

Original article

Math anxiety, a hierarchical construct: Development and validation of the Scale for Assessing Math Anxiety in Secondary education



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ABSTRACT

Secondary students' low achievement and engagement in mathematics is known to relate closely to their math anxiety. Despite the international body of research, the theoretical conceptualization of the construct math anxiety is still debated, showing strong discrepancies regarding its factor structure. Therefore, the aim of this paper is to develop and validate a new instrument, called Scale for Assessing Math Anxiety in Secondary education (SAMAS), by testing several models through confirmatory factor analysis. Data were collected from 563 secondary students, with an average age of 13.96 ($SD = 1.09$) years. Several models for the construct were tested through confirmatory factor analysis. The results largely confirmed that the hierarchical structure showed the best fit to the data ($\chi^2(166, N = 563) = 361.22$; $RMSEA = .046$; $SRMR = .045$; $NNFI = .94$; $CFI = .95$), resulting in the psychometrically sound 20-item SAMAS, wherein math anxiety comprises three underlying factors.

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Ansiedad matemática, un constructo jerárquico: desarrollo y validación de la Scale for Assessing Math Anxiety in Secondary education

RESUMEN

El bajo rendimiento y dedicación de los estudiantes de secundaria a las matemáticas está estrechamente relacionado con la ansiedad matemática. A pesar de la investigación internacional, la conceptualización teórica del constructo ansiedad matemática es todavía debatida, mostrando fuertes discrepancias relativas a su estructura factorial. Por tanto, el objetivo de este estudio es desarrollar y validar un nuevo instrumento, denominado Scale for Assessing Math Anxiety in Secondary Education (SAMAS), para el que se analizan diferentes modelos mediante Análisis Factorial Confirmatorio. La muestra estuvo compuesta por 563 estudiantes, con una edad media de 13.96 ($DE = 1.09$) años. Los resultados ampliamente confirmaron que la estructura jerárquica fue la que arrojó el mejor ajuste del modelo ($\chi^2[166, N = 563] = 361.22$; $RMSEA = .046$; $SRMR = .045$; $NNFI = .94$; $CFI = .95$), resultando en un instrumento psicométricamente robusto de 20 ítems, compuesto por 3 factores subyacentes.

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Escala

Introduction

In recent years, math anxiety has received increasing interest because of its adverse effects on the learning and mastery of

Mathematics from an early age. It is defined as feelings of tension or worries that hinder the successful completion of tasks involving manipulation of numbers and mathematical reasoning not only in school settings, but also in a wide range of daily life situations (Richardson & Suinn, 1972).

Although it has been shown to exist across all age ranges, there is growing evidence that math anxiety has its roots in upper elementary school and increases in severity from 5th through 12th grade,

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reaching peak levels in 14- to 16-year-old students (e.g., Legg & Locker, 2009; Scarpello, 2007). In attempts to summarize these correlational studies, Hembree (1990) and Ma (1999) conducted one meta-analysis each. The results underscored estimated correlation values of $-.27$ to $-.34$ for the previously mentioned age group (that is, secondary students).

Its detrimental impact during this period leads to a math-related avoidance pattern in adulthood, which manifests in a wide range of behavioral symptoms such as trying not to use mathematical reasoning whenever it is possible. This troubling pattern, in turn, results in an adverse effect on individuals' career choices and long-term professional success (e.g., Ashcraft & Krause, 2007; Krinzinger, Kaufmann, & Willmes, 2009), as well as poorer mathematical skills and a continuous struggle to perform simple numerical tasks, namely addition or subtraction (Ashcraft & Ridley, 2005).

In addition, when analyzing its origin, several authors have found that math anxiety is a specific type of anxiety related to, but distinct from, both general anxiety trait and test anxiety (Wu, Willcutt, Escovar, & Menon, 2013). These findings highlight the non-intellectual nature of math anxiety, a hypothesis which was originally proposed in theoretical terms (Ashcraft & Krause, 2007; Beilock & Carr, 2005; Beilock, Gunderson, Ramirez, & Levine, 2010), but has been recently proven in the field of neurocognitive research (Young, Wu, & Menon, 2012).

Despite its relevance, knowledge about the theoretical conceptualization of math anxiety is still inconclusive. A literature review of the existing measures for assessing math anxiety (see Table 1) drawn from peer reviewed articles yielded no agreement in the dimensionality of the construct.

When reviewing the studies summarized in Table 1, it could be concluded that: (a) researchers do not agree on the factor structure for math anxiety; (b) some instruments targeted at measuring math anxiety also include some factors related to other constructs (e.g., attitudes toward math); (c) the great majority of existing instruments have been psychometrically supported by exploratory factor analyses, with still a scarcity of confirmatory consistency; and (d) there is a general lack of peer-reviewed tools for assessing math anxiety among secondary students in Spanish-speaking contexts.

Therefore, based on previous literature and theoretical considerations, in the present research math anxiety is defined based on Hopko's (2003) classification and previous studies on the construct, whereby two factors are proposed as critical elements: anxiety about the process of learning mathematics and anxiety toward math evaluation. Aiming at completing its factor structure, a third factor is proposed as relevant in explaining the construct: anxiety toward everyday life's math-related tasks, which is in line with the widely acknowledged definition by Richardson and Suinn (1972). Accordingly, math anxiety is conceptualized to have three latent factors:

Everyday life's math anxiety encompasses a broad range of affective responses to students' everyday situations that require mathematical reasoning. For example, a student may feel nervous about having to do a mental calculation to estimate the total price of a purchase.

Math learning anxiety includes affective responses that a math student may experience during different situations of the math learning process that take place in the scholar setting. For example, the feeling of worry when having to solve a math problem.

Math test anxiety refers to feelings a math student may experience when either preparing or doing a math test. This dimension is considered different, although related to, the previous one. In fact, it is conceivable that a student enjoys the subject of Mathematics but feels nervous about doing a math test.

Consequently, based on the limitations drawn from the literature review on existing instruments and the theoretical conceptualization exposed above, the main goal of the present

study was to develop and validate, by means of confirmatory analyses, the Scale for Assessing Math Anxiety in Secondary education (SAMAS), wherein math anxiety comprises three underlying factors: everyday life's math anxiety, math learning anxiety and math test anxiety.

Method

Participants

A random sample from six schools was extracted, and the cluster sampling method was then applied. That is, within those selected schools, all secondary student groups from second and fourth grades were considered eligible for the study.

With this procedure, the research sample consisted of 563 secondary students (39.3% females, 60.7% males) from 36 different classes from the province of Biscay (Basque Country Autonomous Region, Spain). The average age of the participants was 13.96 ($SD = 1.09$) years, ranging from 12 to 16. As regards the educational level, 47.42% were enrolled in second grade and 52.58% in fourth grade.

Instruments

Scale for Assessing Math Anxiety in Secondary education (SAMAS). It comprised three underlying factors: everyday life's math anxiety (e.g., "Me pongo nervioso/a al calcular el precio total de lo que he comprado" [*I get nervous when calculating the total price of what I bought*]), math learning anxiety (e.g., "Me pongo nervioso/a cuando toca clase de matemáticas" [*I get nervous whenever it is math's turn*]) and math test anxiety (e.g., "Me pongo más nervioso/a en los controles o exámenes de matemáticas que en los controles o exámenes de otras asignaturas" [*I get more nervous during the math tests than during the exams of other subjects*]). The final version consisted of 20 items (see Appendix 1) on a continuous response scale ranging from 0 (*Strongly disagree*) to 10 (*Strongly agree*). Its development, as well as psychometric properties, is detailed in the present study.

Math performance. It was assessed by students' score on a math curriculum-based test, entirely based on the widely validated diagnostic tests (Gobierno Vasco, 2010) and PISA assessment (Gobierno Vasco, 2011). The former includes basic mathematical contents across the first cycle of Compulsory Secondary Education; whereas the latter does across the second cycle. The time limit to complete the test is 40 min in both cases.

For their correction, the guidelines given by their authors are applied, obtaining a single cumulative score, based on the sum of correct answers, which was then transformed to a standard score ranging from 0 to 10.

A *sociodemographic questionnaire* gathered participants' personal background information: age, sex and secondary grade in which they are enrolled.

Procedure

Once the research project was approved by the Ethics Committee of the University of Deusto, the principals from the selected schools were contacted via email and informed of the nature of the research. They, in turn, presented it for approval at a staff meeting. After written permission was granted by the schools, a cover letter was sent to students' parents or guardians to inform them of the purpose of the study and explain that collected data were going to be dealt with confidentiality and used solely for research purposes. In addition, prior to participation, students were also informed of the general purpose of the study and of their rights as participants, stressing that their participation was anonymous and voluntary.

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