Identifying and cultivating mathematical giftedness through competitive Mathematics: evidence from European participation trends

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ABSTRACT
This study addresses the gap in longitudinal, cross-national research on European mathematics competitions as pedagogical contexts for identifying and fostering diverse mathematical giftedness. Focusing on Bebras, Kangourou, the Henri Poincaré Mathematical Thinking Contest, and the European Statistics Competition, it examines how these competitions nurture creativity, flexible reasoning, and advanced problem-solving beyond standard curricula. Drawing on participation data from 1995 to 2025, the study employs quantitative, descriptive, and comparative analyses to explore student population growth patterns and pedagogical characteristics. Findings demonstrate that these competitions serve as valuable ecosystems for recognizing high-ability learners and cultivating creative, non-formalist mathematical thinking across Europe.

KEYWORDS
Competitive Mathematics, mathematical giftedness, creative problem solving, European participation trends

RÉSUMÉ
Cette étude comble le manque de recherches longitudinales et transnationales sur les concours de mathématiques européens en tant que contextes pédagogiques pour l'identification et le développement des talents mathématiques divers. En se concentrant sur Bebras, Kangourou, le Concours de Pensée Mathématique Henri Poincaré et le Concours Européen de Statistique, elle examine comment ces concours favorisent la créativité, le raisonnement flexible et la résolution de problèmes avancée au-delà des programmes scolaires standards. S'appuyant sur les données de participation de 1995 à 2025, l'étude utilise des analyses quantitatives, descriptives et comparatives pour explorer les tendances de croissance de la population étudiante et les caractéristiques pédagogiques. Les résultats montrent que ces concours constituent des écosystèmes précieux pour reconnaître les élèves à haut potentiel et cultiver une pensée mathématique créative et non formaliste à travers l'Europe.

MOTS-CLÉS
Concours de Mathématiques compétitives, talent mathématique, résolution créative de problèmes, tendances de participation en Europe

INTRODUCTION

Mathematical giftedness is usually considered a distinct form of giftedness, differentiated from general giftedness (Leikin, 2014). More broadly, giftedness has been described as the manifestation of exceptional domain-specific abilities that emerge through the interaction of cognitive potential, creativity, and sustained engagement with a field of interest (Winner, 2000). Beyond this, mathematical giftedness is not limited to high intelligence or the ability to memorize mathematical formulas. Instead, it includes a combination of natural, cognitive, creative, and mathematical abilities. Mathematically gifted students are distinguished by their flexibility, fluency, and originality in problem solving. Modern approaches emphasize that mathematical giftedness is multidimensional, incorporating both specific mathematical abilities and creativity, as well as natural cognitive abilities such as fluid intelligence and working memory (Pitta-Pantazi et al., 2011). Moreover, studies demonstrate that genuine originality in mathematical thinking transcends routine practice and conventional measures of school academic performance (Gridos et al., 2021; Leikin, 2009).

Competitive Mathematics represents a contemporary branch of mathematics that has expanded significantly in recent decades and lies beyond conventional school performance. It focuses on solving original, demanding, and often non-standard problems under strict time constraints within mathematical competitions. In 1969, Hans Freudenthal, then President of the International Commission on Mathematical Instruction (ICMI), published an article on mathematical competitions. Among the issue was the educational value of competitions. Freudenthal observed that while prize winners often become capable mathematicians, not all gifted students perform well in competitive settings, emphasizing appreciation of mathematical beauty over rivalry (Freudenthal, 1969). Although these insights date back to 1969, several decades later the perceived benefits of mathematical competitions have significantly evolved. These competitions aim to foster advanced mathematical thinking, creativity, analytical reasoning, and inventiveness outside the formal curriculum. Participation further enhances interest in mathematical giftedness by providing authentic contexts where complex abilities and creative potential are meaningfully demonstrated (Sujatha et al., 2023).

The purpose of this study is to investigate European mathematics competitions as longitudinal, cross-national pedagogical ecosystems for identifying and developing mathematical giftedness. By analyzing participation trends and competition characteristics from 1995 to 2025, the study examines how such initiatives foster creativity, flexible reasoning, and advanced problem-solving beyond formal curricula across Europe.

