Discovering and Supporting Hidden Talents through Math Olympiads in Colombia*

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Abstract

Mathematical Olympiads are widely regarded as effective mechanisms for identifying high-ability students in STEM fields. Yet participation remains limited, particularly among students from disadvantaged backgrounds, due to informational and financial barriers. We conducted a randomized intervention offering free access to Math Olympiads—including fee waivers and support for travel logistics—to thousands of public school students in Colombia. Despite the offer, only 67% of treatment schools participated, primarily due to logistical constraints. We examine the short-run impacts of this intervention on performance in the national high school exit exam. Among Olympiad participants, students from high-quality schools experienced significant gains in test scores, while those from lower quality schools experienced declines. These heterogeneous effects suggest that while Math Olympiads can foster academic achievement among top students, they may inadvertently impose cognitive or motivational costs on others.

Keywords: Math Olympiads, Talent discovery, Colombia

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1 Introduction

A growing body of literature documents high rates of achievement in science, technology, engineering, and mathematics (STEM) among former Math Olympiad participants. These individuals are disproportionately likely to pursue STEM careers and frequently credit the Olympiad experience as a formative influence. For example, 42% of American Math Olympiad participants go on to earn PhDs, often citing Olympiad participation as a key factor in their academic trajectories (Campbell, 1996). Similar findings have been reported in Germany, Finland, China, Taiwan, and South Korea (Campbell et al., 2018). More recent studies indicate that Olympiad performance predicts future academic output. However, disparities persist: students from lower-income countries with scores equivalent to their peers in wealthier nations exhibit lower subsequent academic productivity (Agarwal & Gaule, 2020). Within Colombia—one of the most unequal countries in the world—49% of the national team members in the sports Summer Olympics come from outside state capital cities, compared to only 4% of International Math Olympiad contestants. Against this backdrop, we investigate the causal impact of providing access to Math Olympiads in a developing country context.

We conducted a randomized controlled trial offering free access to Colombian Math Olympiads, including fee waivers and support for travel, to approximately 26,000 students in 260 public schools across the country. Colombia has a well-established Math Olympiad program and a history of international success. Nonetheless, fewer than 0.07% of public school students participated in the open first round of the competition. Our intervention targeted students in schools that had not previously participated in the Olympiad. We constructed quadruplets of schools based on geographical region and prior test scores. Then, we randomly selected two schools within each quadruplet to receive the treatment. Each treatment school was offered free registration for up to 100 students: 20 students per grade from 11th to 8th grade, and 10 students per grade in 7th and 6th grades.

We achieved an enrollment rate of 81% among treated schools; however, only 67% of these schools ultimately participated in the first round of the Olympiad due to logistical challenges, such as delivery delays. Despite this, all participating schools had at least one student advance to the second round, and 10% of them had students reach the semifinal stage.[1] Six treated students advanced to the final round, held in Bogotá, the capital of Colombia. Although treatment students comprised 50% of all Olympiad participants in the first round, they represented just 7.5% of finalists.

In this paper, we evaluate the effect of the Olympiads treatment on academic perfor-

[1]The Olympiad organization guarantees at least one student per school will advance to the second round, even if all students are below the quaifying cutoff. Nonetheless, 174 out of our 175 schools had at least one student above the cutoff.

mance as measured by the national high school exit exam that every graduating senior presents, called Saber 11. This test is presented approximately four months after the Olympiad.[2] Given that 67% of intent-to-treat schools ultimately participated, we mainly focus our analysis on treatment-on-the-treated estimates.

Our estimates suggest that the average treatment effect and the average treatment-on-the-treated effect are not statistically distinguishable from zero. However, we uncover significant heterogeneity by school quality. Among students from high-quality schools, participation in the Math Olympiad increased mathematics scores on the Saber 11 by 0.19 standard deviations. In contrast, students from lower-quality schools experienced a decline of 0.16 standard deviations. A plausible explanation is that high-achieving students were positively motivated by the opportunity to succeed beyond their school context, while lower-achieving students may have been demoralized by the competitive environment.

We find positive spillovers in non participating students and in other subjects. Non-participating students in high-quality schools experienced gains of 0.07 standard deviations in math scores. Among participants, we observe improvements in other subjects—including Spanish, Natural Sciences, Social Sciences, and English—ranging from 0.06 to 0.14 standard deviations. However, these estimates are not statistically significant at the 5% level.

To the best of our knowledge, this is the first study to randomize access to Math Olympiads and evaluate the causal impacts on student outcomes. Prior literature documents the role of Math Olympiads in nurturing talent globally (Agarwal & Gaule, 2020; Campbell et al., 2018). Calaway, 2025 highlights the importance of engaged mentorship teachers at school to motivate talented students. Related work in Brazil has found positive spillovers on non-participant students in schools with Olympiad participation (Moreira, 2019). Our results corroborate these findings, showing similar spillovers within treated schools.

Outside the context of Math Olympiads, existing literature suggests that awards and competitive environments can have heterogeneous effects: they tend to boost performance among high-ability individuals while discouraging low-ability individuals (Besley & Ghatak, 2008; Chandrasekhar et al., 2018; Lazear, 1989). For example, Fischer and Wagner, 2023 shows that timely feedback—provided 1–3 days before an exam—can improve performance by 0.2 standard deviations, whereas feedback provided immediately before the exam reduces performance by 0.1 standard deviations. In our study, the Olympiad occurred four months prior to the exit exam, yet top students from lower-quality schools

[2]In future work, we will examine the long-term impacts on younger cohorts who began participating in 2024 and in university and labor market outcomes.

still experienced negative effects. Similarly, Goulas and Megalokonomou, 2015 finds that performance feedback reduces test scores by 0.3 standard deviations among low-achievers but increases scores by 0.15 among high-achievers. Ashraf et al., 2014 reports that among health workers in Uganda, social comparisons reduce test scores by 0.35 standard deviations, while awards increase them by 0.41. In our context, the Olympiad included school-level awards (diplomas) and direct competition with peers nationwide, potentially triggering similar dynamics.

The remainder of the paper is organized as follows. Section 2 provides background on Math Olympiads in Colombia and outlines the experimental design. Section 3 describes the data and empirical strategy. Section 4 presents the results on academic performance. Section 5 concludes.

2 Context

2.1 Math Olympiads in Colombia

Mathematics Olympiads in Colombia are organized by a variety of public and private universities across the country. However, the exclusive rights to form Colombia's national team to represent the country at the International Mathematical Olympiad (IMO) are held by Universidad Antonio Nariño (UAN). For over 40 years, the Colombian Math Olympiads organized by UAN have served as the primary mechanism for identifying, selecting, and training the country's IMO team. UAN was our sole institutional partner for the 2024 olympiad analyzed in this paper.

