Recognizing Talent: Evidence from Exposure to Math Award Winners*

Rigissa Megalokonomou† Michael Vlassopoulos‡ Yves Zenou§

November 2025

ABSTRACT

We study how public recognition of academic talent affects schoolmates' outcomes and university choices. Using unique data on national award winners from the Hellenic Mathematical Society linked to administrative records, we estimate the causal impact of exposure to a publicly recognized high-achiever within a student's school or classroom. Identification relies on (i) across-cohort variation within schools, comparing cohorts with and without an award winner, and (ii) quasi-random classroom assignment, comparing classrooms with and without a randomly assigned math award winner within school-cohorts. We find that exposure to a male award winner improves male peers' outcomes: performance rises by 4.5% of a standard deviation on standardized exams, and STEM and academic university enrollments increase by 3 and 1.4 percentage points, respectively. Effects are concentrated in mathematics, are stronger in smaller cohorts, and are amplified by same-class exposure, consistent with visibility and interaction. Within-school comparisons to cohorts with high-achieving non-winners suggest recognition amplifies effects beyond peer quality alone. Female peers show no overall gains, though math scores improve in a representative subsample.

JEL Codes: J24, J21, J16, I24
Keywords: economics of talent, science awards, Olympiads, spillover effects, random classroom assignment, STEM degrees

---

*We would like to thank participants at the NBER Economics of Talent Meeting 2024, Bristol Applied Economics Meetings 2024, International Workshop of Applied Economics of Education 2024, and Labour Econometrics Workshop 2024 at the University of Queensland for many useful comments. We thank Glenn Ellison, Ruchir Agarwal, Patrick Gaule, Victor Lavy, Richard Murphy and Susan Dynarski for helpful discussions. We are grateful to Panagiota Boukouvala and Giorgios Kampakis for outstanding research assistance and for help compiling the data. This project has been reviewed by the Office of Research Ethics at Monash University with a protocol number 47865. This paper uses data collected from school archives and administrative data and we are not at liberty to publish online; however, we can provide the code as well as detailed instructions and assistance with how to apply and access the data in order to enhance the replicability of our analysis. There is no material or financial conflict of interest on the part of any of the authors with respect to any of the research in this paper. Rigissa Megalokonomou acknowledges research support from Monash University, Monash Establishment Grant (No. 1755774).

†Monash University, Australia, CESifo, IZA. Email: rigissa.megalokonomou@monash.edu
‡University of Southampton, UK, IFS, and IZA. Email: m.vlassopoulos@soton.ac.uk.
§Monash University, Australia, CEPR, and IZA. Email: yves.zenou@monash.edu.

1 Introduction

Talented individuals in science are crucial in driving innovation, technological advancements, and economic growth (Agarwal and Gaule, 2020; Hsieh, Hurst, Jones, and Klenow, 2019; Murphy, Shleifer, and Vishny, 1991). Education systems worldwide devote significant resources to identifying and nurturing academic talent, often through awards and prizes. Such recognition serves a dual purpose: It acknowledges individual achievement and aims to inspire a broader audience. While extensive research has examined how recognition affects the outcomes of the individuals being honored (Choudhury, Ganguli, and Gaule, 2023; Levitt, List, Neckermann, and Sadoff, 2016), the broader social impacts of recognizing academic talent remain less understood.[1] Despite the intention to motivate peers, recognition can sometimes lead to unintended effects, such as feelings of inadequacy or reduced motivation (Butera, Metcalfe, Morrison, and Taubinsky, 2022). Even beyond formal recognition, the mere presence of academically talented individuals can also generate spillover effects by influencing the performance and aspirations of those around them through mechanisms such as knowledge exchange and inspiration, or through social comparisons and competitive reactions (Akcigit, Caicedo, Miguelez, Stantcheva, and Sterzi, 2018; Azoulay, Graff Zivin, and Wang, 2010; Mohnen, 2022; Oettl, 2012; Waldinger, 2012).

This line of reasoning prompts our central research question: Does the public recognition of academically talented students influence the behavior and outcomes of peers who witness it? Two key empirical challenges arise in addressing this question. First, achievements are not always publicly recognized, which raises questions about the visibility and salience of talented individuals for their peers. In many educational settings, it is not obvious who receives recognition—such as awards, honors, or distinctions—making it difficult to study how public recognition impacts others. Second, defining the relevant peer group before the recognition takes place is crucial for causal identification of the spillover effects. This identification challenge requires that both recognized and non-recognized students are placed in comparable environments with similar characteristics, such as classrooms, before the recognition occurs. This ensures that there is minimal selection of students into specific groups. We tackle these challenges by examining how the presence of winners of national math competitions in high school classrooms in Greece—specifically,

[1] Beyond education, the effects of awards and recognition have been studied in other contexts, such as the workplace (Bradler, Dur, Neckermann, and Non, 2016; Kosfeld and Neckermann, 2011).

those leading to Olympiads and administered by the Hellenic Mathematical Society—affects their peers' educational outcomes. Because peer groups are determined well before recognition occurs, this context provides a valuable setting to study the effects of exposure to publicly recognized academic talent.

Our setting allows us to examine the heterogeneous effects of these spillovers by gender. This is especially relevant, since males are generally more willing to enter competitive settings, and in our setting the majority of award winners are boys. We preview three empirical results. First, exposure to an award-winning classmate raises boys' national-exam scores by roughly 4–6% of a standard deviation and increases academic-university entry by 1.5 percentage points and STEM enrollment by 3 percentage points. Second, gains are subject-specific: mathematics improves while language shows little change. Third, effects are larger in smaller cohorts, consistent with greater visibility of recognized talent.

The national mathematical competition is the largest annual competition in Greece and engages participants from schools across the country. It is conducted in three sequential stages. Winners of the final stage of the competition represent Greece in the Balkan and International Mathematical Olympiads. Award winners typically receive honorary certificates and medals during school ceremonies and are publicly congratulated by teachers and principals. The public recognition that takes place in the school ensures the salience of the winners' achievements. Further, students are allocated to peer groups at the beginning of the school year following transparent and established rules. Students are not permitted to switch to different cohorts or classrooms at any point during the school year, and especially not in the middle of the year. Since the composition of the peer groups is established months before the winners are announced, this setting ensures that classroom and cohort assignment is quasi-random and unaffected by later recognition.

Our identification strategy leverages two sources of quasi-random variation in exposure to publicly recognized math talent. First, we exploit within-school, across-cohort variation in award winners—since the assignment of an award winner to a specific cohort can be considered quasi-random—following an approach originally employed to estimate peer effects related to gender and race on student achievement (Hoxby, 2000). Second, within a school cohort, students are lexicographically assigned to classrooms based on their surnames, and thus it is quasi-random whether a student ends up in the same classroom as an award winner or another classroom. This design accounts for school-level factors and isolates the additional impact of direct classroom exposure to a publicly recognized award winner. Both strategies support consistent conclusions: public recognition of male math talent improves male peers' outcomes.

This paper is the first to provide a comprehensive analysis of how academic recognition influences peers' educational outcomes within their class and school. In addition, our data allow us to examine the heterogeneous effects of these spillovers by gender. This is especially relevant, since in line with studies that show that males are generally more willing to enter competitive settings, the majority of award winners in our setting are boys (Buser and Yuan, 2019; Croson and Gneezy, 2009; Iriberri and Rey-Biel, 2019; Niederle and Vesterlund, 2010). Our quasi-experimental research design enables us to present causal evidence regarding whether the impact of recognizing individual accomplishments in a male-dominated domain differs by gender, and offers valuable insights for policies aimed at addressing the gender gap in performance and enrollment in scientific fields.

We construct a unique student-level dataset on high school students who have won prestigious awards in the Hellenic Mathematical Society's national competition and who received recognition for exceptional mathematical performance in their school communities. We combine this dataset with student-level administrative records from the Ministry of Education, which allows us to track the performance and educational choices of their peers. We analyze outcomes using a wide range of administrative data on high school performance and postsecondary admission outcomes. Our baseline analysis focuses on students' performance on high-stakes, standardized high school exams. We also examine longer-term outcomes, such as postsecondary admissions and whether students enrolled in academic university programs as opposed to technical institutions.

In our baseline sample, which encompasses all students who took the national university entrance exams in 2009-11, we find that boys quasi-randomly exposed to male winners improve their performance on the national exams by 4.5% of a standard deviation (SD). We also find that the probability of enrollment in an academic university degree program increases by 1.5 percentage points relative to a baseline rate of 67%. The results for females are very small and statistically insignificant. We also investigate whether our results vary by the size of the school cohort. Our intuition here is that ties and imitation tendencies among students might be larger in schools or classes of smaller size. Indeed, we find that the effects on boys are substantially larger in smaller peer groups, while for girls there is not much of a difference. For instance, for boys in small schools the effect size is equal to 7.6% of a SD improvement in their test scores, while it is 4.2% of a SD in large schools. This suggests that salience and interaction frequency are critical channels for the recognition effect.

The baseline spillover effect we find on boys' performance on standardized exams is nonnegligible. The effects are of comparable magnitude to those in the literature on improving school inputs. For instance, our effect size is comparable to that of students who are taught by a teacher of a quality between 1.5 and 2 SDs above the average (Hanushek, Kain, O'Brien, and Rivkin, 2005; Lavy and Megalokonomou, 2024) or to reducing the class size by 20% (Angrist and Lavy, 1999). However, cost-effectiveness comparisons are challenging: producing award winners requires student talent and effort, not direct resource expenditure.

We then use a more detailed dataset with a broader set of outcome measures on a representative subsample of 69 schools to confirm and refine these findings. Our analysis proceeds in multiple steps: First, we confirm the positive effects of exposure to male math award winners for male peers on their university entrance exam scores (5.7% of a SD), after controlling for previous academic performance and academic track. Second, we find that award winners primarily influence peer performance in subjects in which they themselves excel. For instance, male peers exposed to male winners see significant gains in mathematics (8.3 % of a SD), while female peers of male winners also experience gains (14% of a SD). Although female peers show no overall gains, their improvement in math suggests more targeted academic benefits. In contrast, exposure to award winners does not significantly impact performance in language. We also find evidence that male peers exposed to winners are more likely to select STEM fields (an increase of 3.5 percentage points) and less likely to pursue humanities (a decline of 2 percentage points), which indicates that the presence of award-winning students may shape peers' academic aspirations and trajectories.

A central challenge is distinguishing whether our effects arise from public recognition per se or simply from exposure to an exceptionally high-achieving peer. Our primary identification strategy—comparing cohorts with and without award winners within schools—may capture both channels. To isolate the recognition effect, we conduct a supplementary analysis comparing treated cohorts to "near-winner" cohorts within the same school, where the top student ranked in the national 99th percentile on pre-treatment GPA but did not win an award. This comparison, available for 23 schools, yields positive effects for boys (0.19 SD), suggesting that formal recognition amplifies impacts beyond peer quality alone.

Further, we exploit an alternative identification strategy that leverages the quasi-random classroom assignment of students to classrooms. This alternative identification allows us to isolate the effects of direct classroom exposure to an award winner compared with other classrooms of similar characteristics within the same school-cohort. The idea is to compare students in the same school and cohort who are assigned to different classrooms—with and without an award winner. The advantage of this approach is that all students are exposed to the same school-level environment (teachers, policies, peer pool, etc.), and thus it isolates the within-school-cohort effect of direct exposure to an award winner. Using this identification, we find that male students who share a classroom with award winners experience greater gains in test scores, consistent with our main findings based on across-cohort comparisons.

Awarding a math prize to a top-performing student can influence peers through at least two economic mechanisms in our framework: recognition/beliefs and social comparison/visibility. First, public recognition may raise the perceived return to effort through belief updating, whereby observing a classmate succeed shifts perceptions about what is achievable or socially valued, prompting greater investment. Second, recognition can trigger social comparison dynamics, whereby students assess their relative performance against the awardee. Depending on individual preferences for status, competitiveness, or self-image, this may either motivate or discourage effort. Such mechanisms are likely to operate differently across genders, especially if social norms or preferences over competition vary, as suggested by prior work (Niederle and Vesterlund, 2011). In this setting, in which the award is public and linked to a traditionally male-stereotyped subject (math), these comparisons may be particularly salient and have asymmetric effects on boys and girls.

Our paper contributes to several strands of the literature. First, it connects to research on the recognition and development of scientific talent, particularly in STEM fields. Prior work highlights the role of individual characteristics—such as gender and socioeconomic background—in shaping the pathways of academically gifted individuals; it also demonstrates the impact of competition-based recognition on students' outcomes and choices, with heterogeneous effects based on gender and background (Agarwal and Gaule, 2020; Aghion, Akcigit, Hyytinen, and Toivanen, 2017; Airoldi and Moser, 2024; Ellison and Swanson, 2010, 2016; Hoisl, Kongsted, and Mariani, 2023; Moreira, 2019). Our study contributes to this literature by documenting the spillover effects of publicly recognizing high-performing students in math and showing how these effects vary by gender.

Our study also relates to the extensive literature on peer effects in education.[2] Within this large literature, a subset of studies focuses on the impact of high-achieving students on the educational outcomes and choices of their peers (Balestra, Sallin, and Wolter, 2023; Boucher, Rendall, Ushchev, and Zenou, 2024; Cools, Fernández, and Patacchini, 2022; Feld and Zölitz, 2022; Fischer, 2017; Lavy, Silva, and Weinhardt, 2012; Modena, Rettore, and Tanzi, 2022; Mouganie and Wang, 2020). We contribute to this literature by examining the influence of a particular group of high-achieving peers—those who have received public recognition for their excellence in a mathematics competition—thereby isolating the influence of both peer excellence and visibility.

Our paper also connects to the literature on role models in education. Most studies focus on the effects of teachers or advisors as role models.[3] However, to the best of our knowledge, little is known about the causal effect of peer role models on the education outcomes of peers.[4]

Finally, our paper also contributes to the literature that examines the gender gaps in STEM (Buffington, Cerf, Jones, and Weinberg, 2016; Cimpian, Kim, and McDermott, 2020; Goulas, Griselda, and Megalokonomou, 2022; Lavy and Megalokonomou, 2024). Despite the recent increase in girls' mathematics advancements in school, there exists a persistent gender gap in students' propensity to choose a STEM field of study. In our data, girls outperform boys on test scores in school. Nevertheless, we observe fewer girls earning an award in the mathematical competition. Our analysis highlights the fact that this underrepresentation also has important downstream implications for other students, since male winners spur other boys to perform better on the national exam and thereby contribute to the STEM gender gap.

[2] See Epple and Romano (2011) and Sacerdote (2011, 2014) for excellent overviews.

[3] Most studies find that female students benefit when they are assigned female teachers or advisors in male-dominated fields (Bettinger and Long, 2005; Breda, Grenet, Monnet, and Van Effenterre, 2023; de Gendre, Feld, Salamanca, and Zölitz, 2023; Griffith and Main, 2021; Hoffmann and Oreopoulos, 2009; Huntington-Klein and Rose, 2018; Porter and Serra, 2020).

[4] Exceptions include Riise, Willage, and Willén (2022), Goulas, Gunawardena, Megalokonomou, and Zenou (2024), and Riley (2024).

2 Institutional Setting

2.1 The National Mathematical Competition

The national mathematical competition is the largest national annual competition that targets all schools in Greece. Participation is open to all high school students, and teachers encourage voluntary enrollment. It is organized by the Hellenic Mathematical Society and takes place once a year. The competition is conducted in three stages, and the Society's objective is to assess and advance overall mathematical thinking in the student population. The Hellenic Mathematical Society organizes the national competition in three annual national student competitions: Thales, Euclides, Archimedes. The competitions are sequential and held in three rounds in October, January, and February. Only the top performers in the Thales competition can participate in the Euclides competition, and only the top performers in the Euclides competition can participate in the Archimedes competition. Each year, after the top performers in the Archimedes competition are announced, the Hellenic Mathematical Society selects the team members who will form the national team that represents Greece in the Balkan and International Mathematical Olympiads.

