light treatment schools as soon as schools opened in January 2009 in order to share the EGRA assessment results and provide initial training. This was delayed until February, which is when the workshop training was conducted in all light treatment schools. Other challenges were ingrained patterns of insufficient time spent teaching reading in classrooms, a low skill base on which to scaffold reading instructional strategies, and a lack of general pedagogic skills such as lesson planning.

The EGRA Plus reading program was organized into sequential lessons that outlined specific actions and activities for teachers and students; it demanded planning skills from teachers and, most importantly, dedication. If followed, this program was designed to lead to significantly improved student performance in reading in less than one year. However, teaching reading, rather than language arts, was new to many teachers in Liberia and they found it challenging. Teachers also struggled with lesson planning and delivery. Working toward clearly specified goals while measuring their progress along the way was demanding of teachers simply because it required time, skills, and dedication. Our analysis of the curriculum in Liberia indicated that while curriculum goals were specified, the information on how to achieve those goals was insufficient. We also believed that teachers needed to be held accountable for delivery; and that accountability mechanisms, such as strong and empowered parent-teachers associations (PTAs), needed to be supported and strengthened systematically. Throughout the EGRA Plus: Liberia project, this accountability was put into place. Teachers were continually assessed and were supported by Coaches, and they knew that the project was tracking their progress.

Some teachers complained that EGRA work was extra effort imposed in addition to the regular school curriculum. Coaches, in response, reminded teachers that teaching reading is part of the curriculum. They explained that while teaching language arts is very important, teaching children how to read proficiently as early as possible is the most important precondition for the child's further cognitive development. Without reading, children will lag behind and it will become harder and harder for them to catch up as they get older. They will also perform poorly on other subjects given their insufficient reading skills.

Another interesting research and policy issue might be the organization and effectiveness of PTAs. In most of the target districts, some PTAs were recognized only as a formality, in that the PTAs were structured but were not fully functional. The baseline data showed that when asked, almost all principals reported that they held PTA meetings regularly. When we probed further, however, they indicated that the majority of parents did not come to the PTA meetings. We suggest that better understanding of issues like this will be invaluable for MOE planning and will point to the ways in which PTA support and influence can be leveraged to improve reading (or any other education-related outcome, using reading as a case in point). Note that in some districts the PTAs remained for the most part nonfunctioning, whereas in others, EGRA Plus Coaches succeeded in reviving the PTAs in treatment schools.

An important obstacle to the implementation of EGRA Plus was inadequate classroom "time on task," due to several factors. First, teachers' attendance was not regular. They came late or left early, for various reasons such as second employment or going to the market. Schools in some rural areas were only open between 10:00 am and noon. On market days, some schools were closed to allow both teachers *and* students go to the market. Attendance in public schools was highest during examination or testing periods, or when food was distributed, a situation that was more pronounced in rural areas. Students often chose to work for companies in their area rather than go to school, resulting in low student attendance and/or dropout. This was also the case with rural families; they kept their children home to help on the farm. As a result, reading instruction seemed to take place three or four times a week, whereas the MOE was requesting all teachers in the project to teach reading five times a week.

Combined, these obstacles presented significant challenges to the implementation of the program. In sum, the actual teaching of reading by teachers in Year 1 took place primarily between mid-February and the last week of May 2009, when the midterm assessment commenced. This equated to approximately 3.5 months of teaching, quite a limited amount of time for the treatments to take effect. Nevertheless, as we indicate below, some program impact was identified at midterm even with only 3.5 months of effective program time.

3.2 Year 2: Moving Forward with the Intervention

The experiences of the first year resulted in lessons learned that were incorporated into the project and made the intervention more focused. For example, the teachers' lack of planning skills demanded that tightly scripted daily lesson plans be developed. This proved to be one of the key steps toward the improvement of the intervention. Time on task was another problem, and apart from asking teachers to follow the policy that MOE had issued with respect to teaching reading every day for 45 minutes every day, we analyzed, in great detail and with great care, the number of holidays and other interruptions of schooling in Liberia to come up with a realistic number of lesson plans. The result of our analysis indicated that 80 daily reading lessons were the most that could realistically be planned. We distributed these 80 lessons in a two-volume manual: Volume 1 for the first semester and Volume 2 for the second semester.

Apart from making these direct changes to the intervention, we proceeded with the second year of the intervention as planned. Eight support visits, one each month, took place in full intervention schools, and half as many in the light intervention schools. Note that the light intervention school visits focused completely on observations for research sake, rather than on pedagogical support. These support visits were conducted by Coaches. At the beginning of the academic year, a face-to-face training—held at the cluster level—was organized for the teachers in full intervention schools. During this training, teachers were introduced to the newly organized manuals and practiced teaching reading for five full days. The project team led a refresher training of this kind, but shorter in nature, at the beginning of the second semester.

In addition to the regular support visits, the project also reached out to the communities through several radio shows and reading competition events at the cluster level. The impact of radio shows is hard to measure, yet our anecdotal evidence indicates that the shows were well received. The reading competitions definitely were very effective in bringing parents from different schools together to focus on reading. Coaches used this means to continue revitalizing the PTAs and disseminating the results on student improvement in schools. Overall, no major challenges were posed to the project in the second year and all tasks were conducted in accordance with the work plan.

3.3 Lessons That EGRA Plus: Liberia Offers for Future Education Projects

EGRA Plus: Liberia was designed to also pilot an effective model of teacher support that would lead to improved learning outcomes. As such, it pulled all of the levels together—from the national-level staff to the strong involvement of parents. It demonstrated how teachers are best supported by Coaches and District Education Officers (DEOs), and how Coaches and DEOs in turn are supported by the project management and the MOE. This would have not been possible had the project been focused on too many different goals. In the case of EGRA Plus, the sole focus was reading, and all resources and attention were channeled toward improving student reading outcomes.

Currently in Liberia, all efforts to improve the delivery of education services stall at the District Education Office level; thus, little to no further support is provided to teachers by subject-matter specialists. This is because DEOs are responsible for all of their assigned schools, and they do it all—from payroll to school management and teaching, leaving little or no time for pedagogical support to schools. What's missing is the extension of the DEOs' office to the school level. EGRA Plus: Liberia introduced this bridge. The EGRA Plus project used a one-step-only cascade whereby teachers were trained by Coaches at a cluster level for several weeks and then supported through in-school visits per year that included coaching and supervision. In other words, Coaches were trained first, and then they in turn trained, supervised, and mentored the teachers in the classroom. Liberia needs to move in the direction of instituting a role of a pedagogical advisor (Coach) in order to ensure timely and effective support to its teachers.

Apart from this important component, the following notes suggest effective implementation tips, organized around the key inputs that seem to have made a difference.

3.3.1 Teacher and Student Learning Resources

- **Time on task.** Specific lesson plans were provided for EGRA Plus, but there had to be a realistic number. There are numerous holidays and interruptions of teaching in Liberia. It is important to make sure that the scope and sequence designed for a reading intervention are exactly in line with the number of realistically available days for teaching. Yet the lesson plans must, at the same time, ideally be able to produce beginning literacy at the end of their sequence, in one year, if they are to be implemented with fidelity.
- **Lessons need to be tightly scripted.** This is particularly important when teachers do not have necessary lesson-planning skills, or skills in teaching reading, as is most often the case in poor countries. When the lessons are scripted, teachers learn both content and pedagogy as they go. Their application of the scripts will not be perfect in the beginning, but by the end of the first semester, they will have a good sense of the instructional model and how to learn the content. Eventually, good teachers can and will depart from the script. But a tight script is a vital foundation and starting place.
- **Packaging of materials.** The teacher manual needs to be in one book and needs to be durable. If it is too large, it needs to be split into two volumes, one for each semester. This was done in Liberia. But the key is that all resources need to be in one place, and sequentially available, with not much multi-sourcing of alternative techniques and resources. Providing teachers with lots of options often seems good to donors, but can actually be crippling.
- **Curriculum-based assessment.** It is important that teachers assess student performance on a regular basis and issue student report cards to parents about their children's performance. Teachers need to be shown how this is done and be

supported while doing so. By the time they do it two or three times, they will have learned how.

- **Periodic assessment and reporting to parents.** The teacher manual needs to contain step-by-step instructions for assessing students and creating separate student report cards for parents (this would be an individual student card) and parent-teacher association meetings (this would be a card that represents averages for the school).
- **Decodable books.** These books are important for teaching sounds, and must be provided, but they will be used only if they are tied to the lesson plans in the (above-mentioned) manual. No such books exist for Liberia, and they need to be developed.
- **Library books.** The more students have to read the better. The challenge is to secure books for the schools and to enforce their use. Parental involvement is important, as one of the requirements by teachers is that children read at home every day for at least 20 minutes. However, this arrangement must be agreed upon between school authorities and parents.
- **Pocket charts.** Teachers received pocket charts that they could use for arranging letter cards when teaching sounds and spelling, as well as constructing sentences using word cards. Again, the use of pocket charts needs to be required, taught, and checked upon. There may be other techniques that work well, but selecting *one* such technique makes the logistics easy and reduces teacher confusion.
- **Various trackers/logs.** For EGRA Plus these included a library log, log to track students' reading at home, and trackers for assessing students. These trackers were used regularly to introduce and enforce accountability.

3.3.2 Teacher Training and School-Based Support

Teacher training

- **Cluster-based training.** Training in EGRA Plus was organized once per semester at the cluster level. Teachers from intervention schools were invited for training that was one week long. One week really is not enough, especially when teachers completely lack skills, but when coupled with the monthly school-based support that supplements this training, it works. Since this was a cascade—meaning that we first trained Coaches, who then trained teachers in turn—it was important that Coaches were trained in the same way the teachers were going to be trained; i.e., much as if they were themselves going to teach children to read. This way, as Coaches were being trained, they would know exactly what to do with the teachers. A one-stop cascade works under these circumstances, but it is unlikely that more than one stop would work.

School-based support

- **Purpose and frequency of visits.** Visits by the Coaches to the school level were organized for two purposes. The first was to support teachers once per month. Sometimes teachers received more than one visit depending on the need, but one visit per month was a minimum. The second was to work with PTAs and teachers on student report cards, as well as other aspects of the intervention (e.g., request parents to make sure that children read at home every day).
- **Fidelity of implementation.** These visits had to be systemized so that all Coaches were doing exactly the same thing every month. Such systematization was written out specifically for EGRA Plus, and as such it provided clear guidance for both project management and Coaches as to what needed to be done.
- **Accountability.** Coaches were equipped with various logs that tracked teacher performance, and in turn their own performance. One such tracker looked at how far teachers had come with the intervention and, if there was a need, Coaches paid an extra visit to teachers to catch them up. There wass a classroom observation tool that Coaches used to observe a teacher teaching a particular lesson. This was not generic, but was tied very specifically to reading. The feedback was then used to speak about perfecting the skills of teachers.

Coaches

- **Training.** Coaches were trained by a reading expert, either international or local during a week-long training event. Training of coaches was organized once per semester (thus twice per year).
- **Hiring.** The key is to hire committed master trainers who care about what they do. Paper qualifications matter much less than care, intelligence, drive, and willingness to learn.
- **Supervision.** The work of the Coaches was verified through EGRA assessments (both formal and informal) and this was the best indicator of their commitment. If the data from their schools showed no improvement, we knew that they were not doing their job well. So hiring of good master trainers is key, but without strong supervision, hiring is only half the work. Using this approach, out of 15 Coaches, we needed to replace only one.
- **Support to Coaches.** EGRA Plus ensured sufficient funding to Coaches for the use of cell phones. This way they could communicate at any time with our reading expert, who resided in Monrovia. In addition, the reading expert conducted regular weekly or bi-weekly discussions with Coaches in order to determine progress and challenges. Also, the reading expert visited each coach once per semester. During this visit, at least one of the schools (picked by the reading expert and not by the Coach) was visited to determine the uptake by teachers. Finally, district-level competitions were organized through which

Coaches and their respective District Education Officers wrote their success stories and submitted them, with the opportunity to win prizes.

3.3.3 EGRA Assessments

- **Formal assessments.** All schools (control, light, and full) received a baseline, midterm, and final assessment. This was the best way to know if the intervention was working over time.
- **Informal assessments.** Project management conducted informal assessments halfway through each semester in a subsample of intervention schools. This was a good mechanism to determine if Coaches were doing their job and if adjustments needed to be made. At the same time, it served as a good tool to keep the project management working hard.

3.3.4 Community Outreach

- **Reading competition:** It is very important to have cluster schools compete in reading. Coaches organized these with PTAs. Key drivers behind this at the beginning were the Coach, teachers, and principal, and then parents were invited to the competition.
- **District-level competition.** Coaches and DEOs (who were representing their schools) competed among each other. This was organized by the project management during the semiannual refresher training for Coaches.
- **Radio shows.** In each of the target districts, four radio shows were aired, one per month. These radio shows talked about the importance of reading, current reading levels of students in Liberia, and tips for parents and teachers on what they could do to help children learn how to read.
- **PTA meetings:** Student performance and progress were discussed with parents during the PTA meetings. This was the time when the school reading report card was discussed, parents were given tips on what and how to support at home, and the schools told about their efforts to help children learn how to read.

3.3.5 System Improvements

- **Reading policy in the making.** The commitment to the revival of reading in Liberia is best illustrated by the Ministry of Education's issuance of a letter to all EGRA target schools requiring teachers to teach reading every day for 45 minutes. EGRA is currently included in the MOE's Education Plan as a result of this commitment. Our hope is that the explicit teaching of reading will be brought back into the official curriculum.
- **Transfer of reading skills to MOE staff.** MOE staff attended each of the EGRA reading workshops. The key was to train District Education Officers at the central level starting in Year 2 of the project. We should have done this from the beginning, thus as of Year 1. However, initially we relied on Coaches to involve

DEOs, but that did not work in all cases. The formal training at the national level seems to have worked better. This not only helped in terms of skills transfer (a few DEOs even demonstrated teaching reading at the end of the workshops), but also made sure that DEOs visited schools. To this end, the project provided funding for transportation to DEOs to visit some schools along with Coaches. More needs to be done in order to fully strengthen the MOE capacity. For a project that was small in size and also a pilot, EGRA Plus: Liberia made sure to do as much as could be done in a short period of time.

- **Transfer of assessment skills to MOE staff.** Dozens of MOE staff were trained on how to assess student performance, using EGRA, to the point that they could teach it as well.
- **Transfer of data entry and analysis skills to MOE staff.** Data entry was performed and supervised by the MOE. We transferred skills in building the EGRA database (the first built by MOE after the war), as well as in conducting simple statistical analysis. More support is needed, especially in the context of data analysis.

4. Sustainability and Scale-Up

Year 2 of EGRA Plus provided an opportunity to scale up the project and work to ensure sustainability. One component of the EGRA Plus: Liberia project was to assist in building the capacity of MOE staff. By the end of Year 1, EGRA Plus had conducted six capacity-building workshops at which MOE staff were trained, including two EGRA assessment workshops, three EGRA reading workshops, and one workshop on data analysis and reporting.

One of these reading workshops marked the beginning of more in-depth involvement of District Education Officers from the EGRA target districts. While during Year 1 they were engaged in supporting the project at the district level, from August 2009 onward they were fully involved in the training activities and in the support to EGRA target schools. They were all trained in instructional methods for reading during the project's refresher course that took place in August 2009. Between September and December 2009, and then in January and June 2010, each DEO, along with Coaches, visited at least eight schools. This gave the DEOs an opportunity to practice some of their skills in teaching reading as well as to provide pedagogic support to teachers. At the end of the first semester, they attended a refresher training in December 2009 together with the Coaches. Finally, DEOs will be invited to attend the final reading policy workshop planned for the end of the project in December 2010.

At the national level, the capacity building of MOE staff was further deepened to allow more opportunities for turning newly acquired knowledge into practice. Dozens of MOE staff learned how to assess student reading, and most of them were also deployed for data collection. In Year 2 of the project, they were paired with the project staff to learn how to

calibrate (equate) instruments, co-facilitate assessor training, supervise data collection, enter and analyze data, supervise the implementation of reading intervention, and assist with the training and support provided to teachers.

The goal of these capacity-building efforts was to lay the foundation for expansion of reading support to all of the schools in the current EGRA districts, as a first step. It is our hope that the donors and MOE will recognize these efforts and start planning soon for ways to ensure that all children in Liberia can experience the same increases in their early reading skills.

As a result of these efforts, it was agreed by the MOE and USAID that the EGRA Plus schools would be integrated into LTTP2 as of January 2011. Via this integration, EGRA Plus will have demonstrated to the communities and schools, especially the control schools, that hard work and success are rewarded: These schools will receive further support through LTTP2.

5. EGRA and EGMA Assessments

This section briefly introduces the various EGRA and EGMA sections, so that the analysis below will be meaningful. The EGRA tool consists of a variety of sections, and they have been somewhat differentially applied in various countries in order to ensure context-specific relevance. The EGRA Plus: Liberia tool assessed the following set of skills:

1. *Orientation to print*: awareness of the direction of text, and the knowledge that a reader should read down the page. Note that this section is not addressed in the analyses because all the assessed children always answered correctly.
2. *Letter naming fluency*: ability to read the letters of the alphabet without hesitation and naturally. This is a timed test that assesses automaticity and fluency of letter recognition. It is timed to 1 minute, which shortens the overall assessment and also prevents children from having to spend time on something they find very difficult.
3. *Phonemic awareness*: awareness of how sounds work with words. This is generally considered a prereading skill, and it can be assessed in a variety of ways. In the case of Liberia this was assessed by asking the student which word, out of three, started with a different sound (e.g., *ball*, in “mouse, ball, moon”).
4. *Familiar word fluency*: ability to read high-frequency words. This assesses whether children can process words quickly. It is timed to 1 minute.
5. *Unfamiliar (or nonsense) word fluency*: ability to process words that could exist in the language in question, but do not, or are likely to be very unfamiliar. The nonwords used for EGRA are truly made-up words. This section assesses the child’s ability to “decode” words fluently. It is timed to 1 minute.

6. *Oral reading (connected text) fluency*: ability to read a passage, about 60 words long, that tells a story. It is timed to 1 minute.
7. *Reading comprehension*: ability to answer up to five questions based on whatever portion of the passage the child could read.
8. *Listening comprehension*: ability to follow and understand a simple oral story. This section assesses the child's ability to concentrate and focus to understand a very simple story of three sentences with simple noninferential (factual) questions. It is considered a prereading skill.

In order to prevent "teaching to the test," or memorization, the three assessments (baseline, midterm, final) used different passages and reading comprehension questions. The results of a formal calibration exercise are presented in Appendix A.

In addition to the three rounds of EGRA assessments implemented in EGRA Plus, separate funding from the World Bank and collaboration with the Ministry of Education and USAID/Liberia allowed us to evaluate whether the EGRA Plus program had any impact on mathematics outcomes. Therefore, we developed and applied an Early Grade Mathematics Assessment in Liberia, as explained below. The purpose was to evaluate whether the EGRA Plus program had an impact on student achievement in mathematics, although no portion of the EGRA Plus program was developed to target mathematics teaching or learning.

5.1 EGRA Assessor Training

The training occurred May 3–7, 2010, and it was facilitated by the Task Coordinator (Medina Korda), EGRA Technical Coordinator (Ollie White), and RTI's Reading Expert (Marcia Davidson). The MOE coordination committee assigned to work with EGRA from the beginning of the project also attended the training. For any application, EGRA teams always train more assessors than needed, in order to ensure that the assessors who are chosen at the end to be deployed are the best possible performers. The total number of trainees in Liberia was 45, from which the 28 best assessors were selected. The total number of MOE staff trained at this training was 17, and five of them were deployed (note that total number of MoE staff selected for deployment was 10, but the managers of the Core Education Skills for Liberian Youth [CESLY] project[13] and the EGRA Plus: Liberia task split the MOE staff to be deployed evenly through these two projects). Note that formal interrater reliability assessments were used for training and selection.

5.2 EGRA Data Collection

Data collection for the final assessment commenced on May 17, 2010, and it ended on June 11, 2010. This allowed for four weeks of data collection in 179 schools. There were nine teams, each team consisting of three members to account for the increased work due

[13] RTI is a subcontractor to Education Development Center, Inc. (EDC) on the USAID CESLY project. RTI's scope of work is to carry out assessments; also the Liberia-specific EGMA was developed under CESLY.

to EGMA. In total, 176 schools were assessed. Four schools were not assessed. Two of these were affected by a car accident (a bridge collapsed under one car carrying several enumerators). One control school refused to be assessed because it was being denied the treatment. One light school also refused for the same reason.

5.3 EGRA Data Entry

For the final assessment, RTI developed a data entry application using Visual Basic that reduced the time for data entry to a third of what was needed on the baseline and midterm assessments. RTI has been working with a Nicaraguan firm—Centro de Investigación y Acción Educativa Social, or CIASES—for the past several years to develop and improve an efficient and user-friendly data entry system. The EGRA data entry system developed by CIASES offers a low-cost, sustainable solution for minimizing errors.

5.4 EGMA

As with reading, a strong foundation in mathematics during the early grades is crucial for success in mathematics in later years. Mathematics is a skill very much in demand in today's knowledge economy. Most competitive jobs require some level of mathematics skill, and the problem-solving skills and mental agility and flexibility that children develop through mathematics transfer to other areas of life and work. The EGMA is an individually administered oral assessment of foundation mathematics skills. It can be used to bring awareness to policy makers and educational authorities as to levels of foundational mathematics learning in their systems.

As noted above, an EGMA tool for Liberian context was developed through the CESLY project. This tool, which was based on the curricula for grades 2 and 3, was piloted in two schools, and the results were used to improve the assessment. The CESLY EGMA tool was the starting point for development of the EGMA for the EGRA Plus project, which was then improved upon further by RTI math experts and EGRA Plus staff. Once the draft assessment had been developed, it was reviewed during a stakeholder training workshop held May 3–7, 2010. The draft EGMA tool was piloted in one school and feedback from the pilot and the workshop participants was taken into account while the EGMA tool was finalized. The following sections were included in the mathematics assessment:

1. *Number identification* – Learners were asked to identify particular numbers of varying difficulty levels but appropriate for grade 1–3 learners vis-à-vis the curriculum.
2. *Quantity discrimination* – Learners were asked which of two numbers was bigger, testing place value and number sense. This section was timed.
3. *Missing number* – Given a list of three or four numbers, one of which was missing, the child was asked to identify the missing number.

4. *Addition* – A list of common and simple addition facts was presented to the learners, who were asked to solve them as quickly as possible. There were two subsections within this addition section, with the second presenting slightly more computational problems. The first subsection was timed, while the second was not.
5. *Subtraction* – Similar to the addition section above, learners were presented with simple subtraction problems and asked to solve them. There were two subsections within this subtraction section, with the second one slightly more difficult. The first version was timed, while the second was not.
6. *Multiplication* – Learners were presented with a set of multiplication problems and asked to solve them. This was not timed.
7. *Fractions* – Given several items, the learners were asked to identify fractions, add them, and distinguish which fraction was bigger or smaller. This was untimed.

6. Research Design

Table 3 below shows the achieved sample for the baseline, midterm, and final assessments. This table shows that two schools that were in the baseline and midterm full treatment set of schools were not included in the final assessment. Note that the sample of children in the three assessments is presented vis-à-vis treatment status—that is, whether a child was in a control, full treatment, or light treatment school. For the midterm assessment, slightly fewer children were found in control schools and light treatment schools, whereas the numbers of children in full treatment schools were very similar. The achieved sample at the final assessment was smaller for control and full intervention schools, but near the target for the light intervention schools. Note that the sampling procedures for each assessment were done randomly and independently of each other. In other words, no attempt was made to resample children assessed in a previous assessment. Children from the baseline assessment may also have taken part in the midterm assessment, but because children's names were not used, it is impossible to tell with any certainty. Note also that the sampling was done from the students in attendance during the day, therefore using systematic random sampling. Table 3 also shows that the impact analysis contained in this report was based on 2,998 baseline, 2,882 midterm, and 2,688 final assessment participants, for a total of 8,568 children, a substantial sample size for this type of analysis.

Table 3: Achieved EGRA Sample for Baseline, Midterm, and Final Assessments, by Treatment Group, for Schools and Students

		Treatment			
		Control	Full	Light	Total
Schools	Baseline	57	59	60	176
	Midterm	56	59	60	175
	Final	59	58	60	177
Students	Baseline	989	934	1065	2988
	Midterm	944	924	994	2882
	Final	808	916	964	2688

More details about the sample used in this analysis can be found in Table 4 below. Disaggregating by the three assessments, the sex, grade, and treatment status of all of the children can be found. Interestingly, while there were more boys than girls in the baseline sample (1,623 and 1,327, respectively), there were more girls than boys in the midterm assessment (1,470 and 1,345, respectively) and the final assessment (1,363 and 1,231, respectively). This suggests that analyses should be done with control variables for sex, such that the differential sampling by sex does not skew the results. This is particularly true for considering the treatment status of children's schools. Where light and control schools were more heavily male than female at baseline, these same schools were more female than male in the midterm and final assessments. It is important to note that these variations are logical given the sampling method, and are not of concern as long as sex and treatment status control variables are included in latter analyses.

The columns to the right in Table 4 indicate grade level. Note that in all three assessments, there were more grade 2 than grade 3 children. This seems to be indicative of higher enrollment in grade 2, which is plausibly a result of dropout and/or class size in these randomly selected Liberian schools. In any case, this again is not of particular concern giving the sampling strategy, although it suggests that grade level should be a part of future analyses.

Table 4*:* Achieved Sample, by Assessment, Grade, and Treatment Group

		Treatment				Level		
	Sex	Control	Full	Light	Total	Grade 2	Grade 3	Total
Baseline	Boys	525	530	577	1632	820	803	1623
	Girls	453	400	482	1335	724	603	1327
	Total	978	930	1059	2967	1,544	1406	2950
Midterm	Boys	424	471	456	1351	733	612	1345
	Girls	502	456	530	1488	757	713	1470
	Total	926	927	986	2839	1,490	1325	2815
Final	Boys	354	433	461	1248	639	592	1231
	Girls	433	470	478	1381	711	652	1363
	Total	787	903	939	2629	1,350	1244	2594

Table 5 contains basic descriptive statistics for the baseline study (columns to the left), midterm assessment (middle columns), and final assessment (columns to the right). There is a consistent pattern across this table, with children in the midterm assessment outscoring those in the baseline, and children in the final assessment outscoring those in the midterm. For example, children who participated in the final assessment could read more letters (90.4 per minute) than could those at midterm (80.2) or those at baseline (61.1). Given the fact that the midterm and the final assessments occurred at the end of the year and that the baseline was at the beginning of the academic year, it is expected that children would learn skills that would be identified on the EGRA assessment during the academic year. This would cause higher scores at midterm and baseline. However, the consistent improvement between midterm and final assessment scores suggests that there is more to it than that, since scores also increased between 2009 (midterm) and 2010 (final). The pattern holds for every section: letters, phonemic awareness, familiar word fluency, unfamiliar word fluency, oral reading fluency, reading comprehension, and listening comprehension. In each of these sections, average scores were higher at midterm than at baseline (the intergrade learning effect) and at final than at midterm (additional program impact, including secular trend). The magnitude of the differences seems to have been larger between midterm and final than between baseline and midterm. For example, for reading comprehension, baseline (25.1%) and midterm (25.7%) scores were much closer to each other than to final assessment scores (42.4%). The analysis below shows the results of our investigation of whether the differences identified in this analysis occurred because of the EGRA Plus program, because of a continued secular trend of improving literacy scores in Liberia, or because of the learning effect identified between the baseline and the midterm and final assessments.

