

Progressive Math and Science Initiatives in the Gambia: Program Evaluation

Prepared for the Center for Teaching and Learning

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In this report, Hanover Research evaluates the impact of the implementation of the progressive math and science initiatives in the Gambia on student math and science test scores. Our report uses test data and survey responses collected by the Center for Teaching and Learning (CTL) to describe the effects of the program. In addition, our report provides a discussion of the implementation challenges faced by CTL, and recommendations for future evaluation.

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EXECUTIVE SUMMARY

In the following report, Hanover Research evaluates the impact of the progressive math and science initiatives implemented by the New Jersey Center for Teaching and Learning (CTL) in the Gambia. This evaluation uses data from three upper basic and seven senior secondary schools in which the CTL's programming was implemented during the 2012-13 academic year to assess the effects of the programs on student academic performance. In addition, this report draws from both student and teacher responses to qualitative surveys to further contextualize the program's successes and areas for future expansion and improvement.

The key findings from our current research study are presented below.

KEY FINDINGS

PMI AND PSI IMPACTS ON STUDENT LEARNING OUTCOMES

- **Within upper basic schools, PMI and PSI Students outperformed their peers on the June 2013 GABECE.** PMI and PSI students outperformed their peers in all three participating schools by 12.4 to 25.2 percentage points.
- **Students in senior secondary schools that participated in the PMI and PSI programs displayed positive and significant learning growth.** We estimate student learning growth of 11.3 and 21 percentage points associated with the PMI and PSI programs, respectively.
- **PMI and PSI are associated with positive student learning growth across all participating schools.** We estimate that PMI and PSI are associated with student learning growth between 8.1 and 28.9 percentage points between the pretest and posttest, in both algebra and algebra-based physics. All but one school displayed positive and statistically significant student learning growth.
- **Student learning growth was positive and significant across all PSI topic specific exam items.** In addition, **positive student learning growth in PMI algebra can be attributed to statistically significant improvements on PMI Unit I performance.** Further, we identify PMI Unit V as a potential PMI unit that would require further attention for future planning and training purposes.
- **PMI students outperformed non-PMI students at other schools on the November 2013 PMI exam.** PMI students scored 8.8 percentage points higher than their counterparts at other schools who did not teach the PMI curriculum in 2012-13.

PMI AND PSI PROGRAM IMPLEMENTATION LEVEL

- **Student learning growth is positively correlated with the number of PMI and PSI units completed in the school year preceding the posttest.** We use this indicator as a proxy for level of program implementation since not all schools were able to start PMI and PSI instruction with the same amount of initial resource endowments. Additionally, students who received the most instructional time per week performed better than students who had fewer minutes of instructional time per week.
- **Schools that have all the necessary equipment to teach PMI were more successful in improving student achievement.** The effect on PSI was unidentifiable in the data since all schools had all the necessary equipment for PSI instruction.
- **Early arrival dates of PSI printed course materials affected student growth in PSI algebra-based physics positively.** We found no effect on PMI student learning growth as the arrival dates of PMI printed course materials varied.

SURVEY FINDINGS

- **Evidence across both surveys indicates that teachers and students have very positive impressions of the program and its ability to improve academic achievement.** Moreover, students with greater experience in the program assessed the program more positively, and the teachers with more experience also provided more positive feedback around the program, suggesting that the longer individuals participate in the program, the greater the effects of the program can be.
- **Survey responses suggest that the program transformed instructors' teaching methods and improved students' learning experience.** Teachers used technology to engage and motivate students and relied on scaffolded instruction. Students enjoyed working in groups, using SMART responders and SMART boards, and a deeper understanding of physics and math content.
- **Moving forward, CTL should continue to ensure access to technology and professional development in order to continue the success of the program after the first year of implementation.** The main priority areas should be ensuring that every classroom and teacher receives sufficient supplies, working SMART technology, and continual training.

INTRODUCTION

The New Jersey Center for Teaching and Learning (CTL) is a non-profit organization whose mission is to *empower teachers to lead change so that all children have access to a high quality education*. The hallmarks of CTL's programming are the Progressive Science Initiative® (PSI) and the Progressive Mathematics Initiative® (PMI). These programs were developed by CTL's current Executive Director, Robert Goodman, who joined CTL in 2009. Originally piloted in just one New Jersey school, the programs are now implemented in over 157 schools worldwide, including sites in New Jersey, Colorado, Rhode Island, Vermont, the Gambia, and Argentina. Over 1,400 teachers have been trained using CTL's progressive mathematics and science methods, and over 7,200 teachers have registered to use CTL's PMI and PSI assessment materials, strongly suggesting that these teachers are implementing CTL's programming independently.

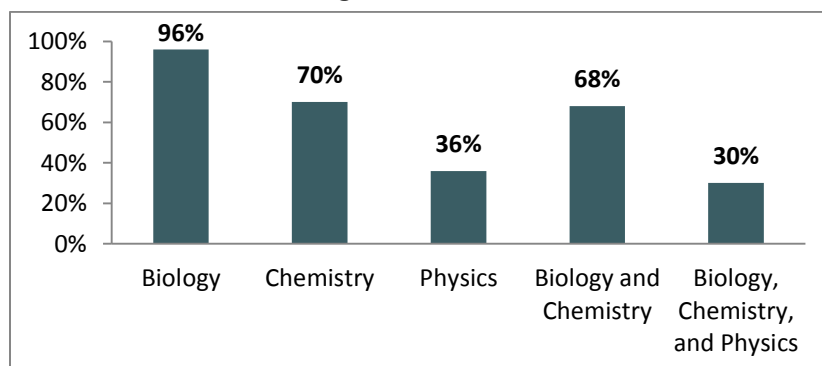
CTL receives support from its activities from both foundation (Morgridge Family Foundation, Overdeck Family Foundation, Thompson Family Foundation, and the National Education Association Foundation) and corporate (Bayer Healthcare, Verizon, Xcel Energy, SMART and eInstruction) funders. CTL's programming is also funded in part by the World Bank and the New Jersey Education Association, and the National Education Association has recently contributed funds to offset costs of PMI and PSI in new locales across the United States in order to speed the implementation of this programming nationwide.

PROGRESSIVE EDUCATION IN MATHEMATICS AND SCIENCE

CTL's focus on PMI and PSI grew out of an understanding that the mathematical skills students gain during high school are necessary for college and career success. Specifically, CTL believes that all high school students should be required to pursue rigorous math and science curricula characterized by proper course sequencing and at least one year of mathematically-rigorous physics. According to the National Center for Education Statistics, only 36 percent of 2009 high school graduates had taken physics during the most recent year for which data are available.¹ By contrast, 70 percent of graduating students had taken chemistry and 96 percent of graduating students had taken biology during the same year. Further, only 30 percent of students had taken biology, chemistry, and physics by the time they graduated from high school.

¹ "Fast Facts: Advanced Mathematics and Science Courses." The National Center for Education Statistics. <http://nces.ed.gov/fastfacts/display.asp?id=97>

Figure I: Percentage of High School Graduates who Completed Selected Science Courses in High School, 2009



Source: The National Center for Education Statistics

In order to address this critical gap in mathematics and science instruction in the United States, CTL developed the Progressive Math Initiative® and the Progressive Science Initiative®--both of which are designed to increase student access to and achievement in rigorous math and science courses. These programs are characterized by free digital materials that teachers can download and use to support teaching in more than 30 math and science courses. All course content includes instructional materials and assessments, and is aligned with either Advanced Placement (AP) science exams (in physics, chemistry, or biology) or the Common Core State Standards. Course content is available for all grade levels spanning pre-kindergarten through AP calculus in the mathematics sequence, and kindergarten through high school science in the science sequence. Course content is also available in Spanish.

PMI and PSI instruction is characterized by 5-10 minutes of direct instruction followed by a period of small group discussion and problem solving. This method of instruction is based on the theory that individuals construct knowledge through group interaction. In other words, the emphasis on group interaction during PMI and PSI instruction *speeds* and *enhances* learning in a way that direct instruction alone cannot.

Instruction is further characterized by the use of technology. CTL recommends that interactive whiteboards be used to deliver PSI and PMI content. The use of whiteboards allows content to be shared across classrooms, and allows for increased collaboration between students. PSI and PMI instruction also rely on whiteboards to allow for real-time formative assessment as content is delivered.

Finally, CTL also offers professional development for teachers designed to complement the PSI and PMI curricula. Currently, CTL offers two courses—one in which teachers can learn about CTL approaches to curriculum, pedagogy, technology, formative assessment, summative assessment, grading, and pacing (CTL Teaching Methods), and one in which teachers can learn content and teaching methods for Algebra-Based Physics (PSI Algebra-Based Physics for Teachers). CTL is an authorized professional development provider in the state of New Jersey.

In addition to providing professional development for existing math and science teachers, CTL also trains and certifies new science teachers in the areas of physics and chemistry through its Progressive Science Initiative endorsement program. CTL has graduated an average of 24 physics teachers in each year since the program started in 2010, and has certified a total of 208 new physics and 32 new chemistry teachers worldwide. Due to CTL's commitment to training new science teachers, the organization is currently the number one producer of physics teachers in the United States.

PROGRAMMING IN THE GAMBIA

As CTL continues to expand its programming within the United States, the organization also seeks new opportunities to share its innovative and cost-effective approach to mathematics and science instruction with schools in countries worldwide. One such international initiative is CTL's work in the Gambia, where CTL has trained teachers to offer PMI and PSI instruction to students in the Gambia's Upper Basic and Senior Secondary schools.

In August of 2012, CTL, in partnership with the World Bank (WB) and the Gambia Ministry of Basic and Secondary Education (MOBSE), began piloting PMI and PSI in 12 upper basic (UBS) and senior secondary (SSS) schools in the Gambia. MOBSE selected the pilot schools based on their regional proximity to the CTL training site, favorable access to power supply, and relatively high numbers of physics teachers who could receive training as part of the project. The ultimate goal of CTL's work in the Gambia was to demonstrate a 25 percent increase in student learning in mathematics and physics. Implementation began when CTL staff members conducted a two-week PMI and PSI training session with 24 UBS and SSS teachers (Cohort 1). Four Peace Corps volunteers also participated in the training so that they could provide ongoing support to Gambian teachers as the project progressed. During this time, teachers were exposed to the interactive whiteboard technology that would be used to deliver PMI and PSI content, and were also exposed to the foundations of the PMI and PSI curricula. Training continued in December of 2012 with a week-long follow-up course. Additionally, during this time students in the 12 pilot schools took PSI algebra-based physics and PMI algebra exams ("pretest" exams).

In February of 2013, students participating in the pilot began receiving PMI and/or PSI instruction from their CTL-trained teachers. Participating schools were provided with Smart responders, a Smart Board, and a computer with access to Smart notebook presentations in order to facilitate the delivery of the PMI and PSI curricula.² In June of 2013, UBS students in Cohort 1 took a modified Gambia Basic Education Certificate Examination (GABECE) in which 10 of the 40 questions were replaced with PMI or PSI items.

Throughout the summer, Cohort 1 teachers completed 10 additional days of PMI or PSI training, while 29 Cohort 2 teachers met to begin training in PMI or PSI. These training sessions were

² Although MOBSE was originally planning to provide all necessary technological equipment by the beginning of the 2012 school year, purchasing issues necessitated a delayed start of the PMI and PSI programs to the winter of 2013. Educators estimate that students in Cohort 1 received instruction in approximately 25 percent of the total PMI and/or PSI curriculum as a result of these equipment delays.

facilitated by turnkey trainers in the Gambia with CTL oversight. In the fall, Cohort 1 students returned to school and continued to receive PMI and/or PSI instruction until November 2013, when they re-took the same benchmark examinations in PSI algebra-based physics and PMI algebra that they took in November of 2012 (“posttest” exams). At this time, Cohort 2 students took the same examinations, which serve as the pretest exams for that cohort.

Since November 2013, CTL has continued to oversee PMI and PSI teacher training in the Gambia. In addition, CTL plans to return to the Gambia in August of 2014 in order to train Cohort 1 teachers in PSI trigonometry-based physics instruction.

In May of 2014, CTL partnered with Hanover Research to conduct an independent evaluation of its first year of programming in the Gambia. The methodology for this evaluation is found in the following subsection.

RESEARCH APPROACH

To evaluate the impact of the PMI and PSI programs on student learning, Hanover Research examines the UBS and SSS programs separately.³ To estimate the effect of the PMI and PSI programs on UBS students, we compare the test scores of students who received PSI or PMI instructions to students who completed typical math and science courses taken by most Gambian students. This evaluation of UBS students was conducted independently of the previous evaluation overseen by Dr. Jenny Hsieh, although both studies produced similar results.

