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TEACHER'S MATHEMATICAL ANXIETY: THEORETICAL ANALYSIS AND CONTENT VALIDITY OF THE MATH ANXIETY SCALE FOR TEACHERS - MAST FOR THE BRAZILIAN CONTEXT

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Abstract: The phenomenon "Math Anxiety" (MA) is characterized by a set of unpleasant reactions, whether physiological, cognitive or behavioral, in situations that require the use and application of mathematical knowledge. This feeling of MA tension is not exclusive to students, it can also occur among teachers who teach the subject. In Brazil, there are few BF studies in students, and none with teachers, in addition to the lack of measurement instruments adapted to our reality. It is intended to present the AM phenomenon, as well as to describe the process of cross-cultural adaptation of the American scale "Math Anxiety Scale for Teachers - MAST" to the Brazilian context. This is a cross-sectional study. The process followed the steps recommended in the literature on the adaptation of instruments in mental health. The study included 265 teachers who work in the Early Years of the Public School in the city of Pelotas/RS. Teachers answered a self-administered online questionnaire consisting of the Informed Consent Form (TCLE), socio-demographic variables and the GAD-7 scales (Generalized Anxiety Disorder-7) and the experimental version of the MAST-BR. Once collection was complete, data were transferred from the Excel spreadsheet, generated in Google Forms, to the statistical package Statistical Package for the Social Sciences (SPSS). The Lavaan package, from the R program, was used for the confirmatory analysis of the scale's dimensional model. The theoretical analysis of the items showed a satisfactory Content Validity Coefficient (total CVC = 0.94). Cronbach's alpha greater than 0.90. The instrument is robust enough to assess MA in teachers.
Keywords: Anxiety; Mathematics; Scale; Teachers; Prevalence.

INTRODUCTION

The Program for International Student Assessment (PISA, 2015) report found a significant decline in Brazil's average math performance scores in the world ranking (66th). According to the Organization for Economic Cooperation and Development (OECD), Brazil registers high levels of aversion to mathematics and, consequently, a low performance in international assessments, pointing out that there is an inverted association between mathematical anxiety and mathematical performance (OECD, 2015).

Mathematics has been perceived as one of the most difficult components of the academic curriculum, arousing concern, stress and negative emotions. However, little attention has been given to the emotional and affective factors that are also crucial for success in mathematics (HAASE, 2012). An emotional factor related to learning mathematics is anxiety, a feeling that is part of human development and can be accentuated in moments of fear, danger or tension (MENDES & CARMO, 2014; CAMPOS, 2022).

According to the American Psychological Association (APA, 2014), anxiety is an emotion characterized by feelings of tension, worried thoughts and physical changes. An affective/emotional factor that plays a central role in mathematical performance is Mathematics Anxiety (MA), defined as feelings of fear and concern related to mathematical stimuli and situations (RICHARDSON & SUINN, 1972). The AM phenomenon that causes feelings of fear and tension in situations that require the manipulation and application of mathematical knowledge can affect both students and teachers (HAASE, GUIMARÃES & WOOD, 2019).

Works related to the "emotionality" of AM in the brain point out that neurobiological markers about AM are associated with the

fear and pain network, with hyperactivity and abnormal connectivity of the cerebral amygdala in areas of the brain linked to threat, fear processing and perception. of pain, when exposed to mathematical situations (YOUNG et al., 2012; SILVA, NETO & GONÇALVES, 2020).

Unlike anxiety disorder, the AM construct is not officially recognized as a psychiatric disorder. Despite its name, MA is not described in the Diagnostic and Statistical Manual of Mental Disorders - DSM-5 as a type of anxiety or learning disorder, being considered only as a significant educational and clinical problem (SILVA, NETO & GONÇALVES, 2020).

