

# A child with maths anxiety may become a parent or a teacher with maths anxiety

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## Introduction

Maths is the basis for the most advanced discoveries in science such as satellites and robotic surgeries. Yet, one rarely thinks that these triumphs were grounded during maths classes in primary and secondary schools. These schooling years will prepare individuals for the workforce, and some of them to apply for a university degree. Recent international large-scale assessments found an average high maths score for Irish students compared with other countries. However, when the students' distribution across the levels of maths performance was analysed, the percentages of Irish students who succeeded in the most complex items, were lower in comparison with other countries with the same average scores (Pitsia et al., 2022). One possible explanation is that Irish students' achievement was hampered by maths anxiety. Maths anxiety has been observed globally regardless of the country's wealth; and higher levels have been reported among Irish students (Perkins & Shiel, 2016).

This article aims to help readers to understand the importance of minimising maths anxiety in home and school environments and to drive the attention of policymakers to the fact that maths anxiety prevalence is shaped by gender and socioeconomic status, among other factors. Because maths anxiety can harm students' performance, career choices and teachers' well-being and instruction skills, it must be addressed for the benefit of society and individuals. The article concisely describes maths anxiety and its impact on maths education, good practices in the school environment to mitigate it and showcases a continuous professional development elaborated, under the Arithmós Project, to support teachers to deal with both maths anxiety in students and the anxiety about teaching maths.

## Why does it matter?

In recent years, maths anxiety has gained attention from the general public through social media. This blooming reflects the work of researchers, mainly from Psychology, Education and Neuroscience, leading to an increase in studies and publications in the field. The accumulated knowledge in this area is beyond the scope of this article, for overview (Ashcraft, 2002; Dowker et al., 2016) and critical account (Cipora et al., 2022). However, I will briefly explore three core

aspects. First, maths anxiety is present early in childhood, second, maths anxiety may continue throughout life, third, a child with maths anxiety may become a parent or a teacher with maths anxiety and their perspectives will influence the next generation.

Maths anxiety is an easy concept to grasp. It consists of nervousness about numbers, quantities, maths homework or classroom activities. Any person can relate to this, for instance, when you were a child and your maths teacher asked you in class to solve a question on the blackboard or called the class for a surprise quiz. You possibly had your hands sweating or shaking, and suddenly your heartbeat became fast (Caviola et al., 2022). Even if you liked numbers, knew the response, and enjoyed the challenge, perhaps there was an inner voice saying “*what if...*” that made you doubt your response for a second.

For some children, this sort of experience is quickly forgotten, especially if there is no negative impact on their grades. Some of them even benefit from this startle to increase concentration and remember the information. But if the situation deviates the child’s attention to ruminations, i.e., thoughts of what another person would say about their performance: “*my teacher will be disappointed, my mates will think I’m dumb or my parents will think I’m lazy*”. This experience could escalate and lead the child to have butterflies in the stomach or panic just thinking of the next maths class or next maths exercise. These are real emotions, maths anxiety elicits brain activation in areas associated with fear (Young et al., 2013; Kucian et al., 2018) or pain (Lyons & Beilock, 2012).

These negative feelings could then interfere with their learning process on a regular basis. For instance, when a child is doing a calculation, such as  $12 \times 6$ , cognitive skills are required to pay attention to number relations, recognise the arithmetical symbols, remember partial scores, etc. If the child is worried or afraid, these overwhelming states will hamper cognitive processing. In this context, the child would deviate attentive and mnemonic resources needed to perform calculations to emotional aspects, such as ruminations or memories of previous failures. This context raises the likelihood for the child to calculate slowly, be unable to complete the series or make mistakes. It remains uncertain if maths anxiety drains working memory<sup>ii</sup> resources affecting maths performance or if low working memory leads to poor maths performance and it could cause maths anxiety, probably it is a mutual and intricate relationship (Carey et al., 2016). Neuroimaging research detected a correspondent brain activation, the higher the maths anxiety the lower are working memory scores and maths performance (Hartwright et al., 2018).