Table 5: Descriptive Statistics for Baseline, Midterm, and Final Assessment

Section	Baseline, November 2008			Midterm, June 2009			Final, June 2010		
	N	Mean	Standard Deviation	*N*	Mean	Standard Deviation	*N*	Mean	Standard Deviation
Letter naming fluency	2,982	61.11	25.30	2,789	80.18	26.69	2,502	90.40	25.26
Phonemic awareness	2,982	3.48	2.29	2,882	4.19	2.62	2,688	5.07	2.86
Familiar word fluency	2,957	9.24	13.89	2,771	14.87	16.30	2,464	24.71	21.63
Unfamiliar word fluency	2,961	2.24	6.01	2,773	2.45	5.88	2,494	7.00	13.30
Oral reading fluency	2,963	19.55	20.03	2,725	25.98	25.21	2,345	34.79	31.98
Reading comprehension	2,963	25.08	24.23	2,725	25.72	28.38	2,345	42.35	37.11
Listening comprehension	2,996	33.56	20.54	2,790	74.69	30.23	2,616	75.20	30.01

7. EGRA Reliability Analysis

In order to examine whether and how the sections in the Liberian EGRA at the final assessment were reliable, and—critically—whether it could be argued that they tested an underlying skill, we carried out the reliability tests described below. Initially, we examined simple Pearson's bivariate correlations; these are presented in Table 6. Note that the findings are remarkably similar to those of the baseline and midterm assessments, largely because the two follow-up versions of the assessment were adapted from the baseline. The lowest correlations are between the listening comprehension and phonemic awareness sections and the rest of the sections, for several potential reasons. First, it appears that these sections assessed different skills from the rest of the instrument. Second, neither of these sections was timed, which means that achievement was less a function of speed, which differentiates them from the rest of the sections.

Table 6: Pearson's Correlations for EGRA Sections

Section	Letter Naming Fluency	Phonemic Awareness	Familiar Word Fluency	Unfamiliar Word Fluency	Oral reading Fluency	Reading Compre-hension	Listening Compre-hension
Letter naming fluency	1.00						
Phonemic awareness	0.33***	1.00					
Familiar word fluency	0.63***	0.42***	1.00				
Unfamiliar word fluency	0.37***	0.40***	0.59***	1.00			
Oral reading fluency	0.60***	0.41***	0.87***	0.56***	1.00		
Reading comprehension	0.53***	0.44***	0.76***	0.50***	0.83***	1.00	
Listening comprehension	0.33***	0.31***	0.33***	0.23***	0.36***	0.42***	1.00

***<.001, **<.01, *<.05, ~<.10

After the correlational matrix analysis, we completed a Cronbach's alpha reliability test to assess whether the entire EGRA instrument was representative of an underlying construct: early grade reading skills (see Table 7). Similar to the midterm assessment, the Cronbach's alpha score for the overall assessment was at 0.87 (midterm was 0.85). These scores are well within the "accepted" range of at least 0.7 for a low-stakes assessment such as EGRA and are in line with what was found at the baseline.[14]

[14] Nunnally, J. & Bernstein, I. (1994). *Psychometric theory* (3rd edition). New York: McGraw-Hill.

Table 7: Cronbach's Alpha Statistics for Midterm Assessment

Item[a]	Item-test correlation	Item-rest Correlation	Average inter-item correlation	Alpha
Letter naming fluency	0.72	0.60	0.49	0.85
Phonemic awareness	0.67	0.49	0.52	0.87
Familiar word fluency	0.87	0.81	0.44	0.82
Unfamiliar word fluency	0.70	0.57	0.50	0.86
Oral reading fluency	0.88	0.83	0.44	0.82
Reading comprehension	0.86	0.79	0.45	0.83
Listening comprehension	0.58	0.41	0.55	0.88
Overall assessment			0.48	0.87

[a]The term "item" in this context refers to the EGRA sections. In other words, letter naming fluency, for example, is an item as well as a section.

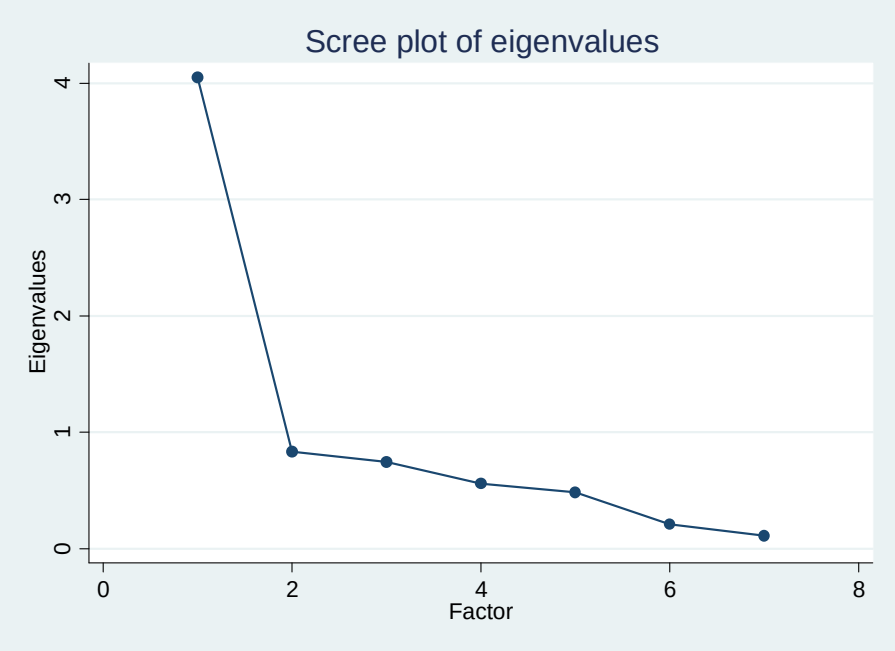
Following the Cronbach's alpha analysis, we carried out a principal components analysis to investigate whether there was an underlying construct that the EGRA sections were evaluating. The first principal component loaded highly on all of the sections, although the loadings were lower for phonemic awareness (0.60) and listening comprehension (0.52). The details are found in the left column of Table 8 below. The right column shows the unique contribution of each section; of particular interest is that both phonemic awareness (0.65) and listening comprehension (0.73) added unique information to the entire assessment.

Table 8: Principal Component Analysis for Early Reading Component

Principal Component 1 Loading		Uniqueness of Each Component	
Letter naming fluency	0.73	Letter naming fluency	0.47
It.Phonemic awareness	0.60	Phonemic awareness	0.65
Familiar word fluency	0.91	Familiar word fluency	0.18
Unfamiliar word fluency	0.70	Unfamiliar word fluency	0.51
Oral reading fluency	0.91	Oral reading fluency	0.17
Reading comprehension	0.87	Reading comprehension	0.24
Listening comprehension	0.52	Listening comprehension	0.73

Following the pattern of the baseline and midterm assessments, we created a visual scree plot (Figure 1) to determine how much of the variation within the total EGRA could be explained by the new principal component that was created with the characteristics of Table 8 above. Figure 1 shows that the first component explains 4.1 eigenvalues of variation, which is larger than at midterm (3.8 eigenvalues). In short, this means that more than half of the variation of all the sections is subsumed within this new component, which can be argued to represent early grade reading skill. The second principal component in Figure 1 below represents less than one eigenvalue, which means that the first principal component does a good job of identifying the underlying construct. This bodes well for our ability to argue that the combined EGRA sections estimate the underlying skill well enough, and mirror the findings in the baseline and midterm reports.

Figure 1: Scree Plot of Eigenvalues for Principal Components Analysis



8. Passage and Word Calibration

In this section, we present the calibration process we used to equate the baseline and midterm assessment oral reading fluency story and the familiar word section in Appendix A. For this discussion we share just the adjustments for the analyses. The midterm results were adjusted as follows:

1. Oral reading fluency in the final assessment passage was multiplied by 1.19 to make it comparable to oral reading fluency in the baseline passage.
2. Reading comprehension in the final assessment passage was multiplied by 1.10 to make it comparable to comprehension in the baseline passage.
3. Familiar word fluency in the final assessment list was multiplied by 1.02 to make it comparable to word fluency in the baseline list.

9. Analysis of Discontinued Assessments

While the descriptive statistics above and the fuller analysis below offer several opportunities to compare the achievement of children in different treatment groups, an analysis of the discontinued assessments—that is, cases in which children were not able to finish all sections of the instrument—provides another take on the impact of the program. Note that the discussion in this section comes from final assessment data, which include the program effect. In several places in the EGRA, a section is discontinued when the child reaches a stop rule, designed so that a child completely overmatched by a task

does not have to endure the entire section, getting item after item incorrect. For letter naming, familiar and unfamiliar word fluency, and oral reading fluency, the stop rule is that the child answers incorrectly on every item in the first line. For phonemic awareness, the stop rule is when a child answers the first five items incorrectly. In all cases, discontinued sections show the subset of children who can be characterized as complete nonreaders. (Although note that the complement—namely 100% minus the percentage who are nonreaders—cannot really be considered readers, as being able to decode a few words can hardly classify one as a reader.[15]) Comparing the numbers of discontinued students across the control, full, and light treatment groups allows us to determine whether the program was able to help those children who had very limited reading skills.

Table 9 below presents this analysis, and shows that, for the most part, boys were more likely to discontinue than girls, which is surprising given that girls performed less well than boys overall. When we compared the treatment groups at the final assessment, the percentage of children who discontinued in control schools was higher than for those in full treatment, for each of the five discontinuable sections. And for each section, the percentages of discontinued scores often were higher for control than for light treatment schools, although for oral reading fluency and familiar word fluency, there were more discontinued assessments in the light treatment population. Across the sections, there remained a noticeable gap between full treatment and control discontinued assessments, and a smaller gap between light treatment and control. It appears that the program helped some of the very lowest-scoring students, the ones who would have scored zero on these sections.

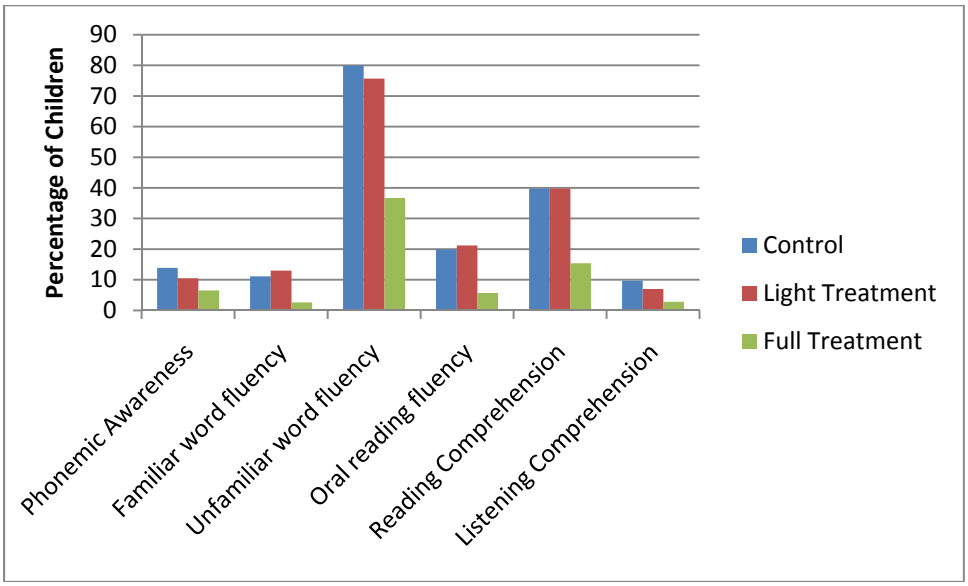
Table 9: Discontinued Sections, by Treatment Status and Sex (Final Assessment)

	Control	Full Treatment	Light Treatment	Boy	Girl	Total
Letter naming fluency	3 (0.4%)	0 (0%)	3 (0.3%)	2 (0.2%)	4 (0.3%)	6 (0.2%)
Phonemic awareness	105 (13.9%)	57 (6.5%)	102 (10.5%)	135 (9.3%)	124 (11.2%)	264 (10.2%)
Familiar word fluency	79 (11.1%)	21 (2.6%)	120 (13.0%)	133 (6.6%)	83 (11.8%)	220 (9.0%)
Unfamiliar word fluency	583 (79.9%)	294 (36.7%)	713 (75.7%)	773 (61.3%)	780 (67.3%)	1590 (64.3%)
Oral reading fluency	133 (19.9%)	45 (5.7%)	184 (21.2%)	185 (13.8%)	168 (17.5%)	362 (15.6%)

[15] This raises the question, of course, of what being a "reader" encompasses. This is also a complicated question, requiring careful investigation of the outcomes identified in this study. As recommended in later sections of the paper, the richness of these data sets provides insight into how fluently children have to read in order to sustain high levels of comprehension. This is likely the form that any definition of "reader" should take: matching fluency levels with comprehension levels in order to determine a suitable Liberian benchmark.

Figure 2 presents the percentage of children who scored zero on the various sections in the final assessment, across each treatment group. Note that the last bar in each set is always the lowest, meaning that children in full treatment schools were less likely to discontinue these sections. The gap in percentages is sometimes large, with the unfamiliar word fluency and reading comprehension scores having the widest gap between full treatment and control (as well as light treatment) schools. This provides strong graphical evidence of program impact, particularly for the full treatment schools.

Figure 2: Zero Scores, by Treatment Group and Section



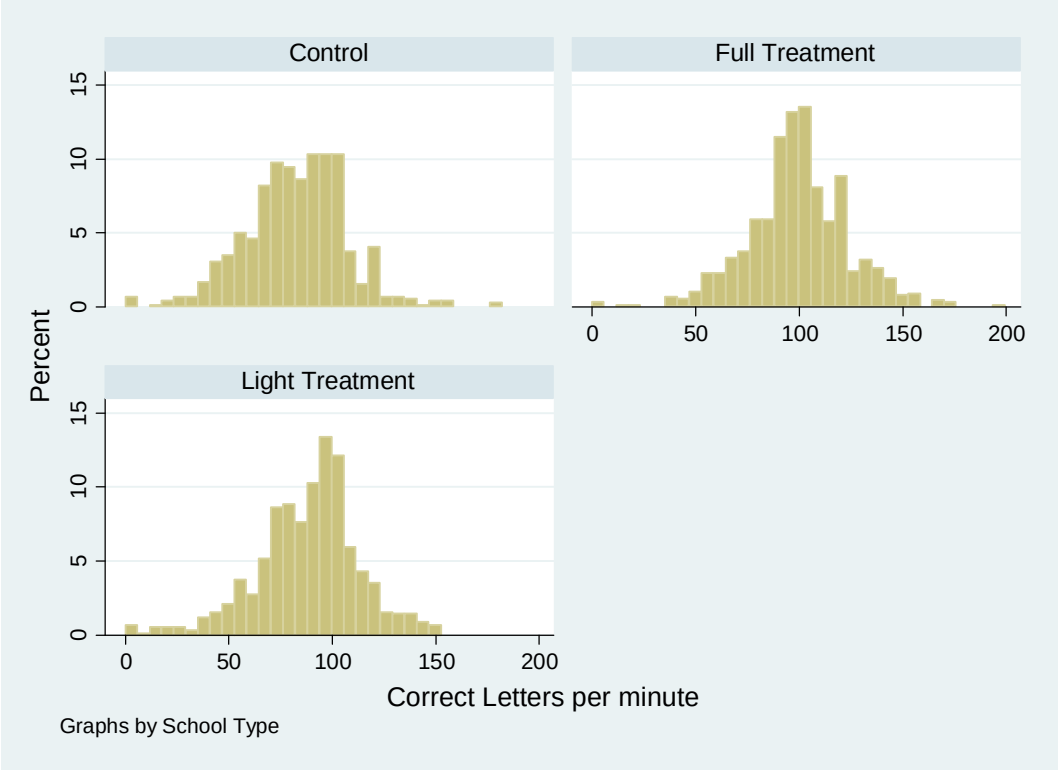
10. Figure Analysis by EGRA Section

Here we present several graphics created to illustrate the relationship between treatment groups and achievements of the program as measured at the final assessment. Under the assumption (explained in other sections of the report) that the treatment and control groups were the same, these figures and the associated analyses show graphically the impact of EGRA Plus on student achievement at the final assessment, across treatment groups. By EGRA section, we look at which of several variables were predictive of reading outcomes, including grade and sex.

10.1 Letter Naming Fluency

Figure 3 shows the scores of control, full treatment, and light treatment children on the letter naming fluency section. Note that each bar presents the percentage of children from that treatment group who scored a particular number of letters per minute. Visual inspection shows that there were fewer children who scored zero or close to zero in the full treatment group than in either the control or light treatment groups. Similarly, more children scored 100 or more letters per minute in the full treatment group than in either of the other groups. In general, the full treatment group has a nearly normal distribution, while the control and light treatment groups have a slight leftward skew.

Figure 3: Histograms Comparing Letter Naming Fluency Scores, by Treatment Group



10.2 Phonemic Awareness

We also generated several figures to analyze the impact of the EGRA Plus program on phonemic awareness scores. In Figure 4 below, which presents box plots for each of the treatment groups on letter naming fluency, notable differences can be detected. First, a lower percentage of children scored zero on the phonemic awareness section in the full treatment schools than in either the light treatment or control schools. Other than those zero scores, the scores are nearly normally distributed for both control and light treatment. On the other hand, for full treatment, there is a rightward skew, with a larger percentage of children reading letters fluently.

Figure 4: Histograms Comparing Phonemic Awareness Scores, by Treatment Group

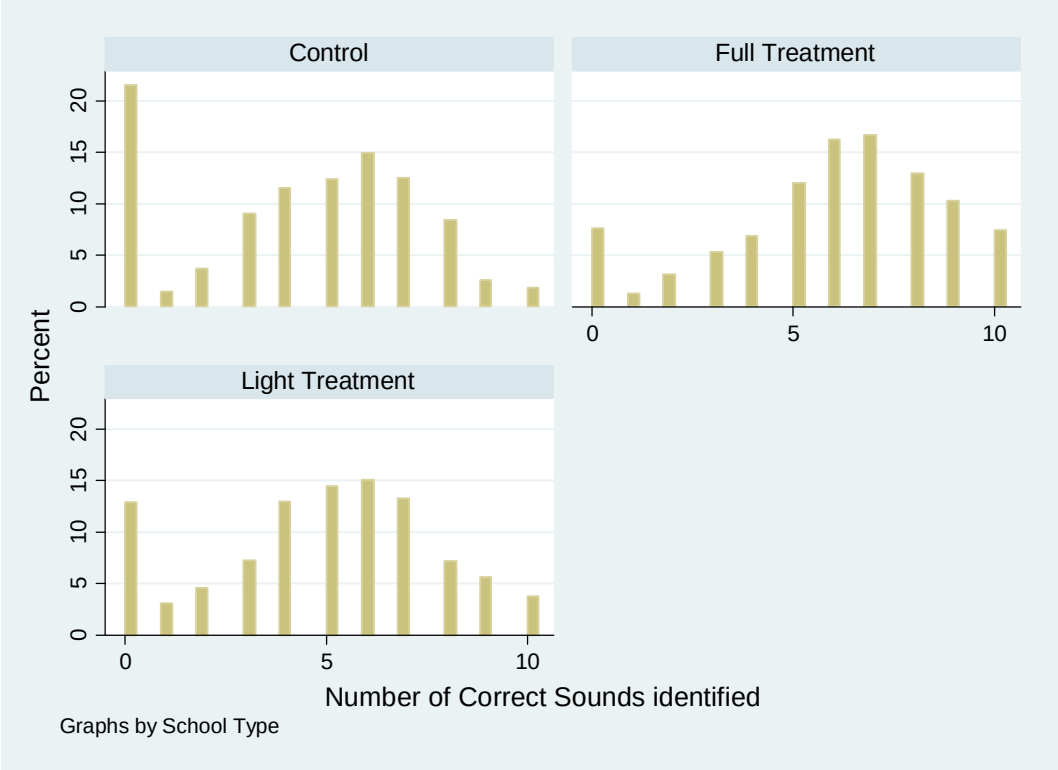
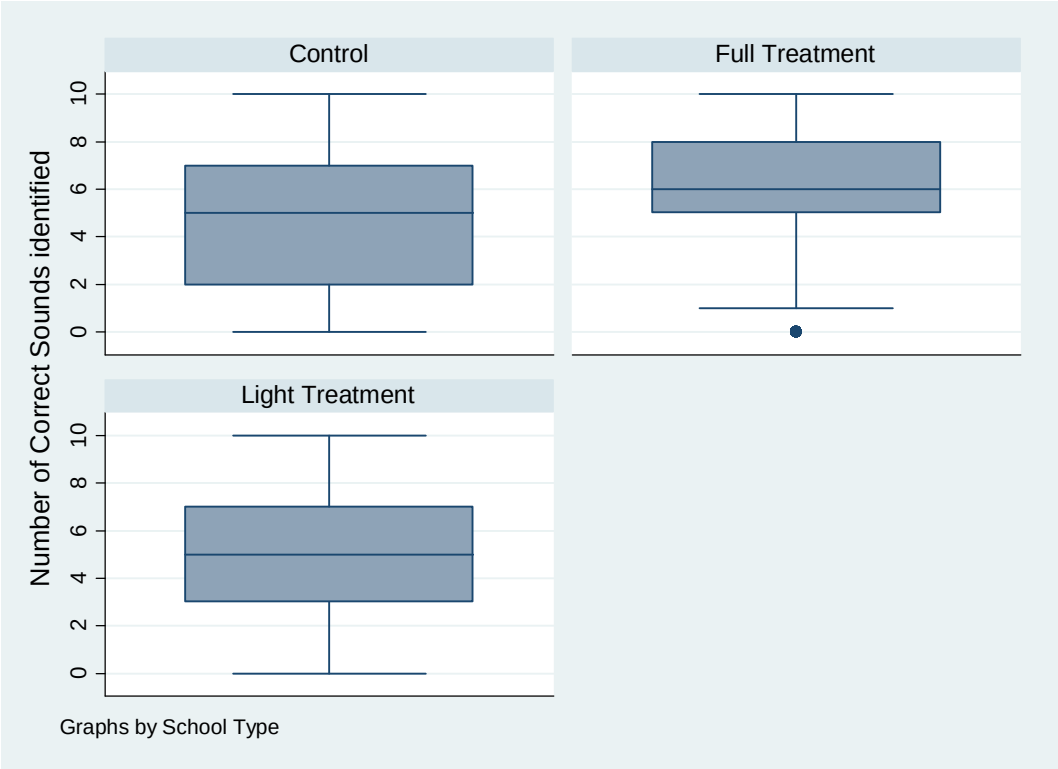


Figure 5 below disaggregates by treatment group the achievement on the number of sounds identified. The mean scores (6.0 words correct) for the children in full treatment schools were much higher than those for either control or light treatment. The 75th-percentile scores also were much higher, with full treatment children reading eight words correctly on this section, compared to between six and seven words in control and light treatment schools. The 10th-percentile scores (the bottom line) were above zero for the full treatment children, allowing light treatment schools to have an outlier with respect to the number of phonemic awareness tasks correctly performed. On the other hand, the 10th-percentile score for both control and light treatment was zero words correct. This indicates a substantial gap in achievement on phonemic awareness between full treatment and light treatment and control schools.