Haase et al. (2019) state that AM is a kind of "phobia", being represented at three levels: affective, cognitive, and behavioral. The affective level refers to emotionality, the feeling of anxiety with its associated physiological manifestations, such as tachycardia, sweating, pallor, etc.; the cognitive level refers to concern with one's own performance and the consequences of failure, characterized by negative attitudes, intrusive dysfunctional thoughts, low self-efficacy, etc.; and finally the behavioral level, which comprises a tendency to avoid, avoid, or escape from performing math-related activities (HASSE et. al, 2019). These negative responses to situations involving mathematics, altering the physiological state, cognitive and behavioral, can cause disinterest, demotivation, escape, avoidance, even school dropout (CARMO & SIMINONATO, 2012; MENDES & CARMO, 2014).

Because it is an emerging topic in Brazilian research, few studies use the concept of MA to describe the relationship between educators and the phenomenon (CAMPOS & MANRIQUE, 2020; FRANÇA & DORNELES, 2021).

Although there are some studies on the BF phenomenon in Brazil, most refer to students (CARMO & SIMINOATO, 2012; MENDES & CARMO, 2014). Furthermore, no measurement instruments are found in the Brazilian literature that are associated with the phenomenon of MA among Brazilian teachers (FRANÇA & DORNELES, 2021).

In this work, the steps of theoretical analysis of the items of the American scale "Math Anxiety Scale for Teachers - MAST" will be described for cross-cultural adaptation to the Brazilian context. The results of the next stage, that is, the empirical analysis of the items, will be released later.

MATHEMATICAL ANXIETY (AM) FOCUSED ON TEACHERS

Initially, AM was described in 1957 as anxiety about numbers. The first definition emerged as a "feeling of tension and anxiety that interferes with the manipulation of numbers and the resolution of mathematical problems in everyday and academic life situations" (RICHARDSON & SUINN, 1972). The definitions of AM vary according to the focus in performance (feelings of tension or fear that interfere with mathematical performance) or in oneself (discomfort in situations involving mathematical tasks that are perceived as threatening to self-esteem).

According to the American Psychological Association (APA, 2014), anxiety is an emotion characterized by feelings of tension, worried thoughts and physical changes. MA has been defined in various ways in the academic world (RICHARDSON & SUINN, 1972; CHINN, 2009; ARTEMENKO, DAROCZY & NUERK, 2015; DOWKER, SARKAR & LOOI, 2016; MOORE, RUDIG & ASHCRAFT, 2014; SUÁREZ-PELLICIONI, NÚÑEZ-PEÑA & COLOMÉ, 2016), however the most common trait is a type of discomfort or nervousness that arises when thinking or doing mathematics, a kind of "phobia", characterized by a set of physiological, cognitive and behavioral

reactions (HAASE, GUIMARÃES & WOOD, 2019). Physiological reactions are associated with emotion and related to what the individual experiences in the body (sweating, tachycardia, headache, tremor, tense posture, discouraged facial expression, high pulse rate, etc.), while cognitive reactions are related to thoughts negative, intrusive and unwanted (constant worry, low self-esteem and self-efficacy, feelings of helplessness, etc.), these thoughts end up generating a pattern of escape and avoidance behavior (evasion, rush to finish mathematical tasks) (MENDES & CARMO, 2014).

The AM phenomenon can be influenced by several factors in the individual's learning history, such as parental influence, the way the family deals with mathematics, social stereotypes and beliefs disseminated in society such as "only very intelligent people learn mathematics", "mathematics is for a select few", "men learn more mathematics than women" and so on. MA can also be due to inadequate methodologies, recurrent experiences marked by failure in trying to learn mathematics and coercive control with excessive punishment by the family and/or teachers with verbal punishment, ridicule, punishment and absence of reinforcing positive stimuli (CARMO & SIMINOATO, 2012). Finally, there are many factors that contribute to AM, which can thus influence self-esteem and socio-emotional development, contributing to a decrease in the feeling of self-efficacy in problem solving and impairing student learning, which may even require specialized care.

Furthermore, in addition to impacting student performance and their physical and emotional well-being, MA can also affect life trajectories and academic choices (FRANÇA & DORNELES, 2021). However, as it is not exclusive to students, it can also occur among teachers who teach the subject. Because it is an emerging topic in Brazilian research, few studies use the concept of MA to describe the relationship between educators and the phenomenon (CAMPOS & MANRIQUE, 2020; FRANÇA & DORNELES, 2021).

International researchers have increasingly recognized the importance of teachers' emotions for their well-being and teaching. Focusing on one of these emotions, anxiety, specifically in the context of mathematics is critical, as college students who specialize in early childhood and elementary school have been found to have higher levels of MA (HEMBREE, 1990).

Since the 1980s, polyvalent or specialized teachers have been identified as a group with high levels of AM. Results from international studies have shown that mathematically anxious teachers tend to conduct their class in a more traditional way, focusing on the mechanics of arithmetic to the detriment of concepts, resisting student questions and being less inclined to alternative practices such as games or group work (BUSH, 1989). Recent studies have found a direct relationship between teachers' MA and their students' performance. More anxious teachers harm their students' performance or performance, and this harm is magnified if students perceive that the teacher does not believe that everyone can do well in mathematics (RAMIREZ et al., 2018).

MA in teachers was identified as a potentially important emotion experienced especially in lower elementary school teachers (GANLEY et al., 2019). Teachers can experience a range of positive and negative emotions related to teaching. These emotions could be about meeting the needs of your students, about the subjects you teach, or about your ability to teach.

According to Ganley et al. (2019), there is a distinction between the components of teacher anxiety in relation to mathematics. The authors consider that there are two forms

of anxiety in teachers: General Mathematics Anxiety (GMA) and Mathematics Teaching Anxiety (AEM). Furthermore, the authors also claim that AM scores correlate with other teacher characteristics, such as: greater AM is associated with lower mathematical knowledge for teaching, more traditional beliefs about teaching and learning mathematics, being a lower elementary school teacher, and lack of specific mathematics teaching credentials (GANLEY et al., 2019).

Because it is still an emerging theme in Brazilian research, few studies use the concept of AM to describe the relationship between teachers and the discipline. Studies show that the aversive relationship with mathematics may have its origin in the teachers' school period, preventing them from having a training that qualifies their pedagogical practice (COSTA & POLONI, 2012), generating a number of teachers who do not feel comfortable with the mathematical content they will teach. There are suspicions that there is a specific manifestation of MA in teachers in Brazil, the anxiety of teaching mathematics, which still needs to be better studied. However, studies with Brazilian teachers still do not use the AM paradigm to describe this aversive relationship with the discipline and it is not clear what are the cognitive and pedagogical impacts on these subjects, nor how this specific manifestation is related to the affective-cognitive model (FRANCE & DORNELES, 2021).

THE MATH ANXIETY SCALE FOR TEACHERS (MAST)

The original version of the Mathematics Anxiety Scale for Active Teachers - MAST was developed by Ganley, Schoen, Lavenia and Tazaz (2019) with the aim of measuring MA symptoms among teachers who teach mathematics. The study included 399 elementary school teachers from public schools in Florida, in which the authors defined evidence of construct validity.

According to the authors of MAST (GANLEY et al., 2019), the items were prepared based on a systematic review of the construct, where their choice was based on the assumption of the distinction between two components or forms of manifestation, namely: the General Mathematics Anxiety (AMG) and Mathematics Teaching Anxiety (AEM). The first form (AMG), would be anxiety about oneself doing math, which could be thought of as math anxiety in the general population. The other form (AEM) refers to the anxiety that the person feels about their ability to teach mathematics.

The MAST is a self-report instrument, self-administered, easy to administer, consisting of 15 statements in order to measure the level of MA of teachers. The authors identified different factorial structures: one-dimensional, two-factor distributed in two distinct factors AMG (in the first 9 items) and AEM (in the last 6 items) and, finally, in a four-factor model. This last model subdivided the AMG factor into three subfactors (emotionality, concern and social/evaluative). The instrument allows responses on a 5-point Likert scale, ranging from 1 to 5, with: *(1)* ***never true*** *to me* ***(2) usually not true*** *to me* ***(3) sometimes true*** *to me* ***(4) usually true*** *to me* ***(5) always true*** *to me,* where the higher the score, the higher the level of AM (GANLEY et. al, 2019). Participants are asked about how they react to situations involving knowledge and teaching of mathematics. The scores are calculated from the total sum and the sum per domain (AMG and AEM). The original version considers some degree of positivity of AM symptoms, when the results are equal to or greater than 16 points. If the teacher scores one point on all questions that correspond to "It is never true for me", the total of 15 points suggests that the teacher does not have any

degree of AM (GANLEY et al, 2019).

The scale presented, in its construction and validation study, good internal consistency (GANLEY et al, 2019). When considered as one-dimensional, the scale items obtained a Cronbach's Alpha of 0.96. When the AMG and AEM factors were considered separately (bifactorial), the indices were α = 0.97 and α = 0.91, respectively, and when the AMG factor was subdivided into three subfactors, they all had high internal consistency (emotionality, α = 0.94; concern, α = 0.94; social / evaluative, α = 0.92) (GANLEY et. al, 2019).

No publication was found in the Brazilian literature that reports the translation and validation of any MA scale for teachers, nor any instrument validated in Brazil that measures symptoms of MB in this population, thus it was necessary to better understand how this phenomenon manifests itself. in the Brazilian context. Thus, because it is up-to-date and close to the Brazilian educational culture and reality, MAST was chosen to carry out the Transcultural Adaptation (CTA) process, as the main author's doctoral research. The study referring to the stages of the theoretical analysis of the items is the focus of this article.

TRANSLATION AND ADAPTATION OF MAST

The steps for the cross-cultural adaptation process (TCA) were based on BORSA et al., (2012), HUNGERBÜHLER & WANG (2016) and PASQUALI (2010). The CTA process of the MAST scale for the Brazilian context followed the steps recommended in the literature on the adaptation of instruments in mental health, consisting of several distinct steps, namely: i) contact and authorization of the authors of the original instrument, ii) translations into Portuguese, iii) synthesis of translations, iv) expert analysis and semantic analysis, v) pre-test vi) back-translation and vii) presentation of the preliminary version to the authors of the original instrument. As shown in figure 1 below.

After approval of the project by the Ethics Committee of the Teaching Institution (UCPEL), under opinion No. 5,541,636 of 07/23/2022, contact was made with the authors of the MAST scale (GANLEY et. al, 2019), via e-mail, requesting your authorization to adapt the instrument to the Brazilian context. Concomitantly, a study of construct equivalence was carried out through bibliographic research to verify the existence of studies and articles that dealt with the BF phenomenon and its characteristics.

In the semantic equivalence stage, the MAST was sent to two bilingual translators to carry out the translations from the source language (English) to the target language (Portuguese). Thus, two translations (T1 and T2) into Brazilian Portuguese were performed. The T1 translation was performed by an English language translator, while the T2 translation was performed by an expert in the construct, also fluent in English. The analysis of the summary version of the translations was carried out by a committee formed by the researcher and two professionals in the area of mathematics.

The summary version of the translations, after a Portuguese revision, was submitted to five specialists to assess the verbal comprehension and pertinence items of each item of the scale. The specialists (1 psychiatrist, 1 psychologist, 1 pedagogue, 1 professional in the area of mathematics and 1 professional in the area of statistics) were invited to participate through telephone and/or digital contacts. These professionals were asked to indicate on a 5-point Likert scale how clear and relevant each item of the scale was to the construct, ranging from 1 "not clear/relevant" to 5 "very clear/relevant", following the model by Hernández- Neto, who considers satisfactory results above 0.80 (2002, quoted

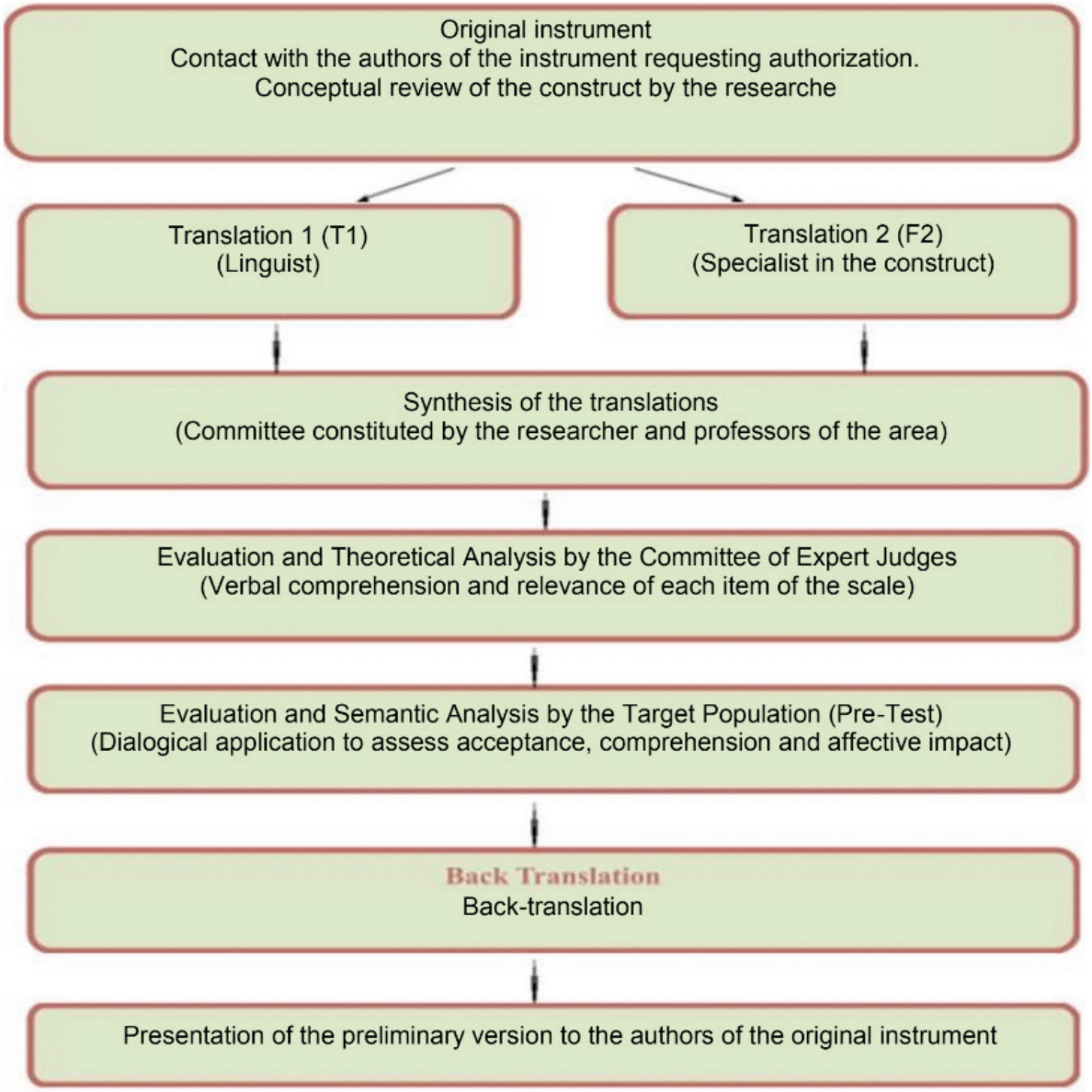

Figure 1 – Flowchart of the steps of the Cross-Cultural Adaptation process (ATC).

Synthesis of translations	Back translation	Trial Version
1. My hands get sweaty when I have to solve a difficult math problem.	1. My palms start sweating if I have to solve a difficult math problem.	1. My hands get sweaty when I have to solve a difficult math problem.
2. I panic when I have to solve difficult/challenging math problems.	2. I panic (I freeze, I get chills, I cannot reason, my heart is racing, I want to escape) when I have to solve difficult/challenging math problems.	2. I panic (I freeze, I get chills, I can't think, my heart is racing, I want to escape) when I have to solve difficult/challenging math problems.
3. I have a feeling it won't work when I think about solving math problems.	3. I have a feeling it will not work when I think of trying to solve math problems.	3. I have a feeling it won't work when I think about solving math problems.
4. Feelings of anxiety interfere with my ability to solve math problems.	4. Feelings of anxiety (fear, tension, excitement, nervousness) interfere with my ability to solve math problems.	4. Feelings of anxiety (fear, tension, agitation, nervousness) interfere with my ability to solve math problems.
5. It gives me a blank when I start to solve a difficult math problem.	5. My mind goes blank when I start a challenging math problem.	5. It gives me a blank when I start to solve a difficult math problem.
6. I get distressed when given more advanced math problems to solve.	6. I get distressed when I receive advanced math problems to solve.	6. Fico angustiado(a) quando recebo problemas de Matemática de nível mais avançado do que estou acostumado(a) a resolver.
7. I feel self-conscious when I don't know how to solve a math problem right away.	7. I feel self-conscious when I do not know how to solve a math problem right away.	7. I feel self-conscious when I don't know how to solve a math problem right away.
8. I get nervous when my math ability is being evaluated.	8. I get nervous when my math ability is being evaluated.	8. I get nervous when my math ability is being evaluated.
9. I would feel nervous if I had to solve a math problem in front of other adults.	9. I feel nervous about solving a math problem in front of other adults.	9. I feel nervous if I have to solve a math problem in front of other adults.
10. I am afraid of making mistakes when solving math problems in front of my class of students.	10. I am afraid of making mistakes while solving math problems in front of my students.	10. I am afraid of making mistakes when solving math problems in front of my students.
11. I would be nervous teaching Mathematics to students at a higher level than I am used to teaching.	11. I get nervous teaching math to students in a grade level any higher than I am used to teaching.	11. I get nervous teaching Mathematics to students at a higher level than I am used to teaching.
12. I would feel uncomfortable if another teacher observed me during my math class.	12. I feel uncomfortable if another teacher observes me teaching a math lesson.	12. I feel uncomfortable if another teacher watches me during my math class.
13. When I'm teaching, I avoid going into detail about mathematical concepts that I don't master very well.	13. When I am teaching, I avoid going into depth about math concepts I do not master highly.	13. When I'm teaching, I avoid going into detail about mathematical concepts that I don't master very well.
14. I would feel uncomfortable if a student asked me to explain why an advanced math strategy works.	14. I feel uncomfortable if a student asks me to explain how an advanced math strategy works.	14. I feel uncomfortable if a student asks me to explain how an advanced math strategy works.
15. I get nervous when I have to solve a math problem in front of my class if I haven't found a solution before.	15. I get nervous when I have to solve a math problem in front of my students if I have not already figured out the solution.	15. I get nervous when I have to solve a math problem in front of my students if I haven't found the solution before.

Table 1 – Stages of synthesis of translations, back-translation and experimental version of MAST-BR items

by CASSEPP-BORGES et al., 2010, p. 506-520).

Based on the suggestions and/or considerations presented by the specialists, minor adjustments were made to the summary version of the scale. Afterwards, a pilot study was carried out with the experimental version of the MAST-BR scale, which was submitted to representatives of the target population as a form of a pre-test, for convenience, consisting of 20 teachers from the Early Years, from different neighborhoods and public schools from the city of Pelotas. At this stage, a dialogued application was carried out in an electronic form to assess the acceptance and understanding of the instrument by the teachers of the target population. Teachers were asked to give feedback on the clarity and understanding of each item on the scale, expressing their suggestion to improve the wording of the item, if it was not clear.

The back-translation of the experimental version of the MAST-BR scale into the source language (English) was performed by a bilingual professional (English/Portuguese), who was unaware of the original instrument (MAST). After this back-translation, the experimental version of the scale was sent to the authors of the original version for consideration. With the favorable opinion of the authors, the experimental version was completed.

THEORETICAL ANALYSIS RESULTS

The synthesis of the translations, after minor adjustments made by the committee composed of the researcher, was evaluated by the specialists (n= 5) regarding the clarity and pertinence of the items by the Content Validity Coefficient (CVC). The scale obtained a total CVC of 0.94, a value considered very satisfactory. All items scored above 0.76, in both criteria, with some items obtaining the maximum score (1.0). Table 1 presents the CVC of the items and the general scale.

Items	CVC	
	Clearness	**Relevance**
1. My hands get sweaty when I have to solve a difficult math problem.	1,0	1,0
2. I panic when I have to solve difficult/challenging math problems.	1,0	1,0
3. I get the feeling that it won't work when I think about solving math problems.	0,76	1,0
4. Feelings of anxiety interfere with my ability to solve math problems.	0,92	1,0
5. I get a blank when I start to solve a difficult math problem.	0,80	1,0
6. I get distressed when given more advanced math problems to solve.	0,84	0,96
7. I feel self-conscious when I don't know how to solve a math problem right away.	0,92	1,0
8. I get nervous when my math skills are being evaluated.	0,84	0,96
9. I would feel nervous if I had to solve a math problem in front of other adults.	0,80	0,96
10. I am afraid of making mistakes when solving math problems in front of my class.	1,0	1,0
11. I would be nervous teaching math to students at a higher level than I am used to teaching.	0,92	1,0
12. I would feel uncomfortable if another teacher watched me during my math class.	0,88	0,96
13. When I'm teaching, I avoid going into detail about mathematical concepts that I don't master very well.	1,0	0,96
14. I would feel uncomfortable if a student asked me to explain why an advanced math strategy works.	0,92	0,92
I get nervous when I have to solve a math problem in front of my class if I haven't found a solution before	0,84	8,96
CVC Total	**0,94**	
Pe	0,000320	

Table 1. Content Validity Coefficient (CVC) after Judging Committee Review.

Caption: CVC = Content Validity Coefficient; Pe = Error Calculation.

Regarding the changes in the scale items, there were few suggestions from the specialists, only small adjustments related to the inclusion/change of pronouns, verb tenses, addition of words and standardization of the text were made. The experts' suggestions were accepted by the researchers with the intention of facilitating understanding. In items 2 and 4, words were added to exemplify panic symptoms (I paralyze, I have chills, I can't reason, my heart races, I want to escape) and feelings of anxiety (fear, tension, agitation, nervousness); the expression "I panic..." in item 2 was replaced by "I panic..."; in item 6, "what I am used to" was added; in items 7, 9, 12 and 14, the expressions "I feel... and I would feel..." were replaced by just "I feel ", adjusting the verb tense to the present and standardizing the expression; likewise in item 10 the expression "I am afraid of..." was replaced by just "I am afraid of..."; in item 11 "I would be nervous..." by just "I get nervous..." fitting all in the same pattern and finally in item 15 "my group of students" was replaced by "my students". The changes can be seen in Chart 1.

In the pre-test, the teachers (n= 20) did not show difficulties regarding the instructions, understanding the items and completing the instrument. Therefore, no adjustments were necessary.

FINAL CONSIDERATIONS

The AM concept has been built over the past 60 years. This field of science is gradually attracting attention in Brazil. Although some national researchers have recently dedicated themselves to the study of the AM phenomenon (CARMO & SIMINONATO, 2012: MENDES & CARMO, 2014; HAASE, GUIMARÃES & WOOD, 2019; CAMPOS & MANRIQUE, 2020; SILVA, NETO & GONÇALVES, 2020; FRANÇA & DORNELES, 2021), the majority refers to students, there is a long way to go regarding the focus on teachers, until more concrete hypotheses and results regarding the phenomenon are reached. However, even in the face of incompleteness, AM was established not only in the field of education, but also in the field of health promotion, discussing the expansion of the concept beyond the cognitive performance of students and teachers, but also physical and emotional.

To expand studies on MA in teachers, it is important to have instruments to quantify and track the phenomenon. In this sense, with the aim of making research possible, the cross-cultural adaptation of the MAST was one of the doctoral goals of the main author of the chapter. With regard to the evaluation of the conceptual equivalence of the items, the bibliographic review on the subject and the discussion and debate among professionals specialized in the area pointed to the clarity and pertinence of the instrument adapted in the culture. It must be noted that the MAST-BR is still in the process of adaptation and needs the completion of psychometric analyzes to assess the validity and reliability of the instrument for the Brazilian context.

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