The Olympiads are structured into four levels based on student grade. The "Superior" level is designed for students in grades 10 and 11 (the last year of high school in Colombia).[3] The "Intermediate" level includes students in grades 8 and 9, while "First" level covers grades 6 and 7. A separate Olympiad is held for Primary students in grades 3 through 5, where we did not provide subsidies in 2024.[4]

As detailed in Table 1, the UAN Olympiads consist of four competitive rounds. The first two rounds are administered by teachers at participating schools. Paper test materials are distributed by postal mail and returned in the same manner to UAN's central office in Bogotá for scoring. These rounds are administered on fixed national dates, and responses are processed using optical scanning technology. The first round has 25 multiple choice questions and the second round 12 numeric answer questions. Students advancing to the semi-final round are required to travel to the nearest UAN campus, where they complete a three hour-three questions formal proof exam. The final round takes

[3]This level includes students in grade 12 from international high schools

[4]We provided subsidies for Primary in 2025.

place in Bogotá and includes two days of preparatory training followed by two days of examination. Semi-final and final round responses are evaluated by trained mathematics educators and former Olympiad participants.

The top 20 students from each level are invited to a three-week training camp. At the conclusion of this training, students complete two IMO-style examinations. Performance on these exams determines the selection of the six-member team that represents Colombia at the International Mathematical Olympiad. The UAN Olympiad also sends students to the Iberoamerican, the Centoramerican and the Rioplatense Olympiads.

Table 1: Colombian Math Olympiads rounds

Round	Duration	Location	# of Questions	Type of Questions
First	1 hour	School	25	Multiple Choice (A-E)
Second	1 hour	School	12	Numerical Answer (000-999)
Semifinal	3 Hours	26 Cities	3	Formal proofs
Final	2x4.5 Hours	Bogotá	2x3	Formal proofs

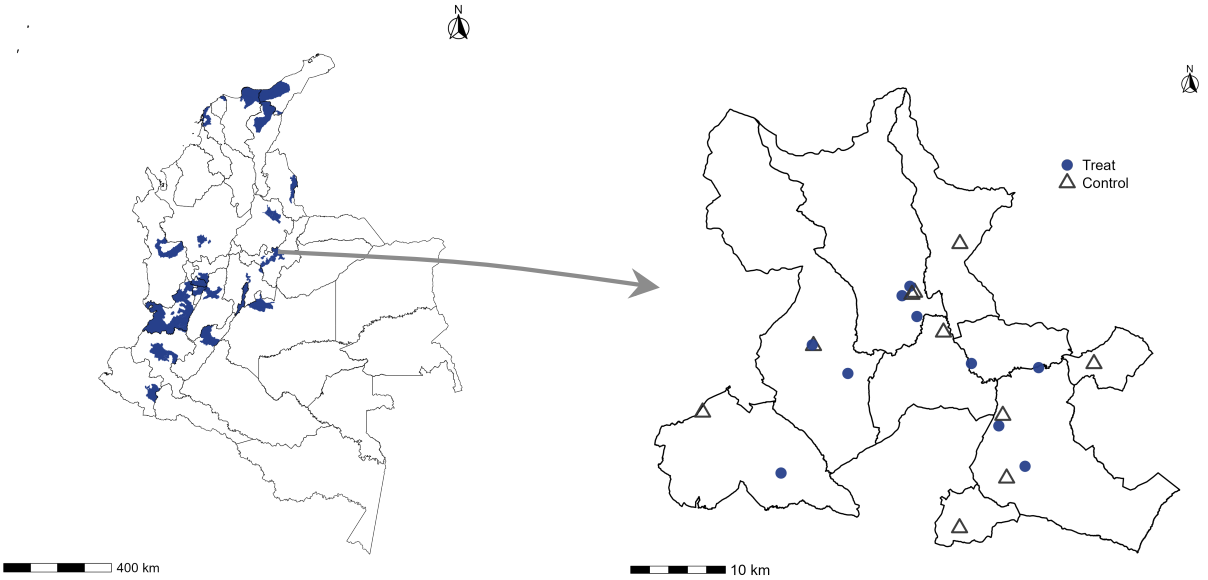
Notes: Characteristics of each of the rounds of the Colombian Math Olympiad. The 26 cities of the semifinal are where Universidad Antonio Narino has campuses thorughout the country. The semifinal is the final round for students in grades 6 and 7. The final is two exams in consecutive days, each consisting of three open questions requiring formal proof.

2.2 Sample and treatment details

Our experimental sample comprises 519 public secondary schools in Colombia that were not previously participating in the UAN national Math Olympiad. All study schools are located in municipalities within approximately one hour of one of 26 cities that have UAN campus, the organizer of the Olympiads. Each school offers instruction through Grade 11—the final year of secondary education in Colombia—and presented the Saber 11 exam in 2022 (the year's data we used for randomization).

We formed school quadruplets based on geographic location and average Saber 11 mathematics test scores. Quadruplets are preferred over pairs for randomized control trails Mckenzie, 2022. Within each quadruplet, we randomly selected two schools to receive free participation in the 2024 Math Olympiad. For example, among the top 5–8 public schools in mathematics performance around Duitama, two were randomly assigned to the treatment group. Figure 1 displays the spatial distribution of the schools included in the study.