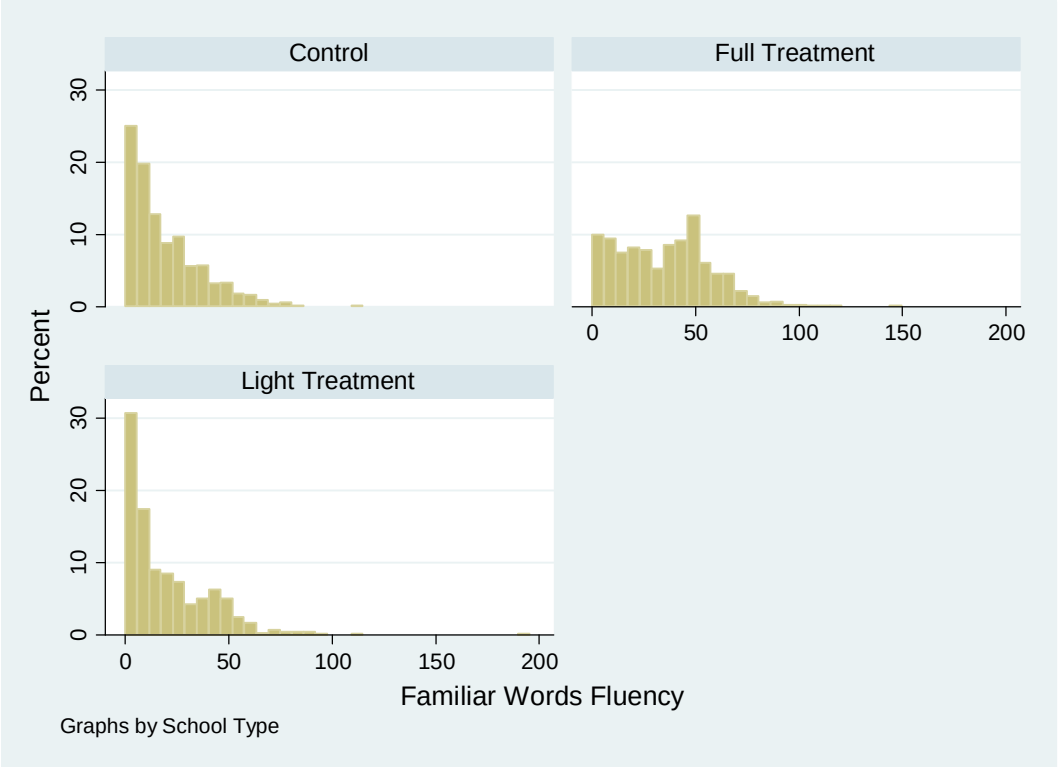
Figure 5: Box Plots Comparing Phonemic Awareness Scores, by Treatment Group



10.3 Familiar Word Fluency

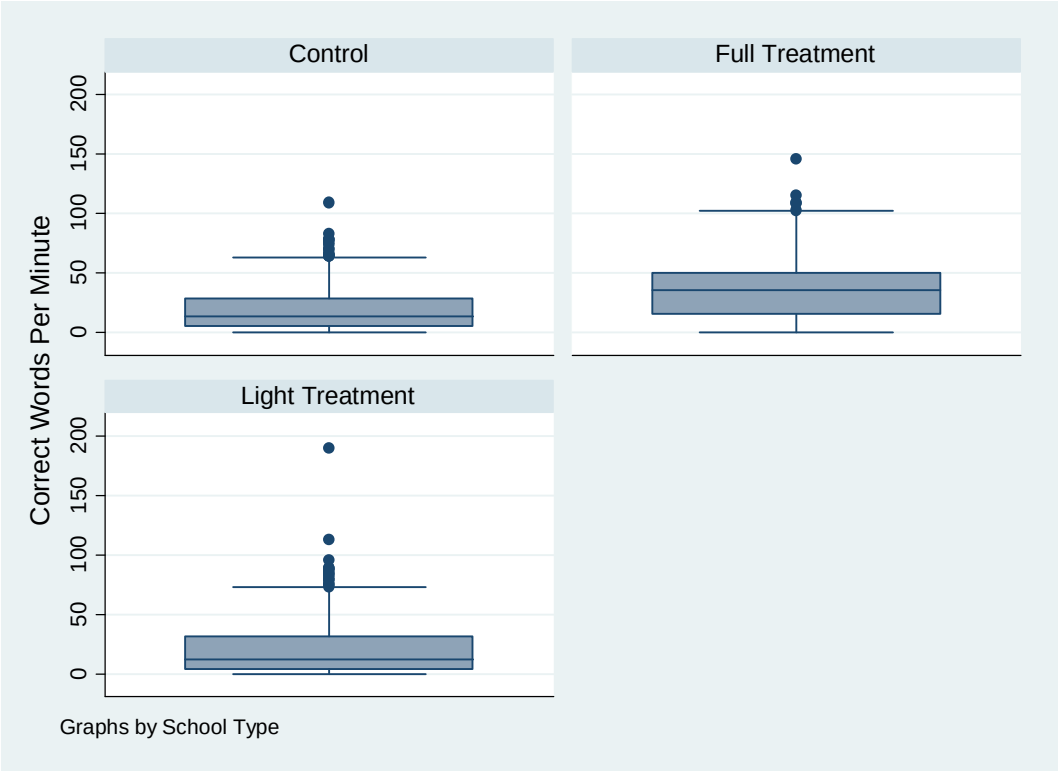
When we analyzed the results of the program's impact on the number of familiar words that children could identify in one minute, we found a relatively large impact of the full treatment when we compared children in each type of school (Figure 6). The score with the highest percentage for control and light treatment schools was zero words per minute, while for full treatment, the modal score was 50 words per minute. Moreover, the tail of the full treatment schools was more evenly distributed beyond the 50-words-per-minute mark. In other words, a significant percentage of children who could read 50 words per minute were in the full treatment schools.

Figure 6: Histograms for Familiar Word Naming Fluency, by Treatment Group



In the box plots comparing treatment groups in Figure 7, it is easy to note substantial differences in word reading fluency. For example, the 75th- and 90th-percentile scores were higher for full treatment schools than for control or light treatment schools. The 90th percentile was nearly 100 words per minute for full treatment schools, but somewhere around 70 words per minute for control and light treatment. Similarly, the means were higher in full treatment schools, with control and light treatment mean scores less than 25 words per minute, and the full treatment schools nearer to 50 words per minute. The small differences between control and light treatment were also notable at the 10th and 25th percentiles, which shows that significant portions of the sampled learners were scoring at those levels. That was not the case for the full treatment schools, however. In short, on familiar word fluency, there was a consistent advantage for full treatment schools at the expense of both control and light treatment schools.

Figure 7: Box Plots Comparing Familiar Word Fluency, by Treatment Group



10.4 Unfamiliar Word Fluency

The descriptive statistics above showed that the scores for unfamiliar words were quite low. This is borne out in Figure 8, which shows that nearly 80% of light treatment and more than 80% of control children read zero unfamiliar words per minute. Less than 40% of full treatment children, on the other hand, read zero unfamiliar words per minute. The histograms also show that the distribution of children reading more than zero words per minute on this section was much more substantial and more widely spread in the full treatment sample than in either full or light treatment.

Figure 8: Histograms Depicting Achievement on Unfamiliar Word Fluency, by Treatment Group

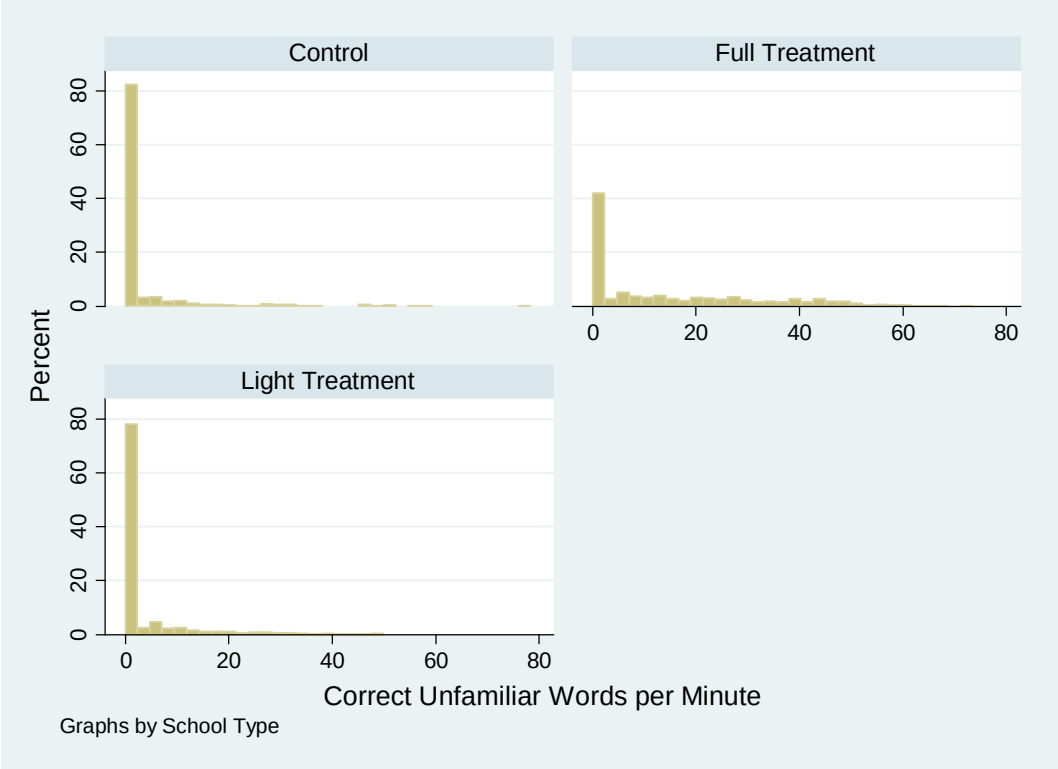
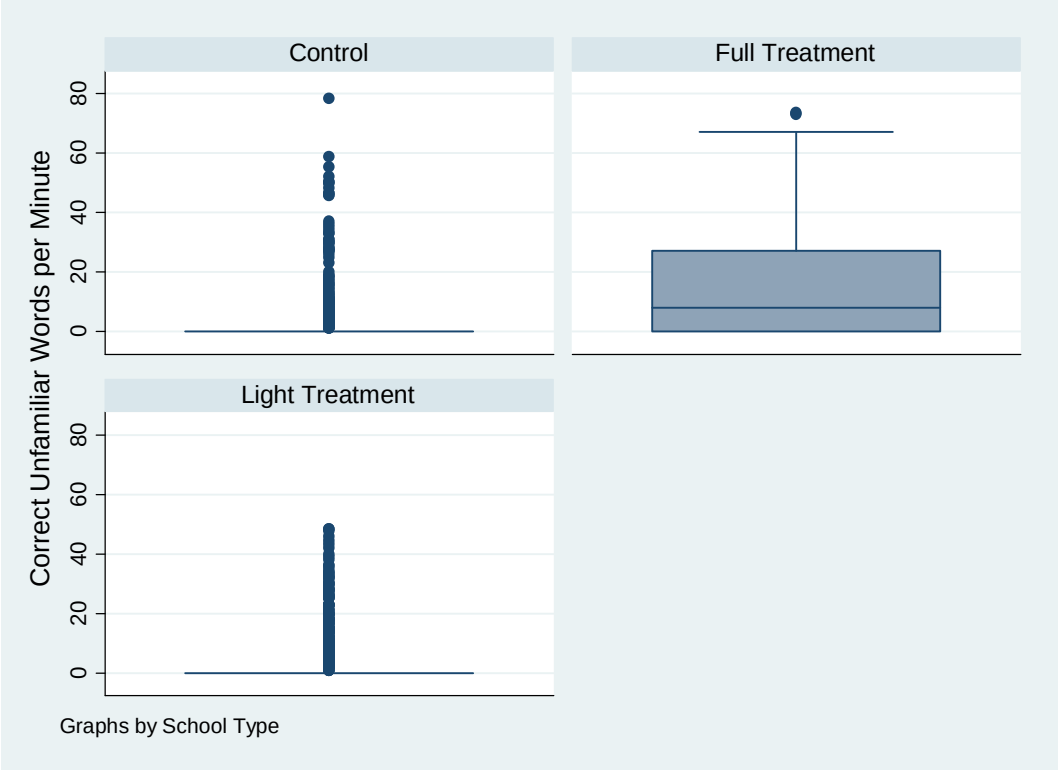


Figure 9 shows this point more clearly. It compares all three treatment groups and the two grades. It shows, particularly when we compare control and full treatment children, that the EGRA Plus program helped children move from zero scores to farther along the distribution. This is an important finding for equity: EGRA Plus not only helped high-achieving children expand their reading knowledge, but also helped the lower-achieving children increase their scores. The Figure 9 box plot illustrates an important point: Children in full treatment schools had enough variation in their scores that the mean, 75th percentile, and 90th percentile were all removed from zero. This shows that in full treatment schools, in particular for nonsense words, the program had an impact on the lowest achieving students.

Figure 9 also makes quite evident the wide gaps between the control/light treatment and full treatment schools. While the 25th-, 50th-, and 75th-percentile scores were all concentrated at zero words per minute for control and light treatment, the mean score for full treatment was more than 10 words per minute and the 75th percentile was significantly more than 20 words per minute. The majority of children in schools that had EGRA Plus full treatment support were much more capable of decoding. Moreover, the 90th percentile of the distribution was 60 words per minute, which is approximately the same as the greatest outlier in control schools, and higher than the entire light treatment sample. This EGRA section was one in which the full treatment had a significant impact on student outcomes, and particularly in the skill of decoding new words.

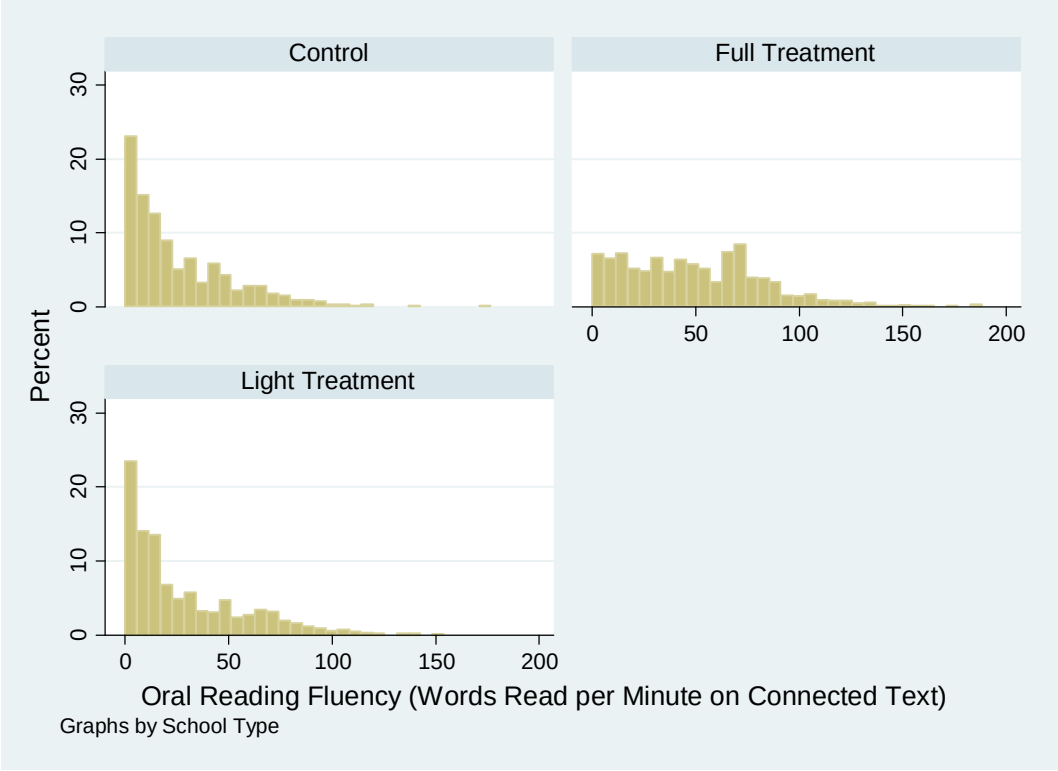
Figure 9: Box Plot Showing Unfamiliar Word Fluency, by Treatment Group, for Grades 2 and 3 Combined



10.5 Oral Reading Fluency (Connected Text)

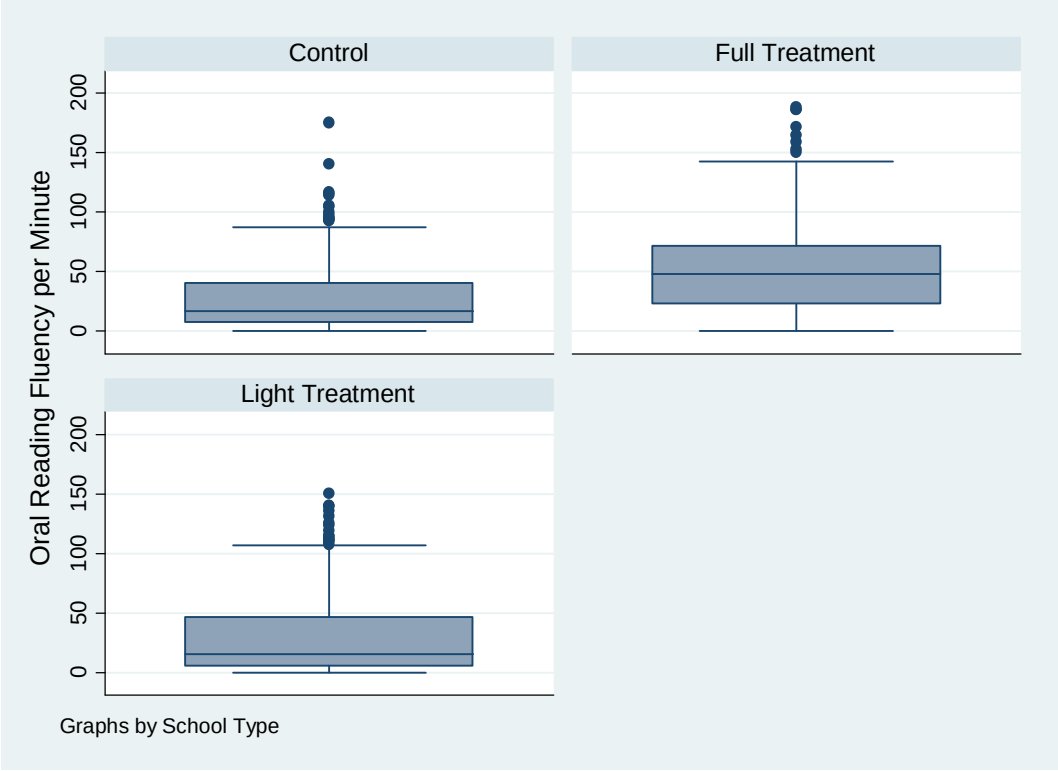
Figure 10 below shows the relationship between oral reading fluency and treatment status. In both control and light treatment schools, more than 20% of the sample read zero words per minute, and significant percentages read quite close to zero words per minute. On the other hand, while the oral reading fluency scores for the full treatment schools were skewed to the left, the percentages of children reading modest amounts on oral reading fluency were significantly less. The percentages of children who read 50 words per minute or more in the full treatment schools were substantial, and much more than the scattering of fluent readers in control and light treatment schools. Note also from Figure 10 that a higher percentage of light treatment school children could read at least a few words.

Figure 10: Histograms Showing Oral Reading Fluency Scores, by Treatment Group



The box plots in Figure 11 were designed to show whether and how the EGRA Plus program had an impact on oral reading fluency scores for children in treatment schools. The mean score for full treatment was higher than the 75th-percentile oral reading fluency scores for both control and light treatment children. More powerfully, the 25th-percentile level for full treatment was higher than the 50th percentile for both of the other groups. The high scores also show the differences by treatment group, with the 90th-percentile score for the full treatment schools being 50 words per minute more than control, and nearly 50 words per minute more than light treatment. The substantial impact of the program therefore is apparent across the whole distribution.

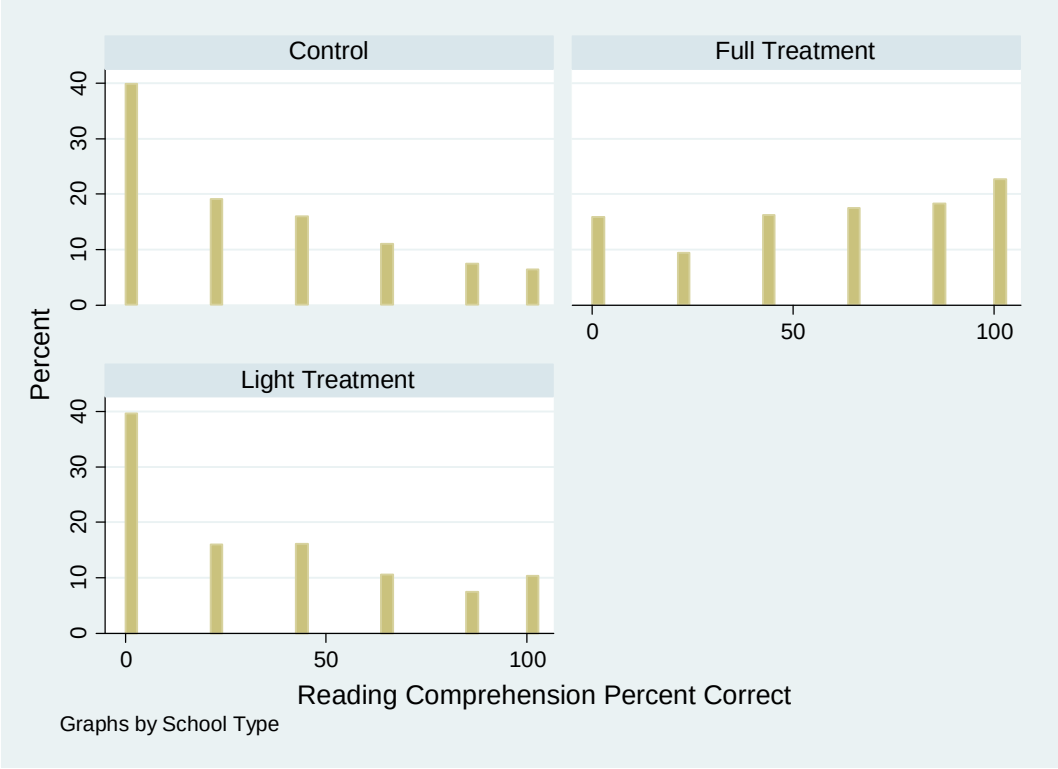
Figure 11: Box Plots of Oral Reading Fluency Scores, by Treatment Group



10.6 Reading Comprehension

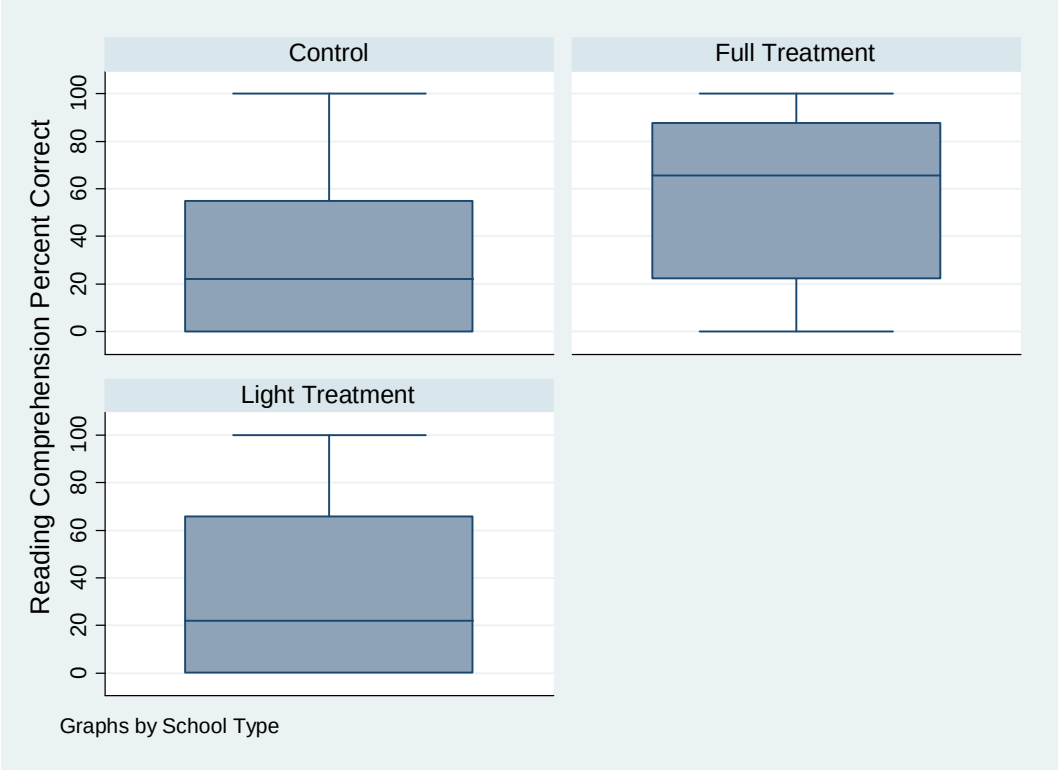
Figure 12 shows the relationships between achievement on reading comprehension and treatment status. Note that we would expect the children in treated schools to outperform their control colleagues since they outscored them on oral reading fluency and the two sections are linked. This might not be the case, however, if the program only increased children's ability to read and sound out words, rather than synthesize and understand what they read. For control and light treatment schools, 40% of children scored 0%correct on this section. The corresponding figure for full treatment was less than 20%. Looking at the other end of the distribution, nearly 20% of the full treatment children scored 80% correct; and more than 20% of them read the story at 100% comprehension. This far surpassed the achievement of both control and light treatment schools, where only about 10% of the entire distribution scored either 80% or 100%. The treatment, then, contributed heavily to students' understanding. This was in contrast to the midterm results, where the impact on reading comprehension was minimal. This was due partly to the lack of calibration between the reading comprehension sections (which has now been rectified) and to the more modest impacts on oral reading fluency found in the midterm. By the time of the final evaluation, children were benefiting a great deal from the full treatment, across sections, and particularly in reading comprehension.

Figure 12: Histograms Showing Reading Comprehension Scores Overall, by Treatment Group



The box plot presented in Figure 13 reinforces the points made above. While it is clear that at the 75th percentile, light treatment schools outperformed control schools, neither group achieved at anything close to the level of the full treatment schools. For example, the 25th-percentile score for full treatment was close to the 75th-percentile score for both control and light treatment. The mean scores for full treatment were significantly higher than the 75th percentile for either full or light treatment. Thus, in the area of reading comprehension, the distribution between the full treatment and light treatment/control school outcomes was quite substantial.

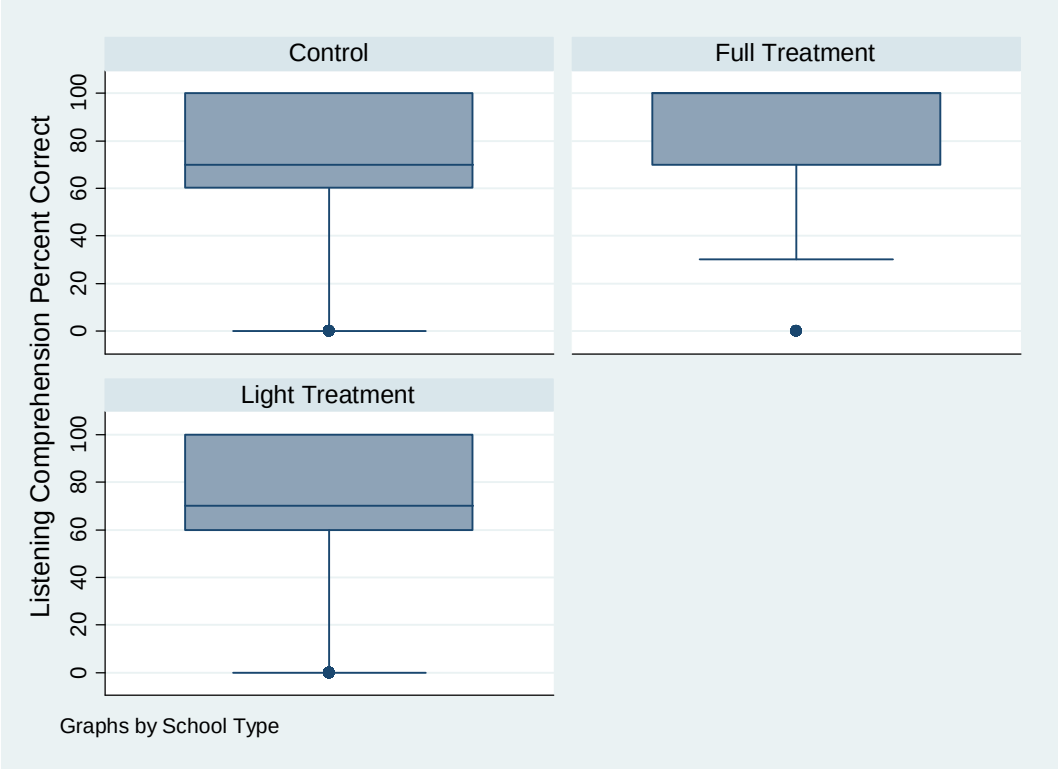
Figure 13: Box Plot of Reading Comprehension Scores, by Treatment Status



10.7 Listening Comprehension

Section 10 closes with a brief investigation of the distribution of scores on listening comprehension, by treatment group, as depicted in Figure 14. Note that the figure indicates that the average score in the full treatment was 100%, while the average for both control and light treatment was 67%. As a result of the program, children were much more able to understand what they heard.