This competition culminates in formal ceremonies in which award winners are publicly acknowledged, which fosters a culture of achievement within schools and local communities. Such recognition not only honors individual accomplishments but also inspires other students to engage with mathematics, which enhances the subject's prestige. These celebratory events create opportunities for students to connect with peers and educators, and thus reinforce their interest in mathematics and potential career paths in the field. Each year, around 10,000 students participate in the first phase of the competition across all relevant grades (8-12). Around 15%-20% proceed to the second phase (1,500-2,000 students in total, which means around 300 students per grade). Only 10% of initial participants proceed to the third and last phase of the competition. During school ceremonies, winners of the first and second stages of the competition are awarded an honorary certificate, and winners of the third stage are awarded gold, silver, and bronze medals. Figure A.3 in the Appendix shows an honorary mention certificate.

Gold medals are awarded to the top-performing students with the highest scores in their category in the Archimedes Mathematical Competition. This distinction is typically limited to a small top percentage of participants (e.g., the top 5–10%). Silver medals are granted to students who perform excellently, just below the gold medal threshold, while bronze medals recognize the next tier of high scorers. There is no fixed number of medals (e.g., a set number of gold, silver, or bronze awards). Instead, medals are awarded based on percentile rankings, as determined each year by the competition committee.

Teachers promote the competition in the class during lessons, so that all students receive the salient information. Principals also promote the competition during school events. Participating students in all regions of Greece take the same exam on the same day. The duration of the exam is 3 hours. Two graders are assigned to each examination script. The Hellenic Mathematical Society selects the examiners for all competitions and decides on the topics to be covered. A student's final grade is the average score submitted by the two independent examiners. Students are compared with each other across all regions in Greece, and the best-performing students in the country proceed to the next competition. Students participate in the Balkan, European, or International math competition, and as a form of appreciation for their advanced skills and talent in mathematics, are awarded automatic admission to university departments without taking a national exam in mathematics (unlike all other applicants).

Teachers and classmates are highly likely to know who the award winners are: Teachers and principals publicly congratulate award winners, and the school usually showcases this achievement on their website; interested individuals can also check the Hellenic Mathematical Society website. Schools usually also post this information on their announcement board at the school's entrance. Classrooms typically contain around 25 students, and the average number of classrooms per school is 3. Students in a given classroom take all core educational subjects together. Classmates in the core education classes remain together for several years until the end of senior high school.

2.2 Access to Postsecondary Education in Greece

The education system in Greece is highly centralized (OECD, 2018). University admissions are also centralized and administered by the Ministry of Education. To be eligible for university admission, students must participate in standardized national tests. All schools adhere to the same curriculum and offer courses in both core and track-specific subjects that align with the material covered on the national exams. University admission decisions rely on algorithms that match students to specific college-major combinations based on their academic performance during the application process (Altjmed, Artemov, Barrios-Fernández, Bizopoulou, Kaila, Liu, Megalokonomou, Montalbán, Neilson, Sun, et al., 2024; Bizopoulou, Megalokonomou, and Simion, 2024; Goulas and Megalokonomou, 2019). Students select an academic track in grade 11 and the majority continue in the same track through grade 12. The three tracks are Classics, Science, and IT, and all schools offer these options. Students take core compulsory exams as well as track-specific exams. When choosing a track, students consider their aspirations for their intended field of study at university.

3 Conceptual Framework

3.1 Setup and notation

Consider a class with n students. One student T is the award-winning (talented) classmate, the remaining $n-1$ are regular peers indexed by i. Let $T_i \in \{0,1\}$ indicate talent and let individual i's marginal return to effort be

$$\theta_i = (1+\Delta T_i)\theta, \qquad \theta > 0,\ \Delta > 0,$$

so the talented student has $\theta_T = (1+\Delta)\theta$ and any regular student i has θ. Let e_i denote the study effort of a regular peer i and e_T the effort of the talented student. We take e_T as predetermined from the perspective of regular peers, and assume an interior solution for regular students.

3.2 Utility

Each regular peer i chooses e_i to maximize

$$U_i = \underbrace{\beta(R)\,\theta\, e_i}_{\text{beliefs/returns}} + \underbrace{\phi\, e_i\, \bar{e}_{-i}}_{\text{behavioral spillover/complementarities}} - \underbrace{\tfrac{1}{2}\gamma(P)\left(e_i - e_T\right)^2}_{\text{social comparison/conformity to the talented student}} - \frac{\kappa}{2} e_i^2, \tag{1}$$

where $\kappa > 0$, $\phi \geq 0$, and $\bar{e}_{-i} \equiv \frac{1}{n-1}\sum_{j \neq i} e_j$ is the average effort of other students. Here, $\beta(R)$ captures how *public recognition* $R \in \{0,1\}$ shifts beliefs about the payoff to own effort. We assume that $\beta(R=1)$ when the talented student T is in the same school (and not necessarily in the classroom) and $\beta(R=0)$ when they are not. We generally expect $\beta(1) \geq \beta(0)$, but allow $\beta(1) < \beta(0)$ in settings where public recognition induces discouragement. Moreover, $\gamma(P) \geq 0$ captures *comparison/status salience* that rises with *proximity/visibility* P (e.g., same classroom, smaller cohorts). We have that $\gamma(P=1)$ when the talented student is in the classroom and $\gamma(P=0)$ when in the school but not in the classroom, with $\gamma(1) > \gamma(0)$.[5]

To summarize, the utility function of each regular student i consists of four terms. First, $\beta(R)\,\theta\, e_i$, the returns to effort, which are increasing if the talented student is in the same school as i. Second, $\phi\, e_i\, \bar{e}_{-i}$, which corresponds to the standard peer effects in study effort, so that the marginal gain of exerting effort increases with peers' efforts. Third, $-\frac{1}{2}\gamma(P)\left(e_i - e_T\right)^2$, which captures the fact that students want to conform to the effort of the talented student, whose cost is increasing if the latter is in the same classroom as student i. Finally, $-\frac{\kappa}{2}\, e_i^2$, which denotes the (quadratic) cost of making effort.

The first-order condition for each i leads to

$$e_i^*(R,P) = \frac{\beta(R)\,\theta \;+\; \gamma(P)\, e_T \;+\; \phi\, \bar{e}_{-i}^*(R,P)}{\kappa + \gamma(P)}. \tag{2}$$

Since all agents are ex ante identical, we can focus on a symmetric equilibrium for which $e_i^*(R,P) = \bar{e}_{-i}^*(R,P) \equiv e^*(R,P)$. Thus, we can write (2) as follows:

$$e^*(R,P) = \frac{\beta(R)\,\theta \;+\; \gamma(P)\, e_T}{\kappa + \gamma(P) - \phi}. \tag{3}$$

Thus, if $\kappa + \gamma(P) > \phi$, there exists a unique symmetric equilibrium $e^*(R,P) > 0$ given by (3).

Proposition 1. *Suppose that $\kappa+\gamma(P) > \phi$. Then, assuming $\beta(1) \geq \beta(0)$ the equilibrium effort $e^*(R,P)$ of each regular student increases with recognition R, that is, $e^*(1,P) \geq e^*(0,P)$. Moreover, if $e_T(\kappa-\phi) > \beta(R)\theta$, then $e^*(R,P)$ increases with proximity/visibility P, that is, $e^*(R,1) > e^*(R,0)$.*

Note that if $\beta(1) < \beta(0)$ for a subgroup, then recognition lowers effort in that subgroup, $e^*(1,P) < e^*(0,P)$, for any given P. The discouragement effect is stronger when P is low (large, impersonal cohorts), because a smaller $\gamma(P)$ amplifies the impact of the negative belief shift.

[5] It is easy to generalize this model to have different β_i and γ_i for each student i.

3.3 Subject alignment (math vs. language)

Given that the talented student is a high-achiever in math, we can differentiate their impact by subject, distinguishing math from (Greek) language. The superscript $s \in \{\text{math}, \text{lang}\}$ refers to math and language, respectively. Thus, we can denote the marginal return parameter of a talented student by θ^s and their effort by e_T^s, with $\theta^{\text{math}} > \theta^{\text{lang}}$ and $e^{T\text{math}} > e^{Tlang}$. Moreover, recognition R and proximity/visibility P are math-specific, thus, we can write $\beta^s(R)$ and $\gamma^s(P)$, with $s = \text{math}$ having a larger impact than $s = \text{lang}$.

Thus, using Proposition 1, it should be clear that agents will exert more effort studying math than language due to better recognition and proximity/visibility, that is, $e^{*\text{math}}(R,P) > e^{*\text{lang}}(R,P)$.

3.4 Gender heterogeneity

We can also introduce heterogeneity by gender. If recognition and visibility induce larger responses for boys $\beta^{\text{male}}(R) > \beta^{\text{female}}(R)$ and $\gamma^{\text{male}}(P) > \gamma^{\text{female}}(P)$, then the model implies $e^{*\text{male}}(R,P) > e^{*\text{female}}(R,P)$.

3.5 Testable predictions

(P1) **Proximity/visibility.** With higher P, *effort levels* rise (if $(\kappa - \phi)e_T > \beta(R)\theta$) implying larger effects for *same-class* exposure and in *smaller cohorts*.

(P2) **Subject alignment.** Recognition R in mathematics raises math outcomes more than language.

(P3) **Gender asymmetry.** If belief/comparison/spillover responses are stronger for boys, effects are larger for boys.

We evaluate (P1)–(P3) using the within-school across-cohort and within-cohort classroom designs introduced in Section 5.

4 Data

4.1 Data Sources and Construction

Hellenic Mathematical Society Data We combine several data sources to construct the sample of Thales-stage award winners and their peers. The Hellenic Mathematical Society publicly announces the winners of the national mathematics competition every year and maintains an online archive.[6] We accessed the archives and constructed lists with the following information on winners: first name, surname, grade, and year in which they participated in the competition; school they attend; and the district to which the school belongs. The district indicates which local school authority is in charge of the school the winner attends. We deduce students' gender from their first names, which are unambiguous in the Greek language. Our sample includes competition data from the 2009 to 2011 academic years.

We define a winner as a Grade-12 student listed by the HMS as receiving a Thales award in the current school year at their school. We focus on Grade-12 winners because our outcomes are final-year national exams and immediate postsecondary choices, allowing baseline Grade-12 performance to serve as a pre-treatment control.

Hellenic Ministry of Education We also use student-level administrative data obtained from the Ministry of Education, which include performance data on the national examinations that all high school students take in 12$^{\text{th}}$ grade (Bizopoulou, Megalokonomou, and Simion, 2024; Dinerstein, Megalokonomou, and Yannelis, 2022). Our data span the universe of students who took the university entry exam in 2009-2011 and include each student's exam score and high school attended. Performance on these exams is the most important determinant for university admission. The exams are externally graded and anonymized—i.e., the name of the student is hidden—to ensure impartiality (Lavy and Megalokonomou, 2024). To facilitate interpretation and comparison of our estimated effects with other studies, we convert the test scores to student standard deviation units by normalizing scores to have mean zero and standard deviation one in each year. This dataset also includes information on students' postsecondary choices and outcomes. In particular, we have information on students' enrolled degree (university and department) in tertiary

[6] We provide an example of Thales exam questions (in both Greek and English) for grade 12 students in Online Appendix A.

education.[7] Each student receives an offer from a unique degree, and thus the majority of students accept the offer and enroll in their offered postsecondary degree.

Smaller Sample of High Schools We also use data from a linked administrative subsample drawn from the population of schools, for which we have classroom level information. This dataset includes a smaller sample of 69 schools in which at least one math competition award winner is present in the classroom. This subsample comprises 13,465 students in the sampled years and includes detailed student-level data on test scores across all subjects and exams taken during senior high school, as well as information on several student-level outcomes. The dataset allows us to examine the short- and long-term impacts of math competition award winners on their peers' performance and academic decisions, and complements the broader analysis based on the Ministry's administrative dataset.

4.2 Descriptive Statistics

Appendix Figure A.1 provides an excerpt from the list of award winners for grade 12 in the 2010–2011 school year, as published by the Hellenic Mathematical Society. Appendix Figure A.2 presents a map of Greece that pinpoints the locations of all schools with award winners in grade 12 during the sampled years, based on data collected by the Hellenic Mathematical Society. Blue dots represent male winners and red dots represent female winners. Award winners are dispersed across various regions of the country. Table 1 reports the number of final-year mathematics award winners in Grade 12 by gender and graduation year. In total, there are 635 winners, of whom 483 (76.1%) are boys.[8] Unfortunately, we do not observe the full set of competition participants or their gender composition.

Table 2 presents summary statistics for the students in our samples. Panel A covers the full population of schools with at least one award winner. Panel B reports statistics for the smaller sample of schools with at least one winner, while Panel C focuses on the sample of classrooms that include at least one award winner. Our full school sample includes 86,458 students, 55% of whom are female. The average high school graduation age is 18 years, and the mean size of each school-cohort (hereafter referred to as school-cohort size) is 90.07 students—though there is substantial variation in this size, which we leverage

[7] Each university department offers a unique degree.

[8] Similar gender disparities at the upper tail of mathematics performance have been documented in the American Mathematics Competition (Ellison and Swanson, 2010, 2016, 2023).

in our heterogeneity analysis. Students' national exam scores, which range from 0 to 20, have a mean of 13.59, and 67% of students are admitted to an academic university program. "Any Winner" is a binary variable equal to 1 if there is at least one winner (of any gender), and 0 otherwise.

5 Empirical Strategy

To identify the spillover effects of award recognition, we exploit the fact that students have no control regarding to which school cohort or classroom they are assigned to. We employ two complementary identification strategies. In the first strategy, we use data from the universe of high schools in the country (or a representative sample) and rely on cohort-to-cohort comparisons within the same school to estimate the effects of exposure to award winners on other schoolmates' outcomes. In practice, we compare cohorts with an award winner with those without. In the second approach, we exploit within-school, across-classroom variation, focusing on a smaller sample of schools in which we can identify the classroom of each student. This allows us to compare classrooms with an award winner with those without an award winner in the same school and cohort. Although the classroom-level comparison provides a more granular analysis, it is limited to a smaller sample, because classroom assignment data are available for only a subset of schools. These complementary strategies allow us to isolate both the general spillover effects of award recognition and the influence of classroom proximity to high-achieving peers.

5.1 Within-School Across-Cohort Analysis

Identifying the impact of an award winner on other students across cohorts is likely to be confounded by the effects of unobserved correlated factors. Such factors could result if the presence of an award winner influences self-selection into peer groups or the sorting of students across schools. This could also occur if the presence of the award winner is associated with other school characteristics that may influence student outcomes.

One potential approach to address this issue is to use variations within schools in exposure to the award winner across adjacent cohorts. In this way, we can examine whether changes in student outcomes across adjacent cohorts are systematically linked to the presence of an award winner in that school for a given year. The basic idea is to compare outcomes between adjacent cohorts of students who share similar characteristics and experience the same school environment, with the only difference being that one cohort had a competition award winner due to factors that are effectively random. This approach allows us to isolate the effect of exposure to an award winner from other school-related influences.

Using repeated cross-sectional data, we estimate the following reduced-form equation separately for boys and girls:

$$Y_{i,s,t} = \theta_s + \theta_t + \beta D_{s,t} + \gamma X_{i,s,t} + \epsilon_{i,s,t}, \tag{4}$$

where $Y_{i,s,t}$ is the outcome of student i in school s and year t. θ_s and θ_t are school and year (cohort) fixed effects, respectively. $D_{s,t}$ is an indicator variable that takes the value of 1 if the school s is treated in year t. A school is treated if a final year student attending the school wins a mathematical competition. $X_{i,s,t}$ is a vector of student (age, gender, and student baseline math performance[9]) and cohort characteristics (average age, class size, and share of female classmates). We cluster standard errors at school-by-year level (since the treatment (the presence of an award winner) varies at the cohort level within a school).

