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PREDICTING MATHEMATICAL COMPETENCE IN COMPULSORY SECONDARY EDUCATION THROUGH MATH ANXIETY AND ATTITUDES TOWARD MATHEMATICS

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PhD Candidate | Supervisor

Bilbao, July 2016

Predicting mathematical competence in Compulsory Secondary Education through math anxiety and attitudes toward Mathematics

By: Lara Yáñez Marquina

Supervisor: Dr. Lourdes Villardón Gallego

To my mum,

who despite her own math anxiety, was my first math teacher.

To my dad,

who despite the shortcomings, taught me how to make advantage of the little things life offers us.

To my brother,

who despite the adversity, encouraged me to pursue my dream until making it come true.

To Aimar,

who despite our little spare time together, constantly showed me what love really means.

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List of abbreviations

AMA	Academic Math Anxiety
ANOVA	Analysis of variance
ATM	Attitudes Toward Mathematics
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CI	Confidence Interval
ELMA	Everyday Life's Math Anxiety
EVT	Expectancy-Value Theory
EFA	Exploratory Factor Analysis
HMA	High Math-Anxious
ICC	Intraclass Correlation Coefficient
IfM	Interest for Mathematics
IoM	Importance of Mathematics
LMA	Low Math-Anxious
MA	Math Anxiety
MACH	Mathematics Achievement
MANOVA	Multivariate Analysis of Variance
ML	Maximum Likelihood
MLA	Math Learning Anxiety
MTA	Math Test Anxiety
PET	Processing Efficiency Theory
PUM	Perceived Usefulness of Mathematics
PUIM	Perceived Usefulness and Importance of Mathematics
SAMAS	Scale for Assessing Math Anxiety in Secondary education
SATMAS	Scale for Assessing Attitudes toward Mathematics in Secondary education
SEM	Structural Equation Modeling
SDT	Self-Determination Theory
SMSC	Student's Math Self-Concept
SPSS	Statistical Package for the Social Sciences
TRAPD	Translation, Review, Adjudication, Pre-testing and Documentation
WM	Working Memory

Introduction

Introduction

In past years, students' mathematical underperformance has become a worrisome issue in many countries (Scherer, 2002; Lipnevich, MacCann, Krumm, Burrus, & Roberts, 2011). Failure in mathematics has often been associated with the so-called myth of mathematics and the individual's intellectual ability (Arem, 2003). That is to say, mathematical aptitude has been traditionally seen as a skill born naturally in such a way that being good in mathematics has meant being intellectually gifted. However, even when students have the proper intellectual skills, intrusive thoughts about doing well in mathematics, lack of interest toward the subject or low self-confidence in their own ability to perform mathematically may hinder the successful completion of mathematical tasks.

Thus, mathematics is not simply a matter of knowing how to crunch numbers. It is a language on its own, as well as a way of thinking. Mathematics mean searching for and finding solutions to different problems, not only for satisfying academic or professional prerequisites but also for facing a broad range of common situations requiring abstract reasoning. Many of today's jobs require mathematical and scientific knowledge. Let's think, for example, in business, social science, health care or engineering occupations. But mathematics flood other non-technical areas. It is, in fact, everywhere. Without becoming aware, mathematical thinking and problem solving skills are used constantly in day-to-day situations such as planning activities, handling data or estimating household finances.

Despite the growing importance of mathematical thinking and mathematics-related skills for individual's full development in society, the subject, unfortunately, is still perceived by most students as abstract, difficult, boring and without relation to everyday life's tasks (Gil, Blanco, & Guerrero, 2006). This distate, which has its roots in upper elementary school (Wigfield & Meece, 1988; Ashcraft & Krause, 2007; Legg & Locker, 2009; Young, Wu, & Menon, 2012), worsens over time and continues in adulthood, stage in which it manifests through several behavioral symptons, such as trying not to use mathematical knowledge whenever possible (Meece, Wigfield, & Eccles, 1990; Ashcraft & Krause, 2007; Krinzinger, Kaufmann, & Willmes, 2009). This mathematics-related avoidance pattern, undoubtedly, shapes individuals' personal and career choices.