Figure 1: Location of schools in the study



(a) Municipalities in the study sample (b) Schools around Duitama

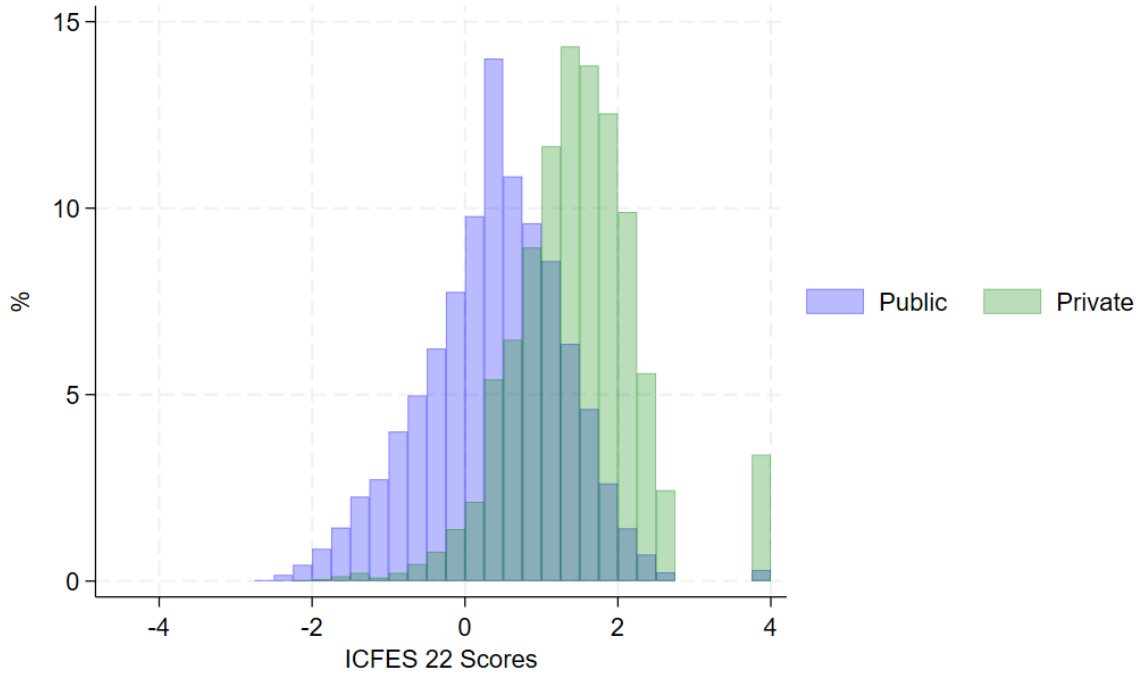
Notes: Figure 1a presents the municipalities where the study schools are located. Treatment and control schools are located basically in the same municipalities so the map scale doesn't allow for visual separation. Figure 1b zooms in on the city of Duitama, showing the spatial distribution of treatment (grey solid circle) and control (white triangle) schools around this city; the arrow highlights the location of Duitama in Colombia.

Due to implementation problems, the actual numbers of participating schools and students in the first round was lower. Invitation letters in 2024 were sent on February 26, with the first round of the Olympiad scheduled for March 19. Initially, only 20% of treatment schools confirmed participation via phone or email. Consequently, we conducted in-person visits to encourage enrollment. We offered scholarships for 100 students per treatment school distributed the following way: 20 students from each grade from 11 through 8, and 10 students from each of grades 7 and 6. This would have yield a total of 100 students across 260 treatment schools, or 26,000 students. The actual numbers were 175 schools and 15,527 students, respectively. Examples of implementation problems are delivery issues, difficulty in reaching certain schools and some schools having less than 20 students per grade.

Prior to the intervention, participation in the Math Olympiads among public schools was exceedingly rare—just 0.07% nationally. Non-participation appears to stem from three primary barriers: lack of financial resources, academic self-selection, and limited access to information. Our treatment sought to alleviate the first and third constraints by covering all participation costs and directly informing schools of the opportunity. Despite these efforts, 3 schools declined the offer; some explicitly cited a perceived lack of qualified students.

Figure 2 compares pre-treatment mathematics scores from the Saber 11 exam for public and private schools that participated in the 2024 Olympiads. While private school students perform better on average, the distribution reveals considerable overlap, with some public school students achieving high scores.

Figure 2: Pre-Treatment Mathematics Scores in Participating Public and Private Schools



Notes: This figure presents the histogram of standardized Saber 11 Mathematics scores of private schools that payed to participate in the 2024 Math Olympiad, and the public schools for which we subsidized access.

We initially planned a second randomized control trial to subsidize student travel costs for the later rounds of the Olympiad. However, logistical delays and a lower-than-expected number of treatment students advancing prompted a revision of our approach. Instead, we offered travel subsidies to all treatment students who qualified for subsequent rounds.

2.2.1 Research Timeline

We followed the timeline presented in Figure 3. As shown in the figure, Students in 11th grade who participated in Math Olympiads presented their high school exit exam around four months after the Math Olympiad. Due to delays in the results' publication, we link Olympiad participation to ICFES Scores in 2025.

Figure 3: Research Timeline

Research Activities	Year	Month	Intervention Activities	Key Dates
	2024	January		
Randomization		February	Invitation letters sent	
		March	Travel to invite schools	First Round Olympiads
		April		Second Round Olympiads
		May	Send travel stipends	Semifinals and Finals Math Olympiads
Olympiad Results Analysis		June		
		July	Travel to invite missing schools	
		August		Saber 11 ICFES presentation
		September		
		October	Travel to invite missing schools	
		November		Saber 11 ICFES publication
		December	Invitation letters sent for year 2	
	2025	January	Travel to invite missing schools	
		February		
Saber 11 ICFES results collection + Data Analysis		March		First Round Olympiads
		April		Second Round Olympiads
		May	Send travel stipends	Semifinals and Finals Math Olympiads
Olympiad Results Analysis		June		
		July		
		August		Saber 11 ICFES presentation
		September		

Notes: This figure presents the timeline of research, intervention and Math Olympiads.

3 Data and Empirical strategy

3.1 Data

We use two main data sources. Data from the Math Olympiad and data from the National high school exit exam (Saber 11). The Saber 11 data is available for treatment and control schools, and is our main outcome of interest. Math Olympiads data is only available for treatment schools that participated. We can link both data sources at the school level.

3.1.1 Math Olympiad Performance data

We will use the competition's results to measure the treatment schools' competitiveness in the Olympiad. The Math Olympiads consist of four different rounds: the first round features multiple-choice questions, the second includes numerical answer questions, and both the semifinal and final rounds require formal proofs. We will measure the average result per school and per top performers against non-treatment schools in each round to find the strengths and weaknesses of the treatment schools. We will also measure the number of students advancing to the next rounds as a percentage of the entire number of students presenting each round.

3.1.2 Student Learning

To measure student learning, we will use the high school exit exam SABER 11. The SABER 11 test scores are published by the ICFES institute, which is the national entity in charge of applying the SABER 11 exam. The databases provided by the ICFES contain

anonymoized information at the individual level about the student's performance -from 0 to 100- in each of the tested subjects in the exam (math, reading, social sciences, natural sciences, and English), as well as the student's overall score (from 0 to 500) in the test. We standaridze the test scores for ease of interpretation.