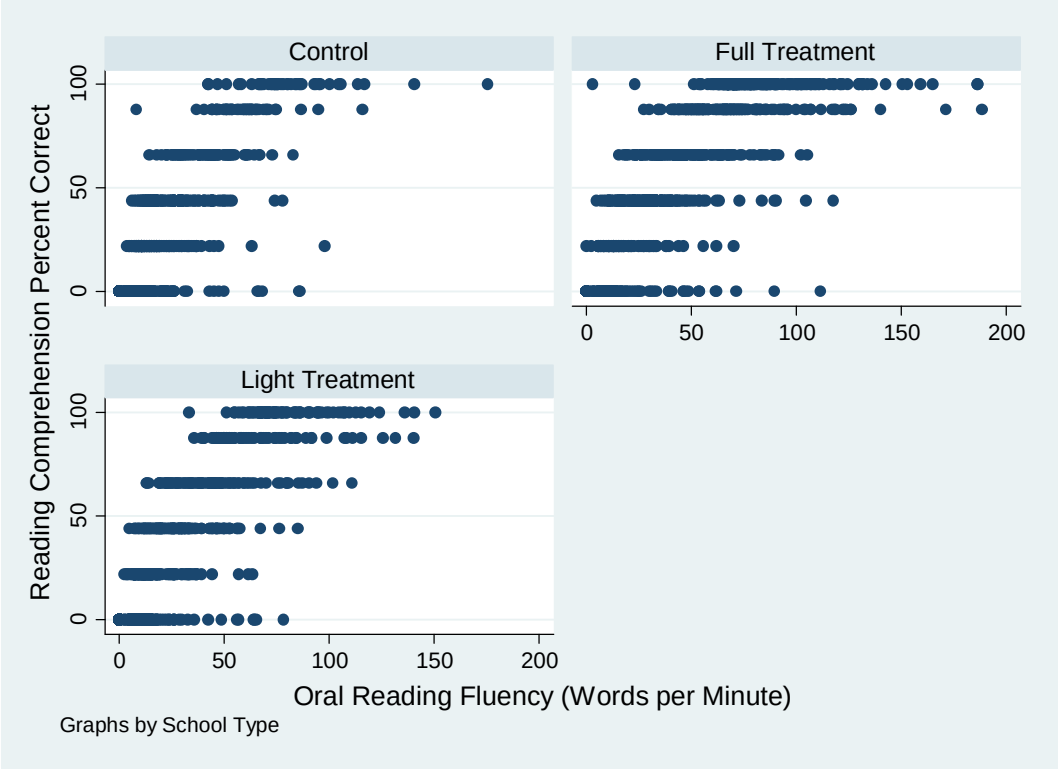
Figure 14: Listening Comprehension Scores, by Treatment Status



10.8 Correlations Between Oral Reading Fluency and Reading Comprehension

In Figure 15 there are three scatterplots. They represent the relationships between children's oral reading fluency and those same children's reading comprehension scores. The scatterplots are divided by treatment group. It is interesting that there is a consistently linear relationship between oral reading fluency and reading comprehension, across all three samples. In other words, children's ability to read fluently was very useful in predicting their ability to comprehend what they read. The issue, therefore, is that far too few children could read with sufficient fluency to comprehend at a high level. The differences between the treatment groups depicted in Figure 15, then, are not in the slope of the predictive relationship, but in the density of the population. That is to say, children in full treatment schools were more likely to read at 50 words per minute, and therefore were much more likely to read with higher levels of comprehension.

Figure 15: Scatterplots between Oral Reading Fluency and Reading Comprehension, by Treatment Group



11. EGRA Plus Program Impact

To determine whether the EGRA Plus program had an impact on student achievement in reading, it was important to compare the scores of children from the three groups of schools. For example, in Table 10 below, scores from the final assessment are

disaggregated by grade 2 and grade 3, as well as by control schools, full treatment schools, and light treatment schools. While analysis in the subsections below compares the achievement by these children with achievement in the baseline assessment, this table was created to reveal whether there were differences in scores by control and treatment schools within the final assessment itself.

Table 10: Final Assessment Statistics and Program Impact, by Grade

Item	School Type	Grade 2				Grade 3			
		N	Mean	Standard deviation	Percent Difference from Control	*N*	Mean	Standard deviation	Percent Difference from Control
Letter naming fluency	Control	369	78.11	23.66		336	86.89	24.33	
	Full	443	94.40	23.96	20.9%	428	104.09	23.22	19.8%
	Light	449	81.38	25.18	4.2%	445	94.99	21.92	9.3%
Phonemic awareness	Control	427	4.01	2.93		364	4.66	2.74	
	Full	466	5.59	2.71	39.4%	442	6.34	2.62	36.1%
	Light	485	4.25	2.74	6.0%	466	5.49	2.68	17.8%
Familiar word fluency	Control	368	15.52	15.03		330	22.42	18.88	
	Full	431	29.36	21.31	89.2%	414	40.57	22.56	81.0%
	Light	453	14.48	16.36	-6.7%	438	25.14	22.29	12.1%
Unfamiliar word fluency	Control	376	2.47	7.54		341	3.32	9.99	
	Full	429	13.10	15.97	430.4%	406	16.46	18.50	395.8%
	Light	463	2.51	7.25	1.6%	449	4.09	8.66	23.2%
Oral reading fluency	Control	349	18.66	20.53		306	32.42	28.11	
	Full	420	43.17	33.98	131.4%	401	56.32	32.50	73.7%
	Light	432	21.99	26.49	17.8%	412	33.96	30.94	4.8%
Reading comprehension	Control	349	24.94	29.86		306	38.73	35.19	
	Full	420	50.92	36.50	104.2%	401	68.13	32.29	75.9%
	Light	432	26.25	33.27	5.3%	412	42.49	36.01	9.7%

Item	School Type	Grade 2				Grade 3			
		N	Mean	Standard deviation	Percent Difference from Control	*N*	Mean	Standard deviation	Percent Difference from Control
Listening comprehension	Control	393	67.18	32.97		349	71.92	31.45	
	Full	466	79.53	27.54	18.4%	438	87.71	19.80	22.0%
	Light	477	66.10	34.18	-1.6%	460	77.61	26.60	7.9%

It is clear that there were quite large differences between full treatment and the rest of the sample on most sections. For example, grade 2 children in full treatment schools outperformed their control school counterparts by 16.3 letters per minute. The difference between light treatment and control children in grade 2 was much smaller, at 3.3 letters per minute. This difference is mirrored in grade 3, with full treatment schools identifying 17.2 more letters per minute and light treatment schools identifying 8.1 more letters. Table 10 shows that for every section, in both grades 2 and 3, full treatment children outperformed both the control and light treatment counterparts. The differences between light treatment and control scores were more modest, and sometimes they were negative. For example, control children outperformed light treatment children on familiar word fluency and listening comprehension in grade 2. The direction of the relationship shows clearly that the full treatment program had an impact on student achievement across EGRA sections. For light treatment, this analysis was not subtle enough to determine whether the gaps between the control and light treatment schools were large enough to argue that the program had an impact on the light treatment schools. This is different from the midterm, where the relationship between control and light treatment schools was a consistently positive, with light treatment schools outperforming their counterparts in control schools. Note that this analysis is a simple comparison of means, and does not take into account the standard errors that would allow us to determine whether these differences are statistically significant. That said, given the fuller technical discussion below, Table 10 shows that the full treatment program had a moderate to high impact on student achievement across the range of sections.

11.1 Program Impact Comparing Grade 2 and Grade 3

One would expect that the lower the baseline performance on a section, the larger would be the program impact. On sections where Liberian children were performing better, such as simple letter recognition, one would expect the impact to be smaller, due to the common-sense notion that it is more difficult to improve on that which is already fairly good. On the other hand, it is also harder to improve on tasks that are intrinsically difficult.

The results confirm this. Sections on which children were already performing fairly well (e.g., letter-naming), and sections that were intrinsically very difficult (e.g., phonemic awareness), were the ones on which the project had smaller impact. For letters, for both grades 2 and 3, the difference between full treatment and control schools was higher than 19.8%. The impacts were a bit larger for phonemic awareness, ranging from 36.1% (grade 3) to 39.4% (grade 2). For familiar words, the difference was larger, with full treatment schools outperforming control schools by 89.2% (grade 2) and 81.0% (grade 3). Enormous percentage gains were identified for unfamiliar words, with full treatment children scoring 430.4% higher at grade 2 and 395.8% higher in grade 3. Decoding skills thus were dramatically improved by the full treatment program. The size of the percentage increases was also large for oral reading fluency, at 131.4% for grade 2 and 73.7% for grade 3. Reading comprehension impacts for full treatment were similar, at 104.2% and 75.9% for grades 2 and 3, respectively. The listening comprehension scores were also interesting, with full treatment increasing over control by 28.4% for grade 2 and 22.0% for grade 3. In short, this is strong and highly consistent evidence that children in full treatment schools dramatically outperformed control schools, particularly in skills areas that were low at baseline and that were intrinsically somewhat easier to improve, such as oral reading fluency, but also including some sections that were of moderate intrinsic difficulty, such as unfamiliar word fluency.

With respect to light treatment, the increases were modest, but usually positive (so, higher than control). In letters, the difference from control was 4.2% (grade 2) and 9.3% (grade 3). The percentage difference was particularly large for oral reading fluency, at 17.8% (grade 2) and 4.8% (grade 3). There were two cases in grade 2 where control schools did 8.1% and 1.6% better than light treatment (familiar word fluency and listening comprehension, respectively). It appears that the impact of light treatment was positive, if quite modest.

11.2 Program Impact Comparing Entire Baseline and Entire Final Assessments

Table 11 compares the baseline sample (from November 2008) with the final assessment sample (from June 2010) disaggregated by test item and treatment status (control, full, or light). The columns to the left show the mean and standard deviation for each of these groups at the baseline. The next set of columns depicts the final assessment scores for these same groups. The columns to the right show the program impact, described several ways. The column “gains over baseline” shows the difference in scores between baseline and final assessment as an absolute difference expressed in letters per minute, words per minute, or percentage scores. The next column, “increase over control,” shows the difference in the gains between baseline and final assessment less the gains for the control group. *This is the true program impact column, since it removes the secular trend identified in the control schools.* The column “pooled standard deviation” is the pooled

standard deviation for the baseline and final assessment administrations. This is useful for identifying effect sizes.

The next column, "percent increase over baseline," changes the "gains over baseline" column to a percent increase against the baseline score. This is reflective of the need from the Performance Management Plan to discuss the increase over baseline effect of EGRA Plus, but is less valid, as a way of establishing impact, than comparing against control group. The next column, "effect size," takes the gains over baseline column and creates a Cohen's *d* effect size. This is inflated slightly because the baseline and final assessments were administered at different times of the year, so it includes some of the "grade effect" of learning in control schools and makes it indistinguishable from the program effect.

Therefore, the final column was created, which is the treatment effect size minus the control effect size. That is, for every EGRA section, the effect size for the control schools was subtracted from the effect size of the full and light treatment schools. This produced a comparable number that allows a discussion of the true impact of the program (minus the grade effect) in a metric that is comparable across sections and other impact evaluations in the literature. This is expressed in terms of units of pooled standard deviation.

Table 11*:* **Comparing Grade 2 and Grade 3 Baseline and Final Assessment, with Program Impact**

Section	School Type	Baseline, Grade 2 + Grade 3			Final Assessment, Grade 2 + Grade 3			Program Impact					
		N	Mean	SD	*N*	Mean	SD	Gains Over Baseline	Increase Over Control	Pooled Standard Deviation	Percent Increase Over Baseline	Effect Size (SD)	Treat. Minus Control Effect Size
Letter naming fluency	Control	984	60.67	25.17	718	82.42	24.37	21.75		24.82	35.85%	0.88	
	Full	929	62.35	24.86	879	99.26	24.07	36.91	15.16	24.47	59.20%	1.51	0.63
	Light	1061	60.37	25.82	905	88.14	24.49	27.77	6.02	25.20	46.00%	1.10	0.23
Phonemic awareness	Control	985	3.41	2.32	808	4.31	2.87	0.9	n/a	2.58	26.39%	0.35	
	Full	930	3.56	2.26	915	5.96	2.70	2.4	1.5	2.49	67.42%	0.97	0.62
	Light	1062	3.49	2.30	964	4.86	2.77	1.37	0.47	2.53	39.26%	0.54	0.19
Familiar word fluency	Control	981	8.51	13.54	711	18.83	17.41	10.32	n/a	15.28	121.27%	0.68	
	Full	921	10.03	14.28	852	34.88	22.62	24.85	14.53	18.75	247.76%	1.33	0.65
	Light	1050	9.24	13.86	901	19.73	20.19	10.49	0.17	17.07	113.53%	0.61	-0.06
Unfamiliar word fluency	Control	978	1.91	5.55	730	2.85	8.73	0.94	n/a	7.08	49.21%	0.13	
	Full	925	2.51	6.22	841	14.70	17.31	12.19	11.25	12.76	485.66%	0.96	0.82
	Light	1053	2.30	6.22	923	3.27	7.98	0.97	0.03	7.09	42.17%	0.14	0.00

Section	School Type	Baseline, Grade 2 + Grade 3			Final Assessment, Grade 2 + Grade 3			Program Impact					
		N	Mean	SD	*N*	Mean	SD	Gains Over Baseline	Increase Over Control	Pooled Standard Deviation	Percent Increase Over Baseline	Effect Size (SD)	Treat. Minus Control Effect Size
Oral reading fluency	Control	979	18.14	19.42	668	25.21	25.52	7.07	n/a	22.08	38.97%	0.32	
	Full	930	20.83	20.26	826	49.61	33.86	28.78	21.71	27.49	138.17%	1.05	0.73
	Light	1049	19.77	20.37	851	27.93	29.38	8.16	1.09	24.80	41.27%	0.33	0.01
Reading comprehension	Control	979	23.70	23.86	668	31.50	33.27	7.8	n/a	28.04	32.91%	0.28	
	Full	930	25.81	24.37	826	59.38	35.49	33.57	25.77	30.10	130.07%	1.12	0.84
	Light	1049	25.74	24.44	851	34.34	35.61	8.6	0.8	29.95	33.41%	0.29	0.01
Listening comprehension	Control	989	32.64	21.56	755	69.43	32.33	36.79	n/a	26.74	112.71%	1.38	
	Full	934	33.58	20.11	912	83.53	24.44	49.95	13.16	22.34	148.75%	2.24	0.86
	Light	1065	34.51	19.84	949	71.79	31.22	37.28	0.49	25.82	108.03%	1.44	0.07

Table 11 above shows that the program had a large impact on all of the sections. Beginning with the substantive increases due to EGRA Plus, first we examine the "percent increase over baseline" column.

- For letter naming fluency, the changes for full and light treatment were 59.2% and 46.0%, respectively, which were quite large gains.
- For phonemic awareness, the changes were 67.4% and 39.3%, respectively.
- For familiar words, the difference was 247.8% and 113.5%, or quite a large gap between baseline and final assessment.
- For unfamiliar words, full treatment children outperformed their baseline counterparts by an exorbitant 485.7%, while the light treatment children did 42.2% better.
- Critically, for oral reading fluency, full treatment schools increased their words per minute by 138.2% and light treatment schools increased by 41.3%. Control schools increased at basically the same rate as light treatment schools did (39.0%).
- Given the connection with oral reading fluency, it is not surprising that the magnitude of the change on reading comprehension was correlated with oral reading fluency. Children in full treatment schools increased their reading comprehension scores by 130.1%, while those in light treatment increased by 33.4%. Note that control schools also increased by 32.9%.
- For listening comprehension, full treatment, light treatment, and control schools increased their scores by 148.8%, 108.0%, and 112.7%, respectively.

In summary, comparing the full baseline data set against the full final assessment, children's scores increased in control schools, but much more so for full treatment schools. Unlike at midterm, when the effects were most clearly seen in letters and familiar words but less so in phonemic awareness, unfamiliar words, and reading comprehension, the impact of the full treatment was felt across every section.

Note that while the percentage increase over baseline is important, it does not take into account the scores from the baseline study collected before implementation. Accounting for baseline scores enables researchers to estimate the secular trend, which in the example of the Liberian program includes a great deal of outside forces working on student achievement outside of the program.[16] The "effect size" column in Table 11 notes the gain over the baseline and expresses it as a measure of the pooled standard deviation of both the baseline and final assessments. As far as the estimation of a true program effect is concerned (removing the learning effect in control schools), there is a better method, expressed in the last column to the right. For letter naming fluency, the effect size for full treatment was large (0.63 SD) and for light treatment (0.23 SD) was small. For phonemic awareness, the effect size for full schools (0.62 SD) was large, while the effect in light schools (0.19 SD) was small. For familiar words, the effect size was large for full (0.65 SD) and negative for light (-0.06 SD) schools. In the unfamiliar word fluency section, the effect was, once again, large for full schools (0.82 SD), and zero for light schools. In oral reading fluency, the effect was large for full schools (0.73 SD) and non-existent for light schools (0.01 SD). We found large effects for full schools for reading comprehension (0.84 SD) and listening comprehension (0.86 SD), but negligible effects for light schools (0.01 SD and 0.07 SD, respectively). Note that these are adjusted effect sizes to indicate the increase over control, as well. If basic effect sizes were presented, they would be remarkably large (over 2 SD in some cases), but also slightly misleading given the grade effect that would be conflated.

11.3 Program Impact Comparing Baseline Grade 2 and Final Grade 2

While the discussion above compares the entire baseline (grades 2 and 3) against the entire final assessment sample, Table 12 below only compares grade 2 students in the baseline and final assessment. The columns on the right—"percent increase over baseline," "effect size," and "treatment minus control effect size"—are the important ones with respect to program impact. Regarding the increase over baseline, full treatment schools increased over baseline by over 80% for every section at grade 2, with many of the sections increasing over baseline above 100% (reading comprehension and listening comprehension) and some over 200% (oral reading fluency, familiar word fluency) and one over 1000% (unfamiliar word fluency). For light treatment schools, there were

[16] More research is necessary to determine whether some of the secular trend identified in this report was due to the EGRA Plus program. It is plausible that this is the case, since there was a general improvement in control schools between the midterm and final assessments.

increases for every section except unfamiliar word fluency, where the 0.5% increase was negligible and less than what was found in control schools.

Table 12: Program Impact, Baseline and Final Assessments, for Grade 2

Section	School Type	Baseline, Grade 2			Final Assessment, Grade 2			Program Impact					
		N	Mean	SD	*N*	Mean	SD	Gains over Base-line	Increase over Control	Pooled SD	Percent Increase over Baseline	Effect Size (SD)	Treatment Minus Control Effect Size
Letter naming fluency	Control	501	54.76	25.02	369	78.11	23.66	23.35		24.42	42.64%	0.96	
	Full	484	55.90	24.89	443	94.40	23.96	38.5	15.15	24.42	68.87%	1.58	0.62
	Light	559	55.26	24.75	449	81.38	25.18	26.12	2.77	24.92	47.27%	1.05	0.09
Phonemic awareness	Control	500	3.09	2.24	427	4.01	2.93	0.92	n/a	2.58	29.77%	0.36	
	Full	485	3.28	2.13	466	5.59	2.71	2.31	1.39	2.43	70.43%	0.95	0.59
	Light	558	3.18	2.20	485	4.25	2.74	1.07	0.15	2.46	33.65%	0.43	0.08
Familiar word fluency	Control	501	5.69	10.90	368	15.52	15.03	9.83	n/a	12.80	172.76%	0.77	
	Full	479	5.83	10.09	431	29.36	21.31	23.53	13.7	16.37	403.60%	1.44	0.67
	Light	553	6.50	11.56	453	14.48	16.36	7.98	-1.85	13.91	122.77%	0.57	-0.19
Unfamiliar word fluency	Control	498	1.51	5.32	376	2.47	7.54	0.96	n/a	6.36	63.58%	0.15	
	Full	484	1.37	3.79	429	13.10	15.97	11.73	10.77	11.28	856.20%	1.04	0.89
	Light	557	1.84	6.03	463	2.51	7.25	0.67	-0.29	6.61	36.41%	0.10	-0.05
Oral reading fluency	Control	497	13.50	16.49	349	18.66	20.53	5.16	n/a	18.24	38.22%	0.28	
	Full	483	14.97	16.17	420	43.17	33.98	28.2	23.04	25.99	188.38%	1.09	0.80
	Light	552	14.91	17.78	432	21.99	26.49	7.08	1.92	22.01	47.48%	0.32	0.04
Reading comprehension	Control	497	19.52	22.64	349	24.94	29.86	5.42	n/a	25.83	27.77%	0.21	
	Full	483	19.09	21.19	420	50.92	36.50	31.83	26.41	29.29	166.74%	1.09	0.88
	Light	552	20.22	22.64	432	26.25	33.27	6.03	0.61	27.78	29.82%	0.22	0.01
Listening comprehension	Control	502	29.84	22.02	393	67.18	32.97	37.34	n/a	27.34	125.13%	1.37	
	Full	486	30.41	20.13	466	79.53	27.54	49.12	11.78	24.02	161.53%	2.05	0.68
	Light	560	31.12	19.84	477	66.10	34.18	34.98	-2.36	27.36	112.40%	1.28	-0.09

A better estimate of the program impact, expressed in effect sizes in the last column to the right, shows that the gains were very large in full treatment schools. The effect size was 0.86 SD in letter naming, 0.88 SD in phonemic awareness, 0.86 SD in familiar

words, 2.36 SD in unfamiliar words, 1.01 SD in oral reading fluency, and 1.03 SD and 1.00 in reading comprehension and listening comprehension, respectively. These are consistently very large, across sections, for grade 2. This suggests that the impact was slightly larger at grade 2 then grade 3, so more research is necessary to determine whether this was because the program was more effective at grade 2 or whether less learning was happening in grade 2 in control schools.

For light treatment schools, the program impact was small in letter naming (0.17 SD), reading comprehension (0.23 SD) and listening comprehension (0.22 SD). It was negligible in letter naming (0.17 SD) and phonemic awareness (0.10 SD), and negative in familiar words (-0.22 SD) and unfamiliar words (-0.19 SD). While scores improved in light treatment schools, across the board in grade 2, those improvements were not enough over the improvements in control schools to argue that the light treatment program had a significant impact on student achievement.

11.4 Program Impact Comparing Baseline Grade 3 and Final Grade 3

Similar to Table 12, which examines grade 2 scores, Table 13 below explores the impact of the full and light treatment programs on their percentage increase in grade 3 over baseline, and the effect size. The pattern follows what was found in grade 2, although at a smaller magnitude. With respect to percentage increases over baseline, children in full treatment schools increased by between 49.4% (letter naming) and 335.5% (unfamiliar word naming), with familiar words, unfamiliar words, oral reading fluency, reading comprehension and listening comprehension all having percentage increases of over 90%. Light treatment scores increased by between 32.7% (reading comprehension) and 103.6% (familiar word fluency). When the changes over baseline are converted to effect sizes of impacts over the control groups, we find that the children in full treatment schools had moderate to large effect sizes. Large effects were found for letter naming (0.66 SD), phonemic awareness (0.64 SD), familiar words (0.67 SD), unfamiliar words (0.78 SD), oral reading fluency (0.65 SD), reading comprehension (0.84 SD) and listening comprehension (1.15 SD).

The consistency of these effect sizes is remarkable. For the most part, though, full treatment effect sizes were slightly smaller for grade 3 than for grade 2. For light treatment children, most of the effects were positive, although there were small negative effects for oral reading fluency (-0.06 SD), and reading comprehension (-0.03 SD). It appears that for those sections that required reading and decoding skills, children in light treatment actually did worse than expected given their baseline scores and the achievement of the control school children. Small effects were found for letter naming fluency (0.36 SD), phonemic awareness (0.30 SD), and listening comprehension (0.29 SD). More research is necessary to investigate the relationship between light treatment and control schools, given that the midterm findings suggested that the light treatment program did have some effect on student outcomes, which for many sections were lost at

the final assessment. This is juxtaposed against the very significant findings for grade 3 children in full treatment schools for each section.