We exclude the award winners in treated schools from our sample. This exclusion ensures that our analysis focuses on the spillover effects on peers—i.e., the impact of exposure to the winner on the outcomes of schoolmates compared with students in other school cohorts that had no winner—rather than capturing the direct outcomes of the award winners themselves.

The estimated coefficient β captures the combined effect of: (i) having an exceptionally high-achieving peer, and (ii) that peer being publicly recognized. Cohorts without award winners still contain high-performing students, but these students have not received formal recognition. To isolate the recognition component, we implement two approaches. First, in some specifications we exclude the top-performing student (by baseline GPA) from control cohorts. This makes treated and control cohorts more similar in peer quality, though differences remain. Second, we restrict the sample to schools containing both treated cohorts (with an award winner) and "near-winner" cohorts (where the top student ranks in the national top 1% on pre-treatment GPA but did not win). This provides a cleaner comparison, holding peer quality approximately constant while varying recognition status. We interpret β from our main specification as the effect of exposure to a *publicly recognized high-achiever*, acknowledging that both peer quality and

[9]Students in all classes have to take a compulsory fall exam in mathematics soon after the beginning of grade 12. This is the earliest exam students take in grade 12. We use performance on this exam as the student's baseline performance. These exams are typically conducted within the first weeks of the first semester of the school year.

recognition are at play. The near-winner analysis provides a bound on the recognition effect.

In a variation of equation (4), we estimate the differential effect of the treatment based on the gender of the award winner separately for boys and girls:

$$Y_{i,s,t} = \theta_s + \theta_t + \beta_b D^b_{s,t} + \beta_g D^g_{s,t} + \gamma X_{i,s,t} + \epsilon_{i,s,t}, \tag{5}$$

where $D^b_{s,t}$ is a binary indicator for whether there was a boy winner in school s at time t, and $D^g_{s,t}$ is a binary indicator for a girl winner. This specification allows us to differentiate between the influence of boy high-achievers and girl high-achievers.

Note that our data consist of a panel of schools with repeated cross-sections of final-year students. This means we observe different cohorts of graduating students from the same school over time, but each student appears only once in the data. Our identification strategy exploits within-school, across-cohort variation: we compare student outcomes in cohorts with a math competition winner to those in cohorts without a winner from the same school. A key identification concern is the presence of time-varying, school-level confounders that may simultaneously influence both the likelihood of producing a competition winner and the academic performance of peers. If such factors evolve in ways correlated with both outcomes, they may bias our estimates. We address this concern by including school fixed effects and controlling for a rich set of time-varying covariates to isolate plausibly exogenous variation in peer exposure to high-achieving students.

To evaluate our identifying assumption that winners are quasi-randomly assigned across cohorts within schools, we test whether the presence of an award winner in a specific cohort is systematically associated with changes in student background characteristics or school-cohort size/enrollment. Table 3 presents results for all students and separately for male and female students. Panels A, B, and C examine whether the presence of an award winner, boy winner, or girl winner in the school cohort is associated with changes in student age, baseline math performance, or school-cohort size, respectively. None of the estimated differences are significantly different from zero. Overall, these findings suggest that having an award winner in a specific cohort within a school is largely uncorrelated with variations in other student background characteristics, and thereby support the validity of our assumption regarding quasi-random assignment.

5.2 Within-School Cohorts and Across-Classroom

We further exploit a unique institutional feature of classroom assignment in Greece for identification: Students are lexicographically assigned to classrooms within each school cohort based on their surname. This assignment occurs in grade 10, and students remain in the same group of peers throughout senior high school (grades 10-12). This alphabetical classroom assignment ensures the randomization of peer characteristics across classrooms, a strategy that is employed in other studies (Algan, Dalvit, Do, Le Chapelain, and Zenou, 2025; Goulas, Griselda, and Megalokonomou, 2022, 2023; Goulas, Griselda, Megalokonomou, and Zenou, 2024; Goulas, Gunawardena, Megalokonomou, and Zenou, 2024; Goulas, Megalokonomou, and Zhang, 2023).

In Table A.5, we report formal checks to confirm the quasi-randomness of student assignment across classrooms. In particular, we regress a binary indicator variable for the presence of an award winner—of any gender (Panel A), boy winner (Panel B), and girl winner (Panel C)—on student characteristics and baseline performance measures, separately for male and female students. The majority of the estimates are practically zero, with only 4 out of 18 being statistically significant. This evidence supports the identifying assumption of quasi-random assignment, since there is no meaningful correlation between the presence of an award winner and student characteristics across classrooms.

To exploit this across-classroom variation, we focus on specific cohorts within schools that have award winners. This allows us to compare the effects of exposure to the award winner on classmates with those in the same cohort but in different classrooms. This approach enables us to better understand how proximity to award winners influences academic performance. That is, if peers who share the same learning classroom environment with an award winner demonstrate greater academic gains, this would suggest that the more frequent interactions with the award winner offer unique benefits, and extend beyond the broader recognition effect that may benefit the entire cohort.

To examine this, we estimate specifications of the following form separately for boys and girls:

$$Y_{i,s,c,t} = \theta_{st} + \beta_1 W^b_{s,c,t} + \beta_2 W^g_{s,c,t} + \gamma X_{i,s,c,t} + \epsilon_{i,s,c,t}, \quad (6)$$

where $Y_{i,s,c,t}$ is the outcome of student i, in school s, classroom c, and year t. θ_{st} are school-by-cohort fixed effects. $W^b_{s,c,t}$ ($W^g_{s,c,t}$) is an indicator variable that takes the value of 1 if in school s, the classroom c had a boy (girl) award winner in year t. The vector $X_{i,c,s,t}$ includes student (age, gender, track) and cohort characteristics (average age, class size, and share of female classmates). Standard errors are clustered at the same level as the randomization—i.e., classroom level.[10]

6 Results from the Universe of Schools

As a starting point, we provide evidence of the impact of award winners on their schoolmates by comparing cohorts that have at least one award winner to cohorts without winners within the same schools. We first discuss results from the universe of schools with an award winner and then from a sample of schools with more detailed student-level data.

National University Entry Exam Table 4 presents our baseline estimates of the impact of award winners on their peers' performance on the grade 12 national university entry exams, derived from equations (4) and (5). In panel A, we report the estimated effects for male students in columns 1-3 and female students in columns 4-6.

Column 1 shows a positive effect of having a winner of any gender in the cohort (0.04 SD), which is statistically significant at the 1% level. When we differentiate by the gender of the winner in column 2, we find that male winners have a more substantial impact (0.039 SD) than female winners (0.006 standard deviation) on male students, and only the effect of male winners is statistically significant at the 1% level. In column 3, as discussed above, we exclude top performers from cohorts without an award winner to capture the effect of recognition beyond only the presence of a high-achieving peer. The effect size for male students increases to 0.045 SD, which is statistically significant at the 1% level. For female peers (columns 4-6), on the other hand, we find no statistically significant effects associated with the presence of a winner, regardless of the winner's gender, with the exception of a marginally significant effect of a female winner in column 6 (0.015 SD).

[10] Results remain very similar if we cluster standard errors at the school level (Abadie, Athey, Imbens, and Wooldridge, 2017).

Academic University Admission Next, we examine the impact of having a math competition award winner in one's school-cohort on peers' likelihood of enrolling in an academic university rather than a vocational institution, with results presented in Panel B of Table 4. Admission to university programs depends on the student's test scores and their list of preferred programs; roughly 67% of students achieve this outcome, as seen in Table 2. The findings in Panel B align with the test score patterns observed earlier: For male students, having a male award winner in their cohort increases the likelihood of academic university enrollment by 1.5 percentage points when top performers are excluded (column 3). For female students, there is generally no statistically significant effect from having an award winner in the cohort, except in column 6, where exposure to a female award winner—after excluding top performers—shows a positive effect of 1.5 percentage points, significant at 10%.

Overall, these results reveal a clear pattern: Male award winners have a substantial positive effect on the academic outcomes of their male peers, while the presence of award winners appears to offer limited benefits for female students.

Intensity In our analysis so far, we have focused on the causal effect of having at least one award-winning classmate. However, students' actual exposure to winners varies: 82% do not encounter a winner, 11.5% have exactly one winner in their cohort, and 6.5% experience multiple winners (up to six). To investigate whether the intensity of exposure impacts outcomes, we estimate a specification that differentiates between having a single winner and having multiple winners within the same school-cohort. The results are presented in Appendix Table A.1 and show that having multiple winners does not yield additional academic benefits to peers beyond the presence of a single winner, which suggests that there are diminishing returns to exposure.

School-Cohort Size Heterogeneity We next turn attention to whether our overall effects may conceal significant heterogeneity by school-cohort size. Specifically, we explore whether the impact of an award winner is stronger in *smaller schools*, where winners are likely to be more prominent and interactions with peers more frequent and intense. In Table 5, we present results that split the sample by the median school-cohort size, with a cutoff of 88 students.

For boys, the results show that in smaller schools, the effect of a male award winner on his male classmates' scores is considerably stronger than in larger schools. Specifically, a male winner raises the scores of male peers by 0.067 SD. This effect rises slightly to 0.076 SD in column 2 when top performers in cohorts without winners are excluded, confirming that the estimate captures genuine spillovers rather than mechanical composition effects. Both estimates are statistically significant at the 5% and 1% levels, respectively. In contrast, in larger schools, the estimated effects on male peers are smaller—0.037 and 0.042 SD—and only marginally significant.

For female students, the heterogeneity analysis by school-cohort size also uncovers some interesting patterns. In smaller schools, exposure to a male winner has no significant impact on female peers. In contrast, the presence of a male winner in large schools is associated with a statistically significant negative effect on girls' performance, with estimates of -0.059 and -0.054 SD in columns 7 and 8 (both significant at the 1% level). Female winners have no detectable effect on female peers' performance in either school size group.

These findings suggest that school-cohort size significantly moderates academic spillover effects, with smaller schools likely increasing the visibility of award winners and the frequency of peer interactions, leading to stronger positive impacts. In larger schools, however, these effects appear weaker or even negative, particularly for female students. This pattern is consistent with a discouragement mechanism in our framework ($\beta(1) < \beta(0)$), where public recognition lowers perceived returns for some girls, especially in large, more anonymous cohorts where proximity (P) to the "star" is lower.

Robustness In this subsection, we present additional evidence that supports the robustness of our results. Specifically, we exclude from the sample students who attend private and experimental schools,[11] since these students may differ systematically from those in public schools. We reproduce the main estimates for the subsample that only includes students who attend public schools. Results are shown in Table A.2. Comparing results in Table A.2 with those in Table 4 demonstrates that for boys, the impact of boy winners in these subsamples remains clearly robust. These findings provide further reassurance regarding the reliability of our main results.

[11] Experimental schools are public schools established to implement innovative teaching methods, test new curricula, and promote excellence in education. Admission to these schools is based on a lottery for the sampled years.

7 Results from a Sample of Schools

We next turn our attention to results from the sample of 69 schools for which we have access to detailed records of students' performance on every exam and in every grade throughout high school. We merged this dataset with the data on award winners. Importantly, as shown in Appendix Table A.3, these 69 schools are representative, because student characteristics in this subset do not systematically differ from those in schools with winners in the broader sample.

Our analysis proceeds in two steps. First, we estimate the effects of award winners on their peers using within-school, across-cohort comparisons, following an approach similar to that employed with the full sample. We also implement a "near-winner" comparison to isolate recognition from the presence of a very strong peer. Then, in a second step, we zoom into schools and cohorts with at least one award winner, and compare the outcomes of peers in classrooms with an award winner with peers in classrooms without one, but within the same school and cohort. This approach allows us to assess whether the direct classroom exposure to an award winner provides additional academic benefits beyond the general recognition effect experienced across the entire cohort.

7.1 Across-Cohort Comparisons

Impact of Award Winners on Peers' Test Scores on University Entrance Exams We begin by presenting results from estimating an augmented version of our baseline specification (4), which includes controls for students' prior academic performance using their GPA from the previous grade and the academic track they are pursuing. These results are presented in Table 6. The key distinction between columns (2) and (3) is that in column (3) we exclude top performers from cohorts without an award winner.

Consistent with our earlier findings in the full sample (Table 4), we find significant positive impacts on university entrance exam scores for boys exposed to male award winners, with an effect size of approximately 0.06 SD, which is statistically significant at the 5% level. However, exposure to female award winners appears to negatively impact boys, though these effects are not statistically significant. For female students, exposure to male winners shows a positive effect, which is marginally statistically significant at 10% level in column 6. In contrast, exposure to female winners has a negative impact of about 0.07 SD on female peers' scores, which is statistically significant at the 10% level.

These results suggest that prior academic performance does not substantially alter the pattern observed earlier whereby exposure to male award winners tends to benefit male students, while the presence of female winners may have a small, negative impact on female peers.

In additional analyses, presented in Appendix Table A.4, we examine whether these impacts on test scores also translate into differences in the quality of university programs that peers eventually enroll in.[12] These findings highlight the potential for peer recognition to shape not only immediate academic outcomes but also the quality of future educational opportunities, and suggest lasting impacts on students' academic trajectories.

Impact of Award Winners on Test Scores in Mathematics and Language (Core Education) To determine whether exposure to award winners leads to general academic improvements or subject-specific gains, we examine performance in two core subjects taken by all students: mathematics and (Greek) language. We use the same specification as before. Results in Table 8 show a significant positive effect of exposure to a winner on test scores in mathematics for boys, with an effect size of 0.069 SD. This is primarily driven by exposure to male winners, with a more substantial effect of 0.081 SD, while the impact of female winners on boys' math performance is small and not statistically different from zero. On the other hand, for boys, exposure to winners does not yield statistically significant effects on Greek language performance.

For girls, exposure to an award winner also positively impacts math performance, with an overall effect size of about 0.09 SD. The winner's gender appears to be crucial, because exposure to a male winner produces a positive, statistically significant effect of approximately 0.14 SD. In contrast, exposure to a female winner has no statistically significant impact. Similar to the results for boys, we observe no significant spillover effects on Greek language scores for female students.

These findings suggest that award winners predominantly influence peers' academic performance in subjects that align with their own academic strengths, with spillover effects concentrated in mathematics rather than in language-based subjects.

[12] The results are robust to an alternative approach for calculating program quality that uses the admissions cutoff score for each university department, defined as the score of the last admitted student. We assign these quality measures to the relevant postsecondary programs and exclude the year 2003 from the regressions. For brevity, we do not report these alternative results.

Impact of Award Winners vs Near-winners Next, exposure to publicly recognized award winners is tested to determine whether it generates larger impacts than exposure to an exceptionally strong student in the same cohort who did not win an award. To do so, cohorts containing at least one award winner are compared to "near-winner" cohorts within the same school. Near-winner cohorts are defined as those in which the highest-achieving student had a pre-treatment GPA (Year 11) in the national top 1% but earned no award. As shown in Table 7, within schools that include both cohort types, boys gain approximately 0.20 SD (wild-cluster $p = 0.009$) in math scores. Estimates for girls are also positive (around 0.18 SD) but statistically imprecise (wild-cluster $p = 0.345$). Effects on national exam scores are smaller and statistically indistinguishable from zero under wild-cluster inference (boys: 0.13 SD, $p = 0.219$; girls: 0.01 SD, $p = 0.914$). The recognition margin is most clearly detected in math performance, where the outcome aligns closely with the award domain and salience is highest. These findings are consistent with the recognition mechanism of the model in Section 3, where $\beta(R)$ increases the return to effort when achievement is publicly acknowledged through awards.

Impact of Award Winners on Test Scores in Specialized Track Subjects The detailed nature of our data allows us to analyze the impact of award winners in specialized track subjects. In Greek high schools, students select one of three academic tracks—Science, Classics, or IT—and take track-specific exams accordingly. Table 9 presents our results by track area, excluding an "Any Winner" column for brevity.