Math Olympiads tests and Saber 11 Math tests have an overlap of around 75% in topics. Both tests overlap in core areas such as algebra, geometry, and basic combinatorics, but differ slightly in emphasis. Saber 11 organizes its problems around Geometry, Algebra, while Math Olympiads uses Geometry, Algebra, Combinatorics, and Number Theory. The main distinction lies in how Saber 11 focuses on applied math and statistics, whereas the Olympiads emphasize advanced problem-solving, logical reasoning, and number theory.[5]

Importantly, the Saber 11 database contains the students' school code, allowing us to identify if they were in treated or control schools. Note that we cannot link each student in the Olympiads to their individual score in Saber11 exam. We can only link schools, and assume that the top students of the school participated in the Olympiad. We assume that each school enrolls its highest-performing math students in the Olympiads, such that the N_s Olympiad participants in the school correspond to the top N_s scorers in the math section of the ICFES exam. To assess the plausibility of this assumption, we compare, at the school level, the share of female students Olympiad participants to the share of female students among the top N_s scorers in the ICFES math test. Figure A.1 shows how these measures are highly correlated ($\rho = 0.74$), providing support for the participation assumption.

The Saber 11 database also contain sociodemographic information for each student, such as if the students work, have access to computers or Internet in their households, consume protein, or their parents' educational attainment among others. Table 2 shows how relevant sociodemographic variables, as well as previous test scores, are balanced between treatment and control groups.

3.1.3 Long term outcomes

In the future, we can track the students through university decisions and labour market outcomes using anonymized administrative data from the Colombian government. In particular, ICFES has college graduation and college exit exam results. Additional data has information on whether the person is employed in the formal sector and the wage.

[5]See ICFES, 2025 for the ICFES syllabus. Colombian Math Olympiads designs its tests based on the International Math Kangaroo. See Math Kangaroo, n.d. for the Math Kangaroo Syllabus.

3.2 Summary Statistics

Table 2 presents summary statistics for the study schools in 2022.[6] On average, 120 students per school take the Saber 11 exam, with 58 percent of them being female. The average age at the time of the exam is 16.7 years. About 62 percent of our study students come from the lowest socio-economic strata (strata 1 or 2), while 30 percent belong to the medium-income strata (strata 3 or 4).

There are no statistically significant differences between treatment and control groups across any of the observed baseline characteristics, including our primary outcome measures. This suggests that the random assignment was successful in achieving covariate balance. Panel B similarly shows no statistically significant differences across baseline variables, with the exception of a marginally significant difference in the proportion of female students between treatment and control schools (a 4-percentage-point difference; $p = 0.079$).

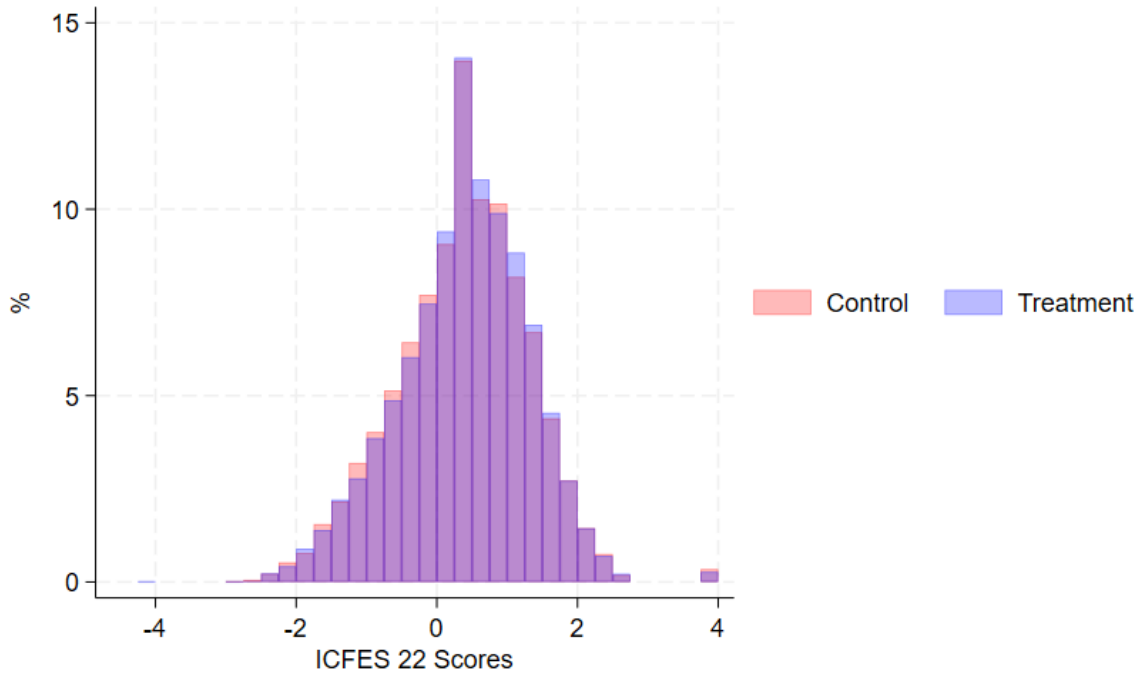
[6]The 2023 data was released after we started the intervention in February 2024, so 2022 is the baseline year.

Table 2: Balance Table on ICFES Scores treat vs. control schools

	(1)	(2)	(3)
	Mean (and SD) for each group		p-value
	Treatment	Control	equality test
Panel A: Variables Randomization Year (2022)			
Number of Students	121.52	124.50	0.778
	(68.56)	(77.19)	
Gender (Female)	0.59	0.57	0.321
	(0.49)	(0.50)	
Age at Exam	16.71	16.71	0.916
	(1.05)	(1.12)	
Low Income SES	0.62	0.61	0.516
	(0.48)	(0.49)	
Medium Income SES	0.29	0.30	0.942
	(0.46)	(0.46)	
Global Score Standardized	0.01	-0.00	0.889
	(0.99)	(1.00)	
Math Score Standardized	0.01	0.00	0.918
	(0.99)	(1.00)	
Number of Schools	260	259	
Panel B: Variables in Treatment Year (2024)			
Number of Students	119.39	124.10	0.633
	(65.52)	(75.14)	
Gender (Female)	0.58	0.54	0.079
	(0.49)	(0.50)	
Age at Exam	16.66	16.67	0.799
	(1.66)	(1.23)	
Low Income SES	0.64	0.63	0.680
	(0.48)	(0.48)	
Medium Income SES	0.32	0.33	0.679
	(0.47)	(0.47)	
Number of Schools	258	259	

Notes: This table reports means and standard deviations (in parentheses) for treatment and control groups. Column (3) reports the p-value of a test of equality of means with clustered standard errors by school.