Maths anxiety has at least four known dimensions, such as feelings, thoughts, physiological, and behavioural responses (Ramirez et al., 2018). Noteworthy, these dimensions are not restricted to scholarly tasks, rather they are observed in quotidian situations (Richardson & Suinn, 1972), for instance, getting the proper change while buying ice cream. More importantly, these manifestations may occur in anticipation of situations that will require working with numerals (Lyons & Beilock, 2012), during learning experiences in the classroom and appraisals, such as scholar exams. It means the child with maths anxiety might be in constant distress towards maths.

This situation can elicit a cascade of avoidance behaviours, such as long visits to the toilet or disruptive behaviour in class among other excuses to not attend maths classes or to complete exercises. The lesser the contact with maths content, the lower will be opportunities to learn. Then, the student may achieve grades below their capacity and this refraining will grow as a snowball and become an avalanche. In the worst-case scenario, a child or young adult may leave school early and never achieve the professional expertise they are capable of. In this stage, as a form of phobia (Kucian et al., 2018), maths anxiety could become a serious problem that may require clinical support and/or class intervention and halt a potentially brilliant future.

Studies have shown that young children such as first graders may show maths anxiety (Ramirez et al 2013; Gunderson et al., 2017). This alarming finding reveals an important sociocultural dimension of maths anxiety. It is not rare to hear adults saying, “*maths is very difficult or for very smart people*”, among other myths. These very young susceptible individuals are modelled by parents and teachers and may be influenced by their adverse views of maths. These ideas can be infused into children’s minds even before schooling starts through nonverbal communication (e.g., facial expressions of fear, anger, or contempt). A powerful example is provided by McCoy and colleagues (2021), using data from a cohort of 8,568 nine-year-old Irish children. Teachers and mothers tended to underestimate girls’ maths performances, no matter if they performed better or were similar to boys. Instead, different perspectives can be offered to children. For instance, comparing three groups, children who received auditory information about scientists (Marie Curie for girls and Isaac Newton for boys), children who did not receive such information and children that pretended to be the scientist indicated in the vignette. Girls aged 4-7 after acting as a woman great scientist increased their persistence in answering a science-related task (Shachnai et al., 2022).

Another aspect of great concern is that maths anxiety instead of disappearing tends to rise. Research carried out with undergraduate students, including studies in our Lab, confirms its presence and pervasive effects. Although maths anxiety is seen regardless of demographics across the globe such as age, gender, and ethnicity (Barroso et al., 2021), it is more frequently reported in girls/women (e.g., Hembree, 1990) and individuals with low income (e.g., OECD, 2013). Importantly, the presence of maths anxiety dictates career choice and grades, in a way that maths anxious students tend to avoid science, technology, engineering and mathematics (STEM) courses or obtain lower grades in these areas, regardless of their maths capacity (Daker et al., 2021). The statistics anxiety seems to be the most common extension, frequently observed in undergraduate students from diverse disciplines (Trassi et al., 2021).

Although maths anxiety is related to general anxiety and other learning-related forms, for example, test anxiety or statistics anxiety (Hembree 1990; Trassi et al., 2021). There is evidence that these are independent constructs, meaning that a child without general anxiety may express specific negative emotions, intrusive thoughts, and physical reactions while manipulating numbers and quantities which may not be observed in other learning experiences (Commodari & La Rosa).

One important aspect is that the learning environment is communicable. Then, if negative attitudes, beliefs, and feelings about maths prevail in a classroom setting, a child probably will fail rather than thrive. By contrast, a child with maths anxiety surrounded by support and encouragement and positive views, feelings and behaviours towards maths will have more possibilities to overcome the impact of their maths anxiety (Lau et al., 2021). In line with these findings, our study analysed data from three waves of Growing Up in Ireland to investigate whether the experience of bullying at age 9 could be an indicator of future academic achievement at age 15. The analysis revealed that the impact of bullying on literacy and numeracy was dependent on the presence of emotional and behavioural difficulties at age 13, therefore, mediated by psychological difficulties (Murphy et al., 2022).