We find significant positive effects of exposure to a male award winner for students within the Science track: Male students experience a 0.12 SD improvement in test scores and female students show a 0.15 SD increase, which are statistically significant at the 10% and 1% level, respectively. For male students in other tracks, there are no statistically significant effects from exposure to award winners. Interestingly, for female students, exposure to a female award winner appears to have a negative impact, though this effect varies by track.

These findings indicate that the benefits of exposure to award winners are primarily concentrated within the Science track, particularly for male award winners, and suggest that the positive spillovers are more pronounced when the award winner's track aligns with the peer's chosen field of study. The results also suggest that female peers may benefit in domains aligned with the recognized peer's strengths.

Admission to STEM or Humanities Degrees We further examine whether award winners influence the types of university degrees pursued by their schoolmates and focus on choices between STEM and Humanities fields.[13] STEM degrees are associated with more competitive career paths (Black, Muller, Spitz-Oener, He, Hung, and Warren, 2021; Goulas, Megalokonomou, and Zhang, 2025; Kirkeboen, Leuven, and Mogstad, 2016). Our results in Table 10 indicate that for male students, exposure to award winners leads to a 3 percentage point increase in STEM enrollment and a 2 percentage point decrease in Humanities enrollment, with these shifts driven primarily by exposure to male award winners. In contrast, for female students, we find no statistically significant effects of exposure to winners on their field of study choices. These results suggest that award winners shape not only academic performance but also influence subject preferences, and particularly encourage male students to pursue STEM fields over Humanities.

7.2 Within School-Cohort and Across-Classroom Comparisons

We next restrict the sample to schools and cohorts with at least one award winner and compare the outcomes of students who share a classroom with an award winner with those in the same school cohorts who are assigned to classrooms without an award winner in that year. The main advantage of this identification is that we isolate the effect of direct exposure to talented peers in STEM from broader contextual influences. This within-school-cohort comparison accounts for unobserved school-level and cohort-specific factors, such as institutional resources, peer environment, and principal leadership. If classroom assignment is exogenous, this identification strategy strengthens the causal interpretation of our effects. An additional advantage of this approach is that it allows us to detect more localized peer dynamics that may be masked in broader across-cohort comparisons.

Table 11 presents the results of estimating specification (6) on the sample of schools that have at least one winner. Our estimation now exploits school-by-year FE allowing variation only across classrooms within school cohorts. In column 1 we only exclude the award winner, while in column 2 we also exclude top performers from the other classrooms of school cohorts with at least one winner. For boys (columns 1-2), we find that male award winners exert a positive influence on male peers within the same

[13] Our definition of STEM degree programs includes degrees in science, engineering, technology, and mathematics. Our results remain similar when we also include (a) economics and business degrees and (b) health science degrees in the definition of STEM degrees.

classroom, with effect sizes of 0.009 SD. This suggests that direct exposure to an award winner within the same classroom setting enhances boys' academic outcomes, potentially due to increased collaborative learning opportunities and potentially stronger social comparison effects facilitated by proximity to a high-performing peer. For girls (columns 3-4), the effects of within-class award winners are mixed: exposure to a male winner is associated with lower performance, while exposure to a female winner has a positive effect.

The classroom-level effects (0.009 SD) are substantially smaller than our main cohort-level estimates (0.045 SD, Table 4). This suggests that most spillover effects operate at the school-cohort level (through general recognition and visibility) rather than through direct classroom interaction. The additional benefit of same-classroom exposure is modest, accounting for roughly 20% of the total effect.

8 Interpretation of Empirical Findings

Our empirical findings reveal that exposure to a high-achieving, publicly recognized peer significantly improves educational performance and university choices among boys. For girls, the effects are less consistent and generally weaker. The theoretical model introduced in Section 3 provides a framework for interpreting this gender asymmetry.

Using the model of Section 3, we see that the presence of talented peers can raise equilibrium effort among other students through two distinct but potentially complementary channels (Proposition 1). First, the *recognition/beliefs channel*, captured by $\beta(R)$ increases the perceived return to effort in the recognized domain (mathematics). Second, the *social comparison/visibility channel*, captured by $\gamma(P)$ operates when the winner is salient (same-class or greater salience). Furthermore, *strategic complementarities* (ϕ) amplify all shocks.

Our empirical findings provide suggestive evidence on these mechanisms: (i) The near-winner analysis (Table 7) shows that formally recognized students generate larger effects than equally talented non-winners, especially in mathematics and for boys. This supports the $\beta(R)$ channel: public acknowledgment shifts beliefs about what is achievable or valued; (ii) Impacts are stronger in smaller cohorts (Table 5) and for same-classroom exposure (Table 11), consistent with $\gamma(P)$ increasing with proximity. When winners are more visible and interaction more frequent, effects strengthen. In large, more anonymous cohorts, exposure to male winners is associated with negative effects for girls, in line with a discouragement mechanism in which recognition lowers perceived returns for some students ($\beta(1) < \beta(0)$) when proximity P is low. In that discouragement case, recognition always reduces effort, but the model also implies that the size of this negative effect is larger in large, impersonal cohorts (low P) and attenuated when proximity/visibility P is high; and (iii) Effects concentrate in mathematics rather than language (Table 8), suggesting mechanisms operate through domain-specific inspiration rather than general motivation. This aligns with $\beta^{\text{math}}(R) > \beta^{\text{lang}}(R)$ and $\gamma^{\text{math}}(P) > \gamma^{\text{lang}}(P)$.

Our empirical findings of stronger and more robust effects for boys suggest underlying heterogeneity in either the peer spillover parameter ϕ, the social comparison sensitivity γ, the recognition channel β or all three. Boys may be more responsive to the behavior of high-effort peers. This may be explained by the documented gender differences in responses to competition (Niederle and Vesterlund, 2011). Moreover, the academic domains from which award winners emerge and the associated social recognition may align more closely with male students' interests and identity in science, and reduce the salience and motivational impact for female peers. While we cannot empirically separate these channels, the observed heterogeneous patterns, by gender, subject domain, and classroom proximity, are consistent with all mechanisms being at play.

9 Conclusion

Recognizing academic excellence is an important part of education, yet its broader effects on peer outcomes are not well understood. In this study, we estimate the spillover effect of having a math award winner in a classroom on other students' academic performance. We leverage unique data from the Hellenic Mathematical Society, which we combine with administrative data sources to study the impact those talented students have on their peers. Our data include detailed information on award winners and their peers' test scores, postsecondary admissions outcomes, and the major of the enrolled university degree.

For identification, we exploit quasi-experimental variation in exposure to those awarded students generated by two sources. First, we exploit within-school and across-cohort variation in award winners;

which cohort will end up having an award winner can be regarded as random. Second, within a school cohort students are lexicographically assigned to classrooms based on their surname, and thus it is quasi-random if a student ends up in the classroom of the award winner or another classroom.

We find positive effects of exposure to award winners in school, and these effects are concentrated among males. In particular, the presence of a same-gender science award winner improves the short- and longer-term outcomes of males but not those of females. In a representative subsample, we do observe improvements in mathematics among female peers of male winners, though these do not translate into aggregate performance or enrollment effects. This suggests more subtle academic benefits for girls, potentially concentrated in subject-specific domains. The estimated effects are economically meaningful: having a male winner in one's peer group improves performance by 4.5% of a standard deviation on standardized exams. They also have long-term implications: Enrollment in academic postsecondary degrees for peers of science award winners increase by 1.4 percentage points and enrollment in STEM university degrees increases by 3 percentage points. The spillover effects are especially pronounced in subjects related to the award winner's strengths, i.e., mathematics. We also find that our estimated effects are stronger in smaller groups in which winners are more salient and interactions are likely to be more intense. Comparisons to near-winner cohorts indicate that public recognition matters for boys' outcomes, over and beyond peer quality. Estimates based on classroom-level variation suggest that proximity amplifies the effects, which points to the importance of direct interaction with the award winner.

Taken together, these findings suggest that publicly recognized male award winners act as a significant motivating factor for their male counterparts. The gender-specific effects are consistent with at least two distinct mechanisms. One possibility is a recognition/beliefs channel in mathematics that raises the perceived return to effort through, for example, increased motivation or revised beliefs about what is achievable in a high-effort environment. Alternatively, gendered responses may reflect differences in how students engage in social comparison if, for example, boys are more sensitive to being outperformed by their peers. Future research is needed to empirically separate these mechanisms, since this would inform the design of effective educational strategies and interventions aimed at maximizing student performance and addressing the gender gap in STEM fields.

While our setting is specific to Greece's national math competition and education system, the underlying mechanisms are likely relevant in other high-stakes educational contexts. Many education systems use competitions and prizes to reward academic talent, which may similarly shape peer behavior. Our analysis focuses on academic outcomes, but future work could also explore peer responses on other dimensions, such as well-being and self-confidence, which may be relevant for understanding female responses. From a policy perspective, these findings suggest that public recognition of academic talent can generate positive externalities for some groups of students and shift attention from peer-group composition per se to the design of award and recognition systems—whose talent is made salient, in which subjects, and to which peers.. However, if award recognition disproportionately highlights boys in male-stereotyped fields like math, these spillovers may reinforce gender disparities in STEM enrollment. Future interventions might explore how to broaden the pool of recognized students or highlight diverse role models to ensure more inclusive peer benefits.

References

Abadie, A., S. Athey, G. W. Imbens, and J. Wooldridge (2017). When should you adjust standard errors for clustering? Nber working paper, National Bureau of Economic Research.

Agarwal, R. and P. Gaule (2020). Invisible Geniuses: Could the Knowledge Frontier Advance Faster? *American Economic Review: Insights 2*(4), 409–424.

Aghion, P., U. Akcigit, A. Hyytinen, and O. Toivanen (2017). The social origins of inventors. Nber working paper, National Bureau of Economic Research.

Airoldi, A. and P. Moser (2024). Inequality in science: Who becomes a star? Nber working paper, National Bureau of Economic Research.

Akcigit, U., S. Caicedo, E. Miguelez, S. Stantcheva, and V. Sterzi (2018). Dancing with the stars: Innovation through interactions. Nber working paper, National Bureau of Economic Research.

Algan, Y., N. Dalvit, Q. Do, A. Le Chapelain, and Y. Zenou (2025). Friendship networks and political opinions. *American Economic Review,* forthcoming.

Altjmed, I. A. A., G. Artemov, A. Barrios-Fernández, A. Bizopoulou, M. Kaila, J.-T. Liu, R. Megalokonomou, J. Montalbán, C. Neilson, J. Sun, et al. (2024). The STEM Major Gender Gap: Evidence from Coordinated College Application Platforms Across Five Continents. *Labour Economics*.

Angrist, J. D. and V. Lavy (1999). Using maimonides' rule to estimate the effect of class size on scholastic achievement. *The Quarterly Journal of Economics 114*(2), 533–575.

Azoulay, P., J. S. Graff Zivin, and J. Wang (2010). Superstar extinction. *The Quarterly Journal of Economics 125*(2), 549–589.

Balestra, S., A. Sallin, and S. C. Wolter (2023). High-Ability Influencers?: The Heterogeneous Effects of Gifted Classmates. *Journal of Human Resources 58*(2), 633–665.

Bettinger, E. P. and B. T. Long (2005). Do faculty serve as role models? the impact of instructor gender on female students. *American Economic Review 95*(2), 152–157.

Bizopoulou, A., R. Megalokonomou, and Simion (2024). Do Second Chances Pay Off? Evidence from a Natural Experiment with Low-Achieving Students. *Journal of Public Economics 239*, 105214.

Black, S. E., C. Muller, A. Spitz-Oener, Z. He, K. Hung, and J. R. Warren (2021). The Importance of STEM: High School Knowledge, Skills and Occupations in an Era of Growing Inequality. *Research Policy 50*(7), 104249.

Boucher, V., M. Rendall, P. Ushchev, and Y. Zenou (2024). Toward a General Theory of Peer Effects. *Econometrica 92*(2), 543–565.

Bradler, C., R. Dur, S. Neckermann, and A. Non (2016). Employee recognition and performance: A field experiment. *Management Science 62*(11), 3085–3099.

Breda, T., J. Grenet, M. Monnet, and C. Van Effenterre (2023). How effective are female role models in steering girls towards stem? evidence from french high schools. *Economic Journal 133*(653), 1773–1809.

Buffington, C., B. Cerf, C. Jones, and B. A. Weinberg (2016). Stem training and early career outcomes of female and male graduate students: Evidence from umetrics data linked to the 2010 census. *American Economic Review 106*(5), 333–338.

Buser, T. and H. Yuan (2019). Do women give up competing more easily? evidence from the lab and the dutch math olympiad. *American Economic Journal: Applied Economics 11*(3), 225–252.

Butera, L., R. Metcalfe, W. Morrison, and D. Taubinsky (2022). Measuring the welfare effects of shame and pride. *American Economic Review 112*(1), 122–168.

Choudhury, P., I. Ganguli, and P. Gaule (2023). Top talent, elite colleges, and migration: Evidence from the indian institutes of technology. *Journal of Development Economics 164*, 103120.

Cimpian, J. R., T. H. Kim, and Z. T. McDermott (2020). Understanding Persistent Gender Gaps in STEM. *Science 368*(6497), 1317–1319.

Cools, A., R. Fernández, and E. Patacchini (2022). The Asymmetric Gender Effects of High Flyers. *Labour Economics 79*, 102287.

Croson, R. and U. Gneezy (2009). Gender differences in preferences. *Journal of Economic Literature 47*(2), 448–474.

de Gendre, A., J. Feld, N. Salamanca, and U. Zölitz (2023). Same-sex Role Model Effects in Education. *Working paper series/Department of Economics* (438).

Dinerstein, M., R. Megalokonomou, and C. Yannelis (2022). Human Capital Depreciation and Returns to Experience. *American Economic Review 112*(11), 3725–3762.

Ellison, G. and A. Swanson (2010). The Gender Gap in Secondary School Mathematics at High Achievement Levels: Evidence from the American Mathematics Competitions. *Journal of Economic Perspectives 24*(2), 109–128.

Ellison, G. and A. Swanson (2016). Do Schools Matter for High Math Achievement? Evidence from the American Mathematics Competitions. *American Economic Review 106*(6), 1244–1277.

Ellison, G. and A. Swanson (2023). Dynamics of the gender gap in high math achievement. *Journal of Human Resources 58*(5), 1679–1711.

Epple, D. and R. E. Romano (2011). Peer effects in education: A survey of the theory and evidence. In *Handbook of Social Economics*, Volume 1, pp. 1053–1163. Elsevier.

Feld, J. and U. Zölitz (2022). The Effect of Higher-achieving Peers on Major Choices and Labor Market Outcomes. *Journal of Economic Behavior & Organization 196*, 200–219.

Fischer, S. (2017). The Downside of Good Peers: How Classroom Composition Differentially Affects Men's and Women's STEM Persistence. *Labour Economics 46*, 211–226.

Goulas, S., S. Griselda, and R. Megalokonomou (2022). Comparative Advantage and Gender Gap in STEM. *Journal of Human Resources*.

Goulas, S., S. Griselda, and R. Megalokonomou (2023). Compulsory Class Attendance versus Autonomy. *Journal of Economic Behavior & Organization 212*.

Goulas, S., S. Griselda, R. Megalokonomou, and Y. Zenou (2024). Disruptive Peers and Academic Performance: Short- and Long-Term Outcomes. *Available at SSRN 5052885*.

Goulas, S., B. Gunawardena, R. Megalokonomou, and Y. Zenou (2024). Gender Role Models in Education. CEPR Discussion Paper No. 19432.

Goulas, S. and R. Megalokonomou (2019). Which Degrees Do Students Prefer During Recessions? *Empirical Economics 56*(6), 2093–2125.