Figure 4: Lagged ICFES scores treatment vs. control schools



Notes: This figure presents the histogram of standardized Saber 11 Mathematics scores for treatment and control schools.

3.3 Estimating Equations

To study the intent-to-treat effect of Math Olympiads' participation in student learning, we will estimate the following equation via ordinary least squares (OLS). This equation was pre-specified in the pre-analysis plan.

$$Y_{isq} = \beta_I RO_s + \gamma_q + \beta_y Y_s^{-1} + \gamma X_i + \epsilon_{ist}, \tag{1}$$

Y_{isq} is the national standardized test score of student i from school s located in the region-performance quadruplet q (our strata for randomization). Our main outcome of interest will be the Math Saber 11 ICFES score, but we will also analyze the global score and other subjects' scores to find out if there are any positive spillovers or substitution effects from math to other subjects. RO_s is a dummy indicating if school s was randomly selected to receive treatment (Math Olympiad invitation), Y_s^{-1} is the lagged average test score of school s, X_i contains sociodemographic variables per student, γ_q represents fixed effects by region-past test scores quadruplet, and ϵ_{isq} are standard errors clustered at the school level.

Our estimation will aim to separate the effect of students participating in the Olympiad, and other students in treatment schools that did not participate. Recall that the Saber 11 data is annonymized and we cannot match students with Math Olympiads participation. We order students in ech school by Saber 11 Math performance, starting with $i = 1$ forthe best student. Assuming the top N_s Saber 11 students per school would have been the students that participated in Math Olympiads, we will calculate for $i \leq N_s$ the effect in "participating" students and for $i > N_s$ the spillover effects in the non-participating students.

Given that only 67% of intent-to-treat schools actually participated the Olympiad, we estimate the treatment on the treated effects using an instrumental variable strategy.

$$PO_s = \pi_0 + \pi_1 RO_s + \alpha_q + \pi_y Y_s^{-1} + \pi X_i + u_{ist}, \tag{2}$$

$$Y_{isq} = \beta_P \hat{PO}_s + \gamma_q + \beta_y Y_s^{-1} + \gamma X_i + \epsilon_{ist}, \tag{3}$$

Here PO_s is a dummy indicating whether the school s actually participated in the Olympiads. The other variables are the same as in equation (1). Through this IV estimation, we can estimate the effect of actually participating in the Olympiads and not just being randomly selected to receive free participation.

We examine whether treatment effects vary across observable characteristics of treatment schools. These characteristics include school quality, location, socioeconomic status, gender, and others.

School quality (proxied by past cohort test scores). We expect that results may vary depending on school quality. In top-performing schools, motivated teachers or students who discover new ways to prepare and develop math skills could achieve better outcomes. In contrast, lower-quality schools might struggle in the Olympiad and experience frustration. This might lead to student disengagement, leading to smaller or possibly negative treatment effects. Another possible explanation is that weaker schools may divert from their regular curriculum to prepare for the Math Olympiads, leaving students less prepared for the Saber 11 exam.

Socioeconomic status (SES). Students with a higher SES may experience a smaller treatment effect as they had the income to participate before if they wished. In contrast, students from lower-income backgrounds may benefit more consciously from the treatment, recognizing it as a valuable opportunity.

Urban-Rural school Annecdotally, rural schools were more thankful for the opportunity to participate in the Olympiads: they "had never had an opportunity like this" so the treatment might have a more substantial effect because rural schools have fewer opportunities than their urban counterparts. However rural schools had more difficulties receiving the Olympiad exams directly at their locations due to delivery companies' logistics policies. As a result, they had to receive their exams either in urban areas or through informal messengers. These geographical obstacles could lead to weaker effects due to the additional effort required to overcome non-academic barriers and access the treatment. Literature indicates that in Colombia, rural schools generally underperform compared to urban schools, and distance from towns and state capitals negatively impacts students' test scores (Bonilla-Mejía et al., 2024).

Students' sex. We do not anticipate any differences in scores between boys and girls. However, differential competitiveness by sex could result in different treatment effects for them. Literature shows that, regardless of performance, men embrace competition more fiercely due to their overconfidence, while women shy away from competition (Niederle and Vesterlund, 2007). However, there could also be cultural differences that don't apply to our case in Colombia. Men in China may be more willing to pay to conceal that they were defeated by another individual. However, this pattern does not hold in the US, suggesting that cultural differences may lead to varying levels of competitiveness by sex (He and Noussair, 2020). In our experiment, 5 out of 6 finalists from treatment schools were boys.

Same city as a UAN venue. These schools were less likely to experience logistical failures in test delivery. When delivery companies failed—due to address errors, absent recipients, or refusals to reach certain locations—regional UAN venues received the materials and held them for pickup. In later rounds, students from these schools did not need to travel outside their hometown, reducing logistical and participation barriers.

Internet access Although associated with SES, internet may independently influence treatment effects. Students with internet access may experience a more favorable treatment effect, as they can utilize a wider range of online resources to prepare for their tests and receive feedback on their work.

4 Results

4.1 Performance of treatment schools in Math Olympiads

Table 3 presents the performance of treatment schools in Math Olympiads. Out of the 260 intent-to-treat schools, 4 schools reached the final round, all high-quality according to baseline Saber 11 performance. 34 Schools reached up to semifinals and all 175 schools

that participated in round one reached up to second round.

A big hurdle in 2024 was enrolling and mantaining schools´participation. We were able to contact about 20% of the treatment schools remotely from our university in Bogotá, so the team had to travel around the country to visit and enroll them in person. We were able to lift the number of contacted schools to about 81% of the intent-to-treat schools. The team had to travel by car, by plane, and by boat to reach schools, even getting to AfroColombian communal councils, Indigenous communities and areas controlled by armed groups.[7] 48 schools couldn't be contacted before the 2024 Olympiads. They have been contacted for the 2025 Olympiads. For 15 enrolled schools the delivery service couldn't find the address, or the tests were not picked up from the delivery office. 41 schools did not present or send back the answer sheets: 21 in first round and 26 in second round.

As for the number of students students, not all schools enrolled their 100 treatment Olympiads fee waivers, either because they did not have enough students or because they did not want to test them all. We had exciting news, as students from isolated parts of Colombia, such as Sierra Nevada, Jambalo, or Buenaventura, classified to the semifinals.