Table 13: Program Impact, Baseline and Final Assessments, for Grade 3

Section	School Type	Baseline, Grade 3			Final Assessment, Grade 3			Program Impact					
		N	Mean	SD	*N*	Mean	SD	Gains over Baseline	Increase over Control	Pooled SD	Percent Increase over Baseline	Effect Size (SD)	Treat. Minus Control Effect Size
Letter naming fluency	Control	480	66.83	23.90	336	86.89	24.33	20.06		24.05	30.02%	0.83	
	Full	436	69.66	22.87	428	104.09	23.22	34.43	14.37	23.02	49.43%	1.50	0.66
	Light	497	66.25	25.82	445	94.99	21.92	28.74	8.68	24.03	43.38%	1.20	0.36
Phonemic awareness	Control	478	3.78	2.35	364	4.66	2.74	0.88	n/a	2.52	23.28%	0.35	
	Full	436	3.86	2.37	442	6.34	2.62	2.48	1.6	2.50	64.25%	0.99	0.64
	Light	498	3.85	2.36	466	5.49	2.68	1.64	0.76	2.52	42.60%	0.65	0.30
Familiar word fluency	Control	477	11.49	15.32	330	22.42	18.88	10.93	n/a	16.85	95.13%	0.65	
	Full	433	14.54	16.52	414	40.57	22.56	26.03	15.1	19.68	179.02%	1.32	0.67
	Light	492	12.35	15.53	438	25.14	22.29	12.79	1.86	18.99	103.56%	0.67	0.02
Unfamiliar word fluency	Control	477	2.35	5.77	341	3.32	9.99	0.97	n/a	7.80	41.28%	0.12	
	Full	432	3.78	7.90	406	16.46	18.50	12.68	11.71	14.05	335.45%	0.90	0.78
	Light	491	2.84	6.42	449	4.09	8.66	1.25	0.28	7.56	44.01%	0.17	0.04
Oral reading fluency	Control	479	22.95	21.05	306	32.42	28.11	9.47	n/a	24.02	41.26%	0.39	
	Full	436	27.34	22.30	401	56.32	32.50	28.98	19.51	27.63	106.00%	1.05	0.65
	Light	491	25.20	21.70	412	33.96	30.94	8.76	-0.71	26.29	34.76%	0.33	-0.06
Reading comprehension	Control	480	28.02	24.39	306	38.73	35.19	10.71	n/a	29.04	38.22%	0.37	
	Full	436	33.30	25.39	401	68.13	32.29	34.83	24.12	28.87	104.59%	1.21	0.84
	Light	491	32.02	24.97	412	42.49	36.01	10.47	-0.24	30.47	32.70%	0.34	-0.03
Listening comprehension	Control	451	35.39	20.40	349	71.92	31.45	36.53	n/a	25.77	103.22%	1.42	
	Full	437	37.25	19.53	438	87.71	19.80	50.46	13.93	19.64	135.46%	2.57	1.15
	Light	498	38.41	19.15	460	77.61	26.60	39.2	2.67	23.01	102.06%	1.70	0.29

11.5 Program Impact Comparing Baseline and Midterm, Disaggregated by Sex

An additional program impact table disaggregated by sex makes an important point. Below, in Table 14, which compares achievement on the various sections disaggregated by both school type and sex, there is a general pattern of increasing scores, particularly for full treatment schools. Comparisons of effect sizes across sex for full treatment schools show that the EGRA Plus program had a larger impact on girls than boys as far as absolute gains. Since the control schools had such small impacts on boys, however, the final effect size column shows that the impacts were higher on boys than girls. In any case, the effect sizes for the full treatment program were greater than 0.63 SD for every section for boys and 0.45 SD for every section for girls. Therefore, the EGRA Plus project was not heavily skewed toward one sex or another. For light treatment schools, the program impacts also are close (by sex), with effect-size gaps between sexes at 0.15 SD or lower. In summary, the impact of the EGRA Plus program was relatively well distributed by sex, and the differentials were much larger in control schools than they were in either full or light treatment schools. It appears that in the control schools, girls learned much more than boys did. The EGRA Plus program was able to ameliorate the sex learning achievement gap to some extent.

Table 14: Program Impact, Baseline and Final Assessments, for Grade 2 and Grade 3, by Sex

			Baseline, Grade 2 + Grade 3			Final Assessment, Grade 2 + Grade 3			Program Impact					
Section	Treat.	Sex	*N*	Mean	SD	*N*	Mean	SD	Gains over Baseline	Increase over Control	Pooled SD	Percent Increase over baseline	Effect Size (SD)	Treat. Minus Control Effect Size
Letter naming fluency	Control	Male	524	61.73	25.51	311	80.14	23.46	18.41		24.74	29.82%	0.74	
		Female	453	59.27	24.82	389	84.01	25.10	24.74		24.92	41.74%	0.99	
	Full	Male	528	64.95	23.89	414	98.38	24.89	33.43	15.02	24.31	51.47%	1.38	0.63
		Female	399	58.83	25.74	453	99.81	23.32	40.98	16.24	24.45	69.66%	1.68	0.68
	Light	Male	577	63.64	25.56	432	88.64	24.95	25	6.59	25.28	39.28%	0.99	0.24
		Female	480	56.31	25.54	449	88.16	24.23	31.85	7.11	24.89	56.56%	1.28	0.29
Phonemic awareness	Control	Male	523	3.57	2.28	354	4.08	2.88	0.51		2.54	14.29%	0.20	
		Female	451	3.22	2.35	433	4.48	2.86	1.26		2.61	39.13%	0.48	
	Full	Male	528	3.57	2.29	433	6.05	2.75	2.48	1.97	2.51	69.47%	0.99	0.79
		Female	400	3.56	2.22	470	5.88	2.64	2.32	1.06	2.45	65.17%	0.95	0.46
	Light	Male	576	3.64	2.35	461	4.82	2.83	1.18	0.67	2.57	32.42%	0.46	0.26
		Female	481	3.32	2.22	478	4.91	2.74	1.59	0.33	2.49	47.89%	0.64	0.16

Section	Treat.	Sex	Baseline, Grade 2 + Grade 3			Final Assessment, Grade 2 + Grade 3			Program Impact					
			N	Mean	SD	*N*	Mean	SD	Gains over Baseline	Increase over Control	Pooled SD	Percent Increase over baseline	Effect Size (SD)	Treat. Minus Control Effect Size
Familiar word fluency	Control	Male	524	10.12	14.76	308	16.98	16.81	6.86		15.53	67.79%	0.44	
		Female	450	6.63	11.75	385	20.08	17.71	13.45		14.78	202.87%	0.91	
	Full	Male	521	11.53	14.96	395	34.25	22.36	22.72	15.86	18.50	197.05%	1.23	0.79
		Female	398	8.12	13.13	446	35.09	22.78	26.97	13.52	18.83	332.14%	1.43	0.52
	Light	Male	571	10.69	14.45	433	18.66	19.60	7.97	1.11	16.85	74.56%	0.47	0.03
		Female	475	7.46	12.93	444	21.05	20.89	13.59	0.14	17.22	182.17%	0.79	-0.12
Unfamiliar word fluency	Control	Male	521	2.37	6.15	321	2.03	7.95	-0.34		6.88	-14.35%	-0.05	
		Female	450	1.39	4.74	391	3.51	9.40	2.12		7.28	152.52%	0.29	
	Full	Male	526	3.14	6.91	396	13.66	17.17	10.52	10.86	12.39	335.03%	0.85	0.90
		Female	397	1.70	5.09	434	15.58	17.30	13.88	11.76	12.97	816.47%	1.07	0.78
	Light	Male	574	2.80	6.85	443	3.06	7.90	0.26	0.6	7.32	9.29%	0.04	0.08
		Female	475	1.70	5.33	456	3.62	8.23	1.92	-0.2	6.90	112.94%	0.28	-0.01
Oral reading fluency	Control	Male	521	20.43	20.01	282	23.93	25.60	3.5		22.10	17.13%	0.16	
		Female	451	15.27	18.26	371	25.85	25.35	10.58		21.72	69.29%	0.49	
	Full	Male	526	23.32	20.38	478	49.39	35.42	26.07	22.57	28.52	111.79%	0.91	0.76
		Female	400	17.65	19.73	436	49.25	32.47	31.6	21.02	27.10	179.04%	1.17	0.68
	Light	Male	570	21.46	20.44	411	27.32	29.83	5.86	2.36	24.78	27.31%	0.24	0.08
		Female	474	17.60	20.12	417	29.10	29.14	11.5	0.92	24.73	65.34%	0.47	-0.02
Reading compre-hension	Control	Male	521	25.14	23.82	282	29.42	33.14	4.28		27.42	17.02%	0.16	
		Female	451	21.82	23.73	371	32.78	33.23	10.96		28.38	50.23%	0.39	
	Full	Male	526	28.40	24.47	378	59.09	36.30	30.69	26.41	29.95	108.06%	1.02	0.87
		Female	400	22.55	23.87	436	59.24	35.00	36.69	25.73	30.16	162.71%	1.22	0.83
	Light	Male	570	27.51	24.09	411	32.96	35.19	5.45	1.17	29.23	19.81%	0.19	0.03
		Female	474	23.42	24.66	417	36.17	36.08	12.75	1.79	30.51	54.44%	0.42	0.03

Section	Treat.	Sex	Baseline, Grade 2 + Grade 3			Final Assessment, Grade 2 + Grade 3			Program Impact					
			N	Mean	SD	*N*	Mean	SD	Gains over Baseline	Increase over Control	Pooled SD	Percent Increase over baseline	Effect Size (SD)	Treat. Minus Control Effect Size
Listening compre-hension	Control	Male	525	33.68	21.39	332	67.74	32.39	34.06		26.17	101.13%	1.30	
		Female	453	31.66	21.70	405	70.35	32.30	38.69		27.19	122.20%	1.42	
	Full	Male	530	35.81	19.71	430	82.60	26.04	46.79	12.73	22.74	130.66%	2.06	0.76
		Female	400	30.60	20.31	469	84.18	23.08	53.58	14.89	21.82	175.10%	2.46	1.03
	Light	Male	577	35.30	19.77	453	70.44	32.02	35.14	1.08	25.86	99.55%	1.36	0.06
		Female	482	33.54	19.88	472	73.54	30.48	40	1.31	25.65	119.26%	1.56	0.14

12. Liberia Comparisons and Benchmarks

12.1 Comparisons with International Benchmarks

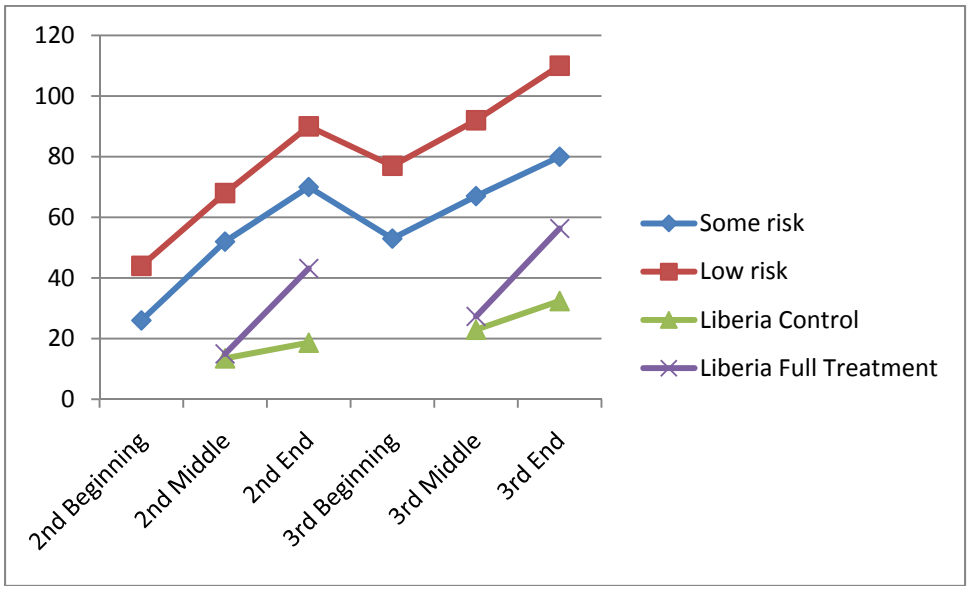
The findings in this report suggest that EGRA Plus had a significant impact on basic reading skills. The impact was large in size for full treatment schools, across the sections. For light treatment schools, the impacts were small or negligible. This section compares some aspects of oral reading fluency in Liberia (both control and full treatment schools) and the DIBELS benchmarks for oral reading fluency.[17]

In Figure 16, the blue line shows the DIBELS "some risk" benchmark for oral reading fluency, while the red line shows the DIBELS "low risk" benchmark. The comparisons for Liberia are from the final assessment for control and full treatment schools. Compared to control schools, although they were still within the "risk" zone, children in full treatment schools were significantly closer to the low-risk benchmarks from DIBELS. Notice that the slopes of the full treatment Liberia curves were more pronounced than the international benchmark curves, particular for Grade 3. In other words, children in the full treatment schools increased their oral reading fluency within grades more than international benchmark children did. Therefore, it appears that there is some "closing of the gap" within the full treatment program.[18]

[17] DIBELS stands for the Dynamic Indicators of Basic Early Literacy Skills and is the assessment format upon which much of EGRA is adapted. DIBELS comparisons are useful, because while they are specific to the United States context, they have well-developed benchmarks for oral reading fluency scores for children who are deemed to be either at some risk or low risk of experiencing reading difficulties. More information can be found at https://dibels.uoregon.edu/.

[18] This might be slightly misleading since the Liberian curves do not refer to individual children, rather to the comparison between the baseline (expressed at the middle point, since the assessment was taken in June) and the final assessment (expressed at the end point).

Figure 16: Oral Reading Fluency Scores Compared to International Benchmarks



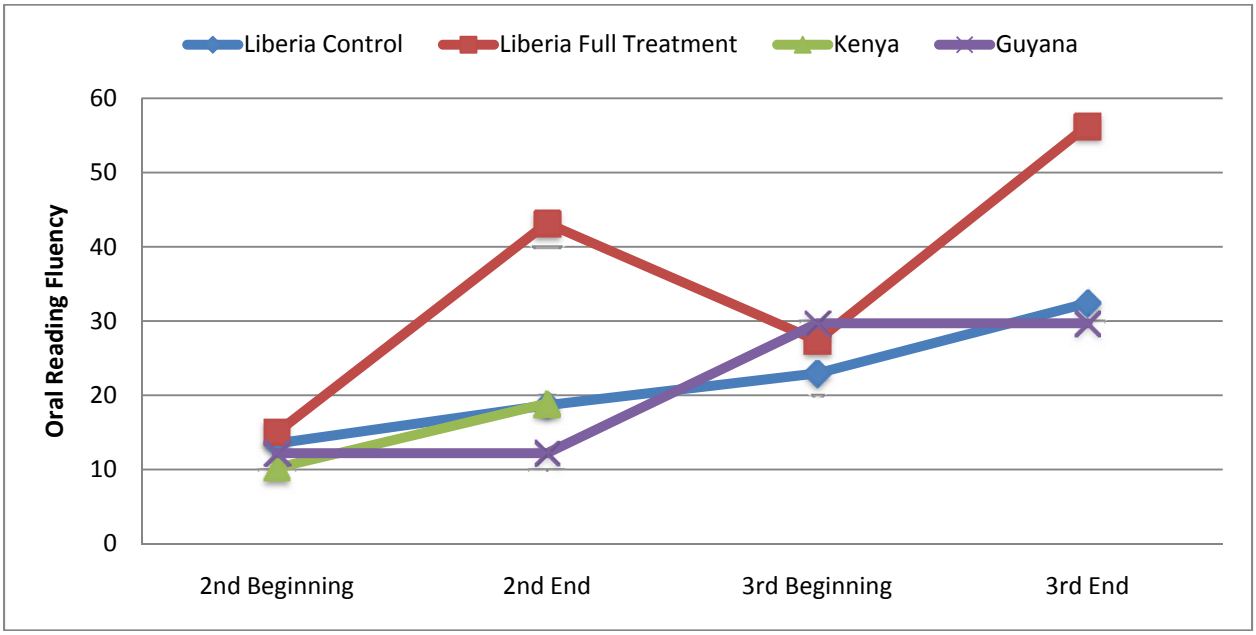
12.2 Comparisons with Kenya and Guyana

While the discussion above is interesting, and there is some value in comparing Liberian children to what is found in the United States DIBELS benchmarks, we felt that it might be even more valuable to compare Liberia's scores to the oral reading fluency scores in other developing countries, namely Kenya and Guyana. Note, however, that even this type of comparison is fraught with problems given the language differences and the local adaptation of EGRA in each country. Even in countries where English is assessed, the assessments can be quite different since each story is locally created. That said, it is still worth taking a look at the comparisons between students in different countries.

This comparison (Figure 17) showed that the Liberia control scores were very similar in level and slope to those in Guyana and Kenya. That is to say, they were reading at about the same levels and gaining approximately the same levels of fluency between the beginnings and ends of grade 2 and 3. The top (red) line shows the levels for children in Liberian full treatment schools. The dots for the beginning of grades 2 and 3 place children at the baseline squarely at the same levels of reading fluency as those in Liberian control schools and Guyanese and Kenyan schools. However, the 2nd End and 3rd End fluency scores for children in full treatment schools show a dramatic departure in both the absolute levels of reading fluency and the slope of the reading gains occurring between grade 2 beginning and grade 2 end (and the same comparisons between grade 3 beginning and end). While children in other countries and Liberian control schools were increasing their fluency levels by 5–10 words per minute within an academic year, full treatment children increased their scores by nearly 30 words per minute. In other words, the intense

EGRA Plus program was able to increase scores by a huge magnitude and with remarkable speed, even compared to experiments and projects in other locations.

Figure 17: Oral Reading Fluency Scores in Liberia Compared to Other Developing Countries

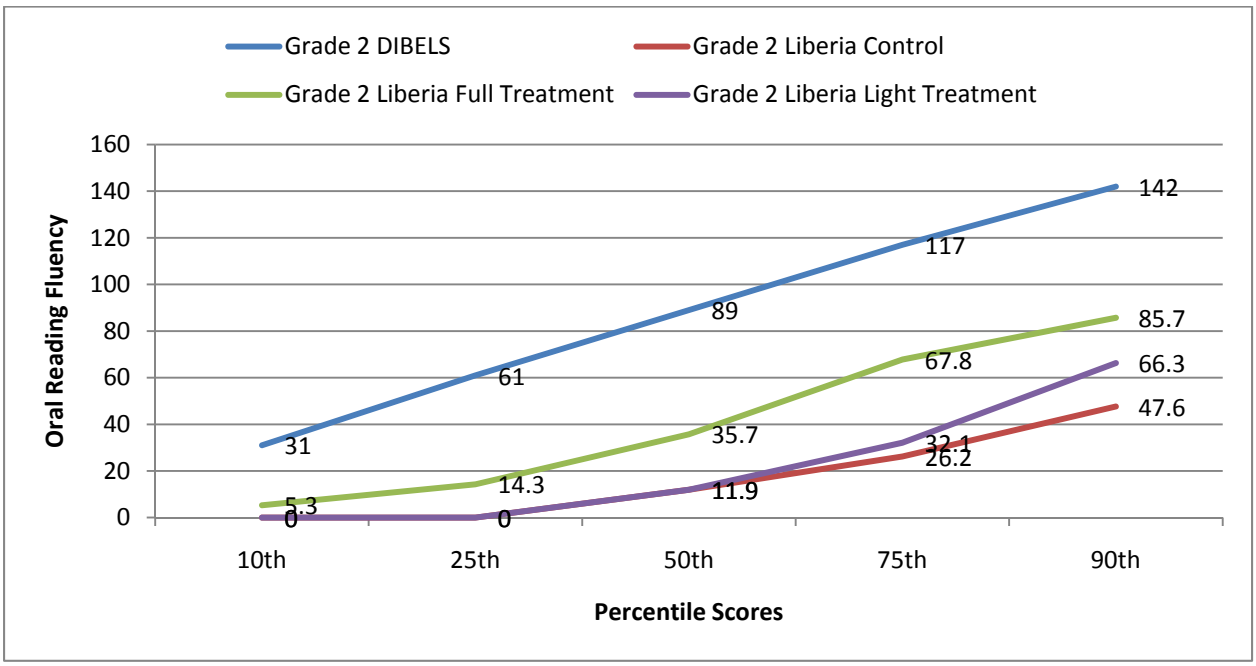


12.3 Percentile Score Comparisons with DIBELS

Figure 18 below shows Liberia's grade 2 and 3 student achievement in oral reading fluency across treatment groups against the grade 2 and 3 international benchmarks. Note that this figure is organized differently from the one above, and is an update of a similar figure in the midterm report. In Figure 18, the percentile scores relate to the distribution of scores within each data set. In other words, for the DIBELS scores (blue line), all of the children assessed are ranked by percentile, and this figure shows how they fall out, from the 10th, 25th, 50th, 75th, and 90th percentiles at the end of grade 2.

What this figure shows is that while the gaps between the 10th-percentile child in the control (red line) and light treatment schools (purple line) and the DIBELS children (blue line) are relatively smaller (31 words per minute), the gap increases rapidly across the distribution, such that children at the 75th and 90th percentiles are enormously far from what is found in end-of-grade 2 DIBELS scores from the United States. However, when we compare the full treatment scores (green line), the gaps are smaller at the 10th, 25th,

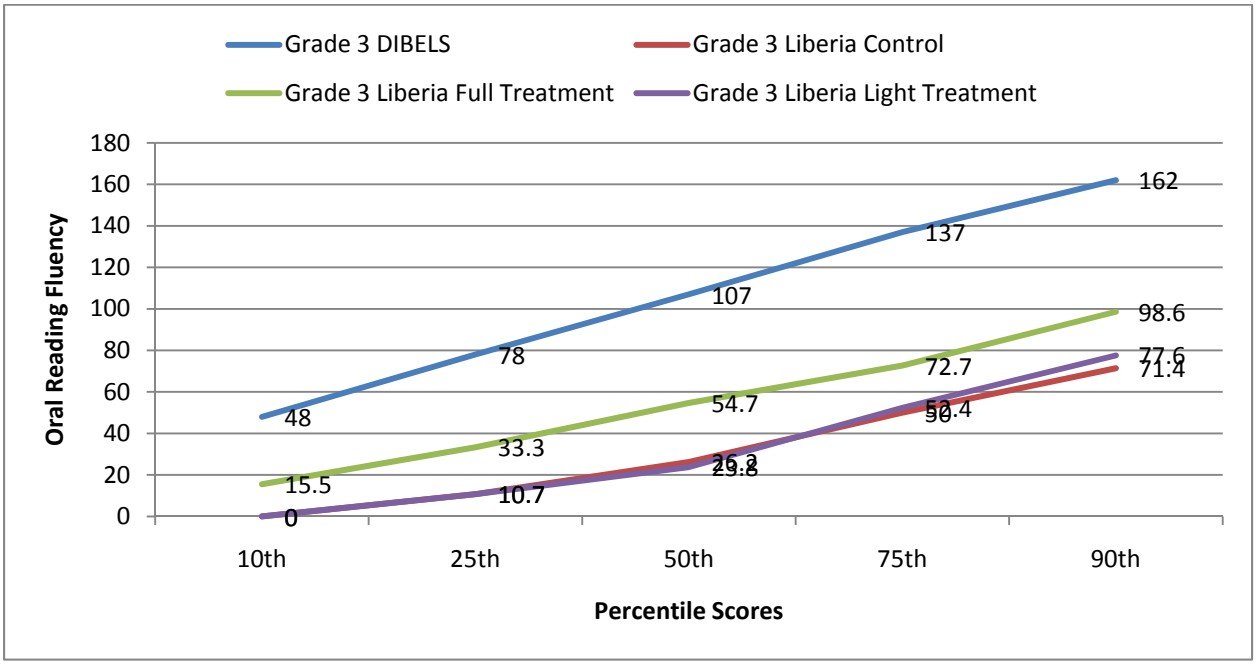
Figure 18*:* **Liberia Percentile Scores Compared to International Benchmarks in Grade 2**



50th and 75th percentiles; at the 75th percentile, the gap in oral reading fluency scores is less than 50 words per minute. The gap at the 90th percentile is more than 55 words per minute. This contrasts with other education-focused development projects that are able to limit the gaps between project schools and schools in the developed world at particular portions of the distribution. EGRA Plus, on the other hand, limited the gaps of its children and the international benchmarks from top to bottom (although the gap was largest at the top of the distribution). That said, it is important to note that EGRA Plus closed only half of the gap between the rest of Liberian schools and the international/U.S. benchmarks. The percentage differences were largest at the lower end of the distribution, as evident by the comparisons between the dark line (full treatment) on the one hand, and bottom two lines (control and light treatment) and the white line (DIBELS scores) on the other. This suggests that while the EGRA Plus program was effective for a significant percentage of children, it was less effective at the bottom of the distribution. Stated another way, while the program was quite effective, there remained a significant portion of children who were not affected by the focused instruction of EGRA Plus.

The grade 3 lines in Figure 19 below show a similar story. Note there are very minimal differences between the control and light treatment schools at each portion of the distribution, and that both sets of schools are very far from the DIBELS benchmarks (between 48 and 91 wpm). The treatment schools, on the other hand, are closer at the 10th (32.5 wpm) and 25th percentile (44.7 wpm). The gaps increase at the 50th (52.3 wpm), 75th (64.3 wpm), and 90th percentiles (64.4 wpm). This suggests that while EGRA Plus limited the gap by a great deal, quite large distances remained between student achievement in treatment schools and what is found in U.S. benchmarking exercises. The difference was largest at the bottom of the distribution, similar to what was found in the grade 2 discussion above. Thus, even with an effective program such as EGRA Plus, there remained a significant percentage of underperforming, basically non-reading students. One hypothesis is that this group represents the segment of the Liberian student population that struggles with instruction in English rather than in local languages. They might be able to be taught how to read, but the leap to reading in English proves difficult.

Figure 19: Liberia Percentile Scores Compared to International Benchmarks in Grade 3

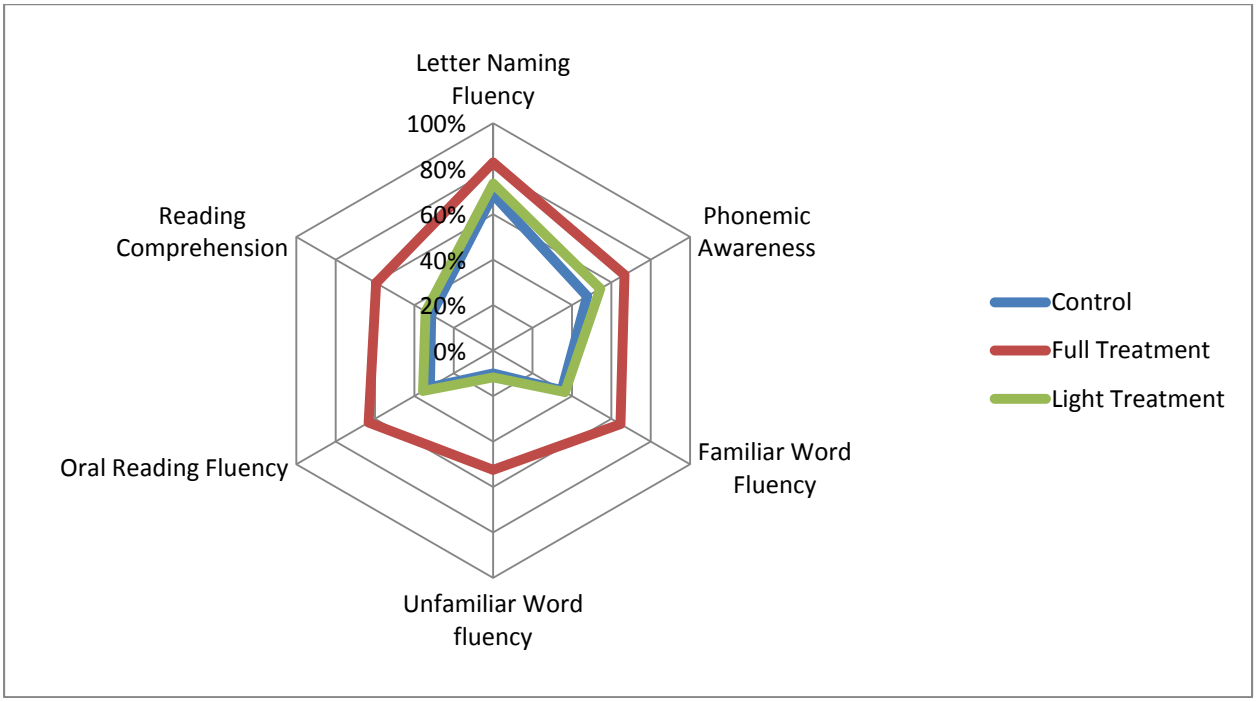


12.4 Liberian Benchmark Example

In the hopes of contributing to the discussion around the creation of a Liberian oral reading fluency benchmark, we created Figure 20 below and subsequently updated it from the midterm figure. This figure takes the 90th percentile of Liberia's distribution of children on several sections: letter naming fluency, phonemic awareness, familiar words, unfamiliar words, oral reading fluency, and reading comprehension. This 90th percentile

score is the "benchmark," then, and serves as the outward point on the radial plot. This was done to create a sort of Liberia-specific ideal for student achievement. Substantively, this means that 120 letters correct per minute, 9 sounds correctly identified, 54 familiar words read, 28 unfamiliar words read, 78.4 words read on connected text, and 100% reading comprehension were used as the target.[19] The blue (control), red (full treatment) and green (light treatment) lines show how closely each group of children was to meeting these targets. It is easy to see that the red children (full treatment) were closest to the targets in general, and the blue and green children (control and light treatment) were farthest away.