Goulas, S., R. Megalokonomou, and Y. Zhang (2023). Female Classmates, Disruption, and STEM Outcomes in Disadvantaged Schools: Evidence from a Randomized Natural Experiment. *CESifo Working Paper*.

Goulas, S., R. Megalokonomou, and Y. Zhang (2025). Female Neighbors and Careers in Science. *Research Policy 54*(7), 105229.

Griffith, A. L. and J. B. Main (2021). The role of the teaching assistant: Female role models in the classroom. *Economics of Education Review 85*, 102179.

Hanushek, E. A., J. Kain, D. O'Brien, and S. G. Rivkin (2005). The market for teacher quality.

Hoffmann, F. and P. Oreopoulos (2009). A professor like me: The influence of instructor gender on college achievement. *Journal of Human Resources 44*(2), 479–494.

Hoisl, K., H. C. Kongsted, and M. Mariani (2023). Lost marie curies: Parental impact on the probability of becoming an inventor. *Management Science 69*(3), 1714–1738.

Hoxby, C. M. (2000). Peer effects in the classroom: Learning from gender and race variation. Nber working paper, National Bureau of Economic Research.

Hsieh, C.-T., E. Hurst, C. I. Jones, and P. J. Klenow (2019). The allocation of talent and us economic growth. *Econometrica 87*(5), 1439–1474.

Huntington-Klein, N. and E. Rose (2018). Gender peer effects in a predominantly male environment: Evidence from west point. In *AEA Papers and Proceedings*, Volume 108, pp. 392–395.

Iriberri, N. and P. Rey-Biel (2019). Competitive Pressure Widens the Gender Gap in Performance: Evidence from a Two-Stage Competition in Mathematics. *The Economic Journal 129*(620), 1863–1893.

Kirkeboen, L. J., E. Leuven, and M. Mogstad (2016). Field of Study, Earnings, and Self-selection. *Quarterly Journal of Economics 131*(3), 1057–1111.

Kosfeld, M. and S. Neckermann (2011). Getting more work for nothing? symbolic awards and worker performance. *American Economic Journal: Microeconomics 3*(3), 86–99.

Lavy, V. and R. Megalokonomou (2024). The short- and the long-run impact of gender-biased teachers. *American Economic Journal: Applied Economics 16*(2), 176–218.

Lavy, V., O. Silva, and F. Weinhardt (2012). The Good, the Bad, and the Average: Evidence on Ability Peer Effects in Schools. *Journal of Labor Economics 30*(2), 367–414.

Levitt, S. D., J. A. List, S. Neckermann, and S. Sadoff (2016). The behavioralist goes to school: Leveraging behavioral economics to improve educational performance. *American Economic Journal: Economic Policy 8*(4), 183–219.

Modena, F., E. Rettore, and G. M. Tanzi (2022). Asymmetries in the Gender Effect of High-Performing Peers: Evidence from Tertiary Education. *Labour Economics 78*, 102225.

Mohnen, M. (2022). Stars and brokers: Knowledge spillovers among medical scientists. *Management Science 68*(4), 2513–2532.

Moreira, D. (2019). Success spills over: How awards affect winners' and peers' performance in brazil. Unpublished manuscript.

Mouganie, P. and Y. Wang (2020). High-performing Peers and Female STEM Choices in School. *Journal of Labor Economics 38*(3), 805–841.

Murphy, K. M., A. Shleifer, and R. W. Vishny (1991). The allocation of talent: Implications for growth. *The Quarterly Journal of Economics 106*(2), 503–530.

Niederle, M. and L. Vesterlund (2010). Explaining the gender gap in math test scores: The role of competition. *Journal of Economic Perspectives 24*(2), 129–144.

Niederle, M. and L. Vesterlund (2011). Gender and competition. *Annual Review of Economics 3*(1), 601–630.

OECD (2018). *Education For A Bright Future In Greece*. OECD Publishing, Paris.

Oettl, A. (2012). Reconceptualizing stars: Scientist helpfulness and peer performance. *Management Science 58*(6), 1122–1140.

Porter, C. and D. Serra (2020). Gender differences in the choice of major: The importance of female role models. *American Economic Journal: Applied Economics 12*(3), 226–254.

Riise, J., B. Willage, and A. Willén (2022). Can female doctors cure the gender STEMM gap? Evidence from exogenously assigned general practitioners. *Review of Economics and Statistics 104*(4), 621–635.

Riley, E. (2024). Role models in movies: The impact of Queen of Katwe on students' educational attainment. *The Review of Economics and Statistics 106*(2), 334–351.

Sacerdote, B. (2011). Peer effects in education: How might they work, how big are they and how much do we know thus far? In *Handbook of the Economics of Education*, Volume 3, pp. 249–277. Elsevier.

Sacerdote, B. (2014). Experimental and quasi-experimental analysis of peer effects: two steps forward? *Annual Review of Economics 6*(1), 253–272.

Waldinger, F. (2012). Peer Effects in Science: Evidence from the Dismissal of Scientists in Nazi Germany. *The Review of Economic Studies 79*(2), 838–861.

Tables and Figures

Table 1: Mathematics Thales Award Winners, Mathematical Society Dataset

Graduation Year	Girl Winners	Boy Winners	Total Winners
2009	32	125	157
2010	50	181	231
2011	70	177	247
Total	152	483	635

Notes: The table presents the number of girl, boy, and total Thales award winners in our sample for the years 2009, 2010, and 2011. The winners originate from 291 distinct high schools.

Table 2: Descriptive Statistics about Sampled Students

	Mean	Std. Dev.	Min.	Max.	N
Panel A: Population of Schools with Winners					
Student Age (in Years)	18.03	0.22	17.00	23.00	86,458
Female	0.55	0.50	0.00	1.00	86,458
Specialty in Classics	0.39	0.49	0.00	1.00	86,458
Specialty in Science	0.16	0.36	0.00	1.00	86,458
Specialty in Exact Science	0.45	0.50	0.00	1.00	86,458
Any Winner	0.39	0.49	0.00	1.00	86,458
Boy Winner	0.32	0.47	0.00	1.00	86,458
Girl Winner	0.12	0.33	0.00	1.00	86,458
Average Student Age (in Years)	18.04	0.05	17.90	22.14	86,458
Share of Female Schoolmates	0.55	0.08	0.00	1.00	86,458
School-Cohort Size	90.07	35.40	6.00	202.00	86,458
National Exam Performance	14.62	3.46	1.85	19.95	74,180
Enroll in Academic University	0.67	0.47	0.00	1.00	74,180
University Entry Exam Test Scores	14666.14	3727.84	1756.00	23623.00	74,217
Panel B: Sample of Schools with Winners					
Age	18.03	0.21	17.00	22.00	13,465
Female	0.56	0.50	0.00	1.00	13,465
Overall Performance in Previous Grade	14.73	2.79	6.00	20.00	13,465
Specialty in Classics	0.40	0.49	0.00	1.00	13,465
Specialty in Science	0.16	0.36	0.00	1.00	13,465
Specialty in Exact Science	0.45	0.50	0.00	1.00	13,465
Any Winner	0.27	0.45	0.00	1.00	13,465
Boy Winner	0.22	0.41	0.00	1.00	13,465
Girl Winner	0.11	0.31	0.00	1.00	13,465
Average Age	18.03	0.04	17.94	18.28	13,465
Share of Female Schoolmates	0.56	0.08	0.30	1.00	13,465
School-Cohort Size	85.41	29.89	12.00	143.00	13,465
National Exam Performance	13.55	4.11	2.07	19.78	13,465
University Entry Exam Test Scores	14558.15	3705.75	2150.00	23392.00	11,591
National Exam Score in Mathematics in Grade 12	11.57	6.34	0.00	20.00	13,465
National Exam Score in Modern Greek in Grade 12	13.47	2.77	0.00	20.00	13,465
Overall National Exam Score in Classics Track Subjects	13.00	4.33	0.70	19.85	5,298
Overall National Exam Score in Science Track Subjects	14.54	4.29	1.35	20.00	2,092
Overall National Exam Score in IT Track Subjects	11.47	4.68	1.40	20.00	5,874
Enrollment in a STEM University Degree	0.13	0.34	0.00	1.00	13,465
Enrollment in a Humanities University Degree	0.12	0.32	0.00	1.00	13,465
Panel C: Sample of Classes with Winners					
Any Winner	0.36	0.48	0.00	1.00	3,166
Boy Winner	0.26	0.44	0.00	1.00	3,166
Girl Winner	0.12	0.33	0.00	1.00	3,166

Notes: The table presents means, standard deviations, and minimum and maximum values for student-level variables. Each panel refers to a different sample: Panel A includes the universe of schools with winners, Panel B the smaller sample of schools with winners for which we have additional data, and Panel C the classes with winners.

Table 3: Balancing Exercise for the Presence of Award Winner

	Boys			Girls		
	Panel A: Winner of Any Gender					
	(1)	(2)	(3)	(4)	(5)	(6)
Student Age (in Years)	0.000			0.002		
	(0.007)			(0.005)		
Baseline Math Performance		0.001			0.001	
		(0.001)			(0.001)	
School-Cohort Size			0.001			0.001
			(0.001)			(0.001)
Observations	38,914	38,909	38,914	47,555	47,548	47,555
	Panel B: Boy Winner					
	(1)	(2)	(3)	(4)	(5)	(6)
Student Age (in Years)	0.004			0.004		
	(0.007)			(0.005)		
Baseline Math Performance		0.001			0.001	
		(0.001)			(0.001)	
School-Cohort Size			0.001			0.001
			(0.001)			(0.001)
Observations	38,914	38,909	38,914	47,555	47,548	47,555
	Panel C: Girl Winner					
	(1)	(2)	(3)	(4)	(5)	(6)
Student Age (in Years)	-0.006			-0.002		
	(0.004)			(0.003)		
Baseline Math Performance		0.000			0.000	
		(0.001)			(0.001)	
School-Cohort Size			0.000			0.001
			(0.001)			(0.001)
Observations	38,914	38,909	38,914	47,555	47,548	47,555
Track FE	✓	✓	✓	✓	✓	✓
School FE	✓	✓	✓	✓	✓	✓

Notes: Each column corresponds to estimation results that come from a different regression. The table reports estimated coefficients of student characteristics and school-cohort size on the likelihood of having an award winner in the school cohort. Standard errors clustered at the school level are reported in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 4: Impact of Award Winners in School Cohort on Schoolmates' Academic Outcomes

	Panel A: National Exam Score					
	Boys			Girls		
	(1)	(2)	(3)	(4)	(5)	(6)
Any Winner	0.040			-0.010		
	(0.015)***			(0.014)		
Boy Winner		0.039	0.045		-0.017	-0.009
		(0.015)***	(0.015)***		(0.014)	(0.014)
Girl Winner		0.006	0.010		0.004	0.009
		(0.021)	(0.021)		(0.019)	(0.019)
Observations	38,909	38,909	38,585	47,548	47,548	47,117
	Panel B: Enrollment in an Academic University					
	(1)	(2)	(3)	(4)	(5)	(6)
Any Winner	0.014			-0.003		
	(0.007)**			(0.006)		
Boy Winner		0.013	0.015		-0.008	-0.005
		(0.007)*	(0.007)**		(0.006)	(0.006)
Girl Winner		-0.001	-0.001		0.013	0.015
		(0.009)	(0.009)		(0.009)	(0.009)*
Observations	33,828	33,828	33,504	40,356	40,356	39,926
Controls	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Track FE	✓	✓	✓	✓	✓	✓
School FE	✓	✓	✓	✓	✓	✓
Exclude Top-Performers			✓			✓

Notes: Each column corresponds to estimation results that come from a different regression. The table reports estimated coefficients of having a winner of any gender, a boy winner, or a girl winner in the school cohort on the national exam score (Panel A) and the likelihood to enroll to academic university (Panel B). The national exam score is an average of the different subjects' exam scores a student obtains. Test scores have been standardized to have a mean equal to 0 and a standard deviation equal to 1. Enroll in an Academic University is a binary indicator that takes the value of 1 if a student enrolls in an academic university and 0 if they enroll in a vocational degree. We focus on schools that have at least one winner in at least one school cohort. The difference between columns (2) and (3), and (5) and (6) is that we drop top performers from school cohorts that do not have a winner in the latter specification. Controls include student age (in years), student baseline math performance, and school-cohort-level controls (average age, class size, and share of female school-cohort peers). Standard errors clustered at the school-by-cohort level are reported in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 5: Heterogeneity Effects by School-Cohort Size

	Outcome: National Exam Score							
	Boys				Girls			
	Small Schools		Large Schools		Small Schools		Large Schools	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Boy Winner	0.067	0.076	0.037	0.042	0.018	0.031	-0.059	-0.054
	(0.027)**	(0.027)***	(0.022)*	(0.022)*	(0.024)	(0.024)	(0.019)***	(0.019)***
Girl Winner	0.005	0.010	0.013	0.015	-0.000	0.008	0.032	0.034
	(0.035)	(0.035)	(0.029)	(0.029)	(0.031)	(0.031)	(0.027)	(0.027)
Observations	19,668	19,430	19,241	19,155	24,227	23,912	23,321	23,205
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Track FE	✓	✓	✓	✓	✓	✓	✓	✓
School FE	✓	✓	✓	✓	✓	✓	✓	✓
Exclude Top-Performers		✓		✓		✓		✓

Notes: Each column corresponds to estimation results that come from a different regression. The table reports estimated coefficients of having a winner of any gender, a boy winner, or a girl winner in the school cohort on the standardized national exam score by school-cohort size. Small schools are those with a school-cohort size below the median (88 students in grade 12). Large schools are those with a school-cohort size above the median (88 students in grade 12). We focus on schools that have at least one winner in at least one school cohort. The difference between columns (1) and (2), (3) and (4), and (5) and (6), and (7) and (8) is that we exclude top performers from school-cohorts that do not have a winner in the latter specifications. Controls include student age (in years), student baseline math performance, and school-cohort-level controls (average age, class size, and share of female school-cohort peers). Standard errors clustered at the school-by-cohort level are reported in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 6: Impact of Award Winners on Schoolmates' Overall National Exam Test Scores and University Entry Exam Test Scores, Sample of Schools

	Panel A: National Exam Score					
	Boys			Girls		
	(1)	(2)	(3)	(4)	(5)	(6)
Any Winner	0.032			0.003		
	(0.026)			(0.028)		
Boy Winner		0.057	0.057		0.042	0.045
		(0.028)**	(0.028)**		(0.027)	(0.027)*
Girl Winner		-0.028	-0.027		-0.074	-0.073
		(0.035)	(0.035)		(0.041)*	(0.041)*
Observations	5,878	5,878	5,802	7,590	7,590	7,519
	Panel B: University Entry Exam Score					
	Boys			Girls		
	(1)	(2)	(3)	(4)	(5)	(6)
Any Winner	0.044			0.012		
	(0.025)*			(0.026)		
Boy Winner		0.066	0.068		0.039	0.044
		(0.027)**	(0.027)**		(0.028)	(0.028)
Girl Winner		-0.030	-0.028		-0.030	-0.027
		(0.040)	(0.041)		(0.041)	(0.040)
Observations	5,134	5,134	5,058	6,460	6,460	6,389
Controls	✓	✓	✓	✓	✓	✓
Track FE	✓	✓	✓	✓	✓	✓
School FE	✓	✓	✓	✓	✓	✓
Exclude Top-Performers			✓			✓

Notes: Each column corresponds to estimation results that come from a different regression. The table reports estimated coefficients of having a winner of any gender, a boy winner, or a girl winner in the school cohort (compared with other school cohorts) on university admissions score. Overall national exam performance is an average national exam score a student obtains in the different subjects. The university admissions score is a weighted average of the different exam scores each student who enrolls in a postsecondary institution obtains (weights depend on the university degrees each student applies to). Both test scores have been standardized to have a mean equal to 0 and a standard deviation equal to 1. The difference between columns (2) and (3), and (5) and (6) is that we drop top performers from school cohorts that do not have a winner. Controls include student age (in years), a student's overall performance in the previous grade, and classroom-level controls (average age, class size, and share of female classmates). Standard errors clustered at the school level are reported in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 7: Recognition Effect: Winner vs. Near-Winner