Over seventy treatment students advanced to the semifinal round. This round involved traveling to one of the 26 UAN campuses to take the test. We were able to help most of the tretament students with travel subsidies. The main problem we faced was the lack of contact information with some students. 26 treatment students were eligible, but did not take the subsidy for the following reasons:

- **13 students** Received results late, so they were not contacted ahead of time
- **2 students** declined the travel stipend for personal reasons
- **11 students** Didn't have contact number or never answered back the subsidy proposal message.

All six treatment students that qualified for the final round were able to participate, and one was selected for the national training camp to choose Colombia's IMO team, having ranked among the top 20 students. We established direct contact with the semi-finalists and finalists; most expressed gratitude for the opportunity, particularly for the chance to travel to Bogotá—a city many had never visited before. See the Appendix for a selection of appreciation messages.

[7] See Appendix 3 for some Field Work pictures

Table 3: Olympiad Participation Summary

Round	(1) N. Schools	(2) N. Students	(3) N.11° Students	(4) % Olympiads	(5) % High Q Schools
Intent to treat	260	26,000	5,200		41%
Accepted	211	21,100			
First round	175	15,527	3,095	51%	38%
Second round eligible	175	6,972	1,280	49%	44%
Second round	146	5,451	1,013	46%	46%
Semifinal eligible	34	75	17	19%	52%
Semifinal	34	74	17	19%	51%
Final	4	6	1	8%	100%

Notes: This table summarizes participation across different stages of the Olympiad in 2024. All percentages are rounded to the nearest whole number. "N Students 11" refers to the number of participants in grade 11 among the treatment schools. "% Olympiads" refers to the share of treatment schools participating in the round relative to all schools. "N.Stud. HQ Schools" refers to the proportion of students from schools with an average lagged math score of .275 standard deviations.

As shown in Table 3, all participating schools had at least one student qualify for the second round, regardless of whether they ultimately chose or were able to present the test. However, from the second round onward, the proportion of treatment students declined sharply by approximately two-thirds. One possible explanation is that we enrolled too many students per school; compared to private schools that had a median enrollment of 66 students. In 2025, we will limit enrollment in new treatment schools to 60 students (10 per grade).

In the semifinal, there is also a drop in half of the share of treatment students. Therefore, to enhance success in next year's Olympiads, formal proof training is needed for these schools.

Since our primary outcome of interest is measured for 11th grade students, it should be noted that on average 17 of them participated per school.

We classify as "high-quality schools" those with an average lagged Saber 11 math score exceeding .275 standard deviations above the mean. This is based on the Saber 11 performance of private schools in the Olympiads. As the competition progresses, the proportion of participating students from these schools rises among treatment schools. In the first two rounds—where submissions do not require formal proofs—this share reaches approximately one-half of all participants. In contrast, by the semifinal stage, when formal proofs are required, all students advancing to the final round originate from top schools.

4.2 Effects of Math Olympiads Participation in student learning

We estimate the Olympiads treatment effects using Saber 11 Math, global and subject-specific test scores from 2024. It is important to note that Olympiad invitations were extended in February, while the standardized tests were administered in August. The Olympiads took place between March and June, providing at least a two-month gap between the two assessments for participating students.

Panel A in Table 4 shows that students in schools offered participation in the Math Olympiads in 2024 did not experience statistically significant changes in their overall or subject-specific test scores. When focusing on the top 20 students within each treatment school, there are also no significant effect on overall scores or mathematics scores.

Panel B of Table 4 presents the treatment-on-the-treated effect by instrumenting actual participation in the Olympiads with randomized assignment to the Olympiad offer. This Instrumental Variables (IV) approach relies on the assumption that assignment to the offer affects test scores only through its impact on actual participation. Actual participation also does not affect test scores on average. These findings are consistent with those reported in Card et al., 2024, which found that a gifted student program in Florida had no effect on test scores.

Table 4: Olympiad Participation Effects on Test Scores

	(1) Global All Stud.	(2) Math All Stud.	(3) Global Top 20	(4) Math Top 20
Panel A: OLS Offered Olympiad Participation				
Offered Olympiads	-0.021	-0.0097	-0.061	-0.034
	(0.0182)	(0.0178)	(0.0414)	(0.0409)
R^2	0.24	0.23	0.40	0.42
Panel B: IV Actual Olympiad Participation				
Participated	-0.031	-0.014	-0.092	-0.052
	(0.0264)	(0.0256)	(0.0623)	(0.0614)
N. of obs.	41,726	41,726	9,921	9,921
N. Schools	517	517	517	517
R^2	0.018	0.014	0.020	0.024

Notes: All regressions include strata fixed effects by randomization quadruplet. All regressions control for average school-level lagged scores. Standard errors clustered at the school level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

We next examine whether there are heterogeneous effects of Olympiad participation as pre-specified in the pre-analysis plan. We focus on heterogeneity by school quality, sex, socioeconomic status, urban/rural school location, and internet access, using math test scores of actual participants as the outcome of interest.

We found that participation in Math Olympiads increased Saber 11 math scores by $0.19\sigma, (p < 0.05)$ for participating students in high-quality schools (average lagged math score was above .275 standard deviations). However, participation in the Olympiad had a negative effect $(-0.16\sigma, p < 0.05)$ on the math test scores of students in lower quality schools. Olympiad participation also had a negative effect $(-0.017\sigma, p < 0.05)$ for students who didn't have Internet at home; nevertheless, there was no significant effect for those who did have internet at home.

Table A.3 shows that the heterogeneous effects with the intent-to-treat specification are consistent with the treatment-on-the treated results. Given that 33% of intent-to-treat schools did not participated the magnitudes are smaller. The effects vary by school quality, with estimates of $(0.11\sigma, p < 0.05)$ for high-quality schools and $(-0.11\sigma, p < 0.05)$

for lower-quality schools.

No statistically significant effects are observed across other heterogeneity dimensions.