Figure 20: 90th Percentile of Liberian Benchmarks, Compared to Treatment Groups



Some other points are worth making here. For example, the differences were small between control and light treatment scores for familiar words, unfamiliar words, oral reading fluency, and reading comprehension. However, light treatment children performed slightly better at letter naming fluency and phonemic awareness. Note how weak the scores were for both of these groups on unfamiliar words, with outcomes less than 20% of the proposed benchmark. Scores were not much better for oral reading fluency or reading comprehension, with both light and control children scoring less than 40% of where these benchmarks were tentatively set. Full treatment children were much closer to the benchmarks than either of the other groups on each section. Of particular

[19] Note that these benchmarks are significantly higher than what was used for the midterm benchmarking figure. This is because the scores on average in the final assessment were much higher than those in the midterm.

interest is how close the full treatment scores were to the expected levels for letter naming fluency and phonemic awareness. Areas of improvement for the full treatment children are unfamiliar words, oral reading fluency, and reading comprehension.

13. EGRA Impact Analysis

Impact studies take a variety of forms and use different strategies to assess the impact of a program on student outcomes. In the sections that preceded this one, the report used simple tabulation analyses to determine whether the program had an impact on student achievement. This is acceptable, but regression models have a variety of benefits over the more simple comparison techniques, which were included to respond to the PMP. For example, the tests inherent in the models allow for an estimate of whether or not an individual predictor (sex or grade, for example) has a statistically significant impact on a particular outcome.

In addition, the research design of this particular study lent itself to an analytic method called differences-in-differences analysis. This type of analysis falls into the category of causal analytic methods, which use statistical techniques to estimate the actual causal impact of a program of interest. This technique uses the longitudinal and the treatment-and-control aspects of a research design to determine two things: (1) whether there are differences between the scores of treatment students before and after the intervention, and (2) whether those differences are distinct from the differences for control students before and after the intervention. It is also possible to determine whether the effects of the interventions are smaller or larger at the midterm or final assessment.

Performing this type of analysis requires creating a combined data set with the baseline, midterm, and final assessments. Children are identified either as baseline or midterm and as treatment or control. In this case, the analysis was slightly more complicated because there were two treatment groups. However, using a system of dummy variables in the regression analysis, one can estimate the effect of being in the midterm assessment, being in the light treatment or full treatment group, and then, critically, being in a treatment group *and* in the midterm assessment.

Finally, post-hoc General Linear Hypothesis (GLH) tests can compare whether the impact of the two treatment groups was equivalent; or, to put it another way, whether the full treatment program worked better than the light treatment program. The models below have several parameters or variables, which are defined here.

- Midterm – represents a child in the midterm baseline, as distinguished from the baseline or final.
- Final – represents a child in the final data set.
- Light treatment – represents a child in the light treatment group.
- Light Treatment*Midterm – identifies children who were in both the midterm and light treatment groups.

- Light Treatment*Final – identifies children who were in both the final and light treatment groups.
- Full treatment – represents children in the full treatment group.
- Full Treatment*Midterm – identifies children who were in the midterm and full treatment groups.
- Full Treat*Final – represents children who were in the final and full treatment groups.
- Sex (girl) – shows the effect of being a girl, compared to boys.
- Grade (3) – shows the effect of grade 3, compared to grade 2.
- Control Group – in this design, a constant variable that is the average score of a boy in grade 2 in the control group at the baseline.

13.1 General Findings

This set of models shows that the full treatment program had a statistically significant impact on student achievement on all of the sections at both the midterm and final assessment. Light treatment had an impact on letter naming fluency, oral reading fluency, reading comprehension, and listening comprehension at the midterm, and on letter naming fluency at the final assessment. The models also show that there were no statistically significant sex differences except for familiar words and unfamiliar words (favoring girls), and grade 3 children outperforming grade 2, as one would expect.

13.1.1 Letter Naming Fluency

This model (see Table 15)[20] shows that both the full and light treatment programs had an effect on achievement in letter naming fluency, and at both midterm and the final assessment. Children in the control group scored 54.7 letters, with children at the midterm (rather than baseline) assessment scoring 10.5 letters higher, and children in the final assessment reading 21.7 letters higher. This shows a quite marked increase in letter reading among control schools, and the fact that the final assessment was so much higher than the midterm suggests that the secular trend was quite substantial. More research is necessary to determine the cause and whether experimental leakage contributed to it. The main effect of being in a full treatment group (regardless of baseline or midterm) was 2.0 letters more (full) and no difference for light treatment. Critically, the causal effect of being a child in a light treatment group was an additional 12.5 letters per minute at midterm and 6.0 letters at the final assessment. The effect of being a child in a full

[20] Note that these analyses were performed using a differences-in-differences model using reg command in Stata. This allowed us to use the beta coefficients ooption, using the listcoef command. The outcomes are very similar whether xtreg is used (to account for the clustering in schools) or reg with a cluster option. Similarly, the findings are very similar when the sample is limited to schools (175) that were in each of the three rounds of data collection. The findings presented here, therefore, are very robust to model specification and sampling decisions.

Table 15: Differences-in-Differences Regression Analysis for Letter Naming Fluency

Section	Predictor	Coef-ficient	Std. Error	*T*	Sig.	Effect Size (SD)	Obser-vations	*F*	Sig.	R^2
Letters naming fluency	Midterm	10.5	1.1	9.2	*<.001*					
	Final	21.7	1.2	17.8	*<.001*					
	Full Treatment	2.0	1.1	1.7	.08					
	Light Treatment	.0	1.1	0.0	.98					
	Full Treat*Mid	13.1	1.6	8.1	<.001	0.46				
	Full Treat*Final	14.8	1.7	8.7	<.001	0.52				
	Light Treat*Mid	12.5	1.6	7.9	<.001	0.44				
	Light Treat*Final	6.0	1.7	3.6	<.001	0.21				
	Grade (3)	12.1	0.5	22.1	*<.001*					
	Sex (Boy)	-0.1	0.5	-0.1	.93					
	Control Group	54.7	0.9	62.2	*<.001*		8096	287.85	<.001	.26

GLH Test (Full Treat*Mid - Full Treat*Final = 0): *F* 0.99, *p* value = .34. Therefore, there was no difference in the magnitude of the impact of full treatment between baseline and midterm and between midterm and final assessment.

GLH Test (LightTreat*Mid - Light Treat*Final = 0): *F* 14.58, *p* value <.001. Light treatment had a larger impact at the midterm than at the final.

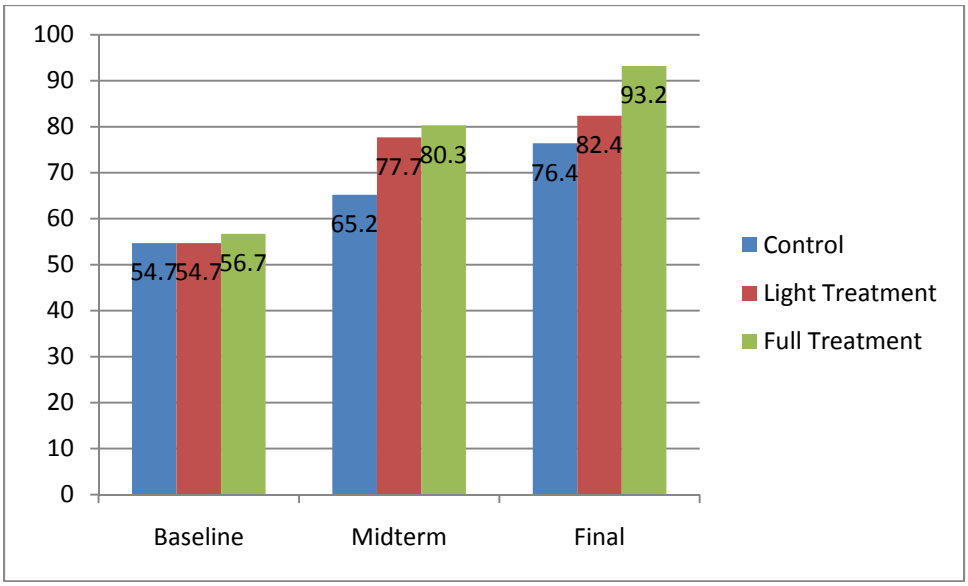
GLH Test (Full Treat*Mid - Light Treat*Mid = 0): *F* .16, *p* value <.001. Full treatment had the same impact as light treatment at mid-term.

GLH Test (Full Treat*Final - Light Treat*Final = 0): *F* 29.24, *p* value <.001. Full treatment had a larger post-intervention impact than light treatment.

treatment group was 13.1 letters per minute at midterm and 14.8 letters at the final assessment. In other words, both treatment groups increased student achievement in letters, and at both the midterm and final assessment. The GLH tests (combined with the standardized coefficients) show that the midterm impacts were larger for light treatment (0.44 SD) than final impacts were (0.21 SD), but that there was no difference between midterm (0.46 SD) and final (0.52 SD) for full treatment.[21] The impact was larger at the midterm for full treatment than for light, and the same was true at the final assessment. The model does a reasonably good job of predicting achievement on letter naming fluency, since the R^2 is .26. If one notes that the grade impact was 12.1 letters per minute, then being in the full treatment group had an impact larger than the grade effect; namely, the full treatment "bumped children up" 1.2 grade levels in performance (assuming the grade 2 to grade 3 difference was linear).

Figure 21 below shows the impact of the treatment groups graphically. Note that at baseline, children in full treatment schools read within 2 letters per minute of the baseline, and at both midterm and final assessments they were the highest scoring by a significant margin. The fact that the control scores were higher at the final assessment than at the midterm shows that there remained a secular trend of improvement that our analyses must account for (and do). At both midterm and final, the light treatment and full treatment programs increased children's letter naming fluency with the impact of full treatment slightly more than that of light treatment.

Figure 21: Histograms Comparing Impact of Light Treatment (red) and Full Treatment (green) Programs on Letter Naming Fluency



[21] Using standardized coefficients, this regression analysis is able to determine the effect size of light and treatment groups at both midterm and final. This is found in the effect size (SD) column of Table 16.

13.1.2 Phonemic Awareness

Table 16 below identifies the impact of the full and light treatments on student achievement in phonemic awareness. The main effects for midterm were that children identified 0.42 sounds more at midterm than at baseline, and an additional 0.91 sounds at the final. The midterm effect suggests a grade learning curve, but the final effect suggests a secular trend in improving phonemic awareness across the sample. In this section, the model shows that the light treatment group had modest impacts on phonemic awareness, 0.36 sounds at mid-term (*p* value <.01) and 0.44 sounds at the final (*p* value <.001). For the full treatment group, on the other hand, the program increased student achievement by 0.47 sounds at the midterm (*p* value <.01) and 1.47 sounds at the final assessment (*p* value <.001). The pattern is the same as for the letter naming fluency section, with no difference by gender (*p* value .58) and grade 3 more than grade 2 (0.79 sounds). The effect sizes for full treatment were small at the midterm (0.18 SD) and moderately large at the final assessment (0.55 SD), and the entire model explains 10% of the variation in phonemic awareness. Note that being in the full treatment group meant an effect of 2.9 times the grade effect; the project "bumped up" the children nearly 2 grades (assuming the grade 2 to grade 3 difference was linear).

13.1.3 Familiar Word Fluency

For familiar words, the main effects at both midterm and final (Table 17) were that all children in the entire sample increased their fluency at midterm (4.8 wpm) and at final (10.2 wpm). Girls outperformed boys by 0.7 wpm and grade 3 children read better than grade 2 (7.9 wpm). The differences-in-differences analysis shows that light treatment had no statistically significant impact on achievement at either midterm (*p* value .18) or final (*p* value .81). Full treatment schools did not increase achievement at the midterm (*p* value .58), but increased by 14.3 words per minute at the final assessment (*p* value <.001). The effect size for full treatment at the final assessment was 0.78 SD. The R^2 for the final model was .21, which is larger than for phonemic awareness. The project "bumped up" the children by 1.8 school years in familiar word fluency.

13.1.4 Unfamiliar Word Fluency

Table 18 presents the relationships between the predictors and unfamiliar word fluency. It shows that there was no difference between baseline and midterm on this variable, and children in the final assessment read 0.9 words per minute more than those at the baseline. The analysis shows that full treatment increased unfamiliar words read per minute by 0.4 words at midterm (*p* value .07) and 11.2 words at the final assessment (*p* value <.001). Effect sizes were 0.11 SD and 1.23 SD, respectively. For light treatment, there was no impact at midterm (*p* value .54) or final (*p* value .92). The entire model has

Table 16: Differences-in-Differences Regression Analysis for Phonemic Awareness

Section	Predictor	Coef-ficient	Std. Error	*T*	Sig.	Effect Size (SD)	Obser-vations	*F*	Sig.	R^2
Phonemic awareness	Midterm	0.42	.12	3.63	<*.001*					
	Final	0.91	0.12	7.46	<*.001*					
	Full Treatment	0.16	0.12	1.39	.17					
	Light Treatment	0.10	0.11	0.86	.39					
	Full Treat * Mid	0.47	0.17	2.83	<.01	0.18				
	Full Treat*Final	1.47	0.17	8.64	<.001	0.55				
	Light Treat * Mid	0.36	0.16	2.24	.03	0.14				
	Light Treat*Final	0.44	0.17	2.64	<.01	0.17				
	Grade (3)	0.79	0.06	14.34	<*.001*					
	Sex (Boy)	-0.03	0.06	-0.56	.58					
	Control Group	3.04	0.09	33.69	<*.001*		8351	96.64	<.001	.10

GLH Test (Full Treat*Mid - Full Treat*Final = 0): *F* 34.14, *p* value <.001. The impact of full treatment was larger at final than at midterm.

GLH Test (Light Treat*Mid – Light Treat*Final = 0): *F* 0.21, *p* value .65. There is no difference in the impact of light treatment between mid-term and final assessment.

GLH Test (Full Treat*Mid - Light Treat*Mid = 0): *F* 0.42, *p* value .51. There is no difference in the impact of full and light treatment at mid-term.

GLH Test (Full Treat*Final - Light Treat*Final = 0): *F* 39.13, *p* value <.001. Full treatment had a larger impact at final than did light treatment.

Table 17: Differences-in-Differences Regression Analysis for Familiar Word Fluency

Section	Predictor	Coef-ficient	Std. Error	*T*	Sig.	Effect Size (SD)	Obser-vations	*F*	Sig.	R^2
Familiar word fluency	Midterm	4.8	0.8	6.3	*<.001*					
	Final	10.2	0.8	12.4	*<.001*					
	Full Treatment	1.6	0.8	2.1	*.03*					
	Light Treatment	0.9	0.7	1.2	*.24*					
	Full Treat * Mid	0.6	1.1	0.6	.58	0.03				
	Full Treat*Final	14.3	1.1	12.6	<.001	0.78				
	Light Treat * Mid	1.4	1.1	1.3	.18	0.08				
	Light Treat*Final	0.3	1.1	0.3	.81	0.01				
	Grade (3)	7.9	0.4	21.5	<.001					
	Sex (Boy)	-0.7	0.4	-1.8	.07					
	Control Group	5.0	0.6	8.6	*<.001*		8022	214.54	<.001	.21

GLH Test (Full Treat*Mid - Full Treat*Final = 0): *F* 142.44, *p* value <.001. Therefore, the magnitude of the impact of full treatment between midterm and final assessment was larger than between baseline and midterm.

GLH Test (Full Treat*Final - Light Treat*Final = 0) F 167.14, p-value <.001. The impact of full treatment was larger than the impact of light treatment at final.

Table 18: Differences-in-Differences Regression Analysis for Unfamiliar Word Fluency

Section	Predictor	Coef-ficient	Std. Error	*T*	Sig.	Effect Size (SD)	Obser-vations	*F*	Sig.	R^2
Unfamiliar word fluency	Midterm	-0.3	0.4	-0.7	*.49*					
	Final	0.9	0.4	2.2	*.03*					
	Full Treatment	0.6	0.4	1.7	.10					
	Light Treatment	0.4	0.4	1.2	.25					
	Full Treat * Mid	0.4	0.5	1.8	.07	0.11				
	Full Treat*Final	11.2	0.6	19.5	<.001	1.23				
	Light Treat * Mid	0.3	0.5	0.6	.54	0.04				
	Light Treat*Final	0.1	0.6	0.1	.92	0.01				
	Grade (3)	1.4	0.2	7.8	*<.001*					
	Sex (Boy)	-0.5	0.2	-2.8	<.01					
	Control Group	1.5	0.3	5.0	*<.001*		8057	169.40	<.001	.17

GLH Test (Full Treat*Mid - Full Treat*Final = 0): *F* 308.39, *p* value <.001. Therefore, the magnitude of the impact of full treatment between mid and final assessment is larger than between baseline and midterm.

GLH Test (Full Treat*Mid - Light Treat*Mid = 0): *F* 1.48, *p* value .22. There is no difference in the impact of full and light treatment at mid-term.

GLH Test (Full Treat*Final - Light Treat*Final = 0): *F* 410.07, *p* value <.001. The impact of full treatment is larger than the impact of light treatment at final.

an R^2 of .17, a bit less than for familiar word fluency. GLH testing shows that the full treatment program had a larger impact at final than at midterm. The program impact was a massive eight times larger than the impact of a year's worth of schooling (11.2 over 1.4). Since this impact was so huge, one hesitates to say how many grades it is equivalent to, since it is risky to say that the grade effect would be linear or nearly linear over such a large gain.

13.1.5 Oral Reading Fluency

The differences-in-differences analysis for oral reading fluency (Table 19) shows that there was, once again, a main effect for the midterm (3.4 words per minute) and final assessments (7.1 words per minute). There was no difference by sex (*p* value .94), and grade 3 children read 11.3 words per minute more than grade 2 children. The model shows that the light treatment program increased oral reading fluency by 3.9 words per minute (0.15 SD) at the midterm, but it had no impact at the final assessment (*p* value .52). The full treatment had a small effect at the midterm (5.0 words per minute, 0.19 SD) and a large effect at the final assessment (21.1 words per minute, 0.80 SD). These are impressive results, particularly at the final assessment. The post-hoc GLH test shows that the impact of full treatment was bigger at the final assessment than at the midterm. The tests also show that the full treatment had a larger impact than light treatment at the midterm. The model had an R^2 of .16. As with the other EGRA sections, being in full treatment was equivalent to roughly two years of schooling, "bumping up" the children about two grade-equivalents in reading fluency.

Table 19: Differences-in-Differences Regression Analysis for Oral Reading Fluency

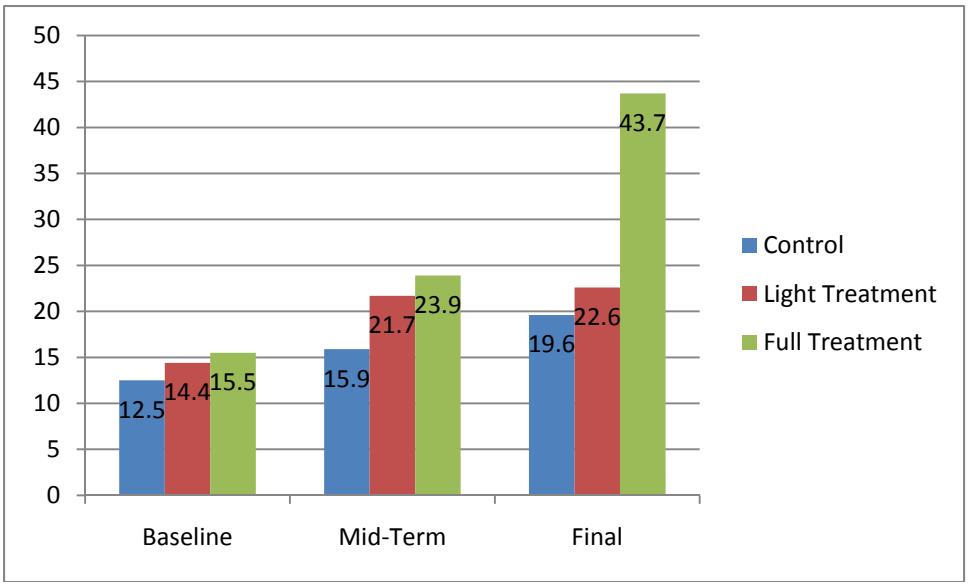
Section	Predictor	Coef-ficient	Std. Error	*T*	Sig.	Effect Size (SD)	Obser-vations	*F*	Sig.	R^2
Oral reading fluency										
	Midterm	3.4	1.1	3.0	*<.01*					
	Final	7.1	1.2	5.8	*<.001*					
	Full Treatment	3.0	1.1	2.7	<.01					
	Light Treatment	1.9	1.1	1.8	.08					
	Full Treat * Mid	5.0	1.6	3.1	<.01	0.19				
	Full Treat*Final	21.1	1.7	12.4	<.001	0.80				
	Light Treat * Mid	3.9	1.6	2.5	.01	0.15				
	Light Treat*Final	1.1	1.7	0.7	.52	0.04				
	Grade (3)	11.3	0.5	20.7	*<.001*					
	Sex (Boy)	-0.1	0.5	-0.1	.91					
	Control Group	12.5	0.9	14.3	*<.001*		7867	144.59	<.001	.16

GLH Test (Full Treat*Mid - Full Treat*Final = 0): *F* 86.83, *p* value <.001. Therefore, the impact of full treatment at final was larger than at midterm.

GLH Test (Light Treat*Mid - Light Treat*Final = 0): *F* 2.75, *p* value .10. The impact of light treatment was larger at the mid-term than at the post assessment.

Figure 22 below shows graphically the impact of full and light treatment on oral reading fluency. When we examine the midterm scores, first it is clear that both light treatment (red bars) and full treatment (green bars) increased oral reading fluency by a significant margin when compared to control (blue bars). When we compare the final assessment, the light treatment had a non-significant impact on oral reading fluency. This suggests that the secular trend increases on oral reading fluency were significant. The full treatment program had an enormous impact on oral reading fluency, causing scores that were more than twice as high as those for control and nearly twice as high as light treatment.

Figure 22: Bar Chart Showing the Impact of Full (green) and Light (red) Treatment on Oral Reading Fluency



13.1.6 Reading Comprehension

For the reading comprehension sections, the main effects for midterm and final assessment (Table 20) show that children performed 1.4% worse on the midterm than at the baseline (though insignificant statistically) and better by 7.9% at the final (*p* value <.001). There were no differences by sex (*p* value .95), and children in grade 3 understood better by 12.3% than grade 2 children (*p* value <.001). The full treatment model increased comprehension by 4.7% at the midterm (0.15 SD) and 25.2% at the final assessment (0.82 SD). Light treatment had no impact at midterm (*p* value .34) or at final assessment (*p* value .74). The GLH tests show that full treatment had a larger impact at final than at midterm. Similar to the oral reading fluency model, the R^2 for the reading comprehension was .15. A child who was in the EGRA Plus program benefited from more than two years of typical grade progression in oral reading fluency.

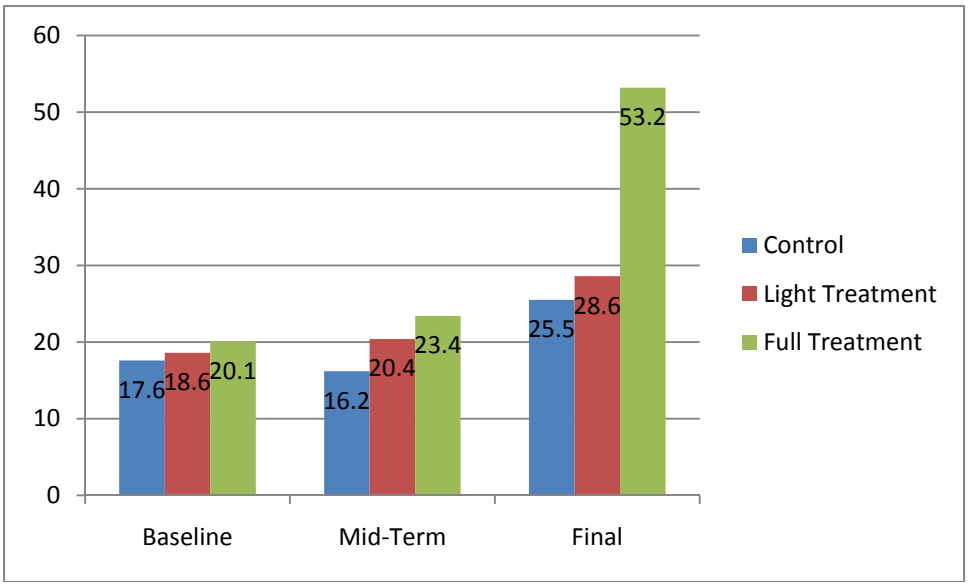
Table 20: Differences-in-Differences Regression Analysis for Reading Comprehension

Section	Predictor	Coef-ficient	Std. Error	*T*	Sig.	Effect Size (SD)	Obser-vations	*F*	Sig.	R^2
Reading Comprehension										
	Midterm	-1.4	1.3	-1.1	*.29*					
	Final	7.9	1.4	5.5	*<.001*					
	Full Treatment	2.5	1.3	1.9	.06					
	Light Treatment	2.4	1.3	1.9	.06					
	Full Treat * Mid	4.7	1.9	2.5	.01	0.15				
	Full Treat*Final	25.2	2.0	12.7	<.001	0.82				
	Light Treat * Mid	1.8	1.8	1.0	.34	0.06				
	Light Treat*Final	0.7	2.0	0.3	.74	0.02				
	Grade (3)	12.3	0.6	19.2	*<.001*					
	Sex (Boy)	-0.0	0.6	-0.1	.95					
	Control Group	17.6	10	17.2	*<.001*		7867	142.52	<.001	.15

GLH Test (Full Treat*Mid - Full Treat*Final = 0): *F* 103.20, *p* value <.001. Therefore, the magnitude of the impact of full treatment between mid and final assessment is larger than between baseline and midterm.