In an effort to address these shortcomings, there has been a resurgent interest in investigating potential factors with a significant effect, either positive or negative, on mathematics achievement and teaching. As a result, research has pointed out the correlation between several variables and mathematical outcomes. Specific examples are students' past experiences in mathematics or mathematics-related situations, parental and/or peer pressure, a dismatch between student's learning styles and curricular subject, or mathematics teachers' own attitudes toward the subject (e.g., Martinez & Martinez, 1996).

Interestingly, throughout literature, these previously noted variables have been shown to be primary factors for the origin and development of two more complex affective- and cognitive-based mechanisms, named mathematics anxiety (math anxiety, for short) and attitudes toward mathematics, widely acknowledged in the field because of their adverse effects on the learning and mastery of the subject. Their definition in the mathematics education as student-related constructs goes back to the early 1950s and 1930s, respectively. Since then, great efforts have been made to conceptualize and operationalize them in a comprehensive and reliant way in order to further analyze their contribution in predicting students' mathematics achievement. However, this task has become really tough because of their multidimensional nature.

Relationships between math anxiety and mathematics achievement, on the one hand, and attitudes toward mathematics and mathematics achievement, on the other hand, have been traditionally studied as separate lines within the field of mathematics education. Indeed, the greatest body of research has focused on highlighting the significant correlations between overall mathematical performance and different dimensions underlying both math anxiety and attitudes toward mathematics. In attempts to summarize and report the main findings of those studies carried out with different age groups worldwide, Hembree (1990), Ma and Kishor (1997), and Ma (1999) conducted a meta-analysis each. As a result, the three studies agreed not only in underscoring moderate to high significant correlations, but also in recognizing the relevance of both math anxiety and attitudes toward mathematics as essential key aspects to consider in every mathematics educational programme.

Recently, this evidence has been supported by Structural Equation Modeling approaches, which have consistently underscored the causal relationships between the variables. Therefore, math anxiety and attitudes toward mathematics are no longer separate research lines within the field of mathematics education, but two multidimensional constructs, woven tighly together, which exert a significant effect on predicting mathematical performance. Even though great steps have been made in this direction, conclusions are still inconclusive and even more important, highly reliant not only on the measures used for the research but also on the sociocultural background of the sample.

Thus, in attempts to expand knowledge on previous research, the main objective has been to analyse Biscayan students' math anxiety and attitudes toward mathematics and their influence in predicting their later mathematical competence from the beginning to the end of the mathematics course in Compulsory Secondary Education. Based on these considerations, the driving topics in the present PhD thesis are math anxiety, attitudes toward mathematics and mathematical competence. To address the previously noted goal, the research has been divided into eight chapters, as explained as follows.

The first chapter, "Math anxiety", presents a literature review of both theoretical and empirical research regarding this key construct. It begins with a historical overview of its definition and intrinsic characteristics, from the first allusion in literature to later definitions. The chapter then continues by exposing the theoretical approaches aiming to explain its origin and prevalence over time. To complement evidence, the latest findings in the field of neurocognitive research are briefly explained, supporting, from another view, previous hypotheses and theories about the mechanisms underlying math anxiety. To conclude the chapter, there is a description of the existing instruments for assessing math anxiety, showing the way in which this construct has been operationalized in differing factor structures through relevant literature.

The second chapter, "Attitudes toward mathematics", focuses on the second main construct of the present PhD thesis. It is divided into four major sections: definition, theoretical frameworks, attitude formation and change, and its factor structure and assessment. Since attitudes towards mathematics cannot be understood without referring previously to the more general term attitude, this second chapter begins with a theoretical background about the definitions given in literature for the construct attitude. A more detailed analysis of these descriptions provides the basis for the subsequent section regarding theoretical frameworks dealing with affective, cognitive and behavioural components of its conceptualization. Next, there is a description of the main approaches aiming to explain the underlying mechanisms for the formation and development of individual's attitudes as time evolves. To conclude, the chapter encompasses another integrative literature review on existing instruments for assessing this second construct.

The third chapter, "Mathematics achievement" summarizes the main findings of empirical research. Firstly, there is a review on the relationship between math anxiety and overall mathematics achievement, taking into account both the correlational and the causal studies carried out until date. Secondly, this very same review is conducted with overall mathematics achievement and attitudes toward mathematics. Thirdly, a more integrative review is included by considering the jointly effect of both math anxiety and attitudes toward mathematics in predicting students' mathematical performance.