Table 5: Heterogeneous treatment effects of Olympiads participation

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. var.	Saber 11 math score					
Heterogeneity	Lower quality Schools	High quality Schools	Low-SES	High-SES	Urban	Rural
Panel A: Heterogeneous effects						
Participated	-0.16**	0.19**	-0.059	-0.0023	-0.0033	-0.13
	(0.0790)	(0.0943)	(0.0670)	(0.0646)	(0.0527)	(0.178)
N. of obs.	5,165	3,651	6,002	2,813	7,216	1,600
N. Schools	304	209	509	473	406	108
R^2	-0.0011	0.082	0.029	0.043	0.047	0.0071
Panel B: Heterogeneous effects						
Heterogeneity	Female	Male	Same city as UAN Venue	Diff. City UAN Venue	Has Internet	Does not have internet
Participated	-0.028	-0.063	-0.034	-0.059	0.0012	-0.17**
	(0.0697)	(0.0628)	(0.0895)	(0.0818)	(0.0587)	(0.0820)
N. of obs.	3,813	5,003	4,811	4,005	6,621	2,193
N. Schools	508	479	281	232	510	470
R^2	0.039	0.029	0.024	0.042	0.039	0.016

Notes: All regressions include strata fixed effects by randomization quadruplet. All regressions control for average school-level lagged scores (we do not have individual student-lagged scores). Standard errors clustered at the school level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

We then study spillovers of the increase in math scores of participating students to other subjects and to their non-participating classmates. Results in Table 6 show that there is a general increase in test scores for Math Olympiad participating students. But, barring mathematics, the effect is not statistically significant at the 5% level. For non-participating students, we observe in Panel B positive spillovers of around a third of the direct effect. The math test scores for non-particpoating studnets increases by 0.078σ ($p < 0.1$). While there is no statistically significant effect on their overall test scores, we also find a positive effect on their English scores (0.093σ, $p < 0.1$). It is important to note that there are fewer schools in Panel B because some schools enrolled all of their 11th-grade students in the Olympiads. Consequently, relative to their total student population, there are non-aprticipating students in these treatment schools.

Interestingly, English shows large spillover effects. One hypothesis for this result would be that in our visits to enroll schools in Math Olympiads, we presented them as am opportunity to pursue studies abroad, conditioning the english-as-a-second-language preparation.

Table 6: Spillover Effects of Olympiad Participation in high quality schools

Dep. var.	(1) Global	(2) Math	(3) Spanish	(4) Science	(5) Social Sciences	(6) English
Panel A: Olympiad Participating Students						
Participated	0.12	0.19**	0.096	0.059	0.071	0.14
	(0.0965)	(0.0943)	(0.0865)	(0.0930)	(0.0869)	(0.0945)
N. of obs.	3,651	3,651	3,651	3,651	3,651	3,647
N. Schools	209	209	209	209	209	209
R^2	0.062	0.082	0.025	0.043	0.036	0.031
Panel B: Non-Participating Students in Schools that Participated						
Participated	0.053	0.078*	-0.0013	0.065	0.027	0.093*
	(0.0482)	(0.0470)	(0.0456)	(0.0490)	(0.0500)	(0.0555)
N. of obs.	14,277	14,277	14,277	14,277	14,277	14,178
N. Schools	198	198	198	198	198	198
R^2	0.051	0.042	0.030	0.038	0.037	0.030

Notes: All regressions include strata fixed effects based on the randomization design. All regressions control for average school-level lagged scores (we do not have individual student-lagged scores). Standard errors clustered at the school level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

In lower-quality schools, the direct effect of Olympiad participation is negative across all subjects for participating students (see table A.4). The largest declines are observed in global scores and science scores, with reductions of 0.018σ ($p < 0.05$) n each, followed by a decrease of 0.016σ in math scores ($p < 0.05$). Spillover effects on non-participating students in these schools are negative for global scores and English, with the global score spillover magnitude approximately one-third of the corresponding direct effect.

5 Conclusions

Our findings provide the first causal evidence on the effects of expanding access to Math Olympiads. While the average impact on high-stakes academic performance is close to zero, we uncover meaningful heterogeneity: students from high quality schools benefit substantially, improving their mathematics test scores and generating positive spillover effects for non-participating students. Conversely, students in lower-performing schools experience declines across all subjects. These results suggest that exposure to elite academic competitions can be motivating for some students, but discouraging for others, particularly in contexts where academic preparation is uneven. This highlights a potential unintended consequence of expanding merit-based opportunities without complementary support for lower-performing environments.

In 2024, 125 countries participated in the International Mathematical Olympiad, suggesting that similar interventions could be feasibly scaled across diverse national contexts to leverage the positive effects of Olympiad participation. To mitigate the negative effects observed among students in lower-performing schools, one possible approach is to introduce a parallel, second-tier competition—an institutional feature already present in countries like Peru and Brazil. Such tiered structures may provide a more supportive entry point for students with less prior preparation, while preserving the motivational benefits of academic contests.

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A Appendix

Figure A.1: Top students enrollment assumption validation through gender percentage comparison