Figure 23 below investigates the impact of full and light treatment on reading comprehension. When we examine the midterm scores, first it is clear that both light treatment and full treatment increased reading comprehension by a modest amount (larger for full treatment). When we compare the final assessment, the light treatment had a non-significant impact on reading comprehension. This suggests that the secular trend increases on reading were significant, just as the trend was for oral reading fluency. The full treatment program had an enormous impact on reading comprehension, causing scores that were more than twice as high as those for control and nearly twice as high as light treatment.

Figure 23: Bar Chart Showing the Impact of Full (green) and Light (red) Treatment on Oral Reading Fluency



13.1.7 Listening Comprehension

Finally, for listening comprehension (Table 21), the model shows that full treatment increased scores by 9.8% at midterm and 13.1% at the final assessment, and light treatment increased the scores at midterm by 8.1% and had no effect at the final assessment. The model explains a large percentage of the variation, with an R^2 of .38.

Table 21: Differences-in-Differences Regression Analysis for Listening Comprehension

Section	Predictor	Coef-ficient	Std. Error	*T*	Sig.	Effect Size (SD)	Obser-vations	*F*	Sig.	R^2
Listening comprehension	Midterm	35.1	1.2	28.5	*<.001*					
	Final	36.5	1.3	28.2	*<.001*					
	Full Treatment	1.0	1.2	0.8	.42					
	Light Treatment	1.9	1.2	1.6	.11					
	Full Treat * Mid	9.8	1.7	5.6	<.001	0.29				
	Full Treat*Final	13.1	1.8	7.3	<.001	0.39				
	Light Treat * Mid	8.1	1.7	4.8	<.001	0.24				
	Light Treat*Final	0.8	1.8	0.4	.66	0.02				
	Grade (3)	7.4	0.6	12.6	*<.001*					
	Sex (Boy)	-0.0	0.6	-0.1	.93					
	Control Group	29.2	0.9	30.9	*<.001*		8215	501.23	<.001	.38

GLH Test (Full Treat*Mid - Full Treat*Final = 0): *F* 3.43, *p* value .06. Therefore, there was no difference in the magnitude of the impact between baseline and midterm and between midterm and final assessment at the .05 level.

GLH Test (Full Treat*Mid - Light Treat*Mid = 0): *F* .94, *p* value .33. Therefore, there was no difference in the impact of full and light treatment at midterm.

This section of the report shows quite clearly that EGRA Plus: Liberia had a remarkably large impact on student achievement, particularly for the full treatment group. This impact was large enough to overcome the secular trend identified at the midterm (probably the grade learning effect) and the larger trend at the final assessment (which will require more research to fully understand). These impacts were consistently large, nearing one standard deviation for many of the critical areas. As explained earlier, note that the design of the differences-in-differences models allows for an investigation of the effect size of the program's impact as measured by final (or midterm) against baseline, and removes the gains in the control groups. The results are quite similar to what was identified by the simpler Cohen's *d* effect size analysis presented above.

13.2 Interacting EGRA Plus with Sex, Age, and Grade

In order to determine whether the sex, age, or grade of the children had a differential effect on student outcomes, we fit additional multiple regression models.[22] First, models were fit to determine whether there was a main effect for age when we controlled for grade. This would answer the question of whether the grade effect would differ for children who were at different ages. Accounting for age is particularly important for a country like Liberia, which has a significant portion of the student population entering school late, due to unrest; or having delays in their schooling, due to the civil war.

We tested this in four ways. First, we used the child's absolute age as a predictor. These models show that, controlling for grade, older children scored statistically significantly lower on all sections assessed except letter naming fluency, phonemic awareness and unfamiliar word fluency. This was less than ideal, since the regression model did not manage the wide variation in ages well (ages 5 through 27). Second, we created a variable that converted the child's age to age in relation to the expected age at that particular grade. That is, we used a variable that was a 1 for a child who was 10 in grade 2 (the expected age was 8 or 9), for example. The fits for these models were better than those using the absolute age. The findings were similar: Every year older than the expected age was statistically significantly negatively correlated with every section except letter naming fluency and unfamiliar word fluency. Third, we created a dummy variable that combined all of the children who were overage for their grade into one group, and compared those to students who were at the expected age or below. This was our preferred specification since there was no reason to think that there should be a substantive difference between a learner who was 20 and one who was 25, for example. These models show that overage children actually were more fluent with letter reading, by 1.8 letters per minute (*p* value .04). They read 1.7 fewer familiar words per minute (*p* value <.01), read aloud 2.7 fewer words per minute of connected text (*p* value <.01), and scored 2.1% lower on reading comprehension (*p* value .03). There was no relationship for

[22] The models are not presented here due to space constraints.

phonemic awareness or listening comprehension.[23] The fourth and final way we assessed the relationship between age and reading outcomes was to examine whether EGRA Plus: Liberia had a differential effect for overage and non-overage children. There were not many statistically significant relationships, which shows that the program was equally effective across ages.[24] Note that all of these models control for grade, as well. This shows that within a grade, or classroom, children who were overage know the alphabet better, but perform less well on the other tasks. The EGRA Plus program did not discriminate with respect to its impact on student achievement.

The models presented above showed little sex differentiation as a main effect. Boys did worse than girls on familiar and unfamiliar word fluency. Another issue is relevant, of course: whether EGRA Plus had a differential effect for boys and girls. Recall that boys did worse at the baseline on many assessments. We found that the program did have a differential effect by sex for a few sections. Girls benefited more on letter fluency at midterm in light schools by 5.5 letters per minute. Boys benefited more in full treatment schools at the final assessment in phonemic awareness, increasing their scores by 1.9 words rather than 1.0 words for girls (p value <.05). For all of the midterm and the rest of the final assessment sections, and for all of the light treatment effects, there were no differences in program impact by sex. This sex differential likely was related to the underachievement of boys at the baseline, but does merit further analysis.

We also fit several models to determine whether EGRA Plus increased the reading of grade 2 or grade 3 children more. We found no differences in the EGRA Plus outcomes for either full or light treatment, at either midterm or final assessment. Only one model had a statistically significant difference. EGRA Plus light treatment increased the letter naming fluency by 4.7 more letters per minute for Grade 3 children than Grade 2. For the rest of the models, however, there were no statistically significant differences between the impact of the program by grade.

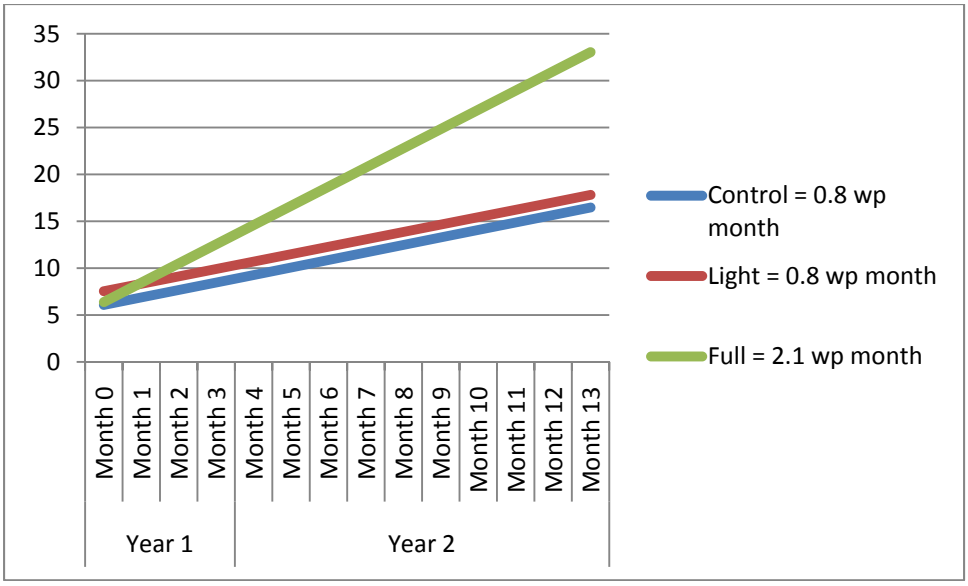
[23] We also fit models that compared children who were underage against the rest of the sample. The relationships were insignificant, except that underage children scored lower on listening comprehension. This makes sense, since younger children would have had less exposure to spoken language.

[24] Two models did have statistically significant interactions between program effects and overage children. Specifically, at midterm, EGRA Plus increased the scores of overage children by 13.5 more letters per minute. At the final assessment, EGRA Plus increased the scores of overage children by 3.0 unfamiliar words per minute less.

13.3 Learning Rate Increases

We felt it would be interesting to determine not only the absolute impact of the program, but also the learning trend over the duration of the program. Therefore, we fit causal models that investigated the month-by-month learning gains by treatment group (control, light treatment, and full treatment) over the life of the program.[25] Figure 24 below presents the monthly slope of learning gains for familiar words. The control schools increased familiar word fluency by an estimated 0.8 words per month, light treatment schools increased word fluency by 0.8 words per month, and full treatment increased outcomes by 2.1 words per month. This means, therefore, that the learning rate for full treatment schools was 2.6 times faster than that of children in control schools, confirming the points made above regarding program impact as compared to average gain between grades. While full treatment schools started at fluency rates below that of light and control schools, the final assessment scores were significantly higher.

Figure 24: Learning Rates for Familiar Words Comparing Control, Light, and Full Treatment Schools Over the Two Years of EGRA Plus



[25] These models were fit by giving the baseline data a value of 0, the midterm data a value of 3, and the final data a value of 13. This equates to the number of months that the program "taught" children. This analysis makes an assumption of linear monthly gains, however, which is likely not true. Moreover, the analysis ignores the summer reading loss that has been shown in a great deal of reading acquisition literature. It is useful, however, as a visual to estimate the effect of the treatment programs against the control schools. To simplify the figures, the grade effect is controlled for, as is gender. The main effects of midterm and final are also controlled for.

Figure 25 below presents the learning rates by month for unfamiliar word fluency, by treatment groups. It shows that the learning gains were very shallow for both light and control schools, with children in those schools gaining almost no fluency with decoding of new words. For full treatment schools, on the other hand, the learning rates were 1.1 words per month. While modest in absolute terms, this represents a rate 11.9 times faster for full treatment children than for those in control schools.

Figure 25: Learning Rates for Unfamiliar Words Comparing Control, Light, and Full Treatment Schools Over the Two Years of EGRA Plus

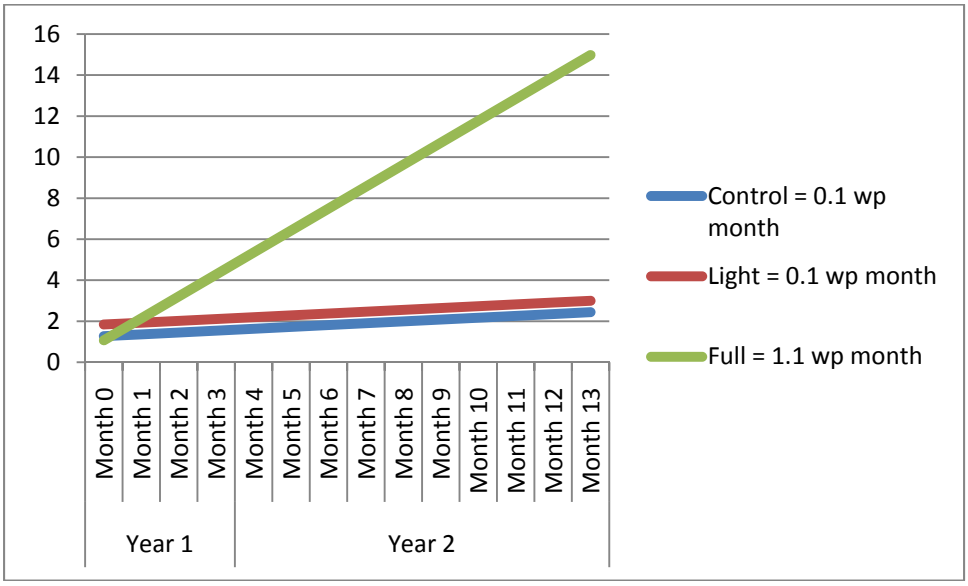
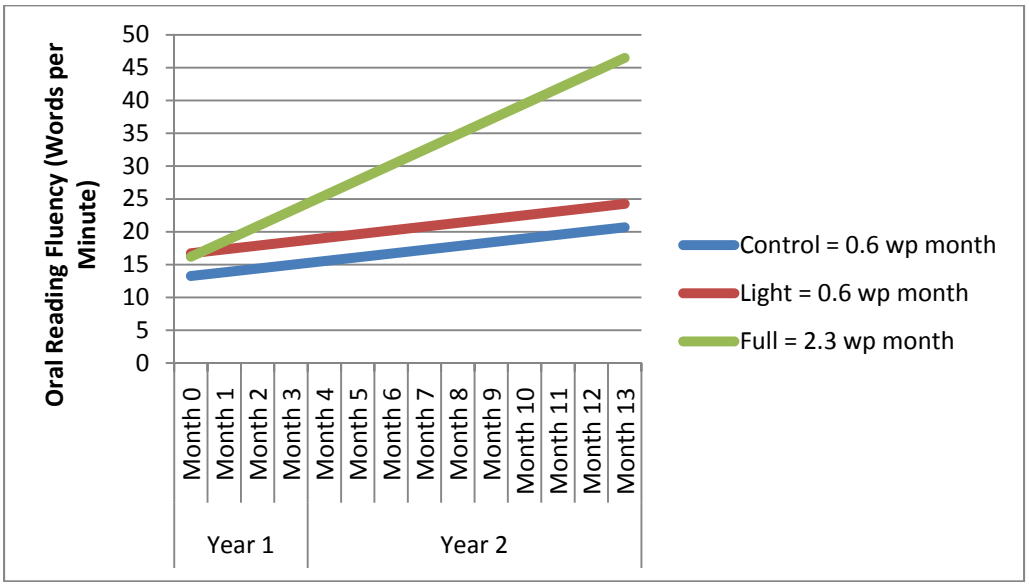


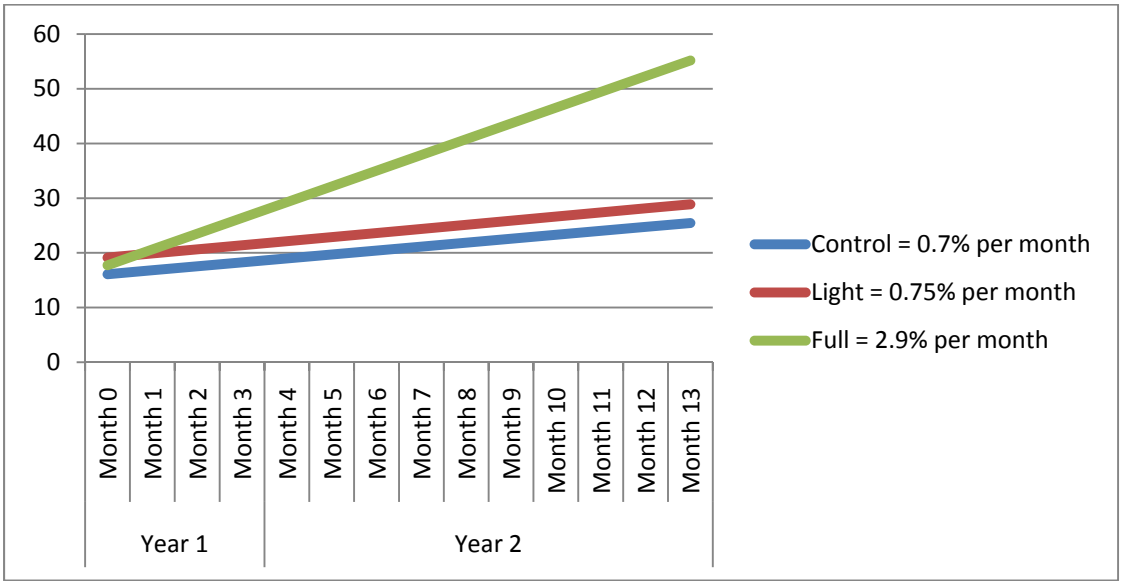
Figure 26 below presents the learning rates by month for oral reading fluency by treatment groups. While more steep than the slopes identified in the unfamiliar word analysis, the impact of the program on learning rates was still quite significant, since the word per minute learning rates for control (0.6 words per minute) and light schools (0.6 words per minute) were much slower than those for full treatment. This means that children learned to read 4.1 times faster in full treatment than control schools.

Figure 26: Learning Rates for Oral Reading Fluency Comparing Control, Light, and Full Treatment Schools Over the Two Years of EGRA Plus



In order to compare the learning rates for reading comprehension across treatment groups, we analyzed the data to determine the learning rates by year, in Figure 27. It shows that children in control and light treatment schools increased their comprehension scores by 0.7% and 0.75% per month, respectively, while full treatment increased by 2.9% per month. This shows that children in full treatment schools were learning at a rate of four times more per month than their counterparts in control schools.

Figure 27: Learning Rates for Reading Comprehension Comparing Control, Light, and Full Treatment Schools Over the Two Years of EGRA Plus



13.4 Effect Sizes from Differences-in-Differences Analyses

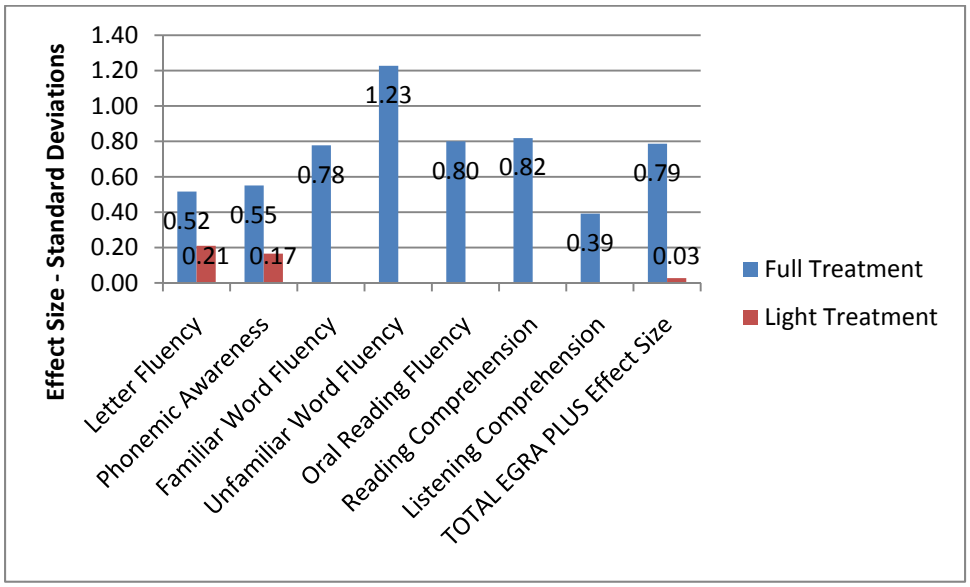
Table 22 below takes the parameter estimates of the regression models from above and summarizes the program effects at the final assessment. The column on the far right, effect size, presents the standardized coefficients from the differences-in-differences analysis presented above for the final assessment. For full treatment, we found large effects for familiar words (0.78 SD), unfamiliar words (1.23 SD), oral reading fluency (0.80 SD), and reading comprehension (0.82 SD). We found moderate effects for letter naming fluency (0.52 SD), phonemic awareness (0.55 SD) and listening comprehension (0.39 SD).For light treatment, most sections found no impact. However, small impacts were found for letter fluency (0.21 SD) and phonemic awareness (0.18 SD).

Table 22: Differences-in-Differences Effect Sizes and Program Effects

Section	Treatment Group	Program Effect	*p* value	Effect Size
Letter naming fluency (per minute)	Light	6.00	<.001	0.21 SD
	Full	14.75	<.001	0.52 SD
Phonemic awareness (of 10)	Light	0.44	<.01	0.18 SD
	Full	1.47	<.001	0.55 SD
Familiar word fluency (per minute)	Light	0.27	.81	*No effect*
	Full	14.32	<.001	0.78 SD
Unfamiliar word fluency (per minute)	Light	0.06	.91	*No effect*
	Full	11.19	<.001	1.23 SD
Oral reading fluency (per minute)	Light	1.09	.52	*No effect*
	Full	21.13	<.001	0.80 SD
Reading comprehension (%)	Light	0.66	.74	*No effect*
	Full	25.21	<.001	0.82 SD
Listening comprehension (%)	Light	0.77	.66	*No effect*
	Full	13.14	<.001	0.39 SD

In Figure 28 below, the effect sizes for each section are presented by treatment group. Recall that these would be much higher if a basic effect size calculation were performed, since those effect sizes do not remove the impacts from the control schools. These much more conservative estimates are remarkable because of their magnitude. Overall, using a conservative estimate of effect size, the overall full treatment effect size is 0.79 SD.[26] Light treatment had a negligible impact on achievement (0.03 SD). This appears to have been because the scores at the final assessment were significantly higher in the control schools, for a reason that requires further research.[27]

Figure 28: Effect Sizes by Full and Light Treatment and by EGRA Sections



13.5 Other Predictors

In this section, we discuss more regression models that we fit to estimate the impact of a variety of student-level predictors on reading outcomes; these are presented in Table 23. Note that the list of models fit here was determined by the strength of the Pearson's correlation as matched to the entire set of student background characteristics and student outcomes. We used simplified models, combining full and light treatment schools, for parsimony and to save degrees of freedom. In all these models, oral reading fluency was the outcome variable. The other estimates are not shown, but in each case the program is shown to have had a statistically significant impact on student achievement.

[26] This effect size weighting procedure was devised by Dr. Luis Crouch and Dr. Marcia Davidson. Letter fluency was 5%, phonemic awareness was 10%, familiar words was 15%, oral reading fluency was 50%, reading comprehension was 25%, and listening comprehension was 10% of the total effect.

[27] Note that it is possible that treatment leakage occurred, and was responsible for the large increases in baseline schools. On the other hand, it is possible that other shifts occurred in the Liberian education sector during the period of EGRA Plus. More research is necessary to examine this more in depth.

Table 23: Regression Analyses by Student Background Predictors

Model	Section	Predictor	Coef-ficient	Std. Error	*T*	Sig.	Confidence Interval	
							Lower	Upper
I	Oral reading fluency	Grade 3	11.42	0.57	19.72	<.001	10.29	12.56
II	Oral reading fluency	Someone reads aloud at home	13.49	1.35	10.01	<.001	10.85	16.13
III	Oral reading fluency	Teacher never practices letters	-17.20	1.44	-11.93	<.001	-20.03	-14.37
IV	Oral reading fluency	Teacher never lets child read aloud	-8.69	1.32	-6.56	<.001	-11.29	-6.09
V	Oral reading fluency	Teacher often lets child read aloud	12.89	1.32	9.74	<.001	10.30	15.49

These models show several interesting things. In Model I, the main effect for grade shows that children in grade 3 read 11.4 words per minute more than the average child in grade 2. This is similar to the grade gains in other countries. Model II estimates the impact of having someone read aloud to the child at home. The coefficient is a remarkable 13.5 words per minute. Model III shows that children whose teachers did not ever practice letters read 17.2 words per minute less than those whose teachers did practice. This shows that even letter fluency is related to word reading fluency. Models IV and V show that teachers allowing children to read aloud made a significant difference. If the child's teacher never let them read aloud, they read 8.7 words less per minute, and if they frequently read aloud, they read 12.9 words more per minute.

13.6 EGRA Plus Impact on Early Grade Mathematics Assessment

Although mathematics was not a part of the intervention assessed in this report, RTI and USAID felt that it would be of interest to investigate whether EGRA Plus had knock-on effects, such as increased pedagogical prowess across subjects on the part of teachers; or whether increased facility with reading would allow children to better understand the mathematics content that they were taught. This section presents a snapshot of mathematics achievement across the three groups of schools (full treatment, light treatment, and control).

Table 24 below presents the results of an Early Grade Mathematics Assessment disaggregated by treatment status (intervention group). A substantive (rather than statistical) investigation of the results shows that children in the full treatment group scored higher than both control and light treatment children on all of the EGMA sections: specifically number identification, quantity discrimination, missing numbers, addition fact fluency subsection 1, addition fluency subsection 2, subtraction fluency subsection 1, subtraction fluency subsection 2, multiplication scores, and fractions problem-solving.

Light treatment schools outperformed control schools on quantity discrimination, addition fluency subsection 1, addition fluency subsection 2, multiplication, and fractions problem-solving, so they outperformed control schools on only five of the nine sections.

Table 24: Early Grade Mathematics Assessment Results, by Treatment Group

	Control			Full Treatment			Light Treatment		
Section	*N*	Mean	Standard Deviation	*N*	Mean	Standard Deviation	*N*	Mean	Standard Deviation
Number identification	749	15.38	4.66	889	15.98	4.31	944	14.88	5.14
Quantity discrimination (per minute)	612	0.86	1.51	720	1.59	2.44	778	1.15	1.92
Missing number (raw)	753	3.22	1.01	891	3.24	1.09	945	3.20	1.15
Addition 1 per minute	751	6.68	4.36	891	7.54	4.93	943	6.90	4.41
Addition 2 per minute	750	4.39	16.25	891	5.79	19.53	942	4.31	9.75
Subtraction 1 per minute	748	4.91	3.25	891	5.38	3.47	943	4.87	3.40
Subtraction 2 per minute	746	2.16	3.58	889	2.39	2.60	941	2.02	2.32
Multiplication (number correct)	745	0.65	1.40	889	0.89	1.52	942	0.78	1.42
Fractions (number correct of 6 items, %)	808	4.52	14.68	891	10.19	21.86	943	9.31	21.26

A simple comparison such as the one in Table 24 above does not have the statistical power to determine whether there were systematic differences between EGMA scores by treatment group, since it does not indicate whether the differences between groups were small enough to be due to chance. Therefore, we fit multiple regression models, controlling for grade and sex, to determine (1) whether the differences in means between the treatment group and control were statistically significant, (2) the magnitude of those differences, and (3) the effect size of the differences (if any). The results of this analysis are in Table 25 below:

- For number identification, full treatment children outscored control children by 0.64 items correct (*p* value .003) for a small effect size of 0.14 SD. Light treatment children, on the other hand, scored 0.39 items lower than control, although at the .10 level of significance.
- For quantity discrimination, both full (*p* value <.001) and light treatment groups (*p* value .004) had higher fluency scores than control children by 0.72 and 0.28 numbers correct, with effect sizes of 0.34 and 0.16 SD.
- There was no statistically significant difference for missing numbers for either full treatment (*p* value .58) or light treatment (0.94) children.