	Boys (Math)	Girls (Math)	Boys (Nat)	Girls (Nat)
Recognized winner	0.199***	0.183**	0.129**	0.013
(vs near-99th)	(0.034)	(0.085)	(0.057)	(0.063)
Observations	1450	1747	1450	1747
R-squared	0.642	0.639	0.717	0.744
Clusters	41	41	41	41
Wild p-value	0.009	0.345	0.219	0.914

Notes: Sample comprises 23 schools with both a recognized-winner cohort and a near-winner cohort. Near-winner cohorts are those where the top pre-treatment student (by Grade 11 GPA, ranked within national year) is in the top 1% nationally but the cohort received no recognition. Sample restricted to schools with both a recognized cohort and a near-winner cohort; the pre-treatment top student is excluded from outcomes. Outcomes are standardized maths grades and standardized national exam scores. Specifications include school fixed effects and year indicators; controls are pathway indicators, Grade 11 GPA, student age, class size, cohort mean age, and cohort female share. Standard errors clustered at school $\times$ year in parentheses. Wild-cluster bootstrap p-values reported in the last row. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Impact of Award Winners on Schoolmates' Test Scores in Mathematics and Language, Sample of Schools

	Panel A: Test Score in Mathematics (Core)					
	Boys			Girls		
	(1)	(2)	(3)	(4)	(5)	(6)
Any Winner	0.069			0.093		
	(0.033)**			(0.045)**		
Boy Winner		0.081	0.083		0.135	0.136
		(0.038)**	(0.038)**		(0.046)***	(0.047)***
Girl Winner		-0.007	-0.006		-0.029	-0.029
		(0.047)	(0.047)		(0.056)	(0.056)
Observations	5,878	5,878	5,802	7,590	7,590	7,519
	Panel B: Test Score in Language (Core)					
	Boys			Girls		
	(1)	(2)	(3)	(4)	(5)	(6)
Any Winner	0.005			0.005		
	(0.047)			(0.041)		
Boy Winner		-0.008	-0.010		0.009	0.008
		(0.048)	(0.048)		(0.043)	(0.043)
Girl Winner		0.047	0.046		0.007	0.007
		(0.069)	(0.069)		(0.057)	(0.057)
Observations	5,878	5,878	5,802	7,590	7,590	7,519
Controls	✓	✓	✓	✓	✓	✓
Track FE	✓	✓	✓	✓	✓	✓
School FE	✓	✓	✓	✓	✓	✓
Exclude Top-Performers			✓			✓

Notes: Each column corresponds to estimation results that come from a different regression. The table reports estimated coefficients of having a winner of any gender, a boy winner, or a girl winner in the school cohort (compared with other school cohorts) on student standardized national test scores in mathematics (Panel A) and language (Panel B). The national exam score is an average of the different subjects' exam scores a student receives. The university admissions score is a weighted average of the different exam results of students who enroll in a postsecondary institution. Both test scores have been standardized to have a mean equal to 0 and a standard deviation equal to 1. The difference between columns (2) and (3) is that we drop top performers from school cohorts that do not have a winner. Controls include student age (in years), a student's overall performance in the previous grade, and classroom-level controls (average age, class size, and share of female classmates). Standard errors clustered at the school level are reported in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 9: Impact of Award Winners on Schoolmates' Test Scores in Track Subjects, Smaller Sample of Schools

	Panel A: Test Score in Specialization Subjects for Boys					
	Science Track		Classics Track		IT Track	
	(1)	(2)	(3)	(4)	(5)	(6)
Boy Winner	0.108	0.124	-0.027	-0.027	0.069	0.069
	(0.064)*	(0.065)*	(0.052)	(0.052)	(0.036)*	(0.036)*
Girl Winner	-0.077	-0.072	-0.033	-0.033	-0.031	-0.031
	(0.075)	(0.080)	(0.070)	(0.070)	(0.044)	(0.044)
Observations	792	721	1,166	1,166	3,803	3,803
	Panel B: Test Score in Specialization Subjects for Girls					
	Science Track		Classics Track		IT Track	
	(1)	(2)	(3)	(4)	(5)	(6)
Boy Winner	0.123	0.152	0.044	0.044	0.032	0.032
	(0.050)**	(0.049)***	(0.036)	(0.036)	(0.037)	(0.037)
Girl Winner	-0.183	-0.161	-0.095	-0.095	-0.069	-0.069
	(0.067)***	(0.065)**	(0.053)*	(0.053)*	(0.049)	(0.049)
Observations	1,218	1,148	4,156	4,156	2,125	2,125
Controls	✓	✓	✓	✓	✓	✓
Track FE	✓	✓	✓	✓	✓	✓
School FE	✓	✓	✓	✓	✓	✓
Exclude Top-Performers		✓		✓		✓

Notes: Each column corresponds to estimation results that come from a different regression. The table reports estimated coefficients of having a winner of any gender, a boy winner, or a girl winner in the school cohort (compared with other school cohorts) on student standardized national test scores in track subjects for students in the science track (columns 1 and 2 for boys in Panel A and girls in Panel B), classics track (columns 1 and 2 for boys in Panel A and girls in Panel B), and IT Track (columns 1 and 2 for boys in Panel A and girls in Panel B). We show the average standardized score across the four compulsory track subjects. Test scores have been standardized to have a mean equal to 0 and a standard deviation equal to 1. The difference between columns (1) and (2), (3) and (4), and (5) and (6) is that we drop top performers from school cohorts that do not have a winner for the science, classics, and IT tracks, respectively. Controls include student age (in years), a student's overall performance in the previous grade, and classroom-level controls (average age, class size, and share of female classmates). Standard errors clustered at the school level are reported in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 10: Impact of Award Winners on Schoolmates' Likelihood to Enroll in a STEM or a Humanities University Degree, Smaller Sample of Schools

	Panel A: Enrollment in a STEM University Degree					
	Boys			Girls		
	(1)	(2)	(3)	(4)	(5)	(6)
Any Winner	0.030			0.002		
	(0.017)*			(0.008)		
Boy Winner		0.035	0.035		0.007	0.010
		(0.017)**	(0.017)**		(0.009)	(0.009)
Girl Winner		-0.007	-0.011		-0.008	-0.007
		(0.018)	(0.017)		(0.009)	(0.009)
Observations	5,878	5,872	5,796	7,590	7,583	7,512
	Panel B: Enrollment in a Humanities University Degree					
	Boys			Girls		
	(1)	(2)	(3)	(4)	(5)	(6)
Any Winner	-0.019			-0.021		
	(0.010)*			(0.014)		
Boy Winner		-0.021	-0.021		-0.023	-0.025
		(0.011)*	(0.011)*		(0.015)	(0.015)
Girl Winner		-0.009	-0.009		-0.010	-0.010
		(0.010)	(0.010)		(0.015)	(0.015)
Observations	5,878	5,872	5,796	7,590	7,583	7,512
Controls	✓	✓	✓	✓	✓	✓
Track FE	✓	✓	✓	✓	✓	✓
School FE	✓	✓	✓	✓	✓	✓
Exclude Top-Performers			✓			✓

Notes: Each column corresponds to estimation results that come from a different regression. The table reports estimated coefficients of having a winner of any gender, a boy winner, or a girl winner in the school cohort (compared with other school cohorts) on the likelihood to enroll in a STEM university degree (Panel A) or a Humanities university degree (Panel B). Enrollment in a STEM university degree is a binary indicator that takes the value of 1 if a student enrolls in a STEM university degree and 0 otherwise. Enrollment in a STEM university degree is a binary indicator that take the value of 1 if a student enrolls in a humanities university degree that takes the value of 1 if a student enrolls in a humanities university degree and 0 otherwise. The difference between columns (2) and (3) is that we drop top performers from school cohorts that do not have a winner. Controls include student age (in years), a student's overall performance in the previous grade, and classroom-level controls (average age, class size, and share of female classmates). Standard errors clustered at the school level are reported in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table 11: Impact of Award Winners in Class on Classmates' Test Scores on National Exams

	Outcome: National Exam Score			
	Boys		Girls	
	(1)	(2)	(3)	(4)
Boy Winner in Class	0.009	0.008	-0.006	-0.007
	(0.004)**	(0.004)*	(0.003)*	(0.003)**
Girl Winner in Class	-0.005	-0.004	0.009	0.009
	(0.007)	(0.007)	(0.005)**	(0.005)*
Observations	1,298	1,265	1,795	1,740
Controls	✓	✓	✓	✓
Track FE	✓	✓	✓	✓
School-by-Year FE	✓	✓	✓	✓
Exclude Top-Performers		✓		✓

Notes: Each column corresponds to estimation results that come from a different regression. The table reports estimated coefficients of having a boy winner or a girl winner in the classroom on the national exam score. The national exam score is the average of the different subjects' exam scores a student obtains. Test scores have been standardized to have a mean equal to 0 and a standard deviation equal to 1. We focus on school cohorts that have at least one winner in at least one classroom. The difference between columns (1) and (2) and (3) and (4) is that we drop top performers from classrooms that do not have a winner from the latter. Controls include student age (in years), a student's overall performance in the previous grade, a student's prior performance in mathematics, and classroom-level controls (average age, class size, and share of female classmates). Standard errors clustered at the classroom level are reported in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Appendix

A Figures and Tables

Figure A.1: Example of a List of Math Award Winners

Σύνδεσμοι | Επικοινωνία

ΕΛΛΗΝΙΚΗ ΜΑΘΗΜΑΤΙΚΗ ΕΤΑΙΡΕΙΑ

Βάση ασκήσεων | Ψηφιακή βιβλιοθήκη

Αρχική | Νέα | Διαγωνισμοί | Συνέδρια | Κατασκηνώσεις | Εκδόσεις | i JME | Bulletin

Διαγωνισμοί - 2010 - 2011

- ΝΕΑ ΤΩΝ ΔΙΑΓΩΝΙΣΜΩΝ
- Θαλής
  - Θέματα & Λύσεις
  - Επιτυχόντες
    - Β' Γυμ.
    - Γ' Γυμ.
    - Α' Λυκ.
    - Β' Λυκ.
    - **Γ' Λυκ.**
- Ευκλείδης
  - Θέματα & Λύσεις
  - Επιτυχόντες
    - Β' Γυμ.
    - Γ' Γυμ.
    - Α' Λυκ.
    - Β' Λυκ.
    - Γ' Λυκ.
- Αρχιμήδης
  - Θέματα & Λύσεις
- Μικρός Ευκλείδης
  - Θέματα & Λύσεις
- Διεθνείς Ολυμπιάδες

Γ' Λυκείου 2010-2011

ΕΠΩΝΥΜΟ	ΟΝΟΜΑ	ΣΧΟΛΕΙΟ	ΝΟΜΟΣ
ΑΘΑΝΑΣΙΑΔΗΣ	ΙΩΑΝΝΗΣ	4ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΒΕΡΟΙΑΣ	ΗΜΑΘΙΑΣ
ΑΘΑΝΑΣΙΟΥ	ΓΕΩΡΓΙΟΣ	ΕΝΙΑΙΟ ΠΕΙΡΑΜΑΤΙΚΟ ΛΥΚΕΙΟ ΠΑΝΕΠΙΣΤΗΜΙΟΥ ΠΑΤΡΩΝ	ΑΧΑΙΑΣ
ΑΘΑΝΑΣΙΟΥ	ΑΠΟΣΤΟΛΟΣ	1ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΗΛΙΟΥΠΟΛΗΣ	Α' ΑΘΗΝΑΣ ΑΤΤΙΚΗ
ΑΝΑΣΤΑΣΙΑΔΗΣ	ΧΑΡΑΛΑΜΠΟΣ	1ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΗΡΑΚΛΕΙΟΥ	ΗΡΑΚΛΕΙΟΥ
ΑΝΤΟΥΛΙΝΑΚΗΣ	ΦΟΙΒΟΣ	1ο ΑΡΣΑΚΕΙΟ ΨΥΧΙΚΟΥ	Β' ΑΘΗΝΑΣ ΑΤΤΙΚΗ
ΑΞΙΩΤΗΣ	ΚΥΡΙΑΚΟΣ	2ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΓΕΡΑΚΑ	ΑΝΑΤΟΛΙΚΗΣ ΑΤΤΙΚΗΣ
ΑΠΟΣΤΟΛΕΡΗΣ	ΔΗΜΗΤΡΗΣ	ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΨΥΧΙΚΟΥ	Β' ΑΘΗΝΑΣ ΑΤΤΙΚΗ
ΑΡΒΑΝΙΤΑΚΗΣ	ΣΤΑΥΡΟΣ	2ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΦΛΩΡΙΝΑΣ	ΦΛΩΡΙΝΑΣ
ΑΡΦΑΡΑΣ-ΜΕΛΑΪΝΗΣ	ΑΓΓΕΛΟΣ	2ο ΑΡΣΑΚΕΙΟ ΨΥΧΙΚΟΥ	Β' ΑΘΗΝΑΣ ΑΤΤΙΚΗ
ΑΣΗΜΑΚΟΠΟΥΛΟΥ	ΣΤΑΥΡΟΥΛΑ	-	ΔΥΤΙΚΗΣ ΑΤΤΙΚΗΣ
ΑΣΤΕΡΗ	ΕΙΡΗΝΗ	2ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΝΑΟΥΣΑΣ	ΗΜΑΘΙΑΣ
ΒΑΛΕΤΑ	ΜΑΡΙΝΑ	ΕΛΛΗΝΟΓΑΛΛΙΚΗ ΣΧΟΛΗ ΚΑΛΑΜΑΡΙ	Α' ΘΕΣΣΑΛΟΝΙΚΗΣ
ΒΑΛΛΙΟΥ	ΜΑΡΙΑ	3ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΘΗΒΑΣ	ΒΟΙΩΤΙΑΣ
ΒΑΡΒΕΛΗΣ	ΒΑΓΓΕΛΗΣ	2ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΕΥΟΣΜΟΥ ΘΕΣΣΑΛΟΝΙΚΗΣ	Β' ΘΕΣΣΑΛΟΝΙΚΗΣ
ΒΑΡΔΑΚΑΣ	ΝΙΚΟΣ	1ο ΕΝΙΑΙΟ ΛΥΚΕΙΟ ΤΡΙΚΑΛΩΝ	ΤΡΙΚΑΛΩΝ
ΒΑΣΔΕΚΗΣ	ΓΕΩΡΓΙΟΣ	ΛΕΟΝΤΕΙΟ ΛΥΚΕΙΟ	Α' ΑΘΗΝΑΣ ΑΤΤΙΚΗ

Πληρωμές Online

Ενημέρωση από Ε.Μ.Ε.

ΕΜΕ

- Η Εταιρεία
- Διοικητικό Συμβούλιο
- Αποφάσεις Δ.Σ. - Γ.Σ.
- Παλαιά Δ.Σ.
- Επιτροπές
- Καταστατικό
- Συμμετοχή
- Συνδρομή
- e-Ενημέρωση

Πυθαγόρας

Νέος πρωτότυπος διαγωνισμός

100 χρόνια ΕΜΕ

100 χρόνια ΕΜΕ, 2018 έτος Μαθηματικών

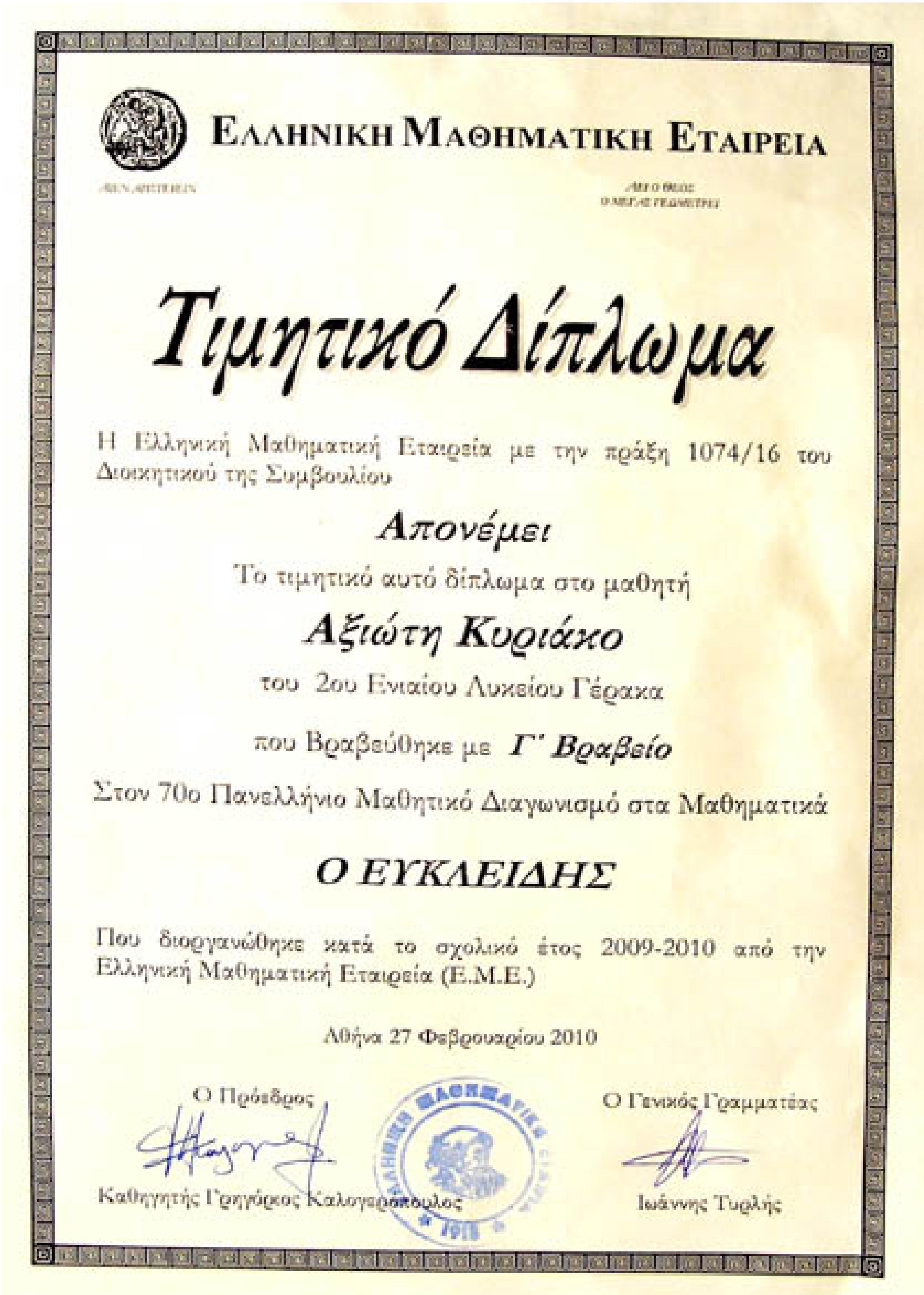
SCGM-2022

Notes: This list shows how the math award winners for a specific competition (Thalis), grade (12) and year (2010-2011) appear on the website of the Hellenic Mathematical Society. The first names of winners are in the first column, the surnames of winners in the second column, the name of the high school winners attended in the third column, and the district in which the high school is located in the fourth column. The district also indicates to which local school authority is each winner assigned.

Figure A.2: Location of Award Winners in the Country, Hellenic Mathematical Society

Notes: The figure shows the school locations of winners in grade 12. Blue dots denote male winners and red dots denote female winners.

Figure A.3: Honorary Mention Certificate



ΕΛΛΗΝΙΚΗ ΜΑΘΗΜΑΤΙΚΗ ΕΤΑΙΡΕΙΑ

Τιμητικό Δίπλωμα

Η Ελληνική Μαθηματική Εταιρεία με την πράξη 1074/16 του Διοικητικού της Συμβουλίου

Απονέμει

Το τιμητικό αυτό δίπλωμα στο μαθητή

Αξιώτη Κυριάκο

του 2ου Ενιαίου Λυκείου Γέρακα

που Βραβεύθηκε με Γ' Βραβείο

Στον 70ο Πανελλήνιο Μαθητικό Διαγωνισμό στα Μαθηματικά

Ο ΕΥΚΛΕΙΔΗΣ

Που διοργανώθηκε κατά το σχολικό έτος 2009-2010 από την Ελληνική Μαθηματική Εταιρεία (Ε.Μ.Ε.)

Αθήνα 27 Φεβρουαρίου 2010

Ο Πρόεδρος

Καθηγητής Γρηγόριος Καλογερόπουλος

Ο Γενικός Γραμματέας

Ιωάννης Τυρλής

Notes: The figure shows the honorary mention certificate awarded by the Hellenic Mathematical Society to winners of the mathematical competitions.

Table A.1: Treatment Intensity: Impact of Single and Multiple Winners on National Exam Scores

	Outcome: National Exam Scores							
	Boys				Girls			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Single Winner Any Gender	0.038	0.046			-0.007	0.004		
	(0.017)**	(0.017)***			(0.016)	(0.016)		
Multiple Winners Any Gender	0.043	0.051			-0.016	-0.008		
	(0.020)**	(0.020)**			(0.019)	(0.020)		
Single Boy Winner			0.043	0.050			-0.019	-0.010
			(0.017)***	(0.017)***			(0.016)	(0.016)
Multiple Boy Winners			0.026	0.032			-0.016	-0.008
			(0.022)	(0.022)			(0.020)	(0.021)
Single Girl Winner			-0.000	0.004			-0.005	0.001
			(0.022)	(0.022)			(0.020)	(0.020)
Multiple Girl Winners			0.062	0.067			0.054	0.056
			(0.052)	(0.052)			(0.052)	(0.051)
Observations	38,909	38,585	38,909	38,585	47,548	47,117	47,548	47,117
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓
Track FE	✓	✓	✓	✓	✓	✓	✓	✓
School FE	✓	✓	✓	✓	✓	✓	✓	✓
Exclude Top-Performers		✓		✓		✓		✓

Notes: Each column corresponds to estimation results that come from a different regression. The table reports estimated coefficients of having one or multiple winner or winners of any gender, a boy winner, or a girl winner in the school cohort on student standardized national exam score. We focus on schools that have at least one winner in at least one school cohort. The difference between columns (1) and (2), (3) and (4), (5) and (6), and (7) and (8) is that we drop top performers from school cohorts that do not have a winner in the latter specifications. Controls include student age (in years), student baseline math performance, and classroom-level controls (average age, class size, and share of female classmates). Standard errors clustered at the school-by-cohort level are reported in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table A.2: Robustness Exercise: Effect of Winners in Different Subsamples

	Panel A: National Exam Score					
	Baseline	Exclude Private	Exclude Experimental	Baseline	Exclude Private	Exclude Experimental
	Boys			Girls		
	(1)	(2)	(3)	(4)	(5)	(6)
Boy Winner	0.045	0.045	0.044	-0.009	-0.010	-0.013
	(0.015)***	(0.016)***	(0.015)***	(0.014)	(0.015)	(0.015)
Girl Winner	0.010	-0.008	0.008	0.009	0.007	0.006
	(0.021)	(0.022)	(0.022)	(0.019)	(0.021)	(0.020)
Observations	38,585	34,026	37,094	47,117	42,349	45,417
	Panel B: Enrollment in an Academic University					
	(1)	(2)	(3)	(4)	(5)	(6)
Boy Winner	0.015	0.017	0.014	-0.005	-0.009	-0.006
	(0.007)**	(0.007)**	(0.007)*	(0.006)	(0.006)	(0.006)
Girl Winner	-0.001	0.002	-0.002	0.015	0.016	0.015
	(0.009)	(0.010)	(0.010)	(0.009)*	(0.010)	(0.009)
Observations	33,504	29,184	32,115	39,926	35,473	38,363
Controls	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Track FE	✓	✓	✓	✓	✓	✓
School FE	✓	✓	✓	✓	✓	✓

Notes: Each column corresponds to estimation results that come from a different regression. The table reports estimated coefficients of having one or multiple boy or girl winners in the school cohort on student standardized national exam score. We focus on schools that have at least one winner in at least one school cohort. We also drop top performers from school cohorts that do not have a winner from all specifications. Controls include student age (in years), student baseline performance in mathematics, and classroom-level controls (average age, class size, and share of female classmates). Standard errors clustered at the school by cohort level are reported in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table A.3: Sample Representativeness Check

Variable	Sample with Winners (69 Schools) (1)	Remaining Schools with Winners (555 Schools) (2)	Difference S.E. (3)
Share of Female Students (%)	0.559	0.553	0.005
	0.077	0.092	0.012
P-value			0.641
Average Student Age	18.043	18.051	-0.008
	0.059	0.156	0.019
P-value			0.687
University Admission Score	14303.399	14339.793	-36.393
	890.415	1280.847	158.815
P-value			0.819
National Exam Score	13.191	13.219	-0.028
	1.164	1.631	0.203
P-value			0.891
District Unemployment	14.592	13.966	0.627
	3.211	3.764	0.473
P-value			0.186
Classics	0.396	0.408	-0.012
	0.056	0.104	0.013
P-value			0.339
Science	0.144	0.143	0.001
	0.053	0.072	0.009
P-value			0.878
Exact Science	0.460	0.449	0.011
	0.062	0.094	0.012
P-value			0.353

Notes: We compare schools with winners from Ministry of Education data with schools with winners from the school sample to check the representativeness of our sample. We use years 2008, 2009, and 2010, as in the main analysis. This table examines the representativeness of the sampled schools with winners compared with the remaining schools with winners in the country. We compare our sample and population of winners in terms of students' characteristics (such as gender, age, being born in 1st quarter of calendar year, track choices); income level; and urban locality at school level. Column (1) presents the means and standard deviation of variables in our study sample (69 schools), column (2) the means and standard deviation of variables in the remaining schools in Greece (containing 1,150 schools). Column (3) presents the differences between the sample and population mean, the standard error of the difference, and p-values.

Table A.4: Impact of Award Winners on Schoolmates' Rank of Enrolled University Degree

	Rank of Enrolled University Degree					
	Boys			Girls		
	(1)	(2)	(3)	(4)	(5)	(6)
Any Winner	0.935			-0.391		
	(1.021)			(0.943)		
Boy Winner		2.295	2.356		1.357	1.516
		(1.029)**	(1.036)**		(0.964)	(0.955)
Girl Winner		-2.417	-2.336		-2.802	-2.635
		(1.144)**	(1.188)*		(1.243)**	(1.222)**
Observations	4,402	4,402	4,351	5,526	5,526	5,479
Controls	✓	✓	✓	✓	✓	✓
Track FE	✓	✓	✓	✓	✓	✓
School FE	✓	✓	✓	✓	✓	✓
Exclude Top-Performers			✓			✓

Notes: Each column corresponds to estimation results that come from a different regression. The table reports estimated coefficients of having a winner of any gender, a boy winner, or a girl winner in the school cohort (compared with other school-cohorts) on the percentile rank of the enrolled university degree. This variable is calculated for students who enroll in a university degree. The rank of the enrolled university degree varies from 0 to 100, with greater values indicating more selective university degrees. The percentile rank of the enrolled university degree is a quality measure for each postsecondary program and is measured in the following way: We use the mean performance of enrolled students in each postsecondary program. The difference between columns (2) and (3), and (5) and (6) is that we drop top performers from school cohorts that do not have a winner. Controls include student age (in years), a student's overall performance in the previous grade, and classroom-level controls (average age, class size, and share of female classmates). Standard errors clustered at the school level are reported in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table A.5: Balancing Exercise for the Presence of an Award Winner at the Classroom Level

	Boys			Girls		
	Panel A: Winner of Any Gender					
	(1)	(2)	(3)	(4)	(5)	(6)
GPA Grade 11	0.002			0.009		
	(0.005)			(0.004)**		
Student Age (in Years)		-0.052			-0.052	
		(0.065)			(0.039)	
Baseline Math Performance			0.017			0.037
			(0.013)			(0.011)***
Observations	1,579	1,675	1,579	2,037	2,151	2,040
	Panel B: Boy Winner					
	(1)	(2)	(3)	(4)	(5)	(6)
GPA Grade 11	0.002			0.004		
	(0.004)			(0.004)		
Student Age (in Years)		0.046			-0.003	
		(0.065)			(0.036)	
Baseline Math Performance			0.009			0.019
			(0.012)			(0.010)*
Observations	1,579	1,675	1,579	2,037	2,151	2,040
	Panel C: Girl Winner					
	(1)	(2)	(3)	(4)	(5)	(6)
GPA Grade 11	-0.003			0.003		
	(0.003)			(0.002)		
Student Age (in Years)		-0.046			-0.027	
		(0.022)**			(0.023)	
Baseline Math Performance			-0.010			0.007
			(0.006)			(0.006)
Observations	1,579	1,675	1,579	2,037	2,151	2,040
Track FE	✓	✓	✓	✓	✓	✓
School-by-Year FE	✓	✓	✓	✓	✓	✓

Notes: Each column corresponds to estimation results that come from a different regression. The table reports the estimated coefficients of student characteristics on the likelihood of having an award winner of any gender, a boy winner, or a girl winner in the classroom. Standard errors clustered at the classroom level are reported in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Online Appendix:

Example of the *Thales* Competition Mathematics Exam in Greek and English for Grade 12 Students

ΕΛΛΗΝΙΚΗ ΜΑΘΗΜΑΤΙΚΗ ΕΤΑΙΡΕΙΑ
Πανεπιστημίου (Ελευθερίου Βενιζέλου) 34
106 79 ΑΘΗΝΑ
Τηλ. 3616532 - 3617784 - Fax: 3641025
e-mail : info@hms.gr, Ιστοσελίδα: www.hms.gr

GREEK MATHEMATICAL SOCIETY
34, Panepistimiou (Eleftheriou Venizelou) Street
GR. 106 79 - Athens - HELLAS
Tel. 3616532 - 3617784 - Fax: 3641025
e-mail : info@hms.gr Site: www.hms.gr

ΕΠΙΤΡΟΠΗ ΔΙΑΓΩΝΙΣΜΩΝ
72ος ΠΑΝΕΛΛΗΝΙΟΣ ΜΑΘΗΤΙΚΟΣ ΔΙΑΓΩΝΙΣΜΟΣ ΣΤΑ ΜΑΘΗΜΑΤΙΚΑ
"Ο ΘΑΛΗΣ"
ΣΑΒΒΑΤΟ, 19 ΝΟΕΜΒΡΙΟΥ 2011

ΟΔΗΓΙΕΣ ΠΡΟΣ ΤΟΥΣ ΠΡΟΕΔΡΟΥΣ ΤΩΝ ΤΟΠΙΚΩΝ ΝΟΜΑΡΧΙΑΚΩΝ ΕΠΙΤΡΟΠΩΝ, ΠΡΟΕΔΡΟΥΣ ΕΞΕΤΑΣΤΙΚΩΝ ΚΕΝΤΡΩΝ ΚΑΙ ΕΠΙΤΗΡΗΤΕΣ

1. Παρακαλούμε να διαβάσετε προσεκτικά τις οδηγίες στους μαθητές.
2. Οι επιτηρητές των αιθουσών θα διανείμουν πρώτα κόλλες αναφοράς, στις οποίες οι μαθητές θα πρέπει απαραίτητα να γράψουν ***ΕΠΩΝΥΜΟ, ΟΝΟΜΑ, ΣΧΟΛΕΙΟ, ΤΑΞΗ, ΔΙΕΥΘΥΝΣΗ ΚΑΤΟΙΚΙΑΣ και ΤΗΛΕΦΩΝΟ,*** τα οποία θα **ελεγχθούν σε αντιπαραβολή με την ταυτότητα** που θα έχουν οι εξεταζόμενοι, πριν καλυφθούν και μετά θα γίνει **η υπαγόρευση ή διανομή φωτοτυπιών** των θεμάτων στους μαθητές.
3. **Να φωτοτυπηθεί και να μοιραστεί σε όλους τους μαθητές η επιστολή που σας αποστέλλουμε μαζί με τα θέματα.**
4. Η εξέταση πρέπει να διαρκέσει ακριβώς τρεις (3) ώρες από τη στιγμή που θα γίνει η εκφώνηση των θεμάτων (9-12 περίπου). Δε θα επιτρέπεται σε κανένα μαθητή ν' αποχωρήσει πριν παρέλθει μία ώρα από την έναρξη της εξέτασης.
5. Οι επιτηρητές των αιθουσών έχουν το δικαίωμα ν' ακυρώσουν τη συμμετοχή μαθητών, αν αποδειχθεί ότι αυτοί έχουν χρησιμοποιήσει αθέμιτα μέσα, σημειώνοντας τούτο στις κόλλες των μαθητών. Η επιτροπή Διαγωνισμών της Ε.Μ.Ε. έχει δικαίωμα να επανεξετάσει μαθητή αν έχει λόγους να υποπτεύεται ότι το γραπτό του είναι αποτέλεσμα χρήσης αθέμιτου μέσου.
6. Υπολογιστές οποιουδήποτε τύπου καθώς και η χρήση κινητών απαγορεύονται.
7. Αμέσως μετά το πέρας της εξέτασης, οι κόλλες των μαθητών πρέπει να σφραγιστούν εντός φακέλου ή φακέλων, που θα έχουν την υπογραφή του υπεύθυνου του εξεταστικού κέντρου και ν' αποσταλούν στην **Επιτροπή Διαγωνισμών της Ε.Μ.Ε., Πανεπιστημίου 34, 106 79 Αθήνα,** αφού πρώτα στα παραρτήματα , εφόσον είναι εφικτό, γίνει μία πρώτη βαθμολόγηση, σύμφωνα με το σχέδιο βαθμολόγησης της επιτροπής διαγωνισμών.
8. Τα αποτελέσματα του διαγωνισμού θα σταλούν στους Προέδρους των Τοπικών Νομαρχιακών Επιτροπών (ΤΝΕ) και τα Παραρτήματα της Ε.Μ.Ε.
9. **Ο «ΕΥΚΛΕΙΔΗΣ»** θα διενεργηθεί στις **21 Ιανουαρίου 2012** και η Εθνική Ολυμπιάδα Μαθηματικών **«ΑΡΧΙΜΗΔΗΣ»** θα γίνει στις **3 Μαρτίου 2012** στην Αθήνα. Από τους διαγωνισμούς αυτούς και επί πλέον από ένα τελικό διαγωνισμό στην Ε.Μ.Ε. και μια προφορική εξέταση με προκαθορισμένη διαδικασία θα επιλεγεί η εθνική ομάδα, που θα συμμετάσχει στην **29η Βαλκανική Μαθηματική Ολυμπιάδα (Τουρκία, Μάιος 2012)**, στην **16η Βαλκανική Μαθηματική Ολυμπιάδα Νέων (Ιούνιος 2012)** και στην **53η Διεθνή Μαθηματική Ολυμπιάδα (Αργεντινή, Ιούλιος 2012).**
10. Με την ευκαιρία αυτή, το Δ.Σ. της Ε.Μ.Ε. ευχαριστεί όλους τους συναδέλφους που συμβάλλουν με την εθελοντική τους συμμετοχή στην επιτυχία των Πανελλήνιων Μαθητικών Διαγωνισμών της Ελληνικής Μαθηματικής Εταιρείας.
11. **Παρακαλούμε τον Πρόεδρο της ΤΝΕ να αναπαράγει με τα ονόματα των επιτηρητών την ευχαριστήρια επιστολή του Δ.Σ. της Ελληνικής Μαθηματικής Εταιρείας και να την παραδώσει στους επιτηρητές.**

Για το Διοικητικό Συμβούλιο
της Ελληνικής Μαθηματικής Εταιρείας

Ο Πρόεδρος	Ο Γενικός Γραμματέας
Γρηγόριος Καλογερόπουλος	Εμμανουήλ Κρητικός
Καθηγητής Πανεπιστημίου Αθηνών	Λέκτορας Οικονομικού Πανεπιστημίου Αθηνών

ΕΛΛΗΝΙΚΗ ΜΑΘΗΜΑΤΙΚΗ ΕΤΑΙΡΕΙΑ
Πανεπιστημίου (Ελευθερίου Βενιζέλου) 34
106 79 ΑΘΗΝΑ
Τηλ. 3616532 - 3617784 - Fax: 3641025
e-mail : info@hms.gr
www.hms.gr

GREEK MATHEMATICAL SOCIETY
34, Panepistimiou (Eleftheriou Venizelou) Street
GR. 106 79 - Athens - HELLAS
Tel. 3616532 - 3617784 - Fax: 3641025
e-mail : info@hms.gr
www.hms.gr

ΕΠΙΤΡΟΠΗ ΔΙΑΓΩΝΙΣΜΩΝ
72^{ος} ΠΑΝΕΛΛΗΝΙΟΣ ΜΑΘΗΤΙΚΟΣ ΔΙΑΓΩΝΙΣΜΟΣ
ΣΤΑ ΜΑΘΗΜΑΤΙΚΑ
“Ο ΘΑΛΗΣ”
19 Νοεμβρίου 2011

Γ΄ ΛΥΚΕΙΟΥ

Πρόβλημα 1
Να λυθεί στους πραγματικούς αριθμούς η εξίσωση
$$\left(x^2+3x+2\right)^4+\left(x^2+x-2\right)^4=16\left(x+2\right)^4.$$
Πρόβλημα 2
Να προσδιορίσετε την τιμή της παραμέτρου $\alpha\in\mathbb{R}$,, αν το σύστημα
$$\left\{\alpha\left(x^2+y^2\right)+2x+y=\lambda,\qquad 2x-y=-\lambda\right\}\qquad(\Sigma)$$
έχει λύση στο $\mathbb{R}$, για κάθε τιμή της παραμέτρου $\lambda\in\mathbb{R}$.

Πρόβλημα 3
Η ακολουθία $a_n, n=0,1,2,\ldots$ είναι τέτοια ώστε η ακολουθία $d_n=a_n-a_{n-1}$, με $n=1,2,.3,\ldots$. είναι αριθμητική πρόοδος με διαφορά $\omega=a_1-a_0$.

1. Να προσδιορίσετε, συναρτήσει των a_0,ω και n τον γενικό όρο a_n και το άθροισμα $S_{n+1}=a_0+a_1+\cdots+a_n$.
2. Αν είναι $a_0=1$ και $a_1=7$, να προσδιορίσετε τον ελάχιστο θετικό ακέραιο n για τον οποίο συναληθεύουν οι ανισώσεις: $a_n>10^3$ και $S_{n+1}\le 8\cdot 10^3$.

Πρόβλημα 4
Δίνεται οξυγώνιο σκαληνό τρίγωνο ΑΒΓ με $\mathrm{AB}<\mathrm{A\Gamma}<\mathrm{B\Gamma}$, εγγεγραμμένο σε κύκλο (c) και Δ τυχόν σημείο της πλευράς ΒΓ . Η διχοτόμος της γωνίας $\hat{\mathrm{B}}$, τέμνει τον κύκλο (c) στο σημείο Σ, τη διχοτόμο της γωνίας $\mathrm{A}\hat{\Delta}\mathrm{B}$ στο σημείο Κ και τη διχοτόμο της γωνίας $\mathrm{A}\hat{\Delta}\Gamma$ στο σημείο Μ. Η διχοτόμος της γωνίας $\hat{\Gamma}$, τέμνει τον κύκλο (c) στο σημείο Τ, τη διχοτόμο της γωνίας $\mathrm{A}\hat{\Delta}\Gamma$ στο σημείο Λ και τη διχοτόμο της γωνίας $\mathrm{A}\hat{\Delta}\mathrm{B}$ στο σημείο Ν. Να αποδείξετε ότι:

α) Τα σημεία $\mathrm{A},\mathrm{I},\Lambda,\mathrm{M}$ και $\mathrm{A},\mathrm{I},\mathrm{K},\mathrm{N}$, όπου Ι το έκκεντρο του τριγώνου ΑΒΓ, είναι ομοκυκλικά σε δύο διαφορετικούς κύκλους, έστω (c_1) και (c_2), αντίστοιχα.

β) Αν η ΑΔ ταυτιστεί με το ύψος του τριγώνου ΑΒΓ που αντιστοιχεί στη κορυφή Α, τότε οι κύκλοι (c_1) και (c_2) είναι ίσοι μεταξύ τους.

Κάθε θέμα βαθμολογείται με 5 μονάδες
Διάρκεια διαγωνισμού: 3 ώρες ***Καλή επιτυχία!***

ΕΛΛΗΝΙΚΗ ΜΑΘΗΜΑΤΙΚΗ ΕΤΑΙΡΕΙΑ
Πανεπιστημίου (Ελευθερίου Βενιζέλου) 34
106 79 ΑΘΗΝΑ
Τηλ. 3616532 - 3617784 - Fax: 3641025
e-mail : info@hms.gr
www.hms.gr

GREEK MATHEMATICAL SOCIETY
34, Panepistimiou (Eleftheriou Venizelou) Street
GR. 106 79 - Athens - HELLAS
Tel. 3616532 - 3617784 - Fax: 3641025
e-mail : info@hms.gr
www.hms.gr

GREEK MATHEMATICAL SOCIETY
72nd National Student Mathematics Competition – "Thales"
Saturday, November 19, 2011

INSTRUCTIONS FOR THE HEADS OF LOCAL COMMITTEES, EXAM CENTER SUPERVISORS, AND INVIGILATORS

1. Please read the instructions to the students carefully.
2. Invigilators must first distribute the cover sheets where students must fill in: **Surname, First Name, School, Grade, Home Address, and Telephone Number.** These details must be **verified against their ID before being covered**. Only then may the exam questions be **dictated or distributed** as photocopies.
3. **The instructions sent with the exam materials should be photocopied and distributed to all students.**
4. The exam must last exactly three (3) hours from the time the questions are read aloud (approximately 9:00–12:00). No student is allowed to leave before one hour has passed since the start of the exam.
5. Invigilators have the right to disqualify students found using unfair means. This should be noted on the student's answer sheet. The Competition Committee of the Greek Mathematical Society (GMS) has the right to re-evaluate a student's paper if there are suspicions of unfair practices.
6. The use of calculators and mobile phones is strictly prohibited.
7. Immediately after the end of the exam, all student answer sheets must be sealed in envelopes signed by the exam centre supervisor and sent to the **GMS Competition Committee** (34 Panepistimiou Street, Athens, GR-10679). If possible, a preliminary grading may be done at local branches based on the grading scheme provided by the Committee.
8. The competition results will be sent to the Presidents of the Local Committees and to the branches of the GMS.
9. The **"Euclides"** competition will take place on **January 21**, **2012**, and the National Mathematics Olympiad "**Archimedes**" will be held on **March 3**, **2012**, in Athens. From these competitions, along with a final selection and oral exam conducted by GMS, the national team will be selected for the **29th Balkan Mathematical Olympiad (Turkey, May 2012), the 16th Junior Balkan Mathematical Olympiad (June 2012), and the 53rd International Mathematical Olympiad (Argentina, July 2012).**
10. The GMS Board of Directors extends its gratitude to all colleagues who voluntarily contribute to the success of the National Student Competitions.
11. **The President of each Local Committee is asked to reproduce and distribute the thank-you letter from the GMS Board to all invigilators.**

On behalf of the Board of Directors of the Greek Mathematical Society,
President: Grigorios Kalogeropoulos, Professor, University of Athens
General Secretary: Emmanouil Kritikos, Lecturer, Athens University of Economics and Business

ΕΛΛΗΝΙΚΗ ΜΑΘΗΜΑΤΙΚΗ ΕΤΑΙΡΕΙΑ
Πανεπιστημίου (Ελευθερίου Βενιζέλου) 34
106 79 ΑΘΗΝΑ
Τηλ. 3616532 - 3617784 - Fax: 3641025
e-mail : info@hms.gr
www.hms.gr

GREEK MATHEMATICAL SOCIETY
34, Panepistimiou (Eleftheriou Venizelou) Street
GR. 106 79 - Athens - HELLAS
Tel. 3616532 - 3617784 - Fax: 3641025
e-mail : info@hms.gr
www.hms.gr

GREEK MATHEMATICAL SOCIETY
72nd National Student Mathematics Competition – "Thales"
Saturday, November 19, 2011

GRADE 12 – FINAL YEAR OF HIGH SCHOOL

Problem 1:
Solve the equation in the set of real numbers:

$$\left(x^2+3x+2\right)^4+\left(x^2+x-2\right)^4=16\left(x+2\right)^4.$$

Problem 2:
Determine the value of the parameter $\alpha \in R$. such that the system:

$$\left\{\alpha\left(x^2+y^2\right)+2x+y=\lambda, \qquad 2x-y=-\lambda\right\} \qquad (\Sigma)$$

has a solution in R, for every value of $\lambda \in R$.

Problem 3:
The sequence α_n, for n= 0, 1, 2,… is such that the sequence $d_n= \alpha_n - \alpha_{n-1}$, for n=1, 2, 3,… is an arithmetic progression with common difference $\omega= \alpha_1 - \alpha_0$.

1. Express the general term α_n, and the sum $S_{n+1}= \alpha_0+ \alpha_1+\cdots+ \alpha_n$ in terms of α_0, ω, and n
2. If $\alpha_0 = 1$ and $\alpha_1 = 7$, determine the smallest positive integer n for which the following inequalities both hold:

$$a_n > 10^3 \text{ και } S_{n+1} \leq 8\cdot 10^3$$

Problem 4:

Let an acute, scalene triangle ABC with AB < ΑΓ < ΒΓ, inscribed in a circle (c), and a point D taken arbitrarily on side ΒΓ. The bisector of angle ∠B intersects the circle (c) at point Σ, the bisector of angle ∠ΑΔΒ at point K, and the bisector of angle ∠ΑΔΓ at point M. The bisector of angle ∠Γ intersects the circle (c) at point T, the bisector of angle ∠ΑΔΓ at point Λ, and the bisector of angle ∠ΑΔΒ at point N.

Prove that:

ΕΛΛΗΝΙΚΗ ΜΑΘΗΜΑΤΙΚΗ ΕΤΑΙΡΕΙΑ
Πανεπιστημίου (Ελευθερίου Βενιζέλου) 34
106 79 ΑΘΗΝΑ
Τηλ. 3616532 - 3617784 - Fax: 3641025
e-mail : info@hms.gr
www.hms.gr

GREEK MATHEMATICAL SOCIETY
34, Panepistimiou (Eleftheriou Venizelou) Street
GR. 106 79 - Athens - HELLAS
Tel. 3616532 - 3617784 - Fax: 3641025
e-mail : info@hms.gr
www.hms.gr

a) The points A, I, L, M and A, I, K, N, where I is the excenter of triangle ABC, lie on two distinct circles, denoted (c_1) and (c_2) respectively.

b) If AD coincides with the altitude from vertex A of triangle ABC, then the circles (c_1) and (c_2) are congruent.

Each problem is graded out of 5 points.
Exam duration: 3 hours

Good luck!