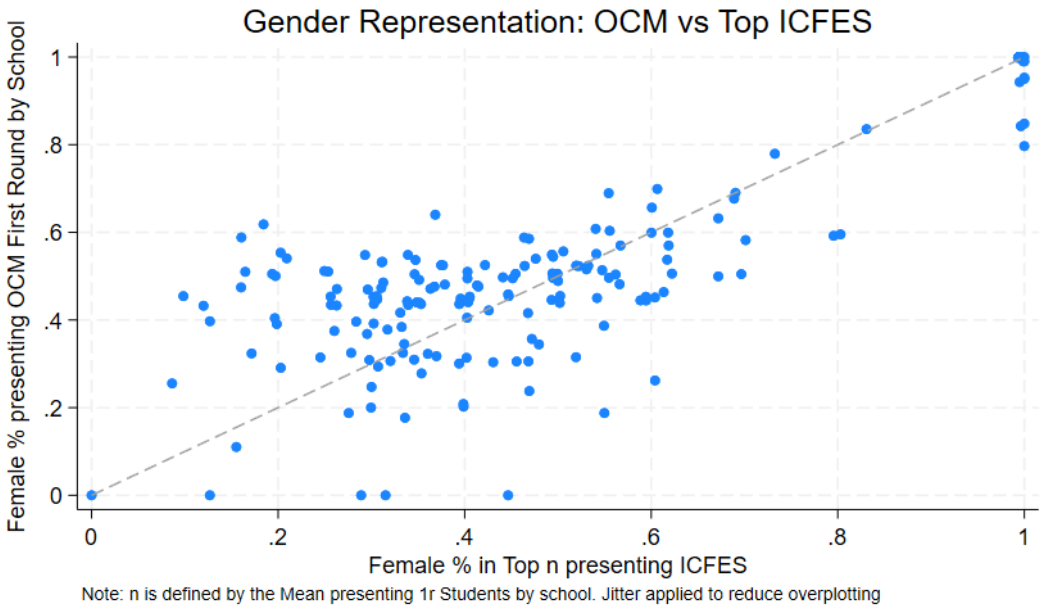


Table A.1: Offered Olympiads Effect on Test Scores by subject

Dep. var.	(1) Global	(2) Math	(3) Spanish	(4) Science	(5) Social Sciences	(6) English
Panel A: Scores for All Students						
Offered Olympiads	-0.021	-0.0097	-0.024	-0.021	-0.023	-0.018
	(0.0182)	(0.0178)	(0.0174)	(0.0185)	(0.0183)	(0.0193)
N. of obs.	41,726	41,726	41,726	41,726	41,726	41,336
N. Schools	517	517	517	517	517	516
Mean (Control)	9.1e-10	7.1e-10	3.5e-09	1.3e-09	6.4e-09	8.5e-10
R^2	0.24	0.23	0.18	0.21	0.17	0.20
Panel B: Scores for Top 20 Students per treatment school						
Offered Olympiads	-0.061	-0.034	-0.056	-0.076**	-0.061*	-0.040
	(0.0414)	(0.0409)	(0.0369)	(0.0383)	(0.0368)	(0.0382)
N. of obs.	9,921	9,921	9,921	9,921	9,921	9,855
N. Schools	517	517	517	517	517	516
Mean (Control)	0.76	0.87	0.57	0.70	0.62	0.49
R^2	0.40	0.42	0.27	0.34	0.28	0.28

Notes: All regressions include strata fixed effects by randomization quadruplet. All regressions control for average school-level lagged scores (we do not have individual student-lagged scores). Standard errors clustered at the school level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.2: Olympiad Participation Effects on Test Scores by subject

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Scores for All students						
Dep. var.	Global	Math	Spanish	Science	Social Sciences	English
Participated	-0.031	-0.014	-0.035	-0.030	-0.033	-0.026
	(0.0264)	(0.0256)	(0.0253)	(0.0267)	(0.0266)	(0.0279)
N. of obs.	41,726	41,726	41,726	41,726	41,726	41,336
N. Schools	517	517	517	517	517	516
R^2	0.018	0.014	0.011	0.014	0.014	0.014
Panel B: Scores for Top 20 Students per school						
Dep. var.	Global	Math	Spanish	Science	Social Sciences	English
Participated	-0.092	-0.052	-0.083	-0.11**	-0.091	-0.060
	(0.0623)	(0.0614)	(0.0557)	(0.0577)	(0.0555)	(0.0574)
N. of obs.	9,921	9,921	9,921	9,921	9,921	9,855
N. Schools	517	517	517	517	517	516
R^2	0.020	0.024	0.0093	0.016	0.0097	0.016

Notes: All regressions include strata fixed effects by randomization quadruplet. All regressions control for average school-level lagged scores (we do not have individual student-lagged scores). Standard errors clustered at the school level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.3: Heterogeneous treatment effects on Math Test Scores (OLS)

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. var.	Saber 11 math score					
Heterogeneity	Low-performing Schools	Top-performing Schools	Low-SES	High-SES	Urban	Rural
Panel A: Heterogeneous effects						
Offered Olympiads	-0.11**	0.11**	-0.040	-0.0015	-0.0023	-0.100
	(0.0574)	(0.0563)	(0.0451)	(0.0433)	(0.0380)	(0.132)
N. of obs.	5,165	3,651	6,002	2,813	7,216	1,600
N. Schools	304	209	509	473	406	108
R^2	0.40	0.26	0.43	0.47	0.49	0.45
Panel B: Heterogeneous effects						
Heterogeneity	Female	Male	Same city as UAN Venue	Diff. City UAN Venue	Has Internet	Does not have internet
Offered Olympiads	-0.019	-0.041	-0.021	-0.043	0.00078	-0.11**
	(0.0481)	(0.0408)	(0.0546)	(0.0597)	(0.0391)	(0.0550)
N. of obs.	3,813	5,003	4,811	4,005	6,621	2,193
N. Schools	508	479	281	232	510	470
R^2	0.48	0.44	0.46	0.54	0.37	0.52

Notes: All regressions include strata fixed effects by randomization quadruplet. All regressions control for average school-level lagged scores (we do not have individual student-lagged scores). Standard errors clustered at the school level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A.4: Spillover Effects of Olympiad Participation in lower quality schools

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. var.	Global	Math	Spanish	Science	Social Sciences	English
Panel A: Olympiad Participating Students						
participated	-0.18**	-0.16**	-0.15**	-0.18**	-0.15**	-0.14*
	(0.0824)	(0.0790)	(0.0753)	(0.0761)	(0.0737)	(0.0735)
N. of obs.	5,165	5,165	5,165	5,165	5,165	5,108
N. Schools	304	304	304	304	304	303
R^2	0.00035	-0.0011	0.00014	-0.000064	0.00047	0.0048
Panel B: Non-Participating Students in Schools that Participated						
participated	-0.065*	-0.062	-0.047	-0.054	-0.056	-0.093***
	(0.0374)	(0.0379)	(0.0356)	(0.0370)	(0.0352)	(0.0327)
N. of obs.	18,795	18,795	18,795	18,795	18,795	18,562
N. Schools	272	272	272	272	272	270
R^2	0.0033	0.0031	0.0022	0.0013	0.0031	0.0016

Notes: All regressions include strata fixed effects based on the randomization design. All regressions control for average school-level lagged scores (we do not have individual student-lagged scores). Standard errors clustered at the school level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B Participants, teachers and/or parents' testimonies

- *I want to express my gratitude for the financial support and accommodation, without which we would not have been able to attend. It has been a wonderful experience.*
- *I would like to see more support with training materials. There are some resources on the Olympiad website, but they are not like the problems in the final rounds. This type of content is essential for practice.*
- *The Olympiad final is a very difficult test, but that is a good thing. It is a great challenge to know that we are here to tackle these difficult problems and push ourselves to the limit. Being able to solve these exercises is evidence that we can achieve something great. We compete against people with more preparation. More training is needed because school classes are designed for the average student, not for math competitions.*
- *It is a great challenge to keep learning and pushing myself. I really enjoy being here. I want to study something related to mathematics, so this is a great opportunity to maintain that connection with what I love. I am always thinking about math problems and how to solve real-life challenges. This is a space where I feel safe.*
- *The students feel in their element. We enter a space entirely dedicated to mathematics during this final week, where we share ideas and continue growing. This type of experience is very important for my students.*
- *The added value of coming to Bogotá for the students lies in the preparatory workshops before the exams. These sessions allow them to grow and learn a lot. It is a great experience, and I've seen it through my son.*

C Field Work pictures

Figure C.2: School with "I love my school" sign



Figure C.3: Students arriving to rural area school





(a) School courtyard



(b) Classroom in treatment school



(a) Road to get into a rural area school (40 min from the nearest town)



(b) School that can only be reached by boat