- In the first addition subsection, full treatment children were more fluent (*p* value <.001) by 0.89 items per minute (effect size 0.19 SD), while there was no difference for light treatment children. The differences were not significant on the second addition subsection either.
- For the simpler subtraction subsection, full treatment children did better by 0.5 problems per minute (*p* value <.001) for an effect size of 0.15 SD. The treatment groups made no difference for the second, more complex subtraction problems.
- For multiplication, both treatment groups had higher achievement by 0.25 and 0.14 problems correct (0.17 and 0.10 SD for full treatment and light treatment, respectively).
- Fractions felt a moderate impact from full treatment (0.31 SD) and a small impact from light treatment (0.26 SD), with children in full treatment schools scoring 6.0% higher while light treatment children did 5.0% better than control children (*p* values <.001).

In short, it appears that EGRA Plus had inconsistent and small impacts on mathematics achievement for light treatment children, but consistent although still small impacts on full treatment children. It must be noted that without a pre and post analysis, using these EGMA outcome measures, it would be difficult to say whether the changes that we have identified in this analysis were due to the reading intervention, or to differences in mathematics achievement that occurred prior to the EGRA Plus program administration, or to a combination of the two.

However, given that full treatment schools scored lower than the light treatment and control schools on most EGRA sections at baseline, it is less likely that the achievement of full treatment schools was lower in reading but higher in math before EGRA Plus commenced in 2008. Thus, it seems probable that the EGRA intervention had a noticeable effect on children's mathematics achievement. Whether this was due to an overall accountability effect, to an overall time-on-task effect, or to the fact that cognitive skills all tend to work together and help each other, is impossible to say without further analysis.

Table 25: Early Grade Mathematics Assessment Regression Results, Controlling for Grade and Sex

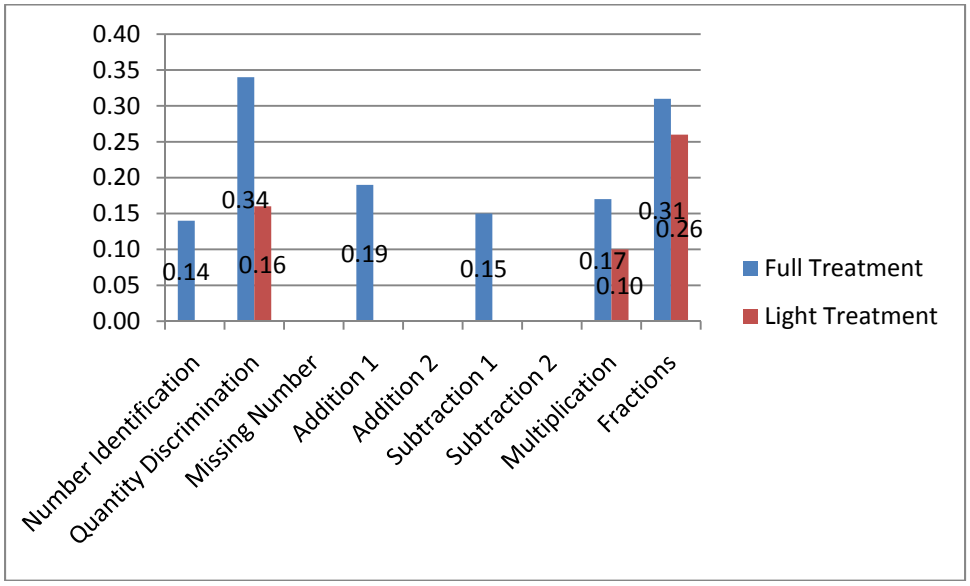
Section	Treatment Group	Coeffi-cient	Std. Error	*T*	Sig.	Confidence Interval		Effect Size (SD)	R^2
						Lower	Upper		
Number identification	Full	0.64	0.22	2.98	.003	0.22	1.07	0.14	.09
Number identification	Light	-0.39	0.23	-1.69	.09	-0.86	0.06	-0.08	.09
Quantity discrimination (per minute)	Full	0.72	0.12	6.19	<.001	0.49	0.94	0.34	.04

Section	Treatment Group	Coeffi-cient	Std. Error	*T*	Sig.	Confidence Interval		Effect Size (SD)	R^2
						Lower	Upper		
Quantity discrimination (per minute)	Light	0.28	0.10	2.90	0.004	0.09	0.47	0.16	.01
Missing number	Full	0.03	0.05	0.64	.52	-0.07	0.14	0.03	.00
Missing number	Light	-0.01	0.05	-0.18	.86	-0.12	0.10	-0.01	.00
Addition 1 (per minute)	Full	0.89	0.23	3.90	<.001	0.44	1.33	0.19	.06
Addition 1 (per minute)	Light	0.26	0.21	1.24	.21	-0.15	0.68	0.06	.05
Addition 2 (per minute)	Full	1.42	0.93	1.53	.13	-0.40	3.24	0.08	.00
Addition 2 (per minute)	Light	-0.09	0.66	-0.13	.90	-1.38	1.21	0.00	.00
Subtraction 1 (per minute)	Full	0.50	0.16	3.03	<.01	0.18	0.82	0.15	.06
Subtraction 1 (per minute)	Light	0.01	0.16	0.08	.94	-.31	0.33	0.00	.03
Subtraction 2 (per minute)	Full	0.21	0.16	1.37	.17	-.09	0.52	0.07	.01
Subtraction 2 (per minute)	Light	-0.15	0.15	-1.00	.32	-.44	0.14	-0.05	.01
Multiplication	Full	0.25	0.07	3.33	<.01	0.10	0.39	0.17	.01
Multiplication	Light	0.14	0.07	1.93	.05	-0.00	0.27	0.10	.01
Fractions (%)	Full	5.95	0.96	6.19	<.001	4.07	7.84	0.31	.03
Fractions (%)	Light	4.98	0.94	5.32	<.001	3.15	6.82	0.26	.02

To investigate these relationships further, we produced the following effect sizes. Figure 29 shows the magnitude of the relationship the EGRA Plus program had with student achievement in mathematics. Note that the relationships were strongest in quantity discrimination and fractions, and modest in number identification, addition 1, subtraction 1, and multiplication. In social science research, particularly education research, effect sizes in the range of 0.20 and above are non-negligible and are evidence of a quite successful program on student achievement.

The question for further research, then (as already noted), is what occurred in the EGRA Plus program to increase mathematics achievement without any intervention whatsoever on the subject. Moreover, it would be useful to investigate the implications of these findings for the mechanisms by which the EGRA Plus program had such large impacts on reading achievement.

Figure 29: Effect Sizes on Early Grade Mathematics Assessment Outcomes



It is a useful (although speculative) thought exercise to examine what mechanisms could have increased the mathematics achievement in this study (that is, if one accepts that the results above are evidence of a program effect of EGRA Plus). Mathematics achievement in general is related, clearly, to reading and comprehension skills. One mechanism might be internal to the children: that is, if children were more skilled in reading (decoding) and understanding what they read, they might do better in mathematics as well since they would now able to understand mathematics text. If that is the case, than we would expect that reading outcomes would predict student achievement in mathematics.

On the other hand, the program might have knock-on effects. It is conceivable that if EGRA Plus trained teachers to teach better,[28] or if they acquired mastery of particular pedagogical techniques as a result of EGRA Plus, or if the frequent visits from the literacy Coaches encouraged better teaching across subjects, then it would be the teachers' improved pedagogy (as a result of EGRA Plus) that was responsible for the improvements in mathematics outcomes. The question of interest, then, is whether the increased reading ability of students increased outcomes, or whether it was teachers' improved pedagogy in mathematics. Of course, it is surely not as dichotomous as this example, in that the causal mechanisms likely emanated from some combination of those two (and a myriad of other) factors.

The quantitative data available allow a simple exploration of these issues, however. Cognizant that this must be supplemented by further in-depth analysis, Table 26 presents R^2 scores from a variety of multiple regression models. The first column presents the outcome variable, the second the portion of variation explained by scores on oral reading fluency, the third the variation explained by models with both oral reading fluency (ORF) and listening comprehension (LC), and the fourth simple models that include the variables indicating the treatment groups.

The findings show that models with oral reading fluency predict more of the variation than do models with listening comprehension. Oral reading fluency is indicative of reading skills (and in many principal components analyses loads heavily as the main predictor of underlying reading achievement), while listening comprehension is more related to oral vocabulary. It appears that children's skills in reading were more predictive of their skills in mathematics than were their oral vocabulary skills, which makes sense given the domains that mathematics skills depend on. The fourth column makes the same point another way: In combination with with oral reading fluency, listening comprehension did not predict much more of mathematics skills than did an oral reading fluency model only (comparing column 3 to column 1). The fifth column includes models with variables indicating full and light treatment groups. This predicted very little of the variation in mathematics outcomes. The sixth column portrays the outcomes of regression models with treatment groups as well as oral reading fluency. Compared to models with just ORF (column 2) the models did not add much to the predictive power except for the quantity discrimination and fraction sections.

Interpretation of this table must proceed cautiously since the study was not designed to determine the causal mechanisms for increased mathematics achievement, but only to examine whether there were differences in achievement by group. That said, it appears that the models do not do a particularly good job predicting mathematics outcomes.

[28] The mechanism of change could have been subtly different at the teacher level, of course, since it might have been the motivational aspects of having Coaches, District Education Officers, and directors more heavily involved in the pedagogical process that encouraged teachers to teach better. That assumes, however, that the teachers already had the skills to teach better, but motivation caused them not to do so. This is again a matter of further research, but for this report suffice it to say that this analysis examined all of the factors (skills, motivation, attendance, etc.) internal to or impinging on teachers.

Where the models are predictive, they depend on oral reading fluency (a child's skill with reading) slightly. Number identification, addition, and subtraction seem to have been related to reading skills, at least somewhat. Note that the treatment groups only increased the predictive power of the models for the fraction and quantity discrimination sections. These might have been more dependent on the improved methods that the teachers gained as a result of the EGRA Plus program.

One interpretation of these findings is that if an increase in student skills was the mechanism by which the mathematics achievement increased, then it likely was not restricted to that which could be measured by oral reading fluency. It appears, then, that EGRA Plus was able to increase student skills beyond the areas that the program intended.

On the other hand, the evidence suggests that at least some of the impact of EGRA Plus on mathematics achievement was as a result of unmeasured (read: nonreading) factors. That is because the predictive power of models with treatment group predicted almost none of the variance. In fact, the two sections whose variation was somewhat predicted by treatment group (quantity discrimination and fractions) might have been the two sections that depended on student comprehension and reading the most.

Table 26: Multiple Regression R^2 Results by Model

Section	Oral Reading Fluency (ORF)	Listening Compre-hension (LC)	ORF + LC	Treatment Groups	Treatment Groups + ORF
Number identification	0.147	0.056	0.162	0.010	0.149
Quantity discrimination (per minute)	0.004	0.000	0.006	0.020	0.031
Missing number	0.008	0.000	0.009	0.000	0.010
Addition 1 (per minute)	0.148	0.031	0.151	0.007	0.150
Addition 2 (per minute)	0.018	0.004	0.018	0.002	0.018
Subtraction 1 (per minute)	0.128	0.038	0.136	0.006	0.131
Subtraction 2 (per minute)	0.076	0.025	0.082	0.002	0.078
Multiplication	0.046	0.007	0.046	0.004	0.048
Fractions (%)	0.007	0.005	0.010	0.018	0.020

In summary, the quantitative data do not allow for a clear understanding of the mechanism by which EGRA Plus increased mathematics achievement. It appears that some sections, particularly quantity discrimination and fractions, were somewhat

sensitive to the types of pedagogical improvements engendered by EGRA Plus. The rest of the sections improved when children could read more successfully, but it remains unclear how and why EGRA Plus increased the scores of the other sections.

Regardless of mechanism, the fact that EGRA Plus increased mathematics achievement, even moderately, is an important finding. Whether it was through increased reading skills or by improved pedagogy or accountability is unclear but also not necessarily relevant. What matters is that the program increased children's ability to learn new skills and teachers' ability to teach new subjects, even if those skills or topics were never explicitly addressed by the program. In other words, increased facility with reading helped children in other topics. This is a very exciting finding from the perspective that reading skills are foundational to other skill sets—that is, learning basic reading skills can transfer across subject area. Nonetheless, the fact remains that the impact from focused pedagogy, as made evident by the specific focus on reading in the full treatment schools, swamps any generalized effects or approaches.

Thus, while these small to moderate increases to mathematics skills might have been due to general pedagogical improvements, clearly the rest of the reading improvements were due to specific skill improvements among teachers; that is, it was not just a general improvement in teaching. It is, instead, evidence that teachers now know how to better teach particular and specific skills in reading. This skill improvement in teaching of reading is also an important finding: It is possible to use modest investments in pedagogical improvement to make trained and untrained teachers more capable pedagogically, with evidence in particular student outcomes. This is a remarkably different approach than much of the recent emphasis on what is normally taken as student-centered and/or learner-centered pedagogy in many reform or improvement projects (but is in most cases only a superficial application of these concepts). These programs often argue that increasing a teacher's general pedagogic skill set (in the areas of classroom management, student-centered pedagogy, etc.) will improve student outcomes across subject areas. That is likely true, to some extent, but EGRA Plus was effective because it taught teachers *particular skills* and other topics (such as learner assessment focused on those skills) and the application of those particular skills increased achievement, quite dramatically.

14. Further Research

The very large effect sizes experienced with EGRA Plus: Liberia suggest the need for further research to better understand the impact of the program on student achievement. Specifically, we suggest the following.

- **Examine more closely the change mechanisms at work in EGRA Plus.** The mechanisms that were responsible for the large impact sizes identified in this program warrant further investigation. That is to say, the EGRA Plus program was so successful that other programs and countries, and scale-up within Liberia

itself, would benefit from investigating the reasons for the success of the project. Section 3.3 above presented a detailed discussion of causal influences, but post-hoc qualitative research is necessary to more adequately explain what happened to make the program quite so successful.

- **Understand the increases in reading outcomes in non-EGRA Plus schools.** EGRA Plus: Liberia showed that the control schools had significant gains both between the baseline and midterm assessments and between the midterm and final assessments. The relationship between baseline and midterm is easily explained as the learning effect of a grade, since baseline was in November 2008 and midterm was in June 2009. The significant increases between June 2009 and June 2010 for control schools are much more difficult to explain, since the learning effect is not the reason. Further research is necessary to determine whether this midterm-to-final-assessment effect was related to EGRA Plus (via some form of leakage) or whether it was due to changes in the literacy efforts in Liberia. (Note that even if unintended leakage to the control schools were revealed, this would be in itself an important finding.)
- **Understand the sex gap in the program effects.** A consistent pattern was identified in the results: While EGRA Plus increased reading outcomes for children across all the measures, effect sizes were larger for girls than for boys in most of the EGRA sections. This is partially because initial scores were lower for girls than for boys, yet it is not clear how the gender dynamic was mitigated by EGRA Plus, or whether it created achievement differences in the opposite direction.
- **Examine the relationship between math and improved reading.** One of the unexpected effects of EGRA Plus was the manner in which it improved mathematics outcomes for children. While EGRA Plus had no specific intervention in mathematics, the treatment program increased outcomes in mathematics by small to moderate amounts, with particularly sizeable gains in the number-sense portions of early mathematics achievement, namely number identification, quantity discrimination, and fractions. Modest gains were identified in addition, subtraction, and multiplication, as well. The mechanism by which this increase occurred is unclear, so further research is necessary to determine whether EGRA Plus increased mathematics scores by helping children read better (allowing for deeper understanding of the mathematics assessment), or whether general improvements to pedagogical quality engendered by EGRA Plus transferred from reading to mathematics. The size of the effects means that the reason for the relationships needs further study and clarification.
- **Examine the cost-effectiveness of EGRA Plus.** The analyses presented in this paper allow for an understanding of whether the EGRA Plus program worked. However, it is less obvious how cost effective EGRA Plus was. Finding out will require deeper analysis of the inputs from the program. Our analysis shows that,

given that EGRA Plus had the approximate effect of an additional two years of reading, the cost-effectiveness question is quite stark: What is the value of two years of schooling?

15. Recommendations

This final assessment report takes stock of the effectiveness of the EGRA Plus program. The discussion of the findings explains how EGRA Plus worked, and suggests several interventions and strategies that might be undertaken to sustain and replicate the findings.

- **Scale up EGRA Plus: Liberia.** The EGRA Plus program was remarkably effective. While control schools increased their reading outcomes over baseline by a significant amount at midterm (due to the grade learning effect) and at the final assessment (due to other improvements in the education sector or to program leakage), the program increased reading outcomes by nearly 1 standard deviation. This is a large effect size and is convincing evidence that the package of interventions in EGRA Plus should be replicated and expanded. The Liberia Teacher Training Program second phase (LTTP2) program could serve as an incubator for further interventions, and for an examination of whether the initial, and remarkable, increases from EGRA Plus can be replicated at scale. USAID agreed that beginning in January 2011, under LTTP2, the EGRA Plus program will be extended to all 180 schools, including control and light intervention schools. Beyond LTTP2, however, it appears that the rest of Liberia's children are likely to benefit greatly from this project. As a result, and given that the lesson plans and systems outcomes are already prepared, the government of Liberia should seriously consider whether the strategy could be scaled up to the rest of the country, resources allowing.
- **Move past focus on letters and words and focus on reading comprehension.** The gains on all of the EGRA outcomes were substantial and reading comprehension scores increased by nearly 1 standard deviation. That said, the reading comprehension scores, even at the full assessment, did not reach the expected level of proficiency. The full treatment children's ability to comprehend was highly correlated with their increased skills in oral reading fluency. However, the effect was not as large as it would have been if more emphasis had been placed on encouraging and developing children's metacognitive skills, including their ability to predict, categorize, and analyze events and situations in written text. This is evident given the gap in achievement between listening comprehension and reading comprehension. In other words, children could understand much more of what they heard than what they read. This shows that the children have the oral vocabulary to understand more of what they read. These skills must be explicitly taught and modeled.

- **Task the Liberian Ministry of Education with developing country-level benchmarks for reading.** Our research provides examples of benchmarks—that is, using the 90th percentile of reading scores as a benchmark. That measure was arbitrarily chosen by a non-Liberian evaluator, and was picked without an evaluation of the appropriate skills that each level of child will achieve based on the curriculum. Such a benchmark development process would help to streamline reading intervention efforts, and allow for within-country, rather than cross-country, comparisons.
- **Target reading pedagogical techniques in teacher professional development.** The findings showed that Liberian teachers were sensitive to the intervention in this program. This suggests that with targeted efforts, and with the use of achievement data at the classroom and school level, teachers can improve how they teach children to read. We recommend that this finding be exploited in the Liberian Ministry of Education's efforts to train teachers at the pre-service and in-service levels. In other words, the targeted efforts used in a small project such as EGRA Plus should be replicated in in-service teacher professional development and adapted to the pre-service professional development.
- **Place considerably more emphasis on within-grade achievement.** While comparisons to international benchmarks are not ideal, Liberian children's progress within a grade was too modest to allow children to achieve reading fluency by grade 4 when most instruction is provided under the assumption that children can already read. If the grade 2 (beginning to end) gain in oral reading fluency is only 4 words on average, and grade 3 gains are nearly 2.5 words in control or standard Liberian schools (but 10 words per minute in full treatment schools), then children are not getting enough within a grade to be able to lessen the gaps between themselves and children elsewhere, even within sub-Saharan Africa.
- **Improve the achievement of girls in Liberian reading.** The baseline data showed that boys outperformed girls across the EGRA sections. This is dissimilar from the gender relationships identified in most other sub-Saharan African countries with EGRA studies. Under EGRA Plus, on the other hand, girls outperformed boys in many of the sections at the *final* assessment. What this shows is that girls can perform quite well under the right instructional conditions. This finding should influence how teachers teach girls. With the perspective that girls can achieve quite well if taught properly, then head teachers, communities, and higher education officials can and should demand high achievement for girls in the classrooms under their jurisdiction.
- **Move beyond community knowledge of reading achievement to teach the more complex aspects of reading.** The light treatment impacts on children showed that simply intensifying the community's focus on reading outcomes improved student outcomes. This was particularly the case in letter naming

fluency. However, for the more technical aspects of reading that depend on decoding and comprehension strategies—such as reading comprehension, oral reading fluency, and unfamiliar word fluency—teachers need professional development to learn techniques and strategies for imparting these areas of expertise to children. In full treatment schools, relatively modest investments in teacher training paid large dividends. In other words, attention and focus on reading and increased accountability, by both teachers and communities, are powerful but insufficient; training and skills are also necessary. As much of the worldwide literature shows, both accountability and support are key. One without the other is not as useful.

- **Underscore decoding skills as a critical step for improved reading outcomes.** The largest impacts of the EGRA Plus program were on children's ability to decode new words. These newfound skills in decoding new words were the jump start that children needed to improve their ability to read texts, and then to increase reading comprehension. Schools of teacher education and in-service programs should increase their focus on these decoding skills, since they seem to be a critical stepping-stone for improved outcomes in more complex reading tasks.
- **Use reading improvements to increase learning in other subjects.** The findings showed that a reading intervention can also have knock-on effects in other subjects, in this case mathematics. This suggests that while Liberia's Ministry of Education is rightly concerned about achievement levels across subjects, reading is an entry point to improving reading outcomes, as well as outcomes in other subjects. We did not study whether reading improvements also were responsible for increases in achievement in other subjects, but given the outcomes identified in mathematics, it is plausible that such a relationship exists. Therefore, we recommend that Liberia focus its human and financial resources on improving the quality of reading in Liberia's children, and then see whether and how these investments can affect what happens in other subjects, while at the same time using the techniques in the other subjects. It will certainly not be sufficient, but reading is a more appropriate initial place for pedagogical investment, since the improvements in this subject might have additional outcome improvements elsewhere and demonstrate that the combination of focus, subject pedagogy, and management gets results.

Expand the use of scripted programs for teacher professional development. The experience of EGRA Plus makes quite clear that the use of scripted programs for teacher professional development can have significant impacts on reading outcomes. While some resistance was noted, in that some teachers did not want to do "extra" work, on the whole the teachers accepted the new methods. Moreover, increasing the scriptedness of the lesson plans increased the effectiveness between the midterm and final assessment. Both factors were quite revealing. It appears that these types of training methods have a high and significant likelihood of continuing to be effective in Liberia.

Appendix A: Calibration of Baseline, Midterm, and Final Assessments

This appendix offers more detail about the process by which we calibrated the versions of the EGRA instrument that were used at the three different time points.

In order to prevent teaching to the test, or memorization, the midterm and final assessments used different word lists and passages. While efforts were made to ensure that the levels of the stories and words were similar, using Spache analysis, this is often not sufficient to ensure calibration. Thus, in addition to the ex ante calibration, we made an empirical or statistical calibration. While this was also done for the midterm assessment, the relatively large differences in reading comprehension scores meant that this EGRA section was calibrated after the final assessment. This was done using a sample of 79 children who were not part of any of the previous three assessments. Children in both grades 2 and 3 participated, from several schools, in August 2010. Some children were given the baseline (2008) passage or set of words first, and then asked to read the midterm (2009) passage or set of words second, and then asked to read the final (2010) passage third. [29] The order was randomized so that we were able to remove the learning effect. The three assessments were well correlated, which was an important part of this calibration procedure. But the analysis also confirmed that the difficulty levels were slightly different, as Table A-1 shows.

Table A-1. Comparison of Calibration Results Across Three Versions of EGRA

Section	2008	2009	2010	Baseline to Midterm Adjustment	Baseline to Final Adjustment
Oral reading fluency	41.94	37.27	35.25	1.13	1.19
Reading comprehension	3.77	3.10	3.44	1.22	1.10

Therefore the results were adjusted, and the analyses presented in this report are calibrated results.

[29] Note that the same familiar word section was used in 2009 and 2010. As a result, and since the calibration exercise results for familiar words were not significantly different from those presented in the midterm report, no adjustments were made for the familiar word section.

Appendix B: Estimating the Impact of Full and Light Treatment on Outcomes, Disaggregated by Sex and Grade (extracted from differences-in-differences estimates)

This appendix investigates whether there were discrepancies by grade and sex on the impact of both full and light treatment. While grade 2 boys' achievement was lower than expected in letter naming fluency, grade 3 boys scored higher than expected on familiar word fluency, and grade 3 boys scored higher than grade 2 boys on oral reading fluency, few of the results deviated much from the aggregated findings (Table B-1).

Table B-1. Impact Disaggregated by Sex and Grade

		Grade 2		Grade 3	
	Treatment	Boys	Girls	Boys	Girls
Letter naming fluency (per minute)	Light	3.9	3.5	10.7**	8.1*
	Full	15.1***	15.7***	16.0***	13.8***
Phonemic awareness (words)	Light	0.6~	-0.2	0.8*	0.7*
	Full	1.9***	1.0**	1.2**	1.9***
Familiar word fluency (per minute)	Light	-0.3	-2.4	3.0	1.7
	Full	16.3***	11.4**	15.7***	14.8***
Unfamiliar word fluency (per minute)	Light	0.9	-1.1	0.7	0.2
	Full	11.3***	10.5***	13.1***	10.3***
Oral reading fluency (per minute)	Light	4.7	0.3	1.6	-2.2
	Full	25.5***	20.9***	20.6***	17.9***
Reading comprehension (%)	Light	2.8	-0.2	3.6	-2.9
	Full	30.1***	23.6***	27.4***	16.4***
Listening comprehension (%)	Light	-3.7	-0.4	2.6	4.9
	Full	8.6*	15.5***	13.6***	9.9**

****<.001, **<.01, *<.05, ~<.10