

# Unveiling the role of maths anxiety on the interplay between beliefs, attitudes towards maths and career choice

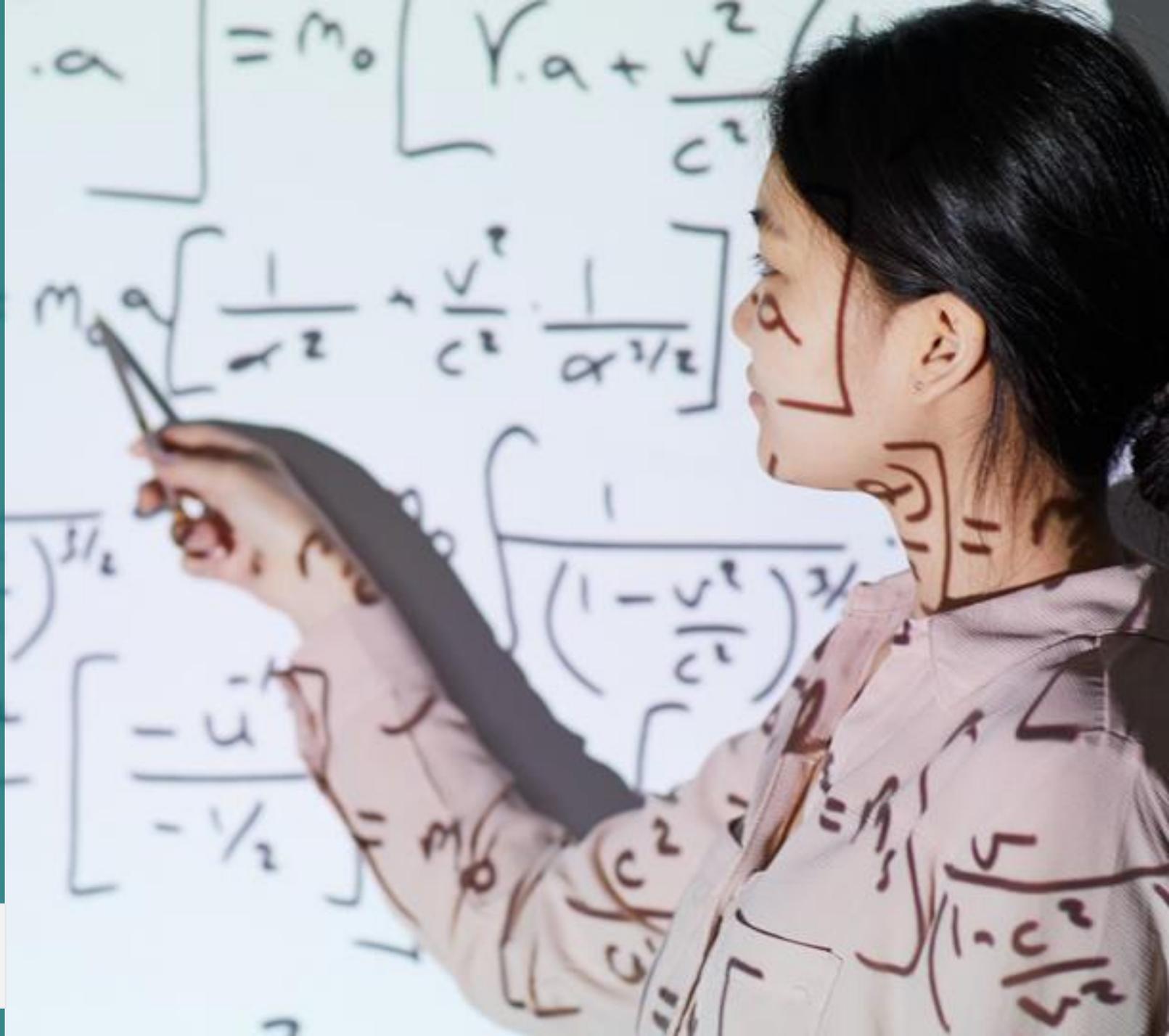
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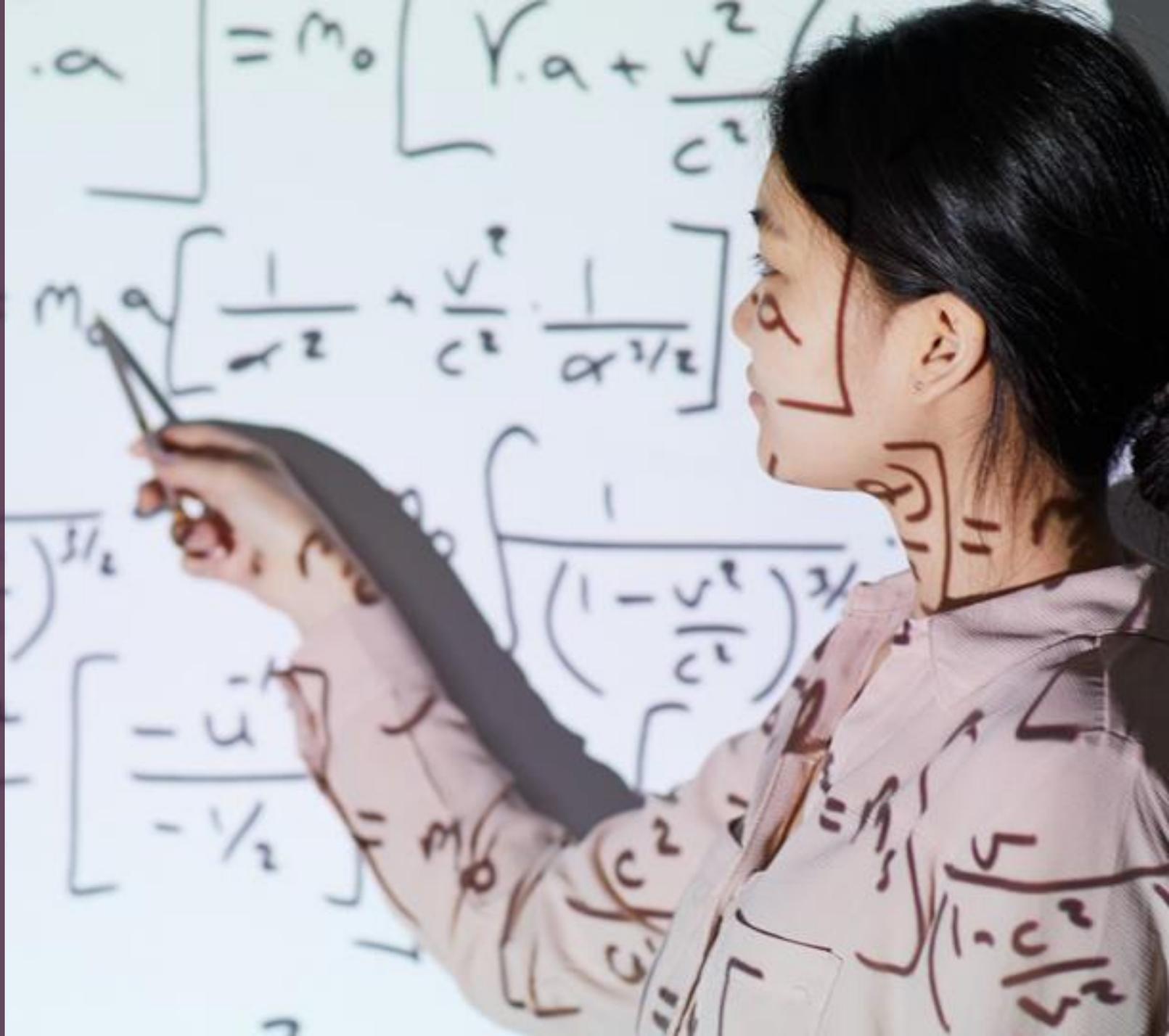
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# Unveiling the role of maths anxiety on the interplay between beliefs, attitudes towards maths and career choice

Malu Gomides, Claire Elliott, Sara Caviola, Krzysztof Cipora, Flavia H. Santos



# Outline

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- The impact of maths anxiety and low maths self-efficacy on maths performance
- Research: *the interplay between maths anxiety, attitudes towards maths and career choice*
- Insights from the  Arithmós Project

## **Policy Paper:**

**A child with maths anxiety might become a parent or a teacher with maths anxiety**



# Maths Anxiety Perspectives

- “a feeling of tension that interferes with the manipulation of numbers and the solving of maths problems in ... **ordinary life** and academic situations” (Richardson & Suinn (1972).
- a feeling of tension, apprehension, or fear towards maths, which is **weakly related** to overall intelligence (Ashcraft, 2002).
- meets all criteria of a **specific phobia** (Kucian et al 2018).

MA is not a diagnosis in ICD-11<sup>1</sup> or DSM-5<sup>2</sup>.

(1) International Classification of Diseases, (2) The Diagnostic and Statistical Manual of Mental Disorders



**Worries**

**Shaking**

**Sweating**

**Heart racing**

**Butterflies in stomach**

**Unable to focus on**

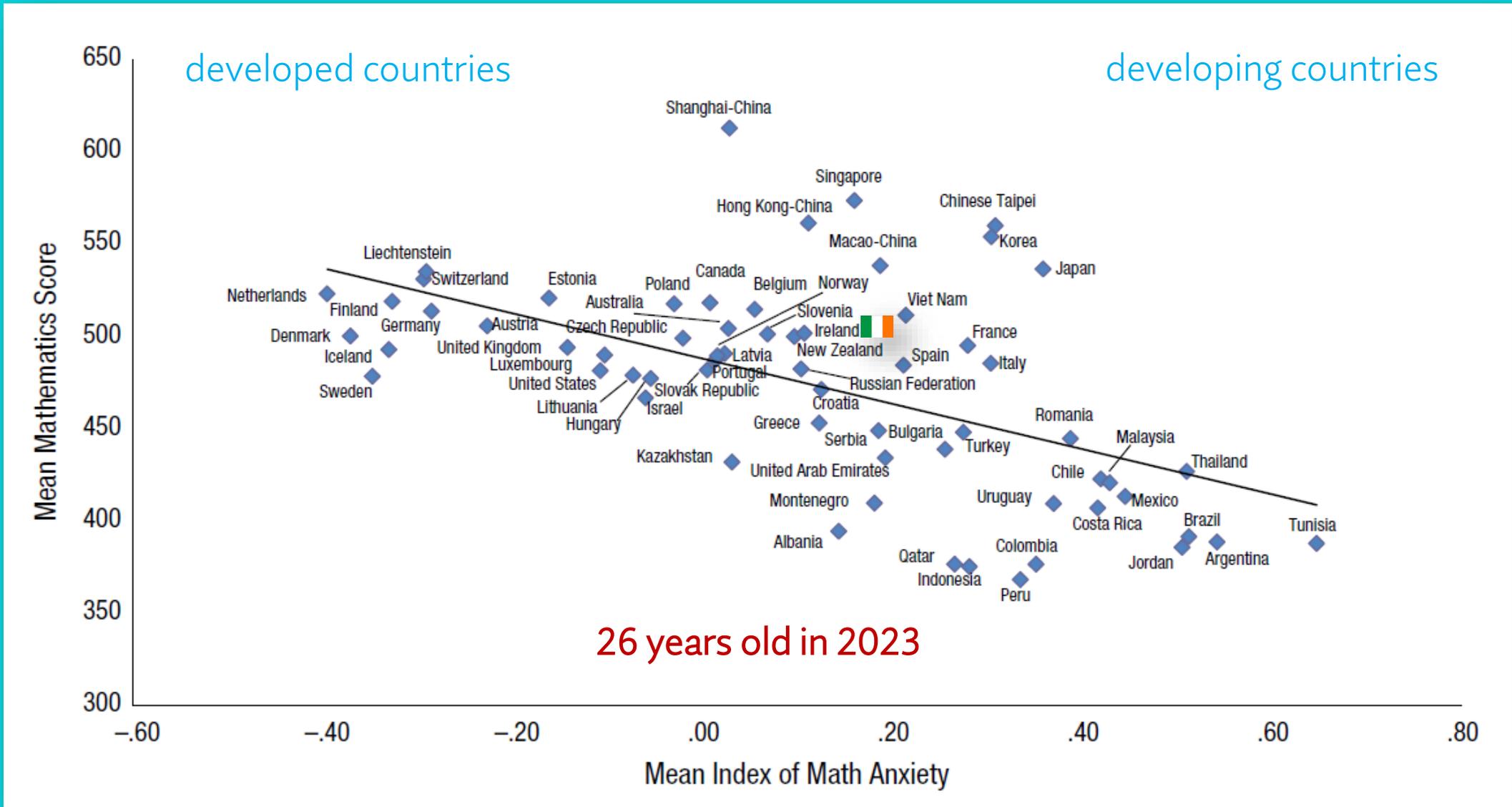
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# **The Math Anxiety-Performance Link: A Global Phenomenon**

**Alana E. Foley<sup>1</sup>, Julianne B. Herts<sup>1</sup>, Francesca Borgonovi<sup>2</sup>,  
Sonia Guerriero<sup>2</sup>, Susan C. Levine<sup>1</sup>, and Sian L. Beilock<sup>1</sup>**

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Co-operation and Development, Paris, France

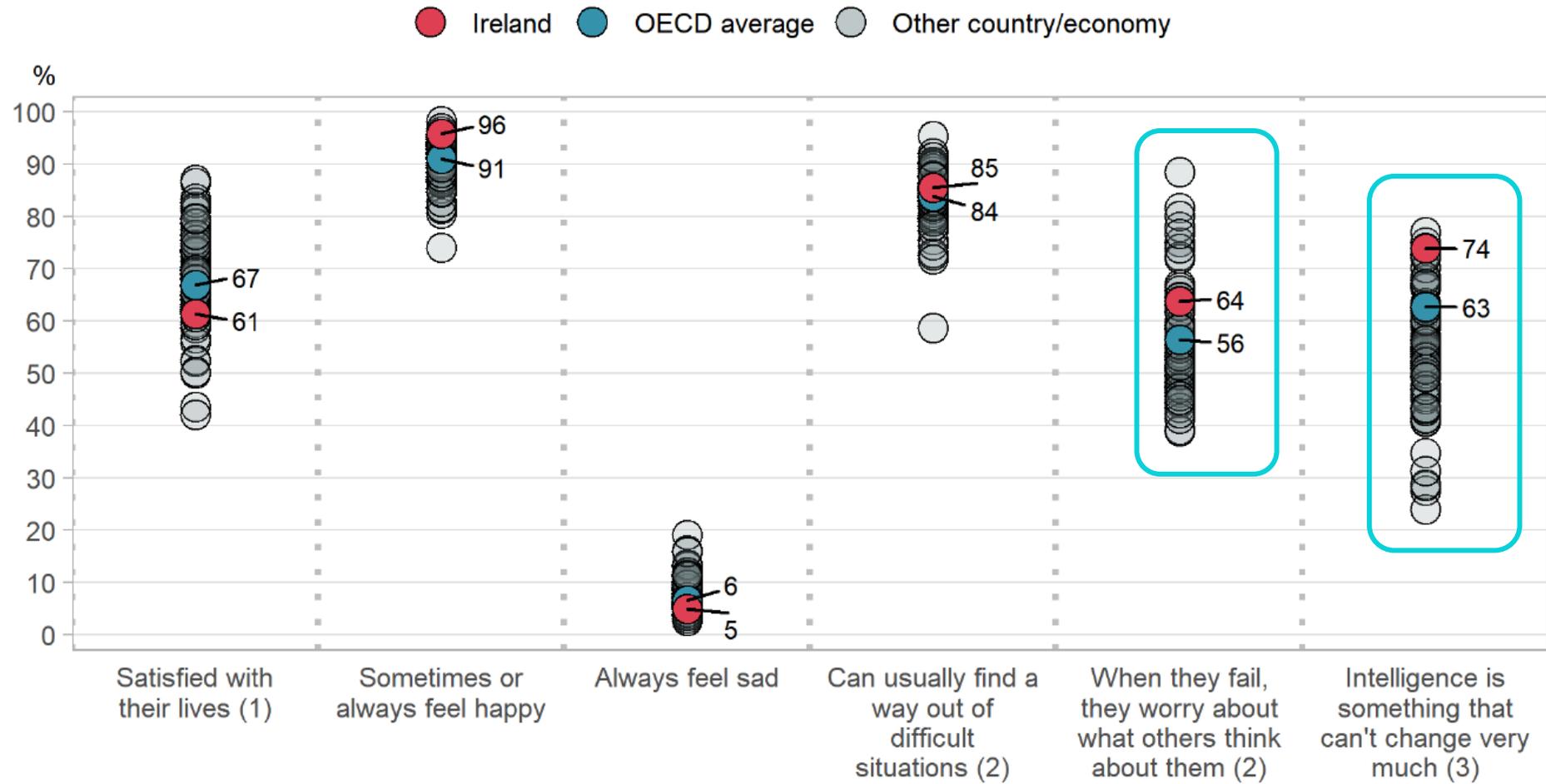
Current Directions in Psychological  
Science  
2017, Vol. 26(1) 52–58  
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[sagepub.com/journalsPermissions.nav](http://sagepub.com/journalsPermissions.nav)  
DOI: 10.1177/0963721416672463  
[www.psychologicalscience.org/CDPS](http://www.psychologicalscience.org/CDPS)  

N=63 education systems  
33% show MA

PISA 2012: math anxiety and math achievement are negatively related across the globe.

Figure 6. Student well-being and growth mindset



PISA 2018, a total of 5,577 students from 157 Irish schools.

Organisation for Economic Co-operation and Development (OECD)

## Maths Self-Efficacy

Refers to student's confidence in their ability to successfully perform a maths exercise or problem at given levels" (Hackett and Betz, 1989, p. 262; Schunk, 1991).

Bandura's Social Cognitive Theory (1986)  
Bandura's Social Learning Theory (1977)



# Maths Self-Efficacy

How confident do you feel about having to do the following mathematics tasks?

Using a train timetable to work out how long it would take to get from one place to another

Calculating how much cheaper a TV would be after a 30% discount

Calculating how many square metres of tiles you need to cover a floor

Understanding graphs presented in newspaper

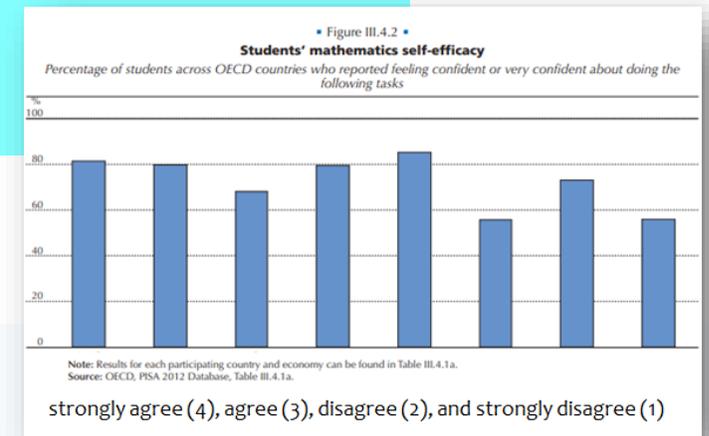
Solving an equation like  $3x + 5 = 17$

\*Finding the actual distance between two places on a map with a 1:10,000 scale

Solving an equation like  $2(x + 3) = (x + 3)(x - 3)$

\*Calculating the petrol consumption rate of a car

OECD, PISA 2012



# Maths Self-Efficacy

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- The higher the maths self-efficacy, the greater the persistence on difficult items, and the more accurate the performance on maths calculation tasks (Collins, 1982).
- Maths self-efficacy can predict maths performance to a greater extent than previous maths experiences (Pajares & Miller, 1995).

## Attitudes towards Maths

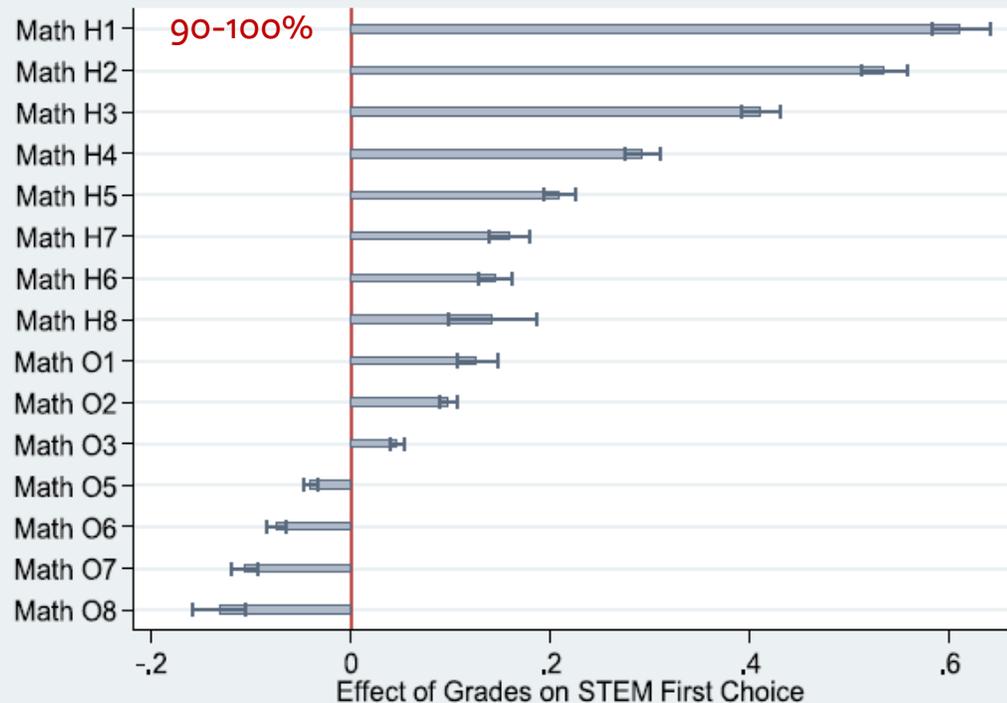
Students with high levels of maths anxiety:

- show lower levels of engagement and enjoyment in learning maths (Henschel & Roick, 2017; Wigfield & Meece, 1988),
- have lower perceptions of their own maths competence (Petersen et al., 2017),
- undervalue maths and its usefulness (Wigfield & Meece, 1988).

Maths anxiety and Self-efficacy ( $r = -0.48$ ) are different constructs (Li et al., 2021)



## The effect of English and Mathematics grade indicators on the probability of doing STEM.



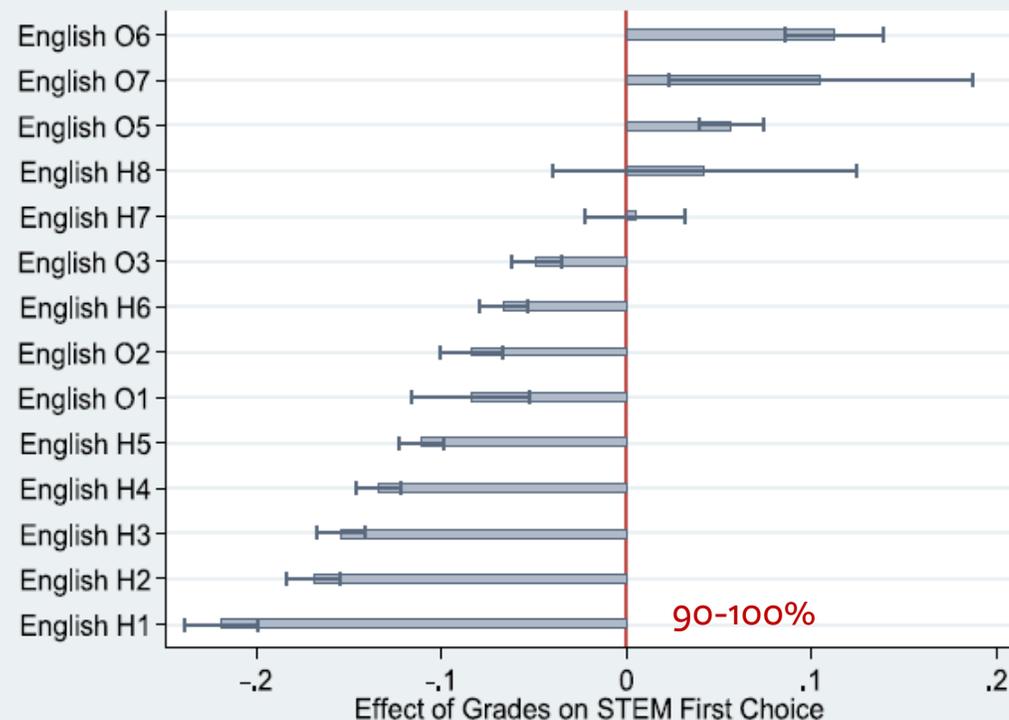
Note: Controls include LC points FE, English Grades FE and a Gender Dummy  
The reference category is obtaining Math O4 Grade

### Leaving Certificate (LC)



## Ireland

Central Admissions Office (CAO) 2015 – 2017  
83% of all persons who did the LC, 52% are girls, all > 18 years



Note: Controls include LC points FE, Math Grades FE and a Gender Dummy  
The reference category is obtaining English O4 Grade

Delaney & Devereux.

Economics of Education Review 72 (2019) 219–238

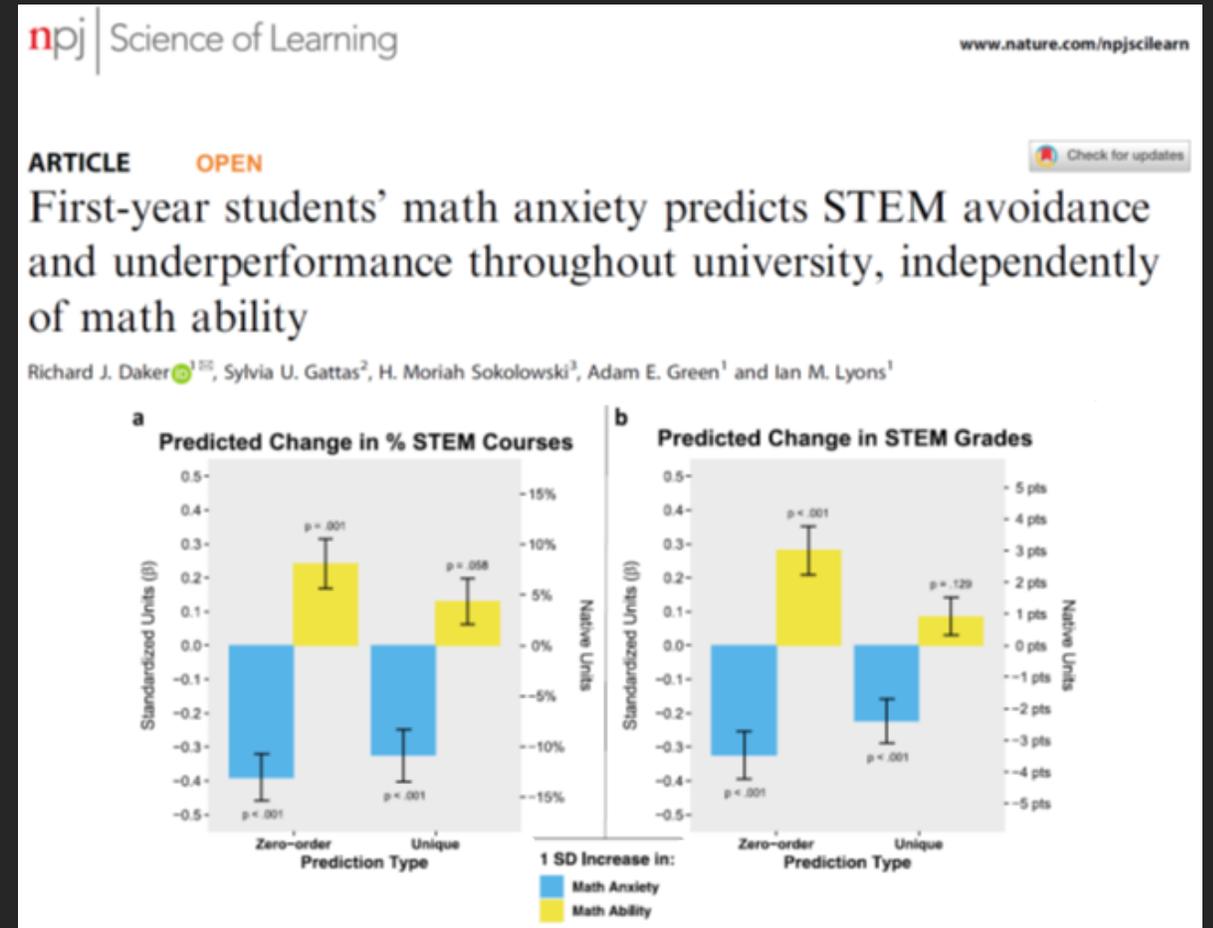
STEM probabilities increasing with mathematics grades and decreasing with English grades

# Maths Anxiety

Despite Maths Ability, STEM Grades, and covariates constant, Maths Anxiety uniquely accounted for a **10.9%** reduction in the proportion of STEM courses students chose to take.

Even holding Maths Ability, % STEM Courses, non-STEM Grades, and covariates constant, Maths Anxiety uniquely accounted for a **2.41 point** reduction specifically in STEM Grades.

Covariates: Trait Anxiety, Verbal Working Memory, Gender, non-STEM Grades, Semesters Absent.



N=183

Undergraduates

# Aim

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- Maths anxiety can be a barrier to pursue, progress and remain in STEM careers (Santos, 2022; Maries et al., 2022). It is associated with avoidance behaviours (Hart & Ganley, 2019) and low achievement in maths (Daker et al., 2021; Devine et al., 2017). It is unclear to what extent attitudes towards maths are mediating these outcomes.
- We delved into how maths anxiety affected individuals' prospects of choosing a career in STEM, their maths self-efficacy, and their maths self-concept in a sample of English-speaking undergraduate students.

# Study Design

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The research had a cross-sectional design. The study was pre-registered ([osf.io/g5264](https://osf.io/g5264)) and approved by the Research Ethics Committee at University College Dublin.

Participants were recruited through social media, e.g., Facebook and Instagram. The survey was created using Qualtrics and completed using a laptop or desktop.

# Participants

One hundred and eighty out of 198 Irish or English undergraduate students aged 18-35 years; 64% women;  $M_{\text{age}}=20.65$  years,  $SD=2.18$ ).

	Non-STEM	STEM*
	N (%)	N (%)
N	120 (66.6)	60 (33.3)
Women	90 (75)	26 (43.3)
Men	30 (25)	34 (56.6)

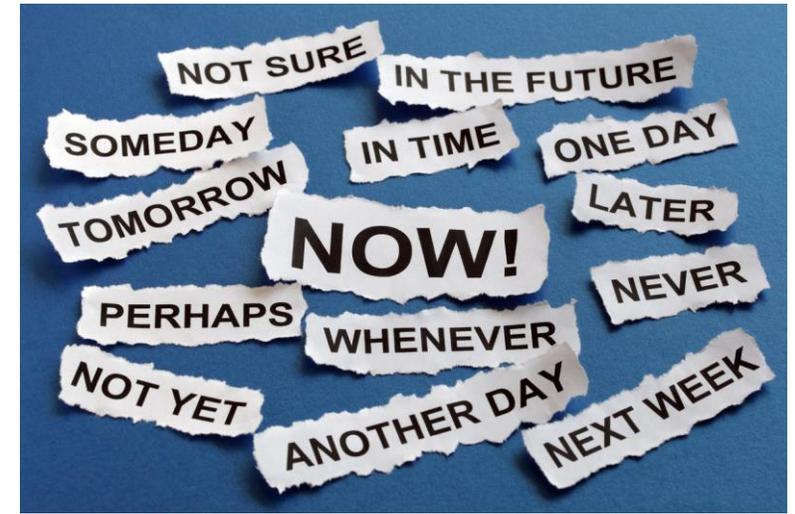
Group STEM: students in the field of mathematics, physics, chemistry, computer science, space science, geology, biology, technology, and engineering

Exclusions: N=18 learning disorders, neurological or psychiatric disorders (n=15) or older than 35 years old (n=3).

(\* ) STEM: Science, Technology, Engineering & Maths

## Materials

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**Maths Anxiety:** Abbreviated Math Anxiety Scale - AMAS (Hopko et al., 2003)

**Maths Self-efficacy:** Math self-efficacy questionnaire (Lee, 2009)

**Trait Anxiety:** Generalised Anxiety Disorder Screener – GAD7 (Löwe, et al., 2008).

**Procrastination:** Academic Procrastination Scale, Short-form, APS-S (Yockey, 2016)

We had other measures not mentioned here...

# Materials

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A single-item slider:

**Liking for maths:** “How would you rate your liking for maths?”

I dislike it very much    0 \_\_\_\_\_ 10    I like it very much

**Maths self-concept:** “How would you rate your maths ability”:

Very Bad    0 \_\_\_\_\_ 10    Very Good

## Materials

$24 + 203 =$

$16 \times 8 =$

$112 / 14 =$

$162 - 87 =$

$65 + 33 =$

$27 / 3 =$

$68 - 44 =$

$15 \times 6 =$

$93 + 28 =$

$3 \times 5 =$

$54 / 6 =$

$213 - 25 =$

$48 / 16 =$

$7 \times 8 =$

$125 + 46 =$

$38 / 19 =$

$25 \times 7 =$

$87 - 13 =$

**Maths fluency:** The Arithmetic Fluency Task (Cipora et al., 2017).

The task comprises 40 single- and multi-digit arithmetic calculations (addition, subtraction, multiplication, and division) to be completed with a time limit of **2 minutes**.

Items were presented and completed in a fixed order. The score was the number of correct responses. The reliability coefficient was high (Cronbach's alpha = 0.92).

# Descriptive Analysis

	Non-STEM M (SD)	STEM M (SD)
Liking for maths	3.38 (2.56)	7.79 (2.49)
Maths self-concept	4.43 (2.22)	7.18 (1.62)
Maths anxiety	28.23 (9.92)	15.59 (7.02)
Maths fluency	10.17 (5.45)	20.29 (8.42)
Maths self-efficacy	14.82 (4.17)	21.27 (4.00)
Trait anxiety	7.47 (5.56)	5.08 (5.23)
Procrastination	16.12 (5.65)	13.68 (6.07)

## Limitations of the study

# Core Inferential Analysis

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## Model 1

*Outcome:* Career choice (STEM vs non-STEM)

*Predictors:* Maths anxiety, gender, trait anxiety, maths self-efficacy, maths fluency.

## Model 2

*Outcome:* How do participants rate their liking for maths?

*Predictors:* Maths anxiety, gender, trait anxiety, maths self-efficacy, and maths fluency.

## Model 3

*Outcome:* How do participants rate their maths self-concept?

*Predictors:* Maths anxiety, gender, trait anxiety, maths self-efficacy, and maths fluency.

## Model 4. Mediation Analysis

How Maths Self-Efficacy mediates the link between procrastination and maths fluency?

## Model 1 Association between career choice and math anxiety

### Outcome: Career choice (STEM vs non-STEM)

	Odds ratio	Std. error	Z-value	Significance
Intercept	0.01	0.02	-2.37	.019
Maths fluency	1.08	0.04	2.16	0.32
<b>Maths self-efficacy</b>	1.22	0.09	2.55	<b>.012</b>
Trait anxiety	1.08	0.05	1.60	.110
Sex	1.42	0.63	0.79	.431
Maths anxiety	0.93	0.04	-1.70	.091

An increase in maths self-efficacy (OR=1.29; 95%CI [1.09-1.53]) scores was associated with an increase in the likelihood of choosing a STEM course.

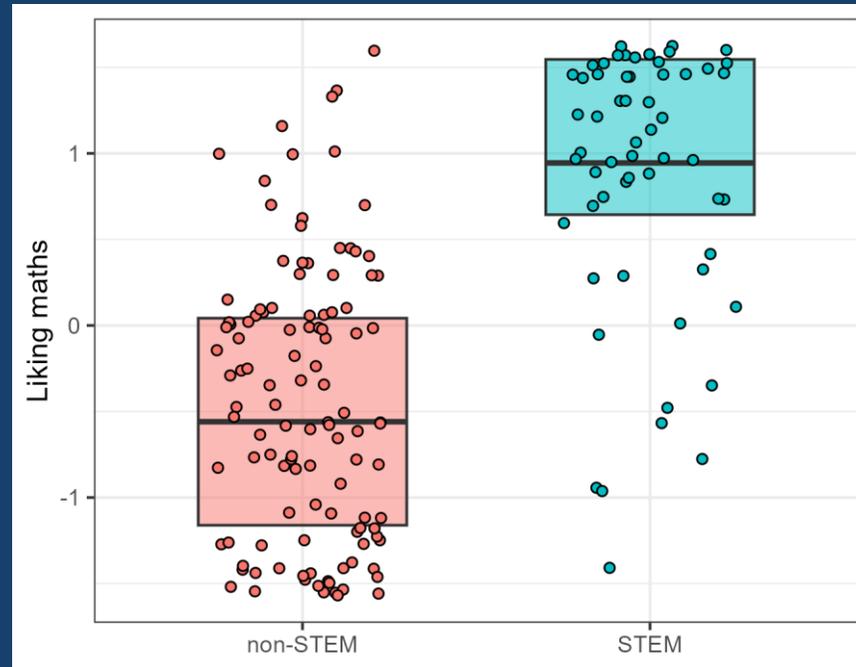
The model explained 45% of the variance (McFadden) in the undergraduate course choice and correctly classified **87.56%** of cases.

The logistic regression model was statistically significant  $X^2(7, 51.73)=103.47, p<.001$ .

## Model 2 Association between liking for maths and maths anxiety

*Liking for Maths:* “How would you rate your liking for maths”:

I dislike it very much 0 \_\_\_\_\_ 10 I like it very much



## Model 2 Association between liking for maths and maths anxiety

Outcome: How do participants rate their liking for maths?

	<b>Beta</b>	<b>Std. error</b>	<b>t-value</b>	<b>Significance</b>
Intercept	3.30	1.15	2.85	.004
<b>Maths fluency</b>	0.07	0.02	3.16	<b>.001</b>
<b>Maths self-efficacy</b>	0.21	0.05	4.50	<b>&lt;.001</b>
Trait anxiety	0.03	0.02	1.17	.253
Sex	0.16	0.29	0.56	.573
<b>Maths anxiety</b>	<b>-0.13</b>	0.02	-6.37	<b>&lt;.001</b>

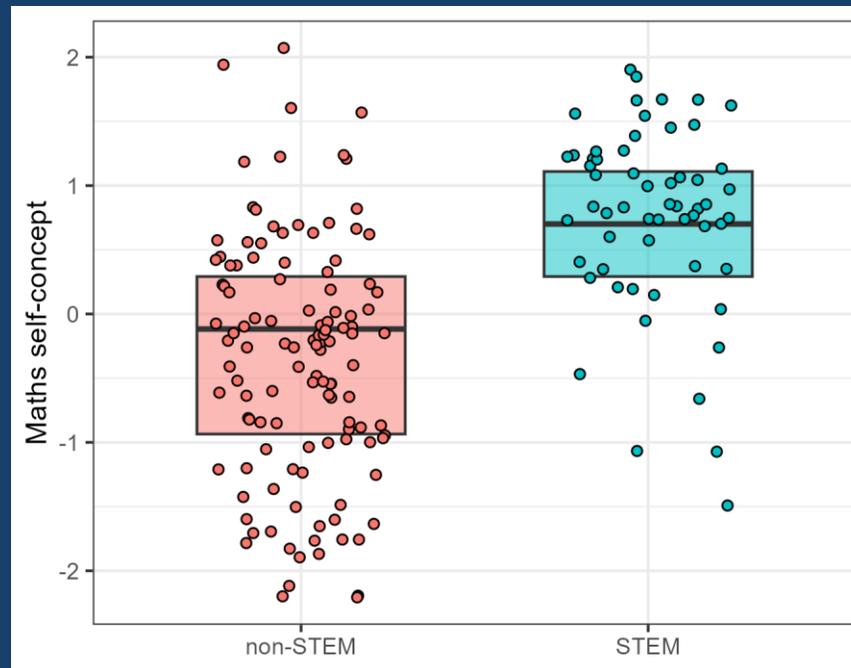
Beta weights indicated that higher levels of math anxiety were associated with lower rates of liking for math, while higher levels of math fluency and math self-efficacy were associated with higher rates of liking for math.

The model explained 75% of the variance of liking for maths.  
Linear Regression  $R^2_{adj}=.75$ ;  $F(5, 174)=107.5$ ,  $p<.001$

## Model 3 Association between self-concept and maths anxiety

**Maths self-concept:** “How would you rate your maths ability”:

Very Bad 0 \_\_\_\_\_ 10 Very Good



## Model 3 Association between self-concept and maths anxiety

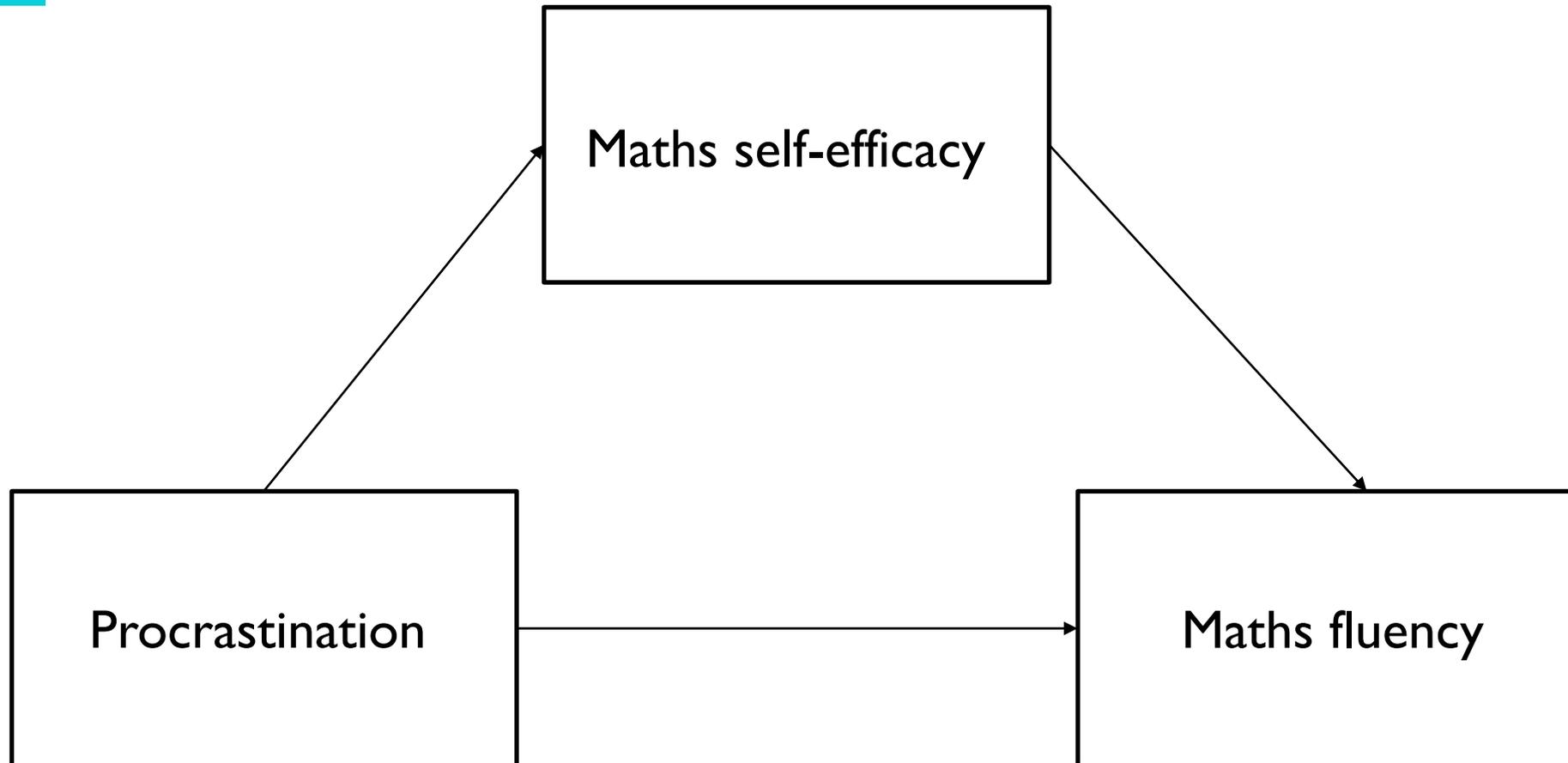
Outcome: How do participants rate their own maths ability?

	<b>Beta</b>	<b>Std. error</b>	<b>t-value</b>	<b>Significance</b>
Intercept	3.30	1.15	2.85	.004
<b>Maths fluency</b>	0.07	0.02	3.16	<b>.001</b>
<b>Maths self-efficacy</b>	0.21	0.05	4.50	<b>&lt;.001</b>
Trait anxiety	0.03	0.02	1.17	.253
Sex	0.16	0.29	0.56	.573
<b>Maths anxiety</b>	<b>-0.13</b>	0.02	<b>-6.37</b>	<b>&lt;.001</b>

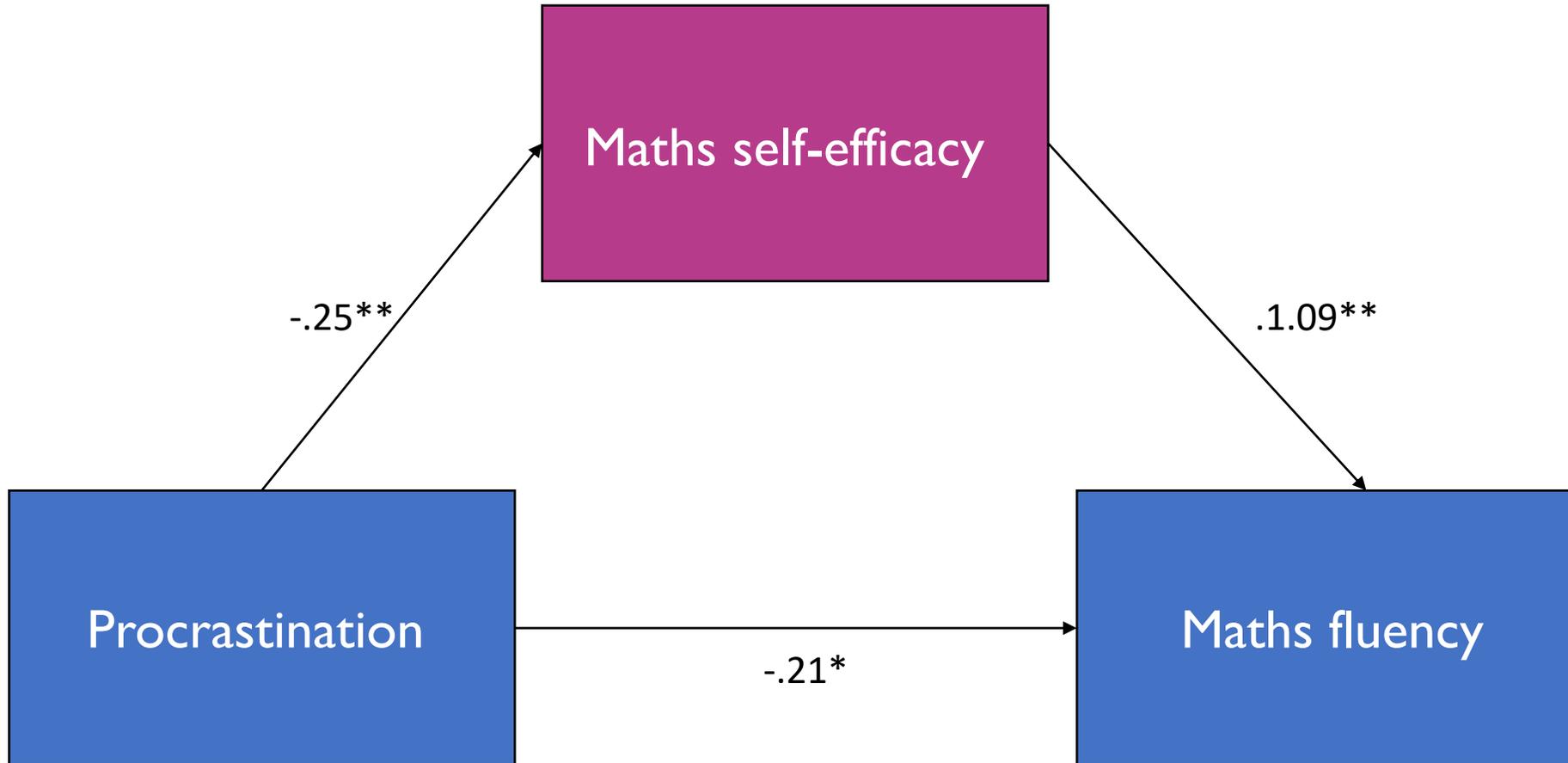
Beta weights indicated that higher levels of math anxiety were associated with lower rates of math ability, while higher levels of math fluency were associated with higher rates of math ability.

The model explained **69%** of the variance on maths ability.  
Linear Regression  $R^2_{adj}=.69$ ;  $F(5, 174)=80.14$ ,  $p<.001$

## Model 4 Mediation effect of maths self-efficacy



## Model 4 Mediation effect of maths self-efficacy

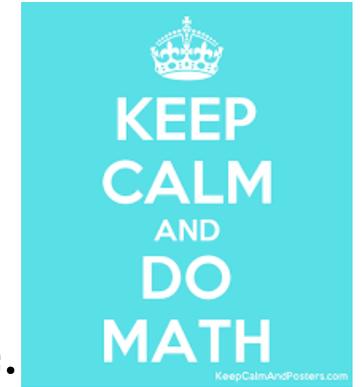


The indirect effect was significant ( $\beta=0.30, p<0.001$ ) and indicated that Maths self-efficacy mediated 57% of the variance in the relationship between Procrastination and Maths fluency.

Legend: \* $<.01$ ; \*\* $<.001$

## Key findings

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- Maths self-efficacy was the sole significant predictor of career choice.
- Maths self-efficacy mediates the link between maths fluency and procrastination.
- Maths anxiety did not predict undergraduates' probability of taking a STEM course while controlling for the effects of maths fluency, maths self-efficacy, trait anxiety, and gender.
- Yet, maths anxiety did predict participants' maths self-concept and liking for maths.
- Interventions targeting maths self-efficacy may promote students' entry and retention into STEM courses.



UCD Music & Math  
Cognition Lab



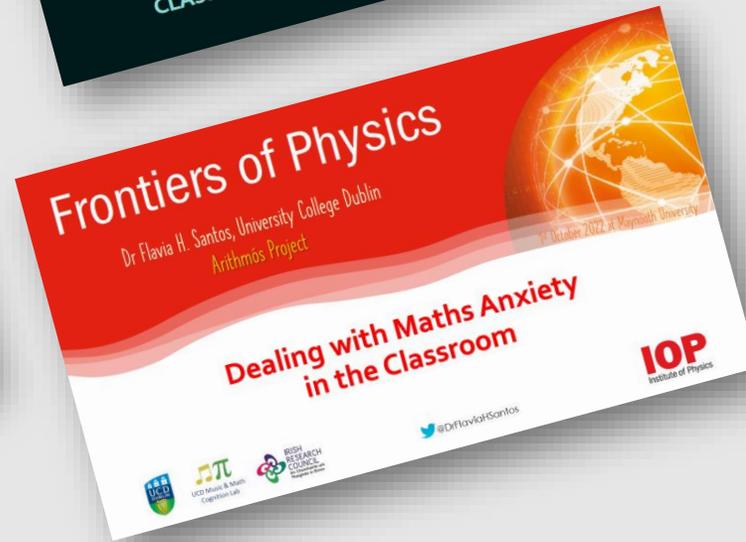
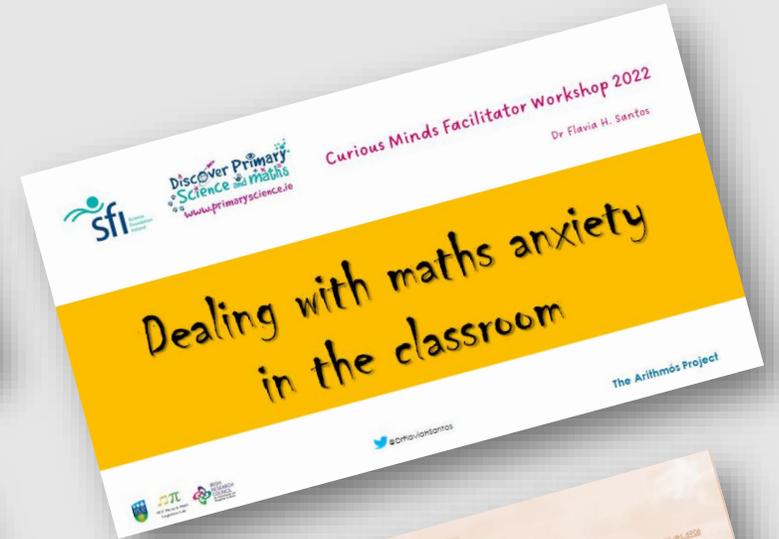
@DrFlaviaHSantos

## Key Outcomes

- A RCT\* study to test whether the digital game will reduce MA and improve maths performance
- Teachers' MA classroom management programme.
- A cartoon video for families and children to raise awareness about MA.

(\* ) Randomised controlled trial

 Arithmós Project



# Teachers' Maths Anxiety Classroom Management



## Arithmós Project

1. Increasing awareness concerning maths anxiety for students, parents and teachers.
2. Reducing gender and race stereotypes related to maths learning and maths performance.
3. Reinforcing maths learning supports for pre-schoolers and 1<sup>st</sup> graders.





## Arithmós Project



4. Avoiding putting students under pressure, especially 1<sup>st</sup> and 2<sup>nd</sup> graders.
5. Cultivating motivation to learn maths and confidence in students' abilities in the classroom.
6. Growing self-efficacy and resilience, particularly in students from disadvantaged contexts.



7. Providing preparation for the Leaving Certificate with incentives for students from disadvantaged areas.
8. Equipping teachers with continuous performance development about maths anxiety and anxiety about teaching maths.
9. Offering cognitive and/or behavioural therapy (Petronzi et al., 2021) for severe cases of maths anxiety.





1:41 min

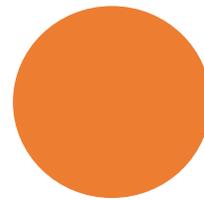
Maths Anxiety - Arithmós Project  
<https://youtu.be/bfLBO5bXRIU>

Please like it on Youtube! 





# Sustaining Accessibility in



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#SAM2023

Thank  
you!