Having exposed the state of the art that provides the basis for this PhD thesis, the fourth chapter collects the major concerns drawn from previous literature and describes the research objectives. For that, there is a description of the method, samples, variables, instruments and analyses for each of the three major empirial sections of the present research. Each of them addresses a specific objective, and consequently, results are then presented in separate chapters in order to facilitate the interpretation and discussion of the corresponding results.

That way, the fifth chapter focuses on the development and validation of the Scale for Assessing Math Anxiety in Secondary education (SAMAS). The sixth chapter, on the development and validation of the Scale for Assessing Attitudes Toward Mathematics in Secondary education (SATMAS). And the seventh chapter, on the structural model for explaining secondary education students' mathematical competence, based upon the jointly effect of both math anxiety and attitudes toward mathematics. As noted, each of these chapters does not limit to a mere exposure of research results but includes a discussion section based upon previous literature in the field.

In the last chapter, there is an initial section summarizing the main findings of the present PhD thesis, which allows taking an integrative overview of the research as a whole. Drawn from these, the following section involves the educational implications and suggests some pedagogical interventions aiming to improve the learning and mastery of mathematics in the context analyzed, that is, Compulsory Secondary Education. Finally, methodological considerations and several issues are suggested for future research to address.

Chapter 1

Math anxiety

CHAPTER

1

Math anxiety

This chapter presents a literature review on one of the key constructs of the present PhD thesis, that is, math anxiety (henceforth, MA). To address this topic, there is a first section with the chronological evolution of the term through literature. A proper understanding of the theoretical approaches aiming to explain its origin and prevalence is presented, which, in turn, is completed with the latest evidence about the neurocognitive mechanisms underlying its arousal. The last part describes the existing instruments for assessing MA. This analysis provides a more in-depth look into both the factor structure proposed for the construct through relevant literature and the major limitations and concerns encountered when defining it.

1.1. DEFINITION

The research on MA has its roots in the early 1950s, when Gough (1954), in attempts to explain her students' dropout rates in mathematics proposed the term *mathemaphobia* to refer to an specific phenomenon that encompassed a broad range of feelings of tension toward the subject. This was the first allusion to MA in literature and even nowadays, it is considered to be a major breakthrough in educational psychology because until that date, any expression of anxiety in the scholastic setting was commonly regarded as a form of the more general traits anxiety or test anxiety. That is to say, prior Gough's (1954) proposal, it was not acknowledged the existence of a specific content type of anxiety which could refer to feelings of tension toward mathematics-related situations.

Over time, the existence of a specific type of anxiety in mathematics has been consistently confirmed through several empirical studies (e.g., Morris, 1981; Dew, Galassi, & Galassi, 1984; Hunsley, 1987; Hembree, 1990; Zettle & Raines, 2000). For example, an early study by Dew, Galassi, and Galassi (1984) found that two thirds of the variance in MA remained unexplained by test anxiety. In line with this finding, Hunsley (1987) concluded that MA had more incremental validity than test anxiety when predicting the cognitive processes involved in mathematical examinations. Also noteworthy, Hembree's (1990) meta-analysis reported a corrected correlation of r = .38 between MA and trait anxiety. As a result, these findings not only supported Gough's (1954) hypothesis, but also underscored that MA does indeed exist and that it is a content specific type of anxiety related to, but conceptually distinct from both the more general traits anxiety and test anxiety.

Besides the empirical studies aiming to support its existence, during the last four decades, MA has been submitted to several definitions. Some of the most worth mentioning on reviewing literature are listed below:

- "an irrational impeditive dread of mathematics" (Lazarus, 1974, p. 551);

- “the panic, helplessness, paralysis and mental disorganization that arises among some people when they are required to solve a mathematical problem” (Tobias, 1978, p. 65);

- “an uneasiness, nervousness or apprehension regarding mathematics and mathematical perfomance” (Chavez & Widmer, 1982, p. 387);

- “a state of discomfort which occurs in response to situations involving mathematical tasks which are perceived as threatening to self esteem” (Cemen, 1987, p. 210);

- “the general lack of comfort that someone might experience when required to perform mathematically” (Wood, 1988, p. 11);

- “a general fear of contact with mathematics” (Hembree, 1990, p. 45);

- “the feeling of tension, apprehension or even dread, that interferes with the ordinary manipulation of numbers and the solving of mathematical problems” (Ashcraft & Faust, 1994, p. 98).