To evaluate PMI and PSI in SSS schools, we estimate the effect of the program on PMI and PSI test score growth between December 2012 and November 2013. It is important to note that Hanover conducted this evaluation of SSS students independently of the June 2014 evaluation conducted by CTL, although both assessments generated similar conclusions. Whereas CTL’s inquiry evaluated student test score data *collectively*, the present study compared the performance of *individual students* who took both the pre-test and post-test. Further, CTL examined test results across all participating schools, while Hanover compared student performance by school. This evaluation disaggregates the SSS analysis at the school level allowing the impact of PMI and PSI to vary across schools. Finally, we correlate differences in student growth across schools with program implementation level. To proxy for level of implementation we use the following indicators: units completed, whether schools had all necessary equipment, timing of receipt of printed course materials, and time allocated for PMI/PSI instruction per week.

In addition to student achievement data, Hanover also examines teacher and student responses to surveys administered by CTL. These surveys were administered at the beginning and the end of the initial implementation phase.

³ We note that for our analysis, data were only available for three Upper Basic schools and seven Senior Secondary schools. No data were received for the other two schools in the pilot implementation year.

Our final report on the effectiveness of CTL's programming in the Gambia is organized as follows:

- **Section I:** Description of the data provided by CTL and the methodology employed to evaluate PMI and PSI implementation in UBS and SSS.
- **Section II:** Analysis of the effect of PMI and PSI instruction on UBS students.
- **Section III:** Evaluation of the impact of PMI instruction on student outcomes in SSS.
- **Section IV:** Evaluation of the impact of PSI instruction on student outcomes in SSS.
- **Section V:** Analysis of survey results.
- **Section VI:** Description of the limitations of this study and recommendations for further research.

SECTION I: DATA ANALYSIS METHODOLOGY

In this section, Hanover Research describes the data provided by the Center for Teaching and Learning (CTL) and the methodology used to evaluate the effect of the progressive math and science initiatives on student learning.

DATA OVERVIEW

UBS DATA

Data for students in UBS are drawn from three schools where PMI and PSI was implemented in the 2012-13 school year. In total, the data include detailed test score information for 177 students who sat for the Gambia Basic Education Certificate Exam (GABECE) in 2013. Note that the students who received PMI and PSI instruction took a modified version of the GABECE where 10 exam items were drawn from the PMI and PSI curriculum, and the remainder of the exam was composed of 30 items drawn from the standard GABECE. Further, school level GABECE math and science test scores were available for the three participating schools to serve as a comparison. However, it is important to note that the GABECE results from the comparison group are from students taking the standard GABECE, which includes standard questions in place of the PMI and PSI questions. Therefore, a quarter of the assessments are dissimilar across both groups.

SSS DATA

Data for students in SSS are drawn from seven schools where PMI, PSI, or both PMI and PSI were implemented. The initial PMI data includes 533 test scores, including 305 pretests and 228 posttests. Importantly, not all students have both a pretest and a posttest score. Therefore, we identify PMI students who were present for both pretest and posttest and track their performance longitudinally. This ensures that our comparison groups do not vary in their composition, essentially, comparing posttest performance to pretest performance for the same set of students. Restricting the analytic sample to students who are tracked over time yields a final sample of 214 observations (107 unique students observed twice).

In addition, we analyze PMI algebra test scores for examinations taken during November of 2013 for both students who received PMI instruction and students who did not receive PMI instruction. Students in the control group, those who did not receive PMI instruction, took general science and math courses that are taken by most students in the Gambia. The sample size for this portion of our analysis is composed of 182 PMI students and 578 non-PMI students.

The analytic sample for SSS students taking the PSI exam is constructed similarly to the PMI sample. In other words, the final analytic sample is restricted to include only those students who were present for the pretest and posttest, yielding a final sample of 258 observations (129 unique students observed twice). Note that in this case, PSI test scores were not

provided for non-PSI students in other schools. Therefore, our evaluation of PSI is restricted to estimating student learning growth over time without comparing PSI-instructed students to students who did not receive PSI instruction.

METHODOLOGY

PMI AND PSI IN UPPER BASIC SCHOOLS

To analyze the impacts of PMI and PSI on student test score performance, we compare the performance of students who were instructed with PMI and PSI to that of students in the same school who were not instructed with PMI or PSI, but completed standard math and science curricula. It is important to note that some UBS students have graduated to various senior secondary schools and were not administered a posttest to track their learning growth over time. Therefore, we rely on a cross-sectional comparison of math and science GABECE scores for PMI/PSI students and non-PMI/PSI students. Subsequently, we compute the difference in mean test scores between the two groups of students and test for statistical significance. Further, we disaggregate the comparisons at the school level to highlight any potential differences in program effectiveness across the three implementing schools. It is also important to note that PMI/PSI students sat for a modified version of the GABECE while non-PMI/PSI students sat for the standard GABECE. The modified version of the GABECE includes 30 out of 40 total exam items from the standard version, while the remaining items are drawn from the PMI/PSI curriculum. To ensure that the comparisons are fair, the ideal research design would compare the performance of PMI/PSI students to non-PMI/PSI students using only the 30 common exam items.⁴ Although our comparisons are not ideal we believe that this analysis allows us, at least, a lens in which we can evaluate the impact of the program in a manner that is informative to stakeholders.

PMI AND PSI IN SENIOR SECONDARY SCHOOLS

To evaluate the impacts of the PMI and PSI programs on test score performance of students in participating senior secondary schools we make use of test score data for students that include pretest and posttest scores. First, we conduct a longitudinal analysis of student test score performance in PMI and PSI. This method allows us to track students over time and measure the learning growth made by each student between the pretest and posttest. The advantage of longitudinal analysis, in this case, is that posttest scores are compared to baseline test scores for the same students and maintains the composition of the student sample. Subsequently, we disaggregate our student growth analysis by school to capture any systematic differences in growth across schools.

Evaluating student test score growth by school allows us an initial observation into whether varying levels of PMI or PSI implementation explain potential differences in student growth levels. To correlate potential differences in student learning growth levels, we introduce several indicators from the Cohort 1 teacher surveys that serve as proxy for level of program

⁴ Note that at this moment, item level data are available only for PMI and PSI students while only aggregate school level data are available for the comparison group.

implementation. We can think of the proxy indicators as means to measure the dosage of the program that varies by schools' level of program implementation. The following four survey questions were used to form a proxy for PMI/PSI implementation across schools:

- The number of PSI and PMI units completed in 2012-13,
- Whether the school had all the necessary technology equipment for PSI and PMI,
- The timeframe during which each school received their PSI and PMI printed course materials, and
- The number of minutes per week allocated to PMI/PSI instruction.

For this analysis, we rely on a linear regression model that serves to compare average student growth across schools with varying levels of implementation. Formally, we estimate the following regression model:⁵

$$[1] \quad \text{Growth}_{is} = \alpha + \beta \text{Dose}_s + \gamma \text{Treat}_{is} + \epsilon_{st}$$

$$[2] \quad \text{Growth}_{is} = \text{Posttest}_{is} - \text{Pretest}_{is}$$

In these models, Growth_{is} denotes student learning growth in PMI or PSI for student "i" attending school "s" and is defined as the difference between each student's posttest and pretest scores. Dose_s represents one of the four dosage variables described earlier, defined at the school level. Note that we do not include all four dosage variables simultaneously in our model due to a limited sample size, thus not providing enough school level variation in implementation level. Treat_{is} is an indicator variable that takes on a value of one if the student was instructed with PMI or PSI in 2012-13, zero otherwise. Therefore, the coefficient of interest in this case is β , where a positive and significant estimate indicates that schools with higher levels of implementation are associated with higher levels of student learning growth.

Finally, in addition to the longitudinal analysis of student test score growth, we perform a cross-sectional evaluation of the PMI program in senior secondary schools. In this case, we compare the test score performance of PMI students to that of non-PMI students on the same exam. Non-PMI students received standard math instruction. The PMI test scores used in this exercise refer to PMI assessments administered in November 2013 across 14 senior secondary schools. For this analysis we only keep students who took the PMI exam for the first time. This methodology provides an additional dimension to the evaluation of the PMI curriculum where we compare students instructed in PMI in the prior year with students that were not. Further, we analyze only students taking the PMI exam for the first time.⁶ This analysis is similar in concept to the UBS analysis described earlier.

⁵ The linear regression model is estimated once for PMI and once for PSI.

⁶ PSI test score data is currently not available for students who were not instructed with the PSI curriculum in the previous year. Therefore, we are not able to recreate the cross-sectional analysis for PSI physics.

SECTION II: PSI AND PMI ANALYSIS – UPPER BASIC SCHOOLS

In this section, we present the results of the PMI and PSI GABECE analysis using a sample of UBS students from the three upper basic schools that implemented PSI and PMI in 2012-13. The analysis, in this case, compares test score performance of PMI/PSI-instructed students to non-PMI/PSI-instructed students on the GABECE. The test scores used in this analysis are drawn from the GABECE administered in June 2013. This can be thought of as a cross-sectional comparison of student test score performance across PMI/PSI participation status. Moreover, we assign students who received PMI/PSI instruction to the treatment group, while students who received standard math and science instruction are assigned to the control group. It is important to note that PMI/PSI students sat for a modified version of the GABECE whereas non-PMI/PSI students sat for the standard GABECE. The data do not therefore allow for direct comparison between the two groups of students, although because three quarters of the GABECE were the same for both students, we are able to form some conclusions about the effectiveness of the program. Our analysis is presented for the overall sample and at the individual school level.

MAIN TAKEAWAYS

- **Students instructed using the PMI curriculum outperformed students in the same school who did not receive PMI instruction.** PMI students outperformed their peers in all three participating schools by an average of 25.2 percentage points.
- **Among schools that implemented PSI, PSI students outperformed non-PSI students.** PSI students outperformed their counterparts in all three participating schools by 12.4 percentage points, on average.

DETAILED ANALYSIS – PMI

Figure 2.1 presents the mean PMI test score, in percentage terms, for each of the three upper basic schools for students that received the PMI treatment, students in the control group (did not receive PMI treatment), and the difference in test score performance between the two groups. Overall, we find that PMI students outperformed non-PMI students by 25.2 percentage points, on average. The estimated difference is substantial in magnitude relative to the average GABECE test score for non-PMI students. Specifically, PMI students, on average, received GABECE scores that are slightly more than 100 percent higher than non-PMI students at 52.1 percent relative to 25.1 percent. In addition, we disaggregate this result at the school level and find that the difference in PMI scores between the treatment and control group ranges between 21.5 and 33.3 percentage points. Further we see that PMI students who attended Greater Banjul and 22nd July Academy outperformed their peers by more than 130 percent, and PMI students at St. Therese's UBS outperformed their counterparts by almost 71 percent.

Figure 2.1: Average GABECE Score for PMI Students and non-PMI Students

	N	MEAN	SE
Treatment			
Greater Banjul Upper Basic School	39	0.394	0.028
St. Therese's Upper Basic School	52	0.519	0.025
22nd July Academy	86	0.581	0.023
<i>Overall</i>	<i>177</i>	<i>0.521</i>	<i>0.043</i>
Control			
Greater Banjul Upper Basic School	354	0.155	0.004
St. Therese's Upper Basic School	668	0.304	0.008
22nd July Academy	315	0.247	0.010
<i>Overall</i>	<i>1,337</i>	<i>0.251</i>	<i>0.012</i>
Difference			
Greater Banjul Upper Basic School	393	0.238***	0.029
St. Therese's Upper Basic School	720	0.215***	0.027
22nd July Academy	401	0.333***	0.025
<i>Overall</i>	<i>1,514</i>	<i>0.270***</i>	<i>0.046</i>

Note: *** p<0.01, ** p<0.05, * p<0.10. N represents the number of observations in each of the treatment and the control groups and SE denotes the standard error. Mean and SE for overall treatment, control, and difference rows are computed using weighted averages and standard errors, respectively.

DETAILED ANALYSIS – PSI

Figure 2.2 displays the UBS analysis for the PSI program by comparing the GABECE test scores of students who received PSI instruction in 2012-13 to students within the same schools who did not receive PSI instruction. Students in the treatment group outperformed their peers by 12.4 percentage points on the science GABECE in June 2013. This is equivalent to a 56.6 percent increase in GABECE performance associated with the PSI program. Further, we disaggregate the results by school and find that, on average, students in the treatment group outperformed their peers in each school by 9.1 to 15.9 percentage points. In terms of percent difference, we translate the effect size to be between 36.3 and 93.6 percent. In other words, PSI students outperformed their peers in each school by 36.3-93.6 percent. Lastly, Greater Banjul UBS and 22nd July Academy exhibited the largest effect at 14.8 and 15.9 percentage points, respectively, while St. Therese's UBS exhibited a 9.1 percentage point increase in GABECE performance. All effects are statistically significant at the 99 percent confidence level.