Maths anxiety is not the only cause of low numeracy. Several extrinsic and a few intrinsic factors lead to low numeracy, which may not even be related to emotional or cultural factors, such as mathematical learning disorders (Santos et al. 2022). However, when maths anxiety is present, correlational studies indicate that maths performance usually is lower (Barroso et al., 2021; Namkung et al., 2019; Zhang et al., 2019). Recent research brings a more comprehensive view, in which the lack of fundamental maths concepts in first graders seems to determine the emergence of maths anxiety and in later schooling, the presence of maths anxiety would worsen maths achievement (Gunderson et al., 2017).

### **What are the policy implications?**

Estimates from 63 different educational systems participating in the 2012 Programme for International Students Assessment (PISA), controlling socioeconomic status and gender, uncovered a global trend. There is a drop in math percentiles of 15 years old students as a function of an increase in maths anxiety scores (Foley et al., 2017). The gender gap across nations, even among higher achievers, was partially explained by maths anxiety. Although Irish average scores in self-efficacy and self-concept were equivalent to most member countries of the Organization for Economic Co-operation and Development (OECD), Ireland's average level of maths anxiety was significantly higher (Perkins & Shiel, 2016; OECD, 2013). Note that these students are currently on the job market at age 24, therefore, this is an issue for the present generation.

According to results from PISA 2018, a total of 5 577 students from 157 Irish schools took part in the most recent edition. On average Irish students scored slightly higher than the OECD average in mathematics. Eight per cent of the sample reached the highest levels of complexity ( $\geq 5$ , on a scale of 1-6) in maths items. Girls obtained equivalent scores to boys in maths, representing an improvement from previous editions. Socioeconomic status explained 12% of the variation in maths performance of Irish students in 2018. In this cohort, 12.5% of high achiever disadvantaged students consider it unpalatable to complete higher education. Concerning well-being, a larger proportion of the Irish cohort consisted of academic non-resilient students and remained below the OECD average (OECD, 2019). Other international large-scale assessments were not included in this article for conciseness, but the findings are generally similar (Pitsia et al., 2022).

Since maths anxiety is observed in early school years, then actions to minimise its effect must be in place in the first years of elementary school, not just making the school experience pleasant but also strongly effective. A child that presents such symptoms may become an adult with an aversion to maths. Then, in adult life they can, as potential parents, discourage children from pursuing careers in STEM. Even if not intentionally subtle attitudes and unhelpful comments shared often, for instance, during homework activities could instil negative views towards maths. Then, information should be offered to parents on ways to increase their awareness about maths anxiety and the impact of their attitudes towards maths on their children's learning.

Teachers, whether due to negative experiences during their childhood or to limitations in their training and resources for teaching, can have attitudes which do not support pupils learning. Teachers' math anxiety is a predictor of children's maths anxiety and in some grades also related to children's maths achievement (Richland et al., 2022). Therefore, actions must be taken to reduce the impact of teachers' anxiety about teaching maths. Because these factors could have a long-lasting impact on educational, economic, and technological development nationwide. That is reducing the intake of STEM courses or engendering lower attainment and lower grades, regardless of maths capacity. Therefore, young adults will also need support not just in the recruitment phase, which is an encouragement to choose such courses, but also in progression, as the number of students who give up STEM courses is high. Finally, for those who completed their careers, action must be taken to ensure their maintenance in the work market. Gender bias is one of the key variables to overcome, women are among those who need more incentive to choose, progress or remain in STEM areas (Ellis et al., 2016).

### **How do mitigate inequities related to maths anxiety?**

The Irish government has already been mobilised to reduce low achievement in maths and to increase the number of students with the highest level of achievement, for instance, through Project Maths [<https://www.projectmaths.ie/>] and supports groups for post-primary teachers via Professional Development Services for Teachers (Pitsia et al., 2022). These projects and initiatives hopefully will change favourably this scenario improving grades in Junior and Leaving Certificates<sup>iii</sup>. The National Educational Psychological Service provides a comprehensive, school-based psychological service to all primary and post-primary schools, which is focused on the well-being, academic, social, and emotional development of learners. Teachers can access the Maths Support 2020 [<https://www.gov.ie/en/publication/430cc-maths-support-2020/>] for reference. These resources were not designed to deal with maths anxiety in the classroom environment.

In this section, I showcase our research in development (Box 1) and collect good practice examples that could be implemented by schools and the government to reduce maths anxiety-related inequalities:

- i) Increasing awareness concerning maths anxiety for parents and teachers.

- ii) Reducing gender and race stereotypes related to maths learning and maths performance.
- iii) Reinforcing maths learning supports for pre-schoolers and 1<sup>st</sup> graders.
- iv) Avoiding putting students under pressure, especially 1<sup>st</sup> and 2<sup>nd</sup> graders.
- v) Cultivating motivation to learn maths and confidence in students' abilities in the classroom.
- vi) Growing self-efficacy and resilience, particularly in students from disadvantaged contexts.
- vii) Providing preparation for the Leaving Certificate with incentives for students from disadvantaged areas.
- viii) Equipping teachers with continuous performance development about maths anxiety and anxiety about teaching maths.
- ix) Offering cognitive and/or behavioural therapy (Petronzi et al., 2021) for severe cases of maths anxiety.

### Box. 1 The Arithmós Project

The Arithmós Project is a collaboration between University College Dublin and Technological University Dublin, funded by the Irish Research Council. It aims to transform maths education through the engagement of children, teachers, families, and policymakers. The pillars of this project are i) the research at the schools which will examine the impact of a digital educational game on maths learning, ii) a programme for teachers to improve maths anxiety management in class, iii) a video for family and children to raise awareness about maths anxiety, and iv) a meeting with policymakers concerning curriculum design.

The outcomes of the Arithmós Project are aligned with Sustainable Development Goals (United Nations, 2022): i) lifting maths education (SDG 4), through innovative interventions for children and teachers to specific needs such as low numeracy and maths anxiety; ii) supporting gender equality through tailored actions to support girls (SDG 5); iii) preventing students psychological distress led by the learning difficulties and increasing their well-being (SDG 3); iv) decrease inequalities by targeting advantaged and disadvantaged schools (SDG 10). In the long term, academic success will have a positive impact on halting poverty (SDG 1).

A key innovation of the Arithmós Project is the continuous performance development programme: “*Teachers’ Maths Anxiety classroom management*” (Santos, 2022)<sup>iv</sup>. This single-session workshop carried out in the schools, offers an opportunity for teachers to become aware of children’s maths anxiety but also their potential anxiety about teaching maths. The training provides core information about both forms of maths anxiety, a space for reflection and development of good practice, in addition, to delving into evidence-based interventions. The toolkit is completed with crucial readings for children, teachers, and parents.

The inaugural session was carried out at St. Philip the Apostle Junior School in April 2022. The Irish Department of Education, National Educational Psychological Service, Teaching Council, The Irish Development Education Association, and Blackrock Education Centre were informed that the programme is available. Special sessions will happen this fall by invitation from the Irish Mathematics Teachers Association and the Curious Minds Programme of Science Foundation Ireland.

I'm currently working on the translation of this programme into Spanish and Portuguese languages to allow the expansion of its dissemination. The programme was shared with the UCD Teaching & Learning Community to establish the foundations for its adaptation to use in STEM higher education.

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<sup>ii</sup> Working memory is the ability to retain and manipulate information for short periods of time. It is crucial for school learning, for instance, to keep in mind pieces of information while mentally calculating 6+4+3.

<sup>iii</sup> Junior certificate (the first three years of secondary school) and leaving certificate (the final exam of the Irish secondary school system and the university matriculation examination) in Ireland.

<sup>iv</sup> Institutions which are not taking part in the Arithmós Project but are interested in this programme may request a session through NovaUCD consultancy services or via the Teaching Council.