However, perhaps the most prominent and widespread definition has been that given by Richardson and Suinn (1972). According to these authors, “mathematics anxiety involves feelings of tension and worry that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations” (Richardson & Suinn, 1972, p. 551). This might be considered the primary and most complete conceptual proposal for MA, from which all above mentioned definitions are derived.

Indeed, although different in their conceptualization, all these definitions highlight that MA hinders individuals' acquisition of mathematical reasoning, meaning an adverse effect on their day-to-day life, career choices and long-term professional success, as also noted in relevant literature (e.g., Hembree, 1990; Ma, 1999; Ashcraft & Krause, 2007; Young, Wu, & Menon, 2012; Wu, Willcutt, Escovar, & Menon, 2013). Consequently, given both the evidence of its own nature and the detrimental effect on individuals' personal and professional life, MA becomes a relevant topic in the field of mathematics education.

1.2. THEORETICAL APPROACHES AIMING TO EXPLAIN ITS ORIGIN AND PREVALENCE

Importantly, the previously noted negative feelings may arise immediately or in anticipation of doing a mathematical task, meaning that MA not only affects the way in which individuals perform mathematically but also the amount of mathematics they learn (Hopko, McNeil, Zvolensky, & Eifert, 2001; Vukovic, Kieffer, Bailey, & Harari, 2013). Moreover, there is growing evidence that MA has its roots in upper elementary school and increases in severity from 5th through 12th grade (Morris, 1981; Wigfield & Meece, 1988; Chiu & Henry, 1990; Hembree, 1990; Miller & Mitchell, 1994; Swetman, 1994; Jackson & Leffingwell, 1999; Ma, 1999; Stuart, 2000; Ashrcraft & Krause, 2007; Scarpello, 2007; Legg & Locker, 2009; Geist, 2010; Young, Wu, & Menon, 2012).

This way, as time evolves, the detrimental impact of MA leads individuals to a mathematics-related avoidance pattern, as well as to a continuous struggle to perform even the simplest numerical tasks, namely addition or subtraction (Hembree, 1990; Meece, Wigfield, & Eccles, 1990; Ma, 1999; Ashcraft, 2002;

Ashcraft & Ridley, 2005; Ashcraft & Krause, 2007; Jackson, 2008; Krinzinger, Kaufmann, & Willmes, 2009). Despite the growing evidence about the topic, there is no consensus when defining the theoretical framework which might explain the mechanisms of origin and development of the phenomenon through individual's life. In literature, two approaches have been commonly taken as the starting points to better ascertain such mechanisms: behaviourism and cognitivism.

On the one hand, the behaviourist perspective is mainly framed within the stimulus-response psychology, according to which, repeating conditioning in the past may affect individual's later behaviour (Bandura, 1977; Martinez & Martinez, 1996). For example, being repeatedly discouraged in mathematics might create a negative association with the subject, which in turn may result in fear, poor self-confidence, an avoidance pattern and finally, a conditioned MA over time. Therefore, within this theory, learners are referred to as reactive agents who match their behaviour based upon the present conditioners. However, repeating conditioning might be reversed to support students' positive feelings toward mathematics, as proposed in the so-called law of effect (Thorndike, 1905). Indeed, repeating conditioning might lead mathematics learners to repeat positively rewarded behaviours because of their positive consequences; whereas they would discard punished acts because of their negative consequences (Papalia & Olds, 1992).

On the other hand, from a cognitive view, MA has been explained as an outcome of the hierarchical cognitive development in mathematics (Bruner, 1966). According to this approach, mathematics learners are active agents in their own progressive growth in mathematics achievement. However, when there is a shift in this continuous progress, as it occurs from the manipulative mathematics in primary education to the more abstract mathematical contents in secondary education, students might suffer from a cognitive mismatch, which ultimately leads to MA. Indeed, this educational transition is considered in previous literature as a critical turning point in which students' levels of MA reach peak levels (Wigfield & Meece, 1988; Chiu & Henry, 1990; Hembree, 1990; Ma, 1999; Ashrcraft & Krause, 2007; Scarpello, 2007; Legg & Locker, 2009; Geist, 2010; Young, Wu, & Menon, 2012). Therefore, it is not a matter of students' lack of ability in mathematics but a lack of a proper adjustment to curricular contents.

As noted, both behaviourism and cognitivism have been the two main approaches attempting to explain the formation and development of MA. However, they have been discussed to provide a partial explanation to the phenomenon. Thus, in attempts to reach a more comprehensive framework, a third alternative theory has been proposed by Triandis (1977). It is the so-called affective-cognitive consistency theory, whereby both the behaviorist and the cognitive components are woven tightly together in a stimulus-response chain. In other words, changes in one component mean changes in the other component. By extending this theory to the field of mathematics education, as MA increases, students are more likely to underperform in the subject, which, in turn, worsens both their confidence about doing mathematics and MA. This way, the next time that students face a mathematical task, since their levels of MA have increased, performance in the subject will be even worse, with an additional negative effect on their affective domain. This reciprocal effect, which manifests in a wide range of both behavioral and cognitive symptons, corresponds to the previously noted stimulus-response chain.

In previous paragraphs, being repeatedly discouraged, a curricular mismatch or a low confidence have been proposed as variables that might trigger MA. However, there are numerous others taking place in this complex stimulus-response chain. A prior classification sorts potential primary factors in three categories: environmental, intelectual and personal (Hadfield & McNeil, 1994).

First, enviromental factors include:

- negative past mathematics-related experiences (Aiken & Dreger, 1961; Parsons, Kaczala, & Meece, 1982; Meece, Wigfield, & Eccles, 1990; Tobias, 1990; Dossel, 1993; Newstead, 1998; Ashcraft, 2002; Ashcraft, Krause, & Hopko, 2007; Bekdemir, 2010);

- social, peer and parental pressure (Williams, 1988; Yee & Eccles, 1988; Osborne, 2001);

- or teachers' own mathematics anxiety (Hembree, 1990; Austin, Wadlington, & Bitner, 1992; Harper & Daane, 1998; Jackson & Leffingwell, 1999; Stuart, 2000; Vinson, 2001; Sloan et al., 2002; Furner & Berman, 2003; Malinsky et al., 2006; Swars, Daane, & Giesen, 2006; Gresham, 2009; Beilock, Gunderson, Ramirez, & Levine, 2010).

Second, intelectual factors include:

- poor mathematics curriculum and ineffective teaching techniques (Burton, 1979; Morris, 1981; Greenwood, 1984; Tobias, 1990; Bush, 1991;

Norwood, 1994; Herbert & Furner, 1997; Steele & Arth, 1998; Jackson & Leffingwell, 1999);

- or the type of mathematics assessment and test instrumentality in the subject (Miller & Mitchell, 1994; Turner et al., 2002).

Third, personal factors include:

- negative thoughts and attitudes, such as lack of confidence or interest in mathematics (Bursal & Paznokas, 2006; Chinn, 2009; Ahmed et al., 2010; Akin & Kurbanoglu, 2011; Jansen et al., 2013).

Interestingly, recent research has suggested that the development of MA might be also due to a combined effect of both environmental and genetic variables. Specifically, those genetic risk factors underlying poor mathematics ability and general anxiety, in addition to individuals' past negative experiences and others' pressure, might play an important role in predicting MA (Wang et al., 2014). This contribution is considered to be relevant, as it extents the previously noted Hadfield and McNeil's (1994) classification by adding a fourth category related to individual's genetic variables.

1.3. NEUROCOGNITIVE MECHANISMS OF ITS AROUSAL

The previously noted finding of genetic risk factors as plausible predictors for MA, along with the empirical evidence supporting the relationship between MA and general trait anxiety, suggests that the neurocognitive mechanisms underlying both general anxiety and MA might be similar. An initial interpretation of this hypothesis was the provided by the Processing Efficiency Theory (PET; Eysenck & Calvo, 1992). According to the PET, MA, as occurs when general trait anxiety awakens, involves worrisome thoughts. In the case of MA, those intrusive thoughts are the result of one or a combination of the previously noted factors (i.e., environmental, intelectual and/or personal factors), and compete for the availability of the limited working memory (henceforth, WM) resources.