Figure 2.2: Average GABECE Score for PSI Students and non-PSI Students

	N	MEAN	SE
Treatment			
Greater Banjul Upper Basic School	39	0.306	0.016
St. Therese's Upper Basic School	52	0.342	0.017
22nd July Academy	86	0.381	0.015
<i>Overall</i>	<i>177</i>	<i>0.353</i>	<i>0.027</i>
Control			
Greater Banjul Upper Basic School	355	0.158	0.004
St. Therese's Upper Basic School	668	0.251	0.006
22nd July Academy	312	0.222	0.007
<i>Overall</i>	<i>1,335</i>	<i>0.219</i>	<i>0.009</i>
Difference			
Greater Banjul Upper Basic School	394	0.148***	0.016
St. Therese's Upper Basic School	720	0.091***	0.018
22nd July Academy	398	0.159***	0.016
<i>Overall</i>	<i>1,512</i>	<i>0.124***</i>	<i>0.029</i>

Note: *** p<0.01, ** p<0.05, * p<0.10. N represents the number of observations in each of the treatment and the control groups and SE denotes the standard error. Mean and SE for overall treatment, control, and difference rows are computed using weighted averages and standard errors, respectively.

SECTION III: SENIOR SECONDARY SCHOOLS – PMI ANALYSIS

In this section, Hanover evaluates the effect of the progressive math initiative (PMI) on the first cohort of participating students in senior secondary schools. To analyze the effect of PMI, we estimate student learning growth over time and across schools. In addition, we disaggregate the student learning growth analysis by unit of instruction as well as by school. This allows us to provide a comprehensive and detailed view of the learning outcomes achieved by students instructed in PMI 2012-13. Further, we compare PMI test scores for students who received PMI instruction in 2012-13 to students from other schools who received standard math instruction.

We estimate the impact of the level of PMI implementation, or program dosage, on student learning growth using a linear regression framework. In essence, this methodology compares the learning growth achieved in schools with high levels of implementation relative to those with low levels of implementation. Lastly, we estimate the impact of PMI using a quasi-experimental research design where one group of students receives the treatment, that is PMI, and another group, called the control group, does not and we compare the performance of both groups on the same assessment. In this case, we make use of the November 2013 PMI test administered in 12 different schools in the Gambia.⁷

MAIN TAKEAWAYS

- **PMI students exhibited an 11.3 percentage point increase in their PMI test scores from their pretests, overall.** Further, we estimate student learning growth of at least 10 percentage points in PMI Units I through IV.
- **Student learning growth is positive across all implementing schools.** The magnitude of student learning growth varies by school ranging between 3.3 and 20.3 percentage points.
- **When disaggregating by school and PMI Unit, overall growth in student learning is attributed to growth in Unit I.** All schools exhibit positive and statistically significant student learning growth on Unit I scores.
- **PMI students outperformed non-PMI students on the November 2013 PMI exam.** On average, PMI students scored 8.8 percentage points higher than non-PMI students.
- **Student learning growth is positively correlated with the number of PMI units completed in 2012-13 and whether a school received all necessary equipment.**

⁷ The data is currently limited for Cohort 1, where we cannot track test score growth for the treatment and control group. However, we believe this research design can be improved upon for subsequent cohorts of PMI/PSI implementation in the Gambia.

PMI TEST SCORE GROWTH – REPLICATION AND LONGITUDINAL ANALYSIS

In the following analysis, we replicate the analysis in CTL’s progress report in June 2014 and provide an additional perspective to evaluate the impact of PMI on student learning.⁸ The main purpose of this exercise is to confirm the data used by Hanover for the analysis of the PMI/PSI program and that all analyses are carried out with the same data elements. Figure 3.1, below, presents the replication of the Cohort 1 PMI analysis conducted by CTL where Hanover was able to get identical results to those reported in CTL’s progress report. Specifically, we also find an overall student growth of 8.1 percentage points in PMI performance, from the pretest. In essence, the analysis compares two cross-sections of test scores, the pretest and the posttest.

Figure 3.1: Student PMI Score Growth - Cohort 1 analysis replication

	NO. OF OBS.	PRETEST	POSTTEST	DIFFERENCE
Unit I Score	533	0.481	0.599	0.118***
Unit II Score	533	0.270	0.336	0.066***
Unit III Score	533	0.234	0.316	0.081***
Unit IV Score	533	0.397	0.471	0.075**
Unit V Score	533	0.279	0.257	-0.021
Overall Score	533	0.380	0.461	0.081***

Note: *** p<0.01, ** p<0.05, * p<0.10. The number of observations in the pretest is 305, whereas the number of observations in the posttest is 228. Statistical significance computed using a t-test. Numbers representing the pretest, posttest, and difference are in percentages.

Therefore, we create an additional sample restriction to initial sample by including only students who have both a pretest and a posttest score in the analysis. This allows the student learning growth to be measured longitudinally while preserving the comparison sample in the pretest and posttest. We present the longitudinal student learning growth in Figure 3.2, by overall score and by PMI unit. When we follow the same student over time and track his/her academic progress, we estimate student learning growth of 11.3 percentage points, on average. Further, we find that PMI students exhibited positive and significant growth on four of the five PMI units, by at least 9.7 percentage points.

Figure 3.2: Longitudinal Student Learning Growth – PMI Students

	NO. OF OBS.	PRETEST	POSTTEST	DIFFERENCE
Unit I Score	214	0.491	0.640	0.149***
Unit II Score	214	0.243	0.340	0.097***
Unit III Score	214	0.192	0.299	0.107***
Unit IV Score	214	0.383	0.514	0.131***
Unit V Score	214	0.255	0.252	-0.003
PMI Score	214	0.371	0.484	0.113***

Note: *** p<0.01, ** p<0.05, * p<0.10. The number of observations in the pretest and posttest is 107. Statistical significance computed using a t-test. Numbers representing the pretest, posttest, and difference are in percentages.

⁸ “CTL Progress Report: Academic Progress of Students in the Gambia Taking PSI and PMI.” The Center for Teaching and Learning. June 2014.

LONGITUDINAL STUDENT LEARNING GROWTH BY SCHOOL

Figures 3.3 and 3.4 display the overall and per-unit student learning growth for each of the seven senior secondary schools that implemented the PMI program in 2012-13. As in Figure 3.2, we find that the growth in student learning between the pretest and the posttest is 11.3 percentage points, on average. However, it is interesting to see that the average learning growth varies by school. Specifically, we observe that the achieved student growth among PMI schools ranged between 3.3 and 20.3 percentage points between the pretest and the posttest. Moreover, Gambia and Kotu SSS display the highest levels of learning growth, at 20.3 and 16 percentage points, respectively. In contrast, Sifoe SSS displayed the lowest level of student learning growth at 3.3 percentage points. All growth estimates, except for Sifoe SSS, were found to be statistically significant at least at the 95 percent confidence level.

Figure 3.3: Longitudinal Student Learning Growth – PMI Students, by School

	NO. OF OBS.	PRETEST	POSTTEST	DIFFERENCE
22nd July Academy	38	0.323	0.446	0.124***
Gambia SSS	6	0.261	0.464	0.203***
Kotu SSS	38	0.382	0.542	0.160***
Muslim SSS	30	0.246	0.328	0.081***
Nusrat SSS	62	0.456	0.575	0.119***
Sifoe SSS	26	0.358	0.391	0.033
St. Joseph SSS	14	0.435	0.534	0.099**
Overall	214	0.371	0.484	0.113***

Note: *** p<0.01, ** p<0.05, * p<0.10. The number of observations in the pretest and posttest is symmetric across all schools and overall. Statistical significance computed using a t-test. Numbers representing the pretest, posttest, and difference are in percentages.

Figure 3.4 presents the school level learning growth achieved by PMI unit. We show that, for the most part, learning growth was most pronounced in Unit I where all schools exhibited positive and statistically significant growth. Further, we find mixed results for Units II-IV where only Kotu and Nusrat SSS displayed consistent growth throughout all four units. Lastly, Figure 3.4 shows that all schools displayed statistically insignificant learning growth in terms of Unit V scores. However, we note that this may be due to the fact that some students did not reach Unit V due to the delayed implementation of the programming. We therefore recommend that this analysis be repeated when students have received instruction in all five units.

Figure 3.4: Longitudinal Student Learning Growth – PMI Students, by Unit and School

	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT V
22nd July Academy	0.177***	0.168**	0.105	0.000	-0.053
Gambia SSS	0.273***	0.067	0.167	0.333	0.111
Kotu SSS	0.230***	-0.000	0.184**	0.289***	0.070
Muslim SSS	0.139***	0.053	0.033	-0.100	0.067
Nusrat SSS	0.088***	0.200***	0.161**	0.242***	-0.011
Sifoe SSS	0.105**	-0.046	-0.077	0.154	-0.103
St. Joseph SSS	0.169***	0.086	0.143	-0.071	-0.048

Note: *** p<0.01, ** p<0.05, * p<0.10. Numbers in each cell represent the difference in mean unit scores between the pretest and posttest for each participating school. Statistical significance computed using a t-test.

PROGRAM IMPLEMENTATION LEVEL AND STUDENT LEARNING GROWTH

Figures 3.3-3.4 provide some evidence that varying levels of learning growth at the school level may be determined by factors outside the control of the teachers or school administrators. We empirically test whether student learning growth varies with level of program implementation. The rationale behind this hypothesis is that different schools may have been constrained by the logistics of receiving all necessary equipment for PMI instruction, or by the number of PMI units that teachers may have completed prior to the posttest as a result. Therefore, we employ four indicators that proxy for program implementation level, called dosage indicators:

- Number of units completed in 2012-13. This variable takes on values between 1 and 5 for PMI schools and zero for non-PMI schools, indicating the units completed in the previous year.
- School had all necessary equipment. This variable takes on a value of 1 if a PMI school had all three of the necessary PMI equipment, Smart Responders, Smart Board, and computer with access to Smart Notes. Zero otherwise.
- Months with PMI printed course materials. This variable computes the number of months between the date of arrival of the PMI printed course materials and the date of the posttest.
- PMI Instruction Minutes per Week. This variable indicates the number of minutes per week allocated to PMI instruction.

The dosage variables are extracted from the Cohort 1 teacher survey results that address the following questions:

- “Which units did you complete in 2012-13?”
- “What equipment do you have to teach PSI-PMI?”
- “When did you receive PSI-PMI printed course materials?”
- “How many minutes does your PSI-PMI class meet per week this year?”

Figure 3.5, on the following page, presents the results of the linear regression model described in equation [1], in the methodology section. Because the program implementation data is relatively in short supply, since the analysis involves only the first implementation cohort, we opted to model the four dosage indicators separately. The motivation behind this modeling decision is that we found overlap within schools over the four dosage variables. The overlap, in the context of a linear regression model, creates a multicollinearity problem where variation in one of the variables can be eliminated at the school level leading to a problem identifying the effect of that variable. Therefore, when separated we can infer the effect of each variable on student learning growth, though not in isolation of the other dosage variables.

Moreover, the results of the regression estimation show that for each additional unit completed in 2012-13, average student learning growth increased by 3.93 percentage

points. For instance, a classroom that covered all five units as compared to another that covered three would be expected to show student learning growth that is 7.86 percentage points higher. The coefficient parameter is found to be statistically significant at the 90 percent confidence level. Further, we estimate that schools that implemented PMI and had all the necessary technology/equipment for instruction displayed student learning growth that is, on average, 10.97 percentage points higher than schools that implemented PMI but had some or even none of the necessary equipment. Lastly, we find that the months with PMI printed course materials and PMI instruction minutes per week are not correlated with student learning growth. Specifically, we estimate coefficients for both indicators that are statistically indistinguishable from zero. This means that the timing of the arrival of the PMI printed course materials and the amount of time allocated to instruction were not found to be relevant to student learning growth between the PMI math pretest and the posttest.

Figure 3.5: Impact of PMI Dosage on Student Learning Growth

	MODEL 1	MODEL 2	MODEL 3	MODEL 4
Dosage Variables				
Number of Units Completed in 2012-13	0.0393* (0.0174)			
School had all necessary equipment		0.1097*** (0.0211)		
Months with PMI Printed course materials			-0.0020 (0.0033)	
PMI Instruction Minutes per Week				-0.0000 (0.0001)
PMI Variable				
PMI Indicator	-0.0104 (0.0327)	0.0025 (0.0290)	0.0086 (0.0469)	0.0176 (0.0493)
Constant	-0.0221 (0.0699)	0.0114 (0.0250)	0.1274 (0.0774)	0.0949 (0.0557)
Observations	70	129	120	129
R-squared	0.0931	0.1021	0.0033	0.0041

Note: *** p<0.01, ** p<0.05, * p<0.10. Sample sizes vary across models depending on response rates from the Cohort 1 teacher surveys. Numbers in the figure correspond to coefficient estimates from the linear regression model described in equation [1]. Numbers in parentheses represent robust standard errors.

CROSS-SECTIONAL COMPARISON OF PMI AND NON-PMI STUDENTS

Figure 3.6 presents the results from comparing the PMI test score performance of students who received PMI instruction in 2012-13 to that of students at other schools that did not receive PMI instruction. Further, we disaggregate the results by PMI unit that differentiates student learning growth by type of content covered in the PMI course. The benefit from this exercise is that it allows us to quantify the impact of the PMI program across students who received PMI instruction relative to students who did not. In addition, by using the same assessment for all students across schools we are able to control for factors that are outside

of the control of the PMI course but are common to all students in the analytic sample. The assessment used, in this case, is the PMI November 2013 exam administered across 12 senior secondary schools.

Overall, we find that students who received PMI instruction in 2012-13 outperformed students who did not on the November 2013 PMI assessment by 8.8 percentage points. The difference is statistically significant at the 99 percent confidence level. Further, we find that PMI students outperformed non-PMI students specifically in Units I, III, and IV by 16.1, 7.6, and 5.5 percentage points, respectively. Therefore, given the new perspective when looking at the impact of PMI we are again able to identify points of strength and points of improvement. As in the longitudinal analysis, we find that PMI instruction is not as effective in terms of Unit V scores, although again we note that this may be due to varying levels of implementation across school sites.

Figure 3.6: Cross-Sectional Comparison of Test Scores for PMI and non-PMI Students

	NO. OF OBS.	NON - PMI	PMI	DIFFERENCE
Unit I Score	760	0.401	0.562	0.161***
Unit II Score	760	0.280	0.301	0.021
Unit III Score	760	0.213	0.288	0.076***
Unit IV Score	760	0.369	0.423	0.055*
Unit V Score	760	0.269	0.229	-0.040*
Overall Score	760	0.338	0.426	0.088***

Note: *** p<0.01, ** p<0.05, * p<0.10. The number of PMI and non-PMI observations is 182 and 578, respectively. Statistical significance computed using a t-test. Test score data used are from the November 2013 PMI assessment.

SECTION IV: SENIOR SECONDARY SCHOOLS – PSI ANALYSIS

In this section, Hanover Research evaluates the effect of the progressive science initiative (PSI) on the first cohort of participating students in senior secondary schools. Therefore, we recreate the analysis presented in Section III of this report. Specifically, we analyze student learning growth longitudinally, overall and segmented by school and PSI sub-topics (kinematics, dynamics, UCM, gravitation, energy, and momentum). In addition, we estimate the impact of program implementation level on growth in student learning in physics. In other words, we estimate the impact of program dosage on student learning growth using a linear regression framework comparing the learning growth achieved in schools with high levels of implementation to schools with low levels of implementation. Note that, in this section, PSI test score data is not available for students attending schools that did not implement PSI. Therefore, we are unable to construct a comparison group for students who sat for the exam but did not receive PSI instruction.

MAIN TAKEAWAYS

- **PSI students exhibited a 21 percentage point increase in their PSI test scores from their pretests, overall.** Further, PSI students displayed learning growth across all PSI topics by at least 8.4 percentage points.
- **Algebra based physics learning growth is positive across all schools that implemented PSI.** The PSI effect size is found to be substantial and statistically significant across all participant schools. The minimum amount of student learning growth is estimated at 16.8 percentage points.
- **Student learning growth is positive and significant across all PSI topics.** PSI students exhibited positive learning growth for all PSI topics, by a minimum of 8.8 percentage points.
- **Student learning growth is positively correlated with the number of PSI units completed in 2012-13 and whether a school received all necessary equipment.** However, we find a negative association between the number of minutes allocated per week to PSI instruction and student growth.⁹

PSI TEST SCORE GROWTH – REPLICATION AND LONGITUDINAL ANALYSIS

Figure 4.1 replicates the PSI analysis performed in CTL’s progress report in June 2014.¹⁰ Our replication of CTL’s analysis confirms that Hanover is using the same dataset in the analysis presented in this report and the results are shown to be identical. We find that, when

⁹ Note that the number of minutes per week varied by a maximum of 40 minutes across schools.

¹⁰ “CTL Progress Report: Academic Progress of Students in the Gambia Taking PSI and PMI.” The Center for Teaching and Learning. June 2014.

comparing the average score from the pretest sample to the average score in the posttest sample, a 19.8 percentage point growth in PSI test scores is associated with the PSI program.

Figure 4.1: Student PSI Score Growth - Cohort 1 analysis replication

	NO. OF OBS.	PRETEST	POSTTEST	DIFFERENCE
Kinematics	506	0.334	0.538	0.204***
Dynamics	506	0.277	0.478	0.200***
UCM	506	0.255	0.501	0.246***
Gravitation	506	0.131	0.477	0.346***
Energy	506	0.171	0.300	0.128***
Momentum	506	0.190	0.274	0.084***
PSI Score	506	0.225	0.423	0.198***

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. The number of observations in the pretest is 297, whereas the number of observations in the posttest is 209. Statistical significance computed using a t-test.

Therefore, to track the performance of the same students over time, we restrict the initial sample by including only students with two test scores: a pretest and a posttest. Figure 4.2 presents the results of the longitudinal PSI analysis by overall score and by PSI topic. We estimate student learning growth in algebra-based physics to be 21 percentage points, on average. Further, we find that PSI students displayed learning growth on all PSI topics ranging between 8.8 and 33.8 percentage points. In this case, we find that all growth estimates are statistically significant at the 99 percent level.

Figure 4.2: Longitudinal Student Learning Growth – PSI Students

	NO. OF OBS.	PRETEST	POSTTEST	DIFFERENCE
Kinematics	258	0.312	0.530	0.219***
Dynamics	258	0.259	0.476	0.217***
UCM	258	0.257	0.498	0.240***
Gravitation	258	0.141	0.479	0.338***
Energy	258	0.163	0.343	0.180***
Momentum	258	0.183	0.271	0.088***
PSI Score	258	0.218	0.428	0.210***

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. The number of observations in the pretest and posttest is 129. Statistical significance computed using a t-test.

LONGITUDINAL STUDENT LEARNING GROWTH BY SCHOOL

Figure 4.3 displays the overall PSI student learning growth for each of the six¹¹ senior secondary schools that implemented the PSI program in 2012-13. Student learning growth in algebra-based physics ranged between 16.3 and 28.9 percentage points across all PSI schools. We identify the highest performing school, in terms of PSI test score growth, to be Koty SSS followed by Nusrat and Muslim SSS with a 21.2 and 21.9 percentage point growth in PSI scores, respectively. Although all schools displayed positive and significant growth we still

¹¹ St. Joseph SSS was removed from this portion of our analysis due to the low number of students for whom we received both pre- and posttest scores, as well as complications with matching students' scores by name.

observe some variance in student growth across schools. It is also interesting to note that all PSI schools displayed a similar level of pretest scores. This is evidence that, on average, the different schools in our sample have students that are similar in terms of their initial ability level.

Figure 4.3: Longitudinal Student Learning Growth – PSI Students, by School

	NO. OF OBS.	PRETEST	POSTTEST	DIFFERENCE
22nd July Academy	34	0.222	0.385	0.163***
Gambia SSS	32	0.226	0.415	0.190***
Kotu SSS	40	0.202	0.490	0.289***
Muslim SSS	48	0.211	0.423	0.212***
Nusrat SSS	64	0.233	0.452	0.219***
Sifoe SSS	40	0.210	0.377	0.168***
Overall	258	0.218	0.428	0.210***

Note: *** p<0.01, ** p<0.05, * p<0.10. The number of observations in the pretest and posttest is symmetric across all schools and overall. Statistical significance computed using a t-test.

Figure 4.4 presents the school-level learning growth achieved by PSI topic. This exercise allows us to identify the points of strength and the topics that require improvement for each participating school. For the most part, we find that all schools are providing evidence of increased student learning across kinematics, dynamics, UCM, and gravitation. In addition, we observe that all schools showed progress in UCM and gravitation where student growth in the two topics ranged between 15 and 54 percentage points across schools. All UCM and gravitation estimates are statistically significant at the 99 percent confidence level. Lastly, we observe that Kotu and Nusrat SSS were the most consistent in terms of display student learning growth across all PSI topics.

Figure 4.4: Longitudinal Student Learning Growth – PSI Students, by Unit and School

	KINEMATICS	DYNAMICS	UCM	GRAVITATION	ENERGY	MOMENTUM
22nd July Academy	0.094	0.059	0.200***	0.459***	0.188**	0.010
Gambia SSS	0.200***	0.363***	0.213***	0.163**	0.313***	-0.063
Kotu SSS	0.190***	0.180***	0.230***	0.540***	0.420***	0.192***
Muslim SSS	0.225***	0.233***	0.392***	0.358***	0.050	0.049
Nusrat SSS	0.306***	0.238***	0.225***	0.325***	0.119**	0.120***
Sifoe SSS	0.220***	0.220***	0.150**	0.170**	0.080	0.167***

Note: *** p<0.01, ** p<0.05, * p<0.10. Numbers in each cell represent the difference in mean unit scores between the pretest and posttest for each participating school. Statistical significance computed using a t-test.

PROGRAM IMPLEMENTATION LEVEL AND STUDENT LEARNING GROWTH

The school level longitudinal analyses provide some evidence that learning growth varies across schools and this section aims to explain this variation. Here, we test whether PSI learning growth varies with level of program implementation across participating PSI schools. Further, the analysis in this section follows the logic of the Section III, but for PSI

instead of PMI.¹² As in Section III, we rely on indicators from the Cohort 1 teacher survey to serve as proxies for level of PSI implementation. Therefore, we employ three dosage indicators (We exclude the indicator referring to having all necessary equipment since all schools responded positively to this particular survey question.):

- Number of PSI topics completed in 2012-13. Takes on values between 1 and 6 for PSI schools. In the PSI sample we found that schools were divided in terms of completing either one topic only or completing all six. Therefore, this compares schools that completed all six topics to those that completed only one. This is accounted for in the calculation of the coefficient estimate.
- Months with PSI printed course materials. This variable computes the number of months between the date of arrival of the PSI printed course materials and the date of the posttest.
- PSI Instruction Minutes per Week. This variable indicates the number of minutes per week allocated to PSI instruction.

The dosage variables are extracted from the Cohort 1 teacher survey results in the manner described in Section III for the PMI analysis. Figure 4.5 presents the results of the linear regression model described in equation [1], in the methodology section. Therefore, the coefficients of interest are those associated with number of units completed in 2012-13, months with PSI printed course materials, and PSI instruction minutes per week. We interpret these coefficients as the effect the dosage variables on student growth by comparing PSI students to each other with varying dosage levels. We note that all schools in the analytic sample had received all the necessary equipment for PSI instruction. Therefore we exclude the equipment variable from the analysis due to lack of variation.

Figure 4.5: Impact of PSI Dosage on Student Learning Growth

	MODEL 1	MODEL 2	MODEL 3
Dosage Variables			
Number of Units Completed in 2012-13	0.0738*** (0.0157)		
Months with PSI Printed course materials		0.0097*** (0.0015)	
PSI Instruction Minutes per Week			-0.0022*** (0.0005)
PSI Variable			
PSI Indicator	-0.1863*** (0.0255)	-0.1872*** (0.0254)	-0.1973*** (0.0199)
Constant	0.3412*** (0.0173)	0.2646*** (0.0269)	0.7272*** (0.0646)
Observations	241	241	241
R-squared	0.3975	0.3981	0.4095

Note: *** p<0.01, ** p<0.05, * p<0.10. Numbers in the figure correspond to coefficient estimates from the linear regression model described in equation [1]. Numbers in parentheses represent robust standard errors.

¹² We are able to create parallel analyses because the structure of the data in both programs are identical.

The results of the regression estimation show that schools that were able to complete the full PSI curriculum in 2012-13 outperformed schools that completed only one topic by 7.38 percentage points. Because we only observe two values for the number of topics covered in the previous school year, it is difficult to extrapolate the effect of covering only one additional topic, as was the case with the PMI analysis. In addition, we estimate that schools that received the PSI printed course materials a month earlier displayed student learning growth that is 0.97 percentage points higher than schools that have had the printed course materials for a shorter amount of time. Finally, we estimate the effect of the weekly amount of time allocated to PSI instruction on student growth. We find that each additional minute of weekly PSI instruction is associated with a 0.22 percentage point decline in student learning growth. We interpret this result as weekly time allocated to PSI instruction may not be as important a factor in determining student learning growth as having the printed course materials for a longer period of time and the number of topics completed in the PSI curriculum. The teacher survey results show that instruction time varied by at most 40 minutes across all schools in the analysis. It is therefore difficult to conclude that a larger amount of time allocated to instruction is detrimental to student learning growth because we do not observe enough variation in the allocations across schools.

SECTION V: SURVEY ANALYSIS

In this section, we use responses to surveys administered to students and teachers participating in CTL's PMI/PSI pilot program in the Gambia to demonstrate the perceived effectiveness of the program among participants. These surveys were administered in the spring of 2014 to Cohort 1 students, and to teachers in Cohort 1 and Cohort 2. In addition, we analyze feedback gathered during focus group sessions with Cohort 1 and 2 teachers led by CTL staff during the spring of 2014.

STUDENT RESPONSE DATA

Student respondents were overwhelmingly positive when assessing a wide variety of statements regarding mathematics, science, PMI, and PSI. Among those statements most relevant to the program:

- 72 percent of student respondents strongly agreed that SMART boards helped their learning;
- More than two-thirds of student respondents strongly agreed that using SMART responders helped their learning; and
- 66 percent of student respondents strongly agreed that the PMI-PSI method of teaching is superior to previous curricula.

More than three-quarters of student respondents agreed or strongly agreed that PMI and PSI have increased their interest in mathematics and science. Nearly 80 percent agreed or strongly agreed that they learned more mathematics with PMI than otherwise, and 70 percent of respondents agreed or strongly agreed that they learned more science with PSI than otherwise.

OPEN RESPONSE

Students were also asked open-ended questions about what they like most about PSI-PMI and how they would make the program better. In addressing the first topic, many students noted the SMART technology and the way the program improved their understanding, learning, and interest. In addition, a number of students indicated that they like the group work and the way the program made learning math and science easier.

In general, students responded to the question of how to improve the program by noting that they could do better by paying more attention and studying harder. However, several respondents also noted the importance of providing and using the SMART technology and having enough printed course materials and electricity. A large number of respondents indicated that regular attendance would be a key to improving, suggesting that incentives or support for attendance may improve outcomes.

Figure 5.1 Student Agreement with Statements Regarding PMI, PSI, Mathematics, and Science: Most Positive Responses (n=603-696)

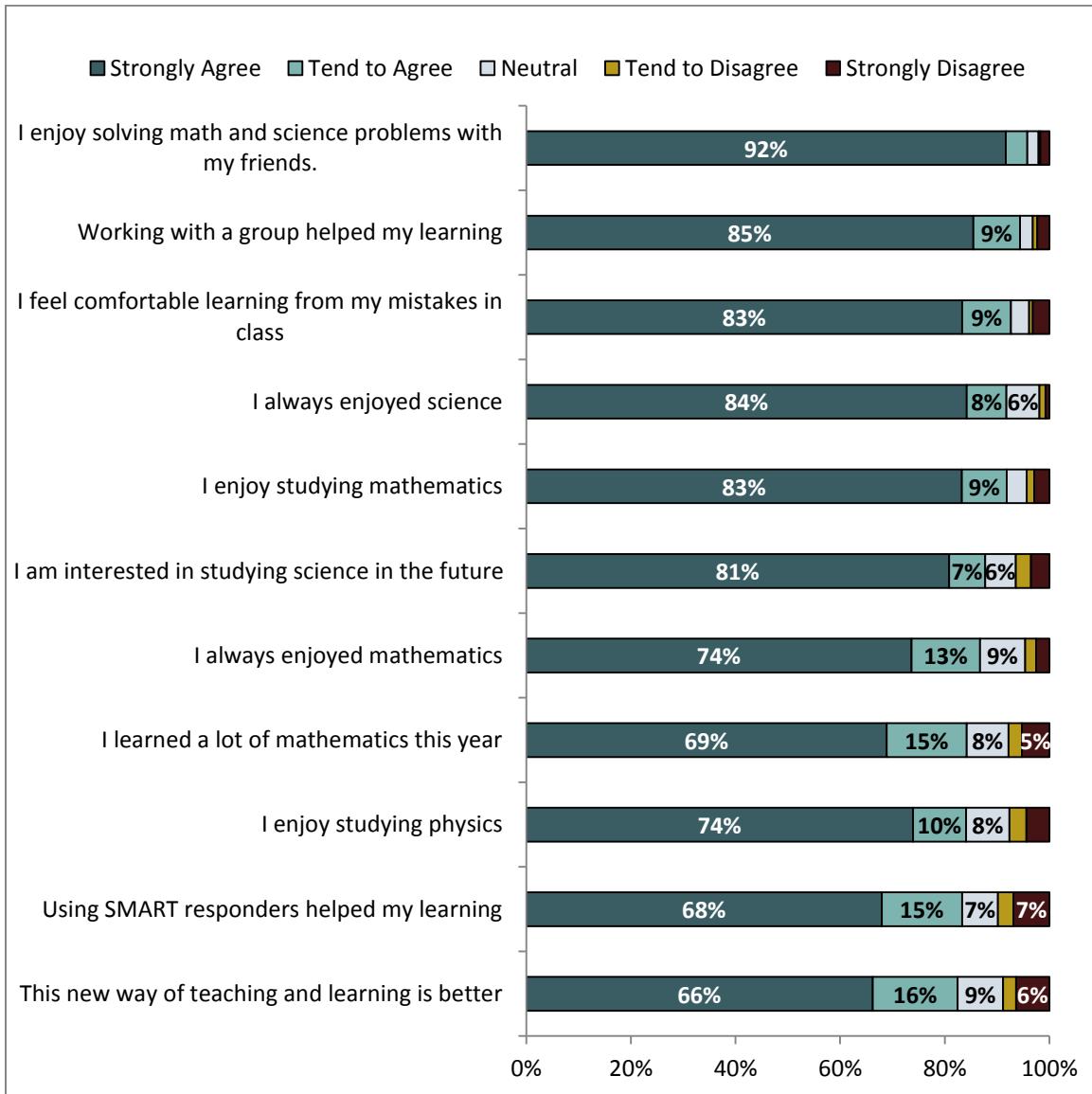
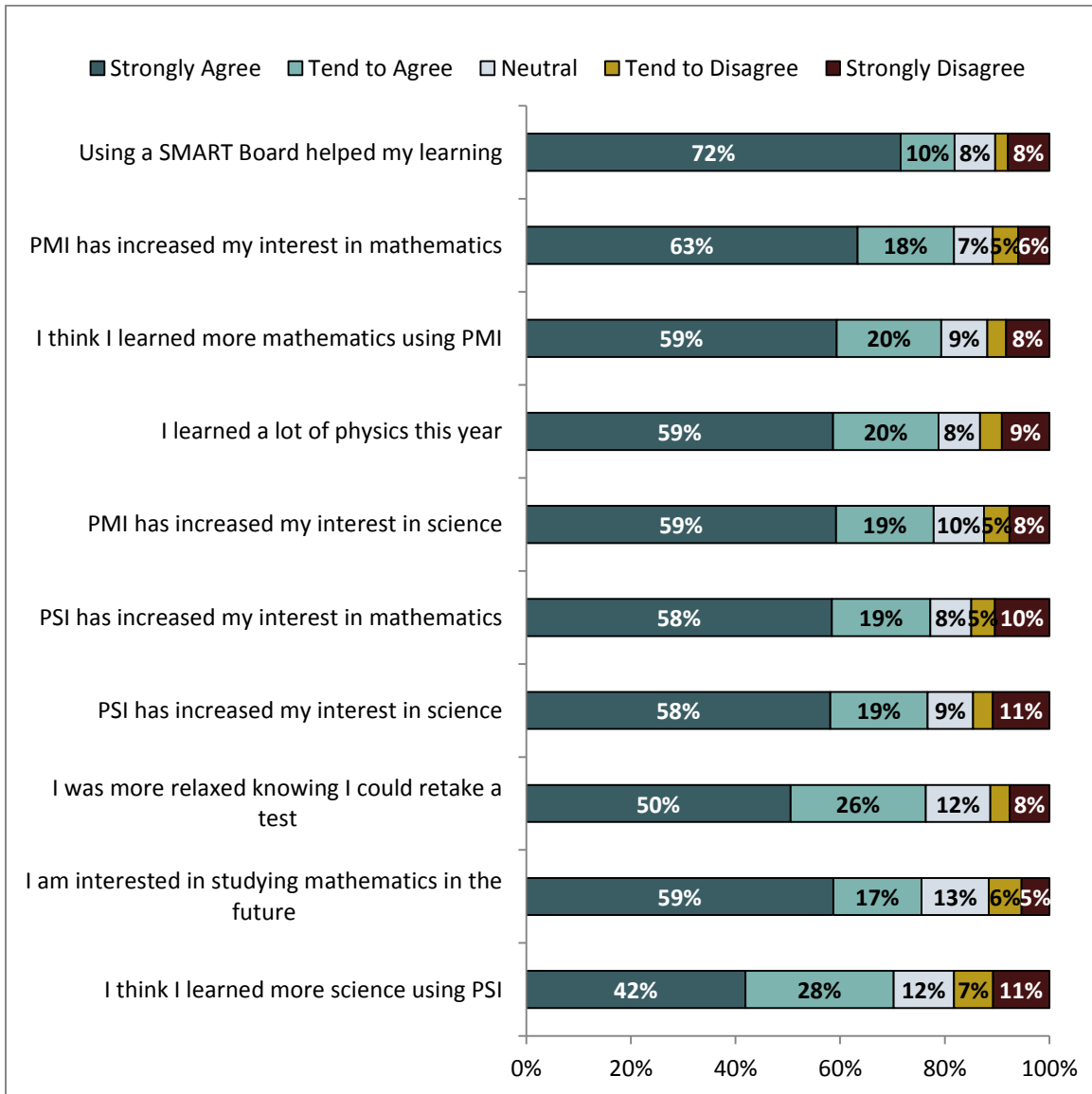


Figure 5.2: Student Agreement with Statements Regarding PMI, PSI, Mathematics, and Science: Least Positive Responses (n=603-696)



DIFFERENCES BY TIME IN PROGRAM AND SCHOOL LEVEL

Notably, in several cases, students who learned with the PMI or PSI curriculum for more than six months expressed significantly more positive support for the programs.

Figure 5.3: PSI – Students responding with “Strongly Agree” or “Tend to Agree”
(n=566-642)

STATEMENT	SIX MONTHS OR FEWER	MORE THAN SIX MONTHS	DIFFERENCE
I enjoy studying physics	77%	87%	10%
I learned a lot of physics this year	73%	82%	10%
I think I learned more science using PSI	65%	73%	9%
Working with a group helped my learning	90%	97%	7%
I always enjoyed science	87%	94%	7%

All differences are statistically significant at 95 percent confidence.

Figure 5.4: PMI – Students responding with “Strongly Agree” or “Tend to Agree”
(n=552-577)

STATEMENT	SIX MONTHS OR FEWER	MORE THAN SIX MONTHS	DIFFERENCE
I learned a lot of physics this year	72%	85%	13%
I enjoy studying physics	76%	87%	11%
PSI has increased my interest in science	73%	81%	8%
Working with a group helped my learning	90%	97%	6%
I always enjoyed science	87%	93%	6%

All differences are statistically significant at 95 percent confidence.

Students in Upper Basic Schools considered the SMART Board to be more effective than did students in Senior Secondary Schools. On the other hand, students in Senior Secondary Schools were more likely to respond that the PSI and PMI programs increased their interest in science. A greater percentage of UBS students reported learning a lot of mathematics in the current year, while a greater percentage of SSS students reported learning a lot of physics during the current year.

Figure 5.5: Students responding with “Strongly Agree” or “Tend to Agree,” by School Level
(n=603-696)

STATEMENT	SSS	UBS	DIFFERENCE
I learned a lot of mathematics this year	81%	92%	11%
Using a SMART Board helped my learning	80%	88%	8%
PSI has increased my interest in science	79%	71%	8%
I always enjoyed science	94%	85%	9%
PMI has increased my interest in science	80%	71%	10%
I learned a lot of physics this year	81%	72%	10%
I am interested in studying mathematics in the future	79%	68%	10%
I enjoy studying physics	90%	68%	22%
I am interested in studying science in the future	95%	68%	27%

All differences are statistically significant at 95 percent confidence.

TEACHER RESPONSE DATA

In response to survey questions, both cohorts of teachers highlighted similar areas of satisfaction and challenge in PMI/PSI implementation. Specifically, respondents from both cohorts consider PSI-PMI to be better than previous curricula in a variety of ways, describing it as:

- Effective,
- Student-centered,
- Less labor-intensive for instructors,
- Incorporating technology that is modern and relevant,
- Simple, and
- Practical and logical.

Respondents also noted that the program emphasizes and fosters collaboration, student interaction, group work, and social learning.

The main challenges identified by teachers include electricity and the supply and maintenance of resources, including time, space, technology, and printed course materials. Teachers consistently note that inconsistent or inadequate supplies of electricity hinder the program's effectiveness. According to respondents, printed course materials have been late. In addition, some teachers noted that their own lack of fluency in technology can be a hindrance.

The three main themes for improvement largely reflect the challenges faced. Teacher respondents noted that they would like more time, more training, and improvements in equipment provision and maintenance. In addition, several respondents requested regular and continued training and engagement from the Center for Teaching and Learning to ensure sustainability and continue to build capacity. Two respondents also suggested introducing PSI and PMI in grade 7.

DISCUSSION FORUM RESULTS

Teachers in the discussion forums largely echoed the results of the survey. However, teachers also noted that the technology engages and motivates students, and this has led to students being more interested in learning mathematics and science. Moreover, the teachers noted that instruction under the program is scaffolded and supports a variety of students. In line with the survey results, teachers from the first cohort indicated that they have become increasingly comfortable with the program as time has passed, while teachers from the second cohort noted that they have faced challenges and many had yet to start at the time of the forum.

COHORT 1

Respondents from the first cohort of teachers overwhelmingly agree that PSI and PMI “will lead to higher levels of student achievement.” A large majority of respondents also agree or strongly agree that they prefer teaching the PSI and PMI curricula over their old curricula, and that they think their students “learn more math or science using the PSI-PMI curriculum.” Notably, teachers who have taught PMI and PSI overwhelmingly agree that the program is not too difficult for their students (Figure 5.7). This finding is significant because when the program was first introduced in the Gambia, parents and teachers expressed concern that the curricula would be too advanced for students. However, it is clear from the survey results that the rigorous program challenged students appropriately.

The only area where teachers responded with any negativity was with respect to the sufficiency of equipment and supplies to effectively teach the curriculum, suggesting a demand for greater support for implementation.

Figure 5.6: Teacher Agreement with Statements Regarding PSI and PMI (n=15-16)

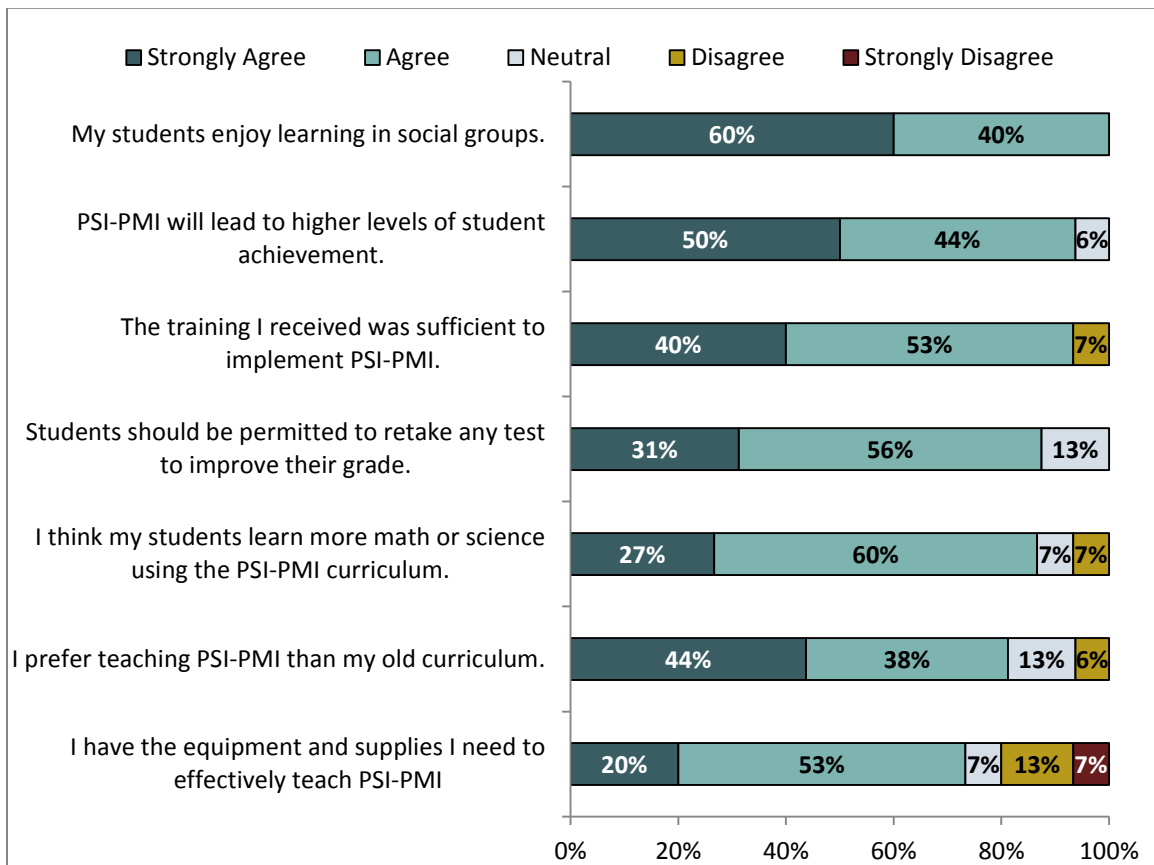
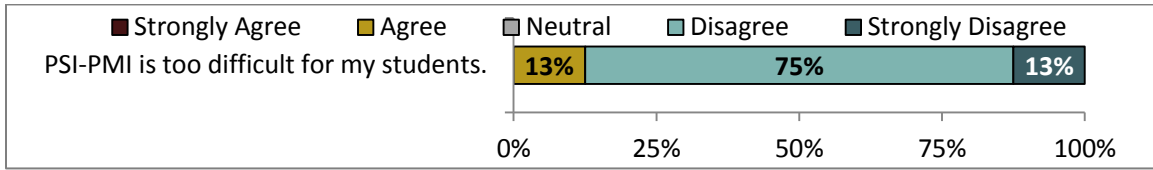
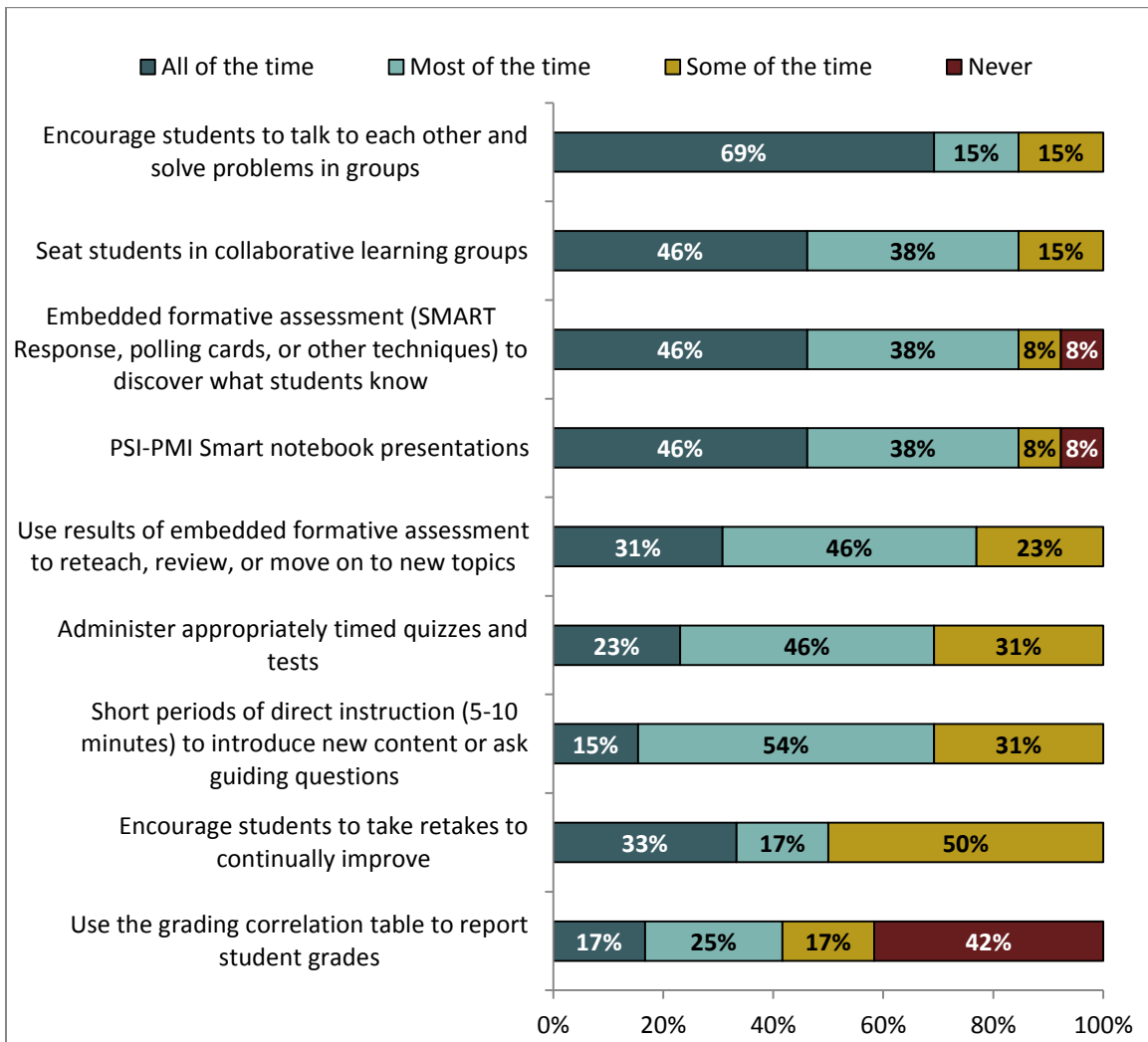


Figure 5.7: Teacher Agreement Regarding the Difficulty of PSI and PMI (n=16)



Forty-six percent of teacher respondents from the first cohort reported using PSI or PMI SMART notebook presentations in all of their lessons, and 84 percent reported using them at least most of the time. Results were the same regarding the incorporation of embedded formative assessment, such as SMART Response, for discovering what students know. Notably, half of all teachers reported that they only encouraged students to take test retakes “some of the time,” and 58 percent of teachers reported that they used CTL’s grading correlation table “some of the time” or “never.” These results suggest that the importance of these two practices may need to be emphasized in CTL training moving forward.

Figure 5.8: Frequency of Teachers’ Use of PSI and PMI Teaching Methods (n=12-13)



Class sizes fell slightly over the first two years for teachers in the first cohort. Class time remained fairly constant, though no teacher maintained a class time shorter than one hour.

The graphs below show the minimum, twenty-fifth percentile, mean, seventy-fifth percentile, and maximum values for the reported number of students in PMI and PSI classes and the reported duration of PMI and PSI classes in minutes.

Figure 5.9: Number of Students in Class (n=15)

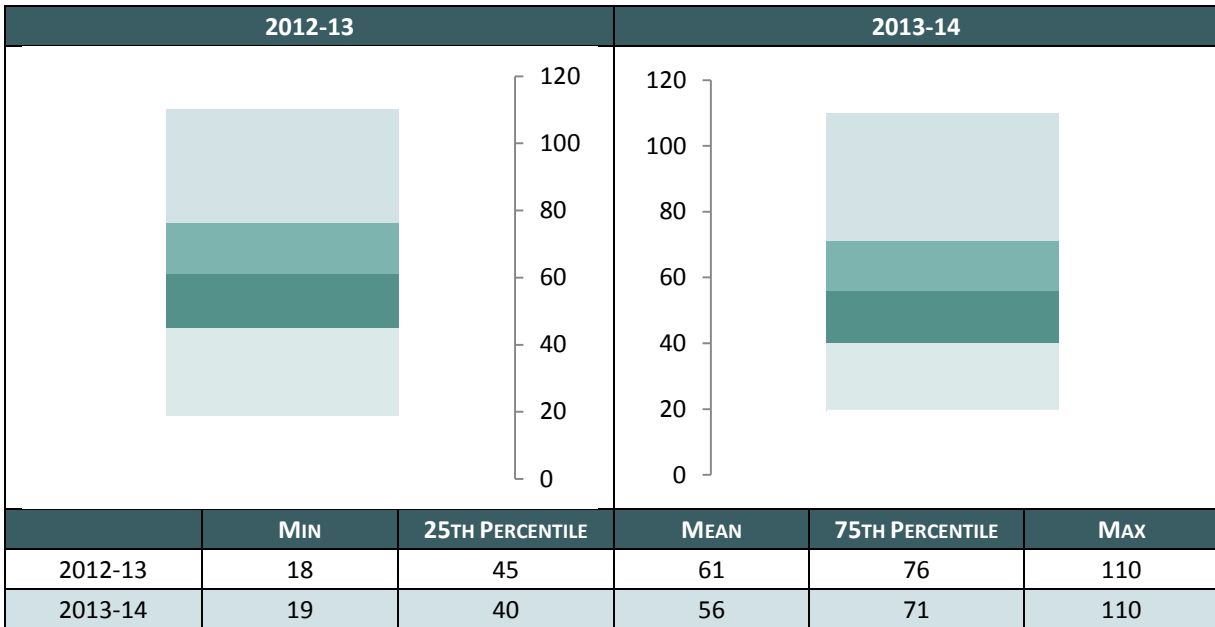
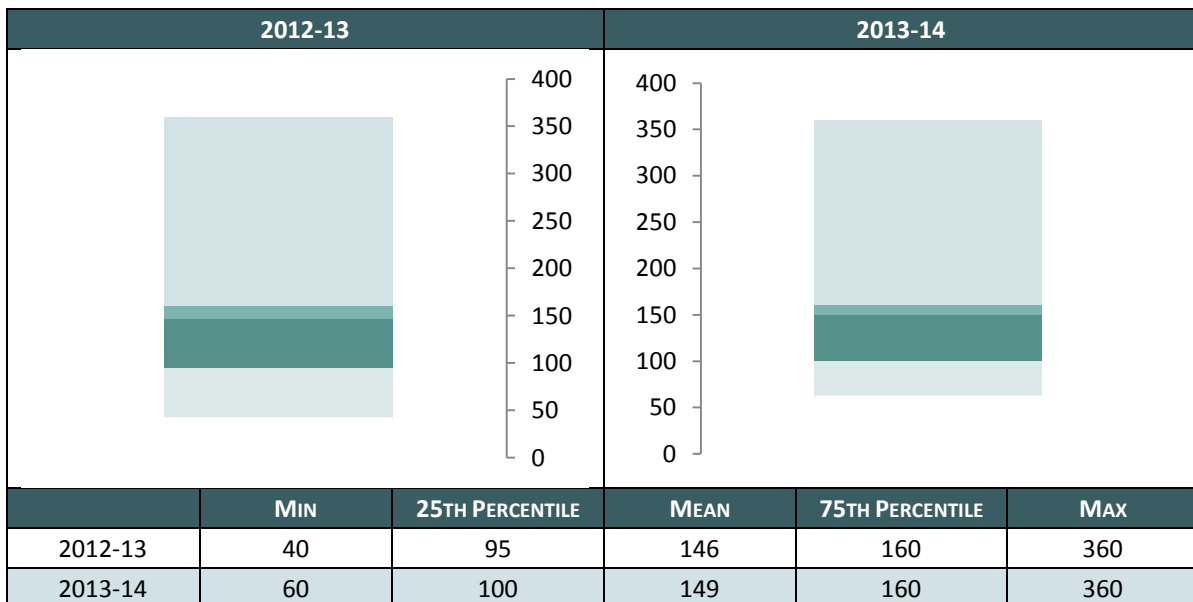


Figure 5.10: PSI or PMI Class Length in Minutes (n=15)



Only 12 respondents answered the question regarding whether they have a computer in their classroom and access to SMART notebook presentations, but only one of those responding to the question lacks a computer and access.

Figure 5.11: Presence of computer in classroom and access to SMART notebook presentations (n=12)

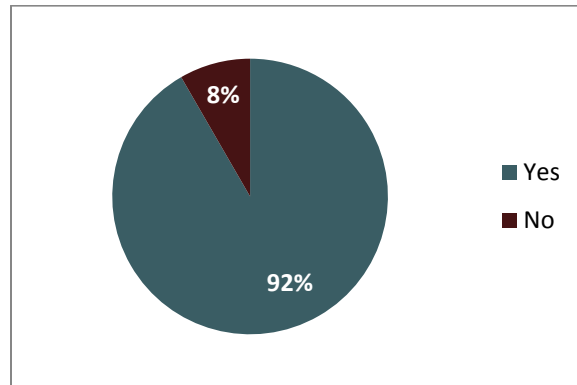
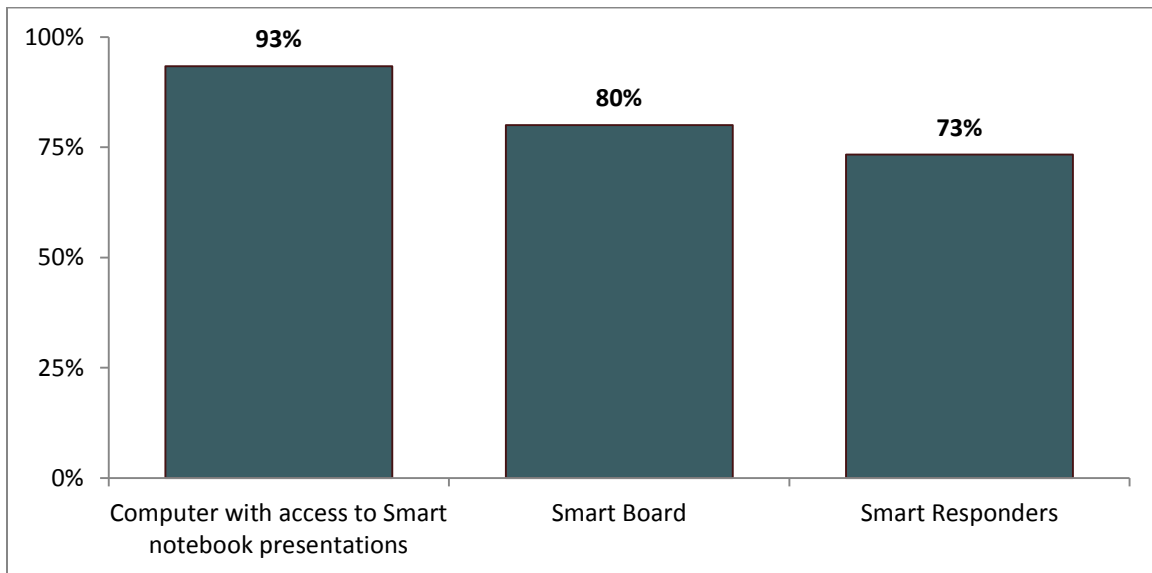


Figure 5.12: Equipment for Teaching PMI or PSI (n=15)



COHORT 2

Teacher respondents in the second cohort reported substantially more negative feelings about the sufficiency of training and materials for implementation, and nearly one-half of respondents report never using SMART notebook presentations for PMI or PSI lessons. As with Cohort 1 respondents, a majority (71 percent) of Cohort 2 teachers also reported that they do not use CTL’s grading correlation table. These areas should be emphasized in future CTL training sessions to ensure compliance. Respondents did indicate, however, that they feel optimistic about the ability of the program to lead to higher achievement, but they expressed more lukewarm feelings about the current state of their implementation.

In addition, note that teachers in Cohort 2, who have not yet begun PMI or PSI instruction, expressed more concern about the difficulty of the PMI-PSI curriculum than teachers in Cohort 1 (Figure 5.14). As was the case with Cohort 1 teachers, we expect to see this concern about the curriculum taper as teachers begin teaching the curricula to students.

Figure 5.13: Teacher Agreement with Statements Regarding PSI and PMI (n=20-22)

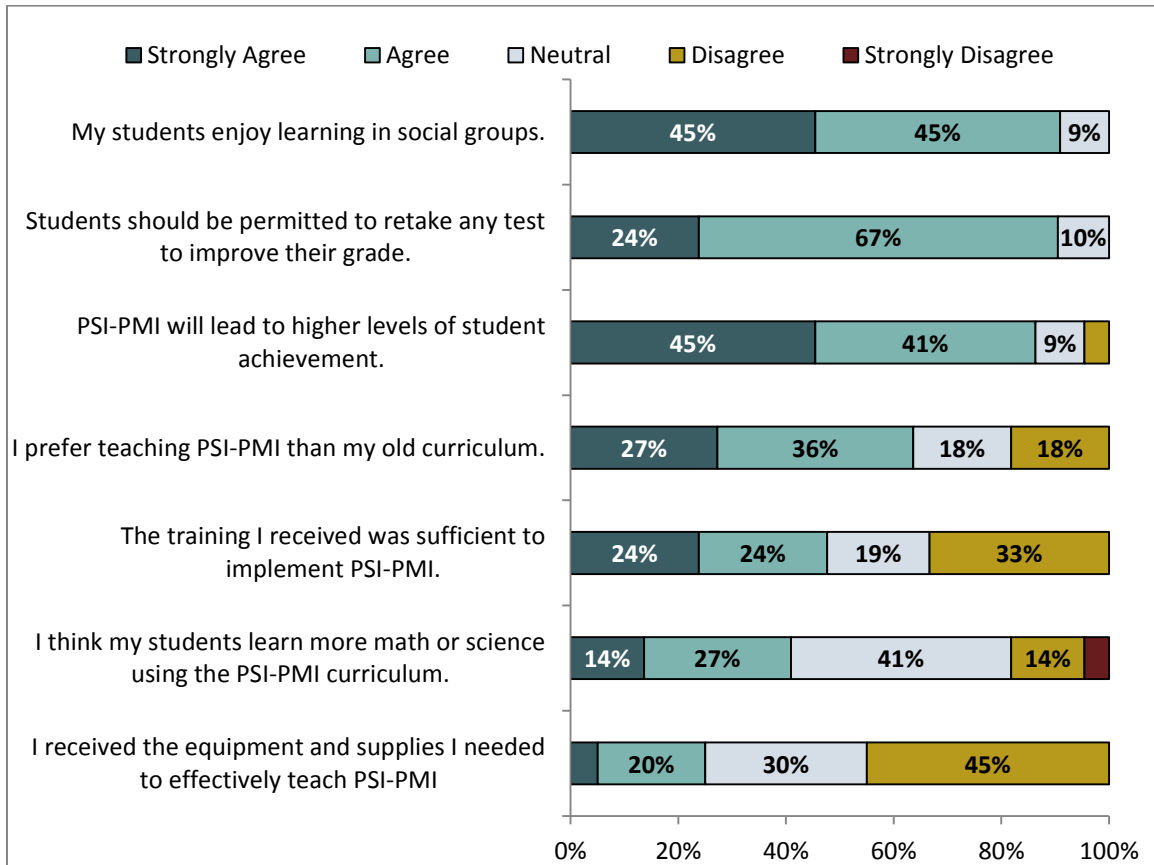


Figure 5.14: Teacher Agreement Regarding the Difficulty of PSI and PMI (n=21)

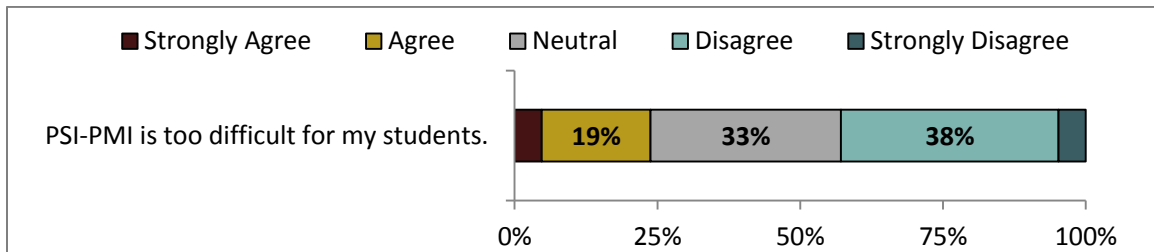
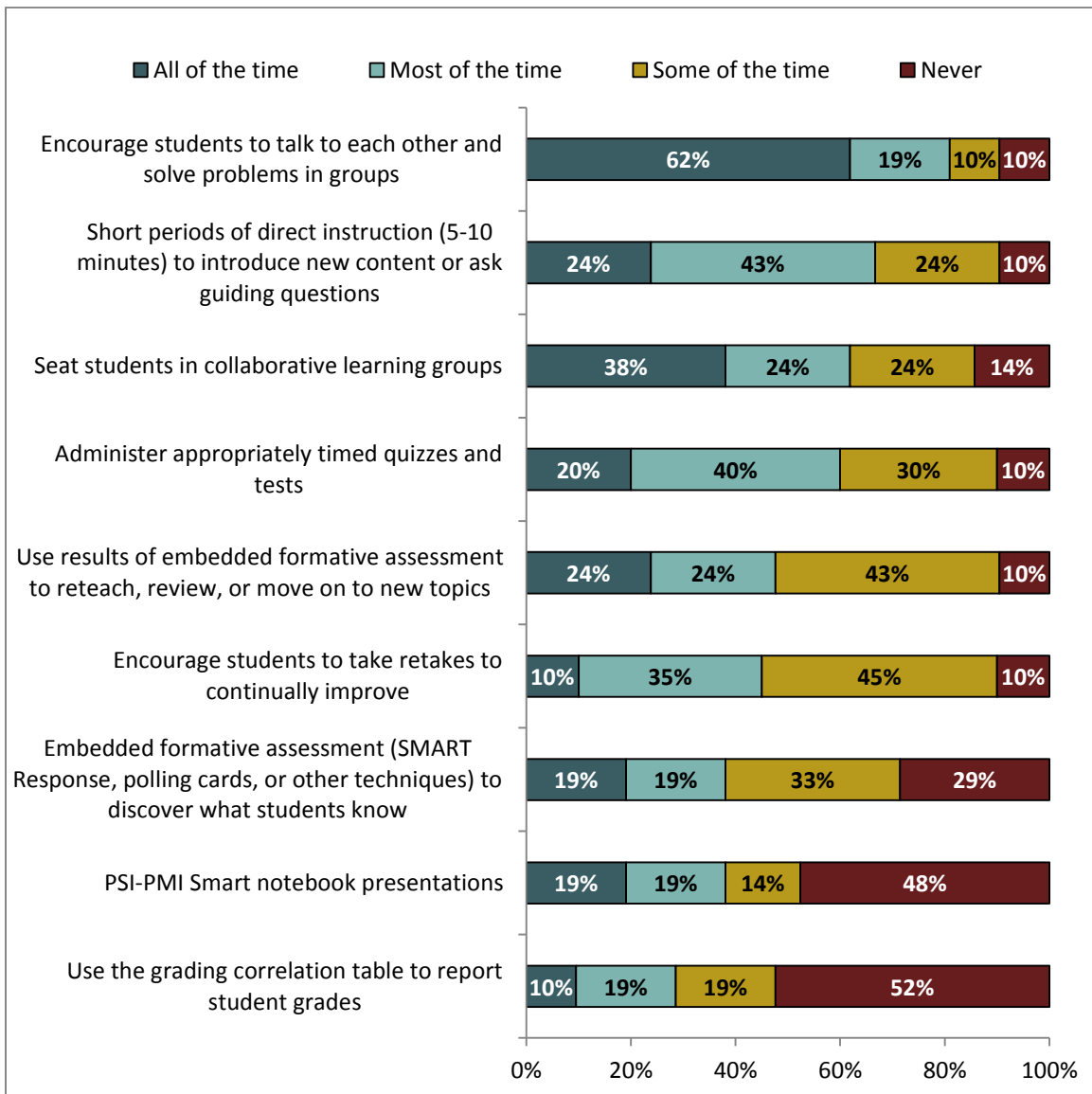


Figure 5.15: Frequency of Teachers' Use of PSI and PMI Teaching Methods (n=20-21)



SECTION VI: IMPLEMENTATION CHALLENGES AND RECOMMENDATIONS

In this final section of our report, we discuss challenges faced by CTL during the initial implementation year, and discuss ways to improve upon both the program itself and on this analysis in the future.

IMPLEMENTATION CHALLENGES

DELAYED START

Although the initial training of Cohort 1 teachers began in August of 2012, these teachers did not begin teaching using the PMI and/or PSI curriculum until February or March of 2013. Similarly, Cohort 2 teachers began training in August 2013, but these students did not receive PSI or PMI instruction until the spring of 2014. This delay meant that students spent the first half of each school year learning content from the traditional Gambian mathematics and science curricula, rather than actively engaging with PSI or PMI curriculum. Although some teachers did note the adoption of the social constructivism pedagogy during the first half of the year, the delayed start likely impacted the effectiveness of the program due to the fact that participants had to change their teaching and learning styles mid-way through the academic year.

PURCHASE AND INSTALLATION OF EQUIPMENT

One of the issues affecting the timely start of the program was that MOBSE faced significant challenges in procuring and installing the technology necessary to deliver the PMI and PSI curricula. The original plan for the pilot year was to deliver and install the interactive whiteboard technology in time for the September 2012 start of the school year; however, the technology was not delivered until the fall, which delayed the start of PMI and PSI instruction to the winter of 2013.

Procuring the necessary technology and equipment to implement the program has been an ongoing challenge. Similar issues with the timely delivery of technology equipment arose during the second year of implementation, and students in Cohort 2 did not begin to receive PMI and/or PSI instruction until the spring of 2014. Similarly, teachers who participated in discussion forums facilitated by CTL also noted that the physical roundtables that encourage collaboration are not present in some schools. CTL has recognized the issue with delays in equipment procurement, and has responded to this challenge by intervening on behalf of MOBSE and contacting vendors of the necessary equipment to expedite purchases.

FACILITIES AND EQUIPMENT

The PSI curriculum requires that students spend some portion of their time in a laboratory setting. This posed a challenge for CTL in the Gambia, as limited funding meant that schools

had to share laboratory spaces. In order to stay within budget, CTL generated a new equipment list specifically for the Gambia schools, which allowed CTL to provide a modified set of lab equipment to each school while still staying within budget.

STUDENT CONTACT TIME

Gambian mathematics and science courses tend to meet for approximately 170 to 180 minutes per week, which is roughly 10 percent less than Algebra 1 courses in the United States and 20 percent less than physics courses in the United States. In addition, researchers with CTL found that students teaching the new PMI/PSI curriculum for the first time taught it more slowly than experienced teachers of the curricula.

CTL staff members estimate that approximately 40 percent of the intended content will be delivered to students during the second year of implementation (approximately the same as a typical U.S. student would learn during the first half of a single school year). CTL is addressing this problem by administering midterm exams to PSI/PMI-instructed students this year in order to record a measure of student learning.

RECOMMENDATIONS

CTL RECOMMENDATIONS

The following recommendations were compiled by staff members at CTL, and reflect ways in which the organization plans to improve programming in the Gambia moving forward:

- **Instructional Time:** Review school scheduling to allot more instructional time for PSI-PMI courses. The reduced student contact time means that it takes longer for students in the Gambia to learn the content of PSI and PMI courses. Another possible solution would be to introduce PSI physics in grade 7, and to consolidate science instruction so that only one science subject is taught each year. : 8th grade teachers in the current UBSs should be trained so that PSI and PMI can begin a year earlier. This will compensate for the lower number of contact hours by allowing both Algebra Based Physics and Algebra I to be taught over two years, and be completed before students enter SSS in the 2015-16 school year.
- **Ongoing Teacher Training:** Continue teaching teachers PMI Geometry and PSI Trigonometry-Based Physics after completion of PMI Algebra and PSI algebra-based Physics. These teachers would be the lead teachers in expanding the curriculum to more students.
- **Curriculum Alignment and Assessments:** Review the curriculum map that shows how PSI-PMI units cover WAEC/WASSCE objectives to help prepare Grade 12 students for WAEC exams. MOBSE and CTL should continue to work on alignment between PMI and PSI curricula and end-of-course tests administered in public schools. Moving forward, more rigorous assessments should be considered as alternatives to the GABECE and WAEC exams. Teachers and administrators should

- be informed about the end-of-course testing requirements for students currently enrolled in PSI Physics and PMI Algebra I, especially students in SS schools.
- **Equipment:** An evaluation should be done to see if additional equipment is needed to set up an additional classrooms to accommodate students taking PSI and PMI courses in both UBS and SSS.
 - **Laptops or Computers for Teachers:** Teachers in Cohort 2 will need computers to run SMART interactive projectors and use the digital materials. If there are no remaining equipment funds to purchase laptops for Cohort 2, the schools should provide computers for each of the PSI and PMI classrooms.
 - **Scheduling:** The same students should be scheduled to take both the physics and algebra courses. Ideally, these should be students from all skill levels (not just the top math and science students). The program is designed for science classes to meet on a daily basis for 40 minutes 4 days a week and 80 minutes 1 day a week to allow time for labs and review, which is a total of 240 minutes/week. If the 80-minute day is not possible, the classes should at least meet 200 minutes per week. Math classes should meet for 40 minutes on a daily basis, 200 minutes/week.
 - **Procedures:** The UBS teachers who became trainers could facilitate a principal/lead teacher meeting to advise administrators on key procedures like how to assign printed course materials and responders, using letter cards for formative assessment in the absence of SMART responders (or in the event of power outages), and pacing. These experienced local trainers can then advise on any other logistical concerns and offer support.
 - **Principal/Lead Teacher meeting:** Administrators from the 24 participating schools should meet with each other as well as any available PSI-PMI trained teachers to discuss implementation procedures and scheduling.
 - **Communication:** CTL and MOBSE should continue to communicate via email and Skype to evaluate test data and coordinate upcoming training sessions.
 - **Pre-test and Post-test.** All students should take the PSI and PMI pre-test and post-tests at the beginning of the program at the end of each school-year until course completion.

HANOVER RECOMMENDATIONS

The following commentary comprises Hanover's recommendations for improved data collection moving forward. As CTL continues its important work in the Gambia, improved data collection methodologies will allow for more rigorous evaluation of the effects of the program, and will allow CTL to demonstrate the broader impacts of its work.

Hanover's analysis of the PMI and PSI programs implemented in upper basic and senior secondary schools in the Gambia found consistent evidence of a positive impact on student learning outcomes. We used a number of research designs to make inferences regarding the effectiveness of the progressive math and science initiatives in improving student

achievement. The following describes the strengths and limitations of each of the methods used in this report, and outlines how we can improve our current methods further.

First, we compared the performance of UBS students who received PMI/PSI instruction in 2012-13 to students within the same school who did not. The advantage of this method is that we compared groups of students within schools, rather than across schools, who differ mainly in their receipt of the treatment, which is PMI/PSI instruction. However, it is difficult in this case to completely isolate the impact of the PMI/PSI program because the students in the treatment and control group sat for slightly different versions of the GABECE. As noted in Section II, the ideal comparison would allow us to compare the two groups of students on the GABECE items that were common to all students. Further, the comparison can be improved upon by controlling for students' initial ability level. In other words, this would allow us to compare GABECE performance of students who are as similar to each other as possible, in terms of ability, but differ only in their assignment of the treatment.

Second, we evaluated the effectiveness of PMI/PSI among SSS students in two ways: by estimating student learning growth for PMI/PSI students and by comparing PMI/PSI students to non-PMI/PSI students in other schools. Due to data limitations, we were not able to combine the two methods where we compared the performance of PMI/PSI students to that of non-PMI/PSI students on the pretest and posttest. This follows from not having pretest data available to students in the comparison group. Therefore, the ideal research design would allow us to compare student learning growth for students who received the treatment to students who did not. This methodology will allow us to better isolate the effect of the progressive math and science initiatives on student learning growth by controlling for students initial ability level and eliminating factors outside of the influence of PMI/PSI that may affect student outcomes.

To summarize, the methods used in this report and in CTL's progress report are sufficient for demonstrating the initial impact of CTL's programming, but can be improved upon by adding an additional dimension to each method. Specifically, when creating a cross-sectional analysis and comparing students across PMI/PSI instruction, we can further sharpen our comparison by adding a longitudinal dimension to the data. We can do so by including pretests and posttests for students instructed in PMI/PSI and students who are not. Similarly, when evaluating the impact of PMI/PSI longitudinally, adding a cross-sectional dimension in the form of a comparison group, we are able to better isolate the impact of PMI and PSI on student learning.

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