THEORETICAL FRAMEWORK

Aligned with the aims of this study, mathematical giftedness has received increasing scholarly and educational attention, particularly through students' participation in national and international mathematical competitions. Across countries, diverse forms of competitions are organized, often independently of national committees, and their formats cannot be easily classified as inclusive or exclusive. Each design serves specific educational purposes, supporting the identification, nurturing, and development of students' mathematical thinking (Falk de Losada & Taylor, 2022). These competitions function as longitudinal and cross-

national pedagogical ecosystems that both recognize and cultivate advanced mathematical abilities. Moreover, they operate as socio-cultural mechanisms that promote creativity, flexible reasoning, and high-level problem-solving beyond formal curricula. Empirical research further associates sustained participation with improved mathematical achievement, critical thinking, and problem-solving performance (Andreescu et al., 2008; Sujatha et al., 2023).

Competitions as contexts for giftedness identification

According to Andreescu et al. (2008), international and national mathematical competitions offer distinctive contexts for identifying students with exceptional abilities in solving complex problems. Evidence from such competitions indicates that top performers demonstrate skills "at the level of one in a million," seldom captured by conventional school assessments or intelligence measures. Consequently, mathematical competitions play a crucial role in stimulating interest in mathematics and in shaping conceptions and identification of mathematical giftedness (Pitta-Pantazi et al., 2011).

Cultural and social dimensions of interest

Studies emphasizes that increased participation reflects broader societal endorsement of mathematical excellence and gifted education (Subotnik et al., 2011). Large-scale international reports document sustained growth in competition-based enrichment initiatives across Europe and North America (OECD, 2019). Within this framework, the present study explores rising student involvement in European mathematical competitions as an recognition of high mathematical ability.

Contemporary approach to mathematical giftedness

Current perspectives on mathematical giftedness emphasize multidimensionality, integrating creativity with cognitive ability (Kontoyianni et al., 2013). Giftedness is conceptualized not only as logical processing or correctness but also as the capacity for original, flexible, and innovative problem solving. Participation in mathematical competitions fosters the creative dimension, encouraging multiple strategies and imaginative reasoning (Leikin, 2009; Kontoyianni et al., 2013). Studies indicates that competition involvement enhances flexibility, originality, and persistence in tackling complex mathematical tasks (Krutetskii, 1976).

Despite rising participation in European mathematics competitions, longitudinal, cross-national research remains scarce, leaving open the question of how increasing engagement reflects and influences the development of mathematical giftedness and advanced problem-solving.

THE STUDY

In this study, four mathematics competitions, Bebras, Kangourou Sans Frontières, The Henri Poincaré Mathematical Thinking Contest, and the European Statistics Competition, were selected to represent a broad and nuanced spectrum of the discipline. Their syllabi span multiple branches, inviting students to engage with Algebra, Number Theory, Geometry, Solid Geometry, Combinatorics, Logic, Probability, Statistics, Spatial Orientation, and even Recreational Mathematics. The selection was primarily guided by the nature of the items: these competitions employ closed-ended questions that privilege critical skills over formalism and require concise, accurate responses within strict time constraints. The analysis draws on numerical data obtained from the official organising bodies of mathematics competitions. Detailed profiles of each competition follow, together with a discussion of their mathematical aims and pedagogical emphases.

To achieve the aims of the study, the following research question is examined:

How do European mathematics competitions contribute to the identification and cultivation of mathematical giftedness, and what are the longitudinal participation trends and pedagogical impacts from 1995 to 2025?

Bebras International Student Competition

The Bebras International Student Competition in Informatics and Computational Thinking aims to introduce students to Computational Thinking. The competition provides a free opportunity for students aged 8 to 17, of all backgrounds to participate, regardless of their experience with digital technology. Its questions are designed to challenge logical and analytical skills, not requiring any prior digital knowledge. Through engaging and accessible activities, Bebras encourages young learners to think critically and solve problems creatively, helping them develop essential skills for the digital age while making logical skills fun and approachable for everyone.

International Kangourou sans Frontieres Mathematics Competition

The mathematics competition originated in 1993, when eight European countries collaborated to broaden access beyond elite performers. In 1994, Kangourou Sans Frontières was founded in Paris to promote inclusive, engaging mathematics for all students, irrespective of background, inspired by a successful Australian model that lent the playful name 'Kangourou'. Kangourou Sans Frontieres' competition seeks to make mathematics approachable to a broad audience, nurturing skills such as creative problem-solving, logical reasoning, and adaptability. Through participation, students, aged 8 to 17, are encouraged to engage with mathematics from diverse perspectives, cultivating critical thinking and innovative approaches.

Henri Poincaré Mathematical Thinking Contest

The Henri Poincaré Mathematical Thinking Contest, founded in 2016, has evolved into a significant academic initiative designed specifically for mathematically gifted students. Now offered to learners aged 10 to 13 across French international schools in the European Zone, the competition exposes participants to a broad spectrum of problem types that foster deep conceptual understanding. Rather than emphasizing formal definitions or rigid classifications, the contest prioritizes mathematical reasoning based on observation, insight, and structural comprehension—key elements in identifying and nurturing high-ability learners. A central pedagogical aim of the contest is the cultivation of heuristic thinking. Students engage with tasks that require the use of logical inference, geometric pattern recognition, recursive strategies, and algorithmic reasoning. These non-standard problems encourage intuitive exploration, careful interpretation, and the confident application of prior knowledge, mirroring the cognitive processes characteristic of mathematically gifted individuals.

European Statistics Competition

The European Statistical Contest exemplifies a strategic initiative aimed at enhancing statistical literacy among youth. This competition targets students aged 13 to 17 and promotes a collaborative, team-based approach to learning. Participants are encouraged to delve into the science of statistics, covering both the methodological processes of producing official statistics and their implications across various spheres, such as economics and public policy. By fostering analytical thinking and data interpretation skills, the contest not only introduces students to the practical uses of statistics in everyday life but also seeks to identify and nurture emerging talent in the field. Through engagement in realistic projects and exposure to genuine statistical challenges, students gain valuable insights, preparing them to navigate and contribute to a data-driven society.

Data analysis

The analysis first identifies the inauguration year of each competition, situating each launch within its educational and cultural context. Initial participation figures are recorded to provide comparative insight into early recognition of mathematical giftedness. Participation in 2025 is then documented, enabling longitudinal comparison and revealing trends over three decades. This approach highlights how engagement with mathematical talent has evolved, illustrating shifts in educational priorities, the accessibility of competitions, and the recognition of mathematical ability across Europe.

RESULTS

Participation growth in the Bebras International Student Competition: Case studies from Greece and the UK

Participation in the Bebras competition has accelerated in both Greece and the United Kingdom, revealing growing institutional commitment to spotting mathematical and computational thinking through problem solving.

TABLE 1

Growth in student participation in the Bebras Competition: evidence from Greece and the UK

Country	Initial Entries	2025 Entries	Absolute Increase	Percentage Growth (%)	CAGR (% per year)
Greece	13000	28000	15000	115,4	13,8
United Kingdom	21473	467190	445717	2076	28,3

Participation in the Bebras competition has increased markedly in both Greece and the United Kingdom, reflecting growing institutional commitment to identifying mathematical and computational giftedness. In Greece, entries rose from 13,000 to 28,000, a 115.4% increase with a 13.8% CAGR, while the UK experienced a striking rise from 21,473 to 467,190 entrants, a 2,076% increase with a 28.3% CAGR. These trends indicate widespread integration of Bebras into national educational practices and heightened engagement with problem-solving initiatives.

From seed to scale: Cross national growth in Kangourou Sans Frontières Participation (1995-2025)

This research examines cross-national participation dynamics in the Kangourou Sans Frontières competition through 2025, drawing on reported start years, initial entry counts, 2025 entries, and the values presented in the “Increase” column. To achieve comparability across countries, we compute absolute and percentage growth as well as compound annual growth rates (CAGRs).

Absolute growth measures the difference between 2025 and initial entries, percentage growth reflects proportional change, and CAGR represents the geometric mean annual growth. The data reveal substantial, sustained expansion in European engagement with mathematical giftedness. Countries such as Germany, Sweden, Switzerland, Italy, and Russia show remarkable long-term increases, while even smaller systems like Cyprus and the UK exhibit steady growth, collectively indicating intensified institutional and societal commitment to nurturing mathematical talent across Europe.

TABLE 2

Kangourou participation growth by country (1995-2025)

Country / Segment	Start Year	Initial Entries	2025 Entries	Absolute Increase	Percentage Growth (%)	CAGR (% per year)
Sweden	1999	1000	100000	99000	9900	25,2
Germany	1995	184	881000	880816	478700	32,9
Finland	2004	1000	21000	20000	2000	16,6
Russia	1995	1500	250000	248500	16567	19,1
Greece	2008	3000	12000	9000	300	8,1
Switzerland	2003	1500	60000	58500	3900	20
Bulgaria	1998	10000	59000	49000	490	6,6
Italy	1997	2000	64000	62000	3100	14,8
Spain	1995	1000	27000	26000	2600	12,1
France	1995	550000	350000	-200000	-36,4	-1,5
Lithuania	2000	22849	31358	8509	37,2	1,3
Cyprus	2008	1100	5406	4306	391	9,1
UK Senior	2011	900	8104	7204	800	16,2
UK Junior	2015	4325	11905	7580	175	10,7

Revealing Advanced Thinking: consistent participation in the Henri Poincaré Mathematical Thinking Contest

The steady participation in the contest 1.500-2.000 students annually across the European Zone - demonstrates a clear need to highlight and cultivate mathematical giftedness through such thoughtfully designed educational initiatives. This sustained engagement underscores the contest's role in enriching and revealing advanced mathematical thinking.

Comparative Statistical Analysis of participation in the European Statistics Competition: Insights from Greece and Europe

Since its establishment in Greece in 2018, the European Statistics Competition has witnessed a remarkable escalation in participation, underscoring the burgeoning interest in mathematical creativity and giftedness among students. In 2018, 621 Greek students participated, but by 2025 this figure had surged to 1.265, a substantial growth of 104%. This dramatic rise clearly demonstrates an increasing enthusiasm for the field of statistics among young learners, as well as an enhanced recognition of its societal importance. The upward trend is not confined to Greece alone; it is mirrored across Europe on a much larger scale. In 2023, the competition attracted 19,388 students from various European countries. By 2025, this number had climbed to 26.924, representing an impressive increase of 7,536 participants within just two years, a growth rate of approximately 39%. This growth indicates heightened public valuation of

statistics and highlights how such initiatives, amid advances in artificial intelligence, foster expertise in data science while inspiring generations of mathematically gifted individuals.

DISCUSSION AND CONCLUSION

The findings of the present study provide strong evidence that European mathematics competitions function as sustained pedagogical ecosystems for identifying and cultivating mathematical giftedness across diverse educational contexts. The longitudinal participation data from 1995 to 2025 reveal a consistent and, in many cases, exponential increase in student engagement, suggesting a growing institutional and societal recognition of mathematical talent. These trends align with prior research indicating that mathematical competitions offer authentic environments in which advanced mathematical abilities, creativity, and flexible reasoning can emerge beyond the constraints of formal curricula (Andreescu et al., 2008; Falk de Losada & Taylor, 2022).

A key contribution of this study lies in highlighting the diversity of pedagogical orientations embedded within different competitions. Competitions such as Bebras and Kangourou emphasize accessibility and broad participation, fostering logical reasoning, creativity, and problem-solving skills among large and heterogeneous student populations. In contrast, initiatives such as the Henri Poincaré Mathematical Thinking Contest are explicitly designed to target high-ability learners, prioritizing deep conceptual understanding, heuristic reasoning, and non-formalist approaches. This differentiation supports contemporary views of mathematical giftedness as a multidimensional construct that manifests through diverse profiles rather than a single, uniform trajectory (Leikin, 2014; Pitta-Pantazi et al., 2011).

The marked growth in participation observed across multiple countries further suggests that mathematical competitions serve not only as identification mechanisms but also as motivational structures that cultivate sustained engagement with mathematics. Prior studies have shown that repeated exposure to non-routine problems enhances students' cognitive flexibility, originality, and persistence, core components of mathematical creativity (Kontoyianni et al., 2013; Leikin, 2009). The present findings reinforce this perspective by demonstrating that competition-based participation creates opportunities for students to engage in mathematical practices resembling those of professional mathematicians, such as conjecturing, generalizing, and evaluating alternative solution strategies.

From a socio-cultural perspective, the increasing scale of participation across Europe reflects broader educational shifts toward valuing creativity, data literacy, and advanced problem solving. The growth of competitions such as the European Statistics Competition is particularly indicative of emerging priorities in mathematics education, where statistical reasoning and data interpretation are increasingly recognized as essential competencies in contemporary societies (OECD, 2019). These developments echo Subotnik et al. (2011) argument that talent development should be understood as a dynamic process shaped by educational opportunities, cultural values, and sustained engagement.

Despite these insights, the study also highlights the need for further research examining the qualitative dimensions of students' experiences within competitive mathematics contexts. While participation trends provide valuable indicators of engagement and recognition, future studies should explore how different competition formats influence students' mathematical identities, creative dispositions, and long-term trajectories in mathematics. Overall, the present study underscores the pedagogical value of European mathematics competitions as powerful, evolving ecosystems that contribute meaningfully to the identification and development of mathematical giftedness across national boundaries.

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