To better ascertain this effect, it is important to explain that WM is a short-term memory system that controls and regulates the limited amount of information immediately relevant for the task at hand (Miyake & Shah, 1999; Engle, 2002). Thus, when a high math anxious (henceforth, HMA) individual faces a mathematical task highly reliant on WM resources for its completion, its performance is disrupted (Ashcraft & Faust, 1994; Faust et al., 1996; Ashcraft & Kirk, 2001). Indeed, HMA individuals are unable to block out intrusive thoughts and maintain focus on the mathematical task, which prevents them from using the mathematical knowledge they possess to perform it successfully (Hopko, McNeil, Gleason, & Rabalais, 2002; Beilock & Carr, 2005; Ashcraft & Krause, 2007; Legg & Locker, 2009; Beilock, Gunderson, Ramirez, & Levine, 2010). For example, operations such as two-column addition have been shown to take HMA three times longer than their LMA counterparts (Faust, Ashcraft, & Fleck, 1996) because of this effect.

Recent research on the neurocognitive field has strongly supported this interpretation (Young, Wu, & Menon, 2012; Wu, Willcutt, Escovar, & Menon, 2013). Specifically, when facing mathematics-related tasks involving WM resources, HMA individuals show an abnormal effective connectivity of the amygdala with other regions related to negative emotions, as well as an ineffective connectivity of the amygdala with the brain regions important for numerical processing. Likewise, their brains show hyperactivity in those regions associated with processing intrusive thoughts, while there is a reduced activity in brain regions associated with mathematical processing and attentional control (Young, Wu, & Menon, 2012).

An additional study by Lyons and Beilock (2012) completed this evidence by showing that these cognitive control resources not only are commited in HMA individuals during the mathematical task, but also in anticipation to have to perform mathematically. These empirical findings are completely consistent with the theoretical definition of MA given by Richardson and Suinn (1972) in the early 1970s, making it so prominent in the field.

1.4. THE FACTOR STRUCTURE AND ASSESSMENT

As seen, a sizeable international body of research on MA has focused on its factors, consequences and relationship with mathematics achievement. However, both correlational and causal studies involving MA are contingent on the psychometric properties of the instruments used for its assessment. Thus, a literature review on existing instruments for measuring MA is worth mention.

The focus has been put on measures with relevant constructs based on consistent definitions, broadly cited pieces of work in the field and recent findings that present the current state of research on MA. Additionally, studies involving secondary education students have been prioritised but those involving other cohorts have been considered when relevant. Details of that review are provided in Table 1.

Table 1

Instruments for assessing math anxiety

Instrument	Dimensions/Items	Description	Psychometric evidence
Numerical Anxiety Scale (Dreger & Aiken, 1957).	A 3-item scale, with two underlying factors. These items were integrated within the 47-item Taylor Manifest Anxiety Scale (TMAS; Taylor, 1953), showing that both scales, although related, were conceptually different.	It measures emotional responses in college students enrolled in basic mathematics courses (N=704).	Correlational studies with general trait anxiety (r =.33, p < .05) and IQ (r = -.25, p > .05)
Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972)	A 98-item scale, with no dimensions.	It measures math anxiety in students enrolled at university (N=397). Math anxiety is considered as a homogeneous construct.	EFA Test-retest reliability: r = .78 and r =.85 Cronbach's alpha: α=.97
Math anxiety subscale of the Fennema-Sherman Mathematics Attitude Scale (MAS; Fennema & Sherman, 1976)	A set of 9 subscales: mathematics anxiety scale (12), attitude toward success in mathematics scale (12), confidence in learning mathematics scale (12), effectance motivation in mathematics scale (12), father scale (12), mother scale (12), mathematics as a male domain (12), teacher scale (12)	Nine domain-specific scales measuring attitudes toward mathematics. One of them assesses math anxiety in high school age-populations (N=1,600).	EFA Split-half reliability (for the mathematics anxiety scale): r=.89

	and usefulness of mathematics scale (12).		
Anxiety Toward Mathematics Scale (ATMS; Sandman, 1980)	A set of 6 subscales, resulting in a total of 48 items: perception of mathematics teachers, value of mathematics, self-concept in mathematics, math anxiety, enjoyment of mathematics and motivation in mathematics.	It measures attitudes towards mathematics in secondary students. One of subscales assesses math anxiety in secondary students (*N*=5,034).	EFA Reliability coefficients ranged from *r* = .69 to *r* = .89 for the subscales
Revised version of the Math Anxiety Rating Scale (MARS-R; Plake & Parker, 1982)	A 24-item scale with two underlying factors: learning math anxiety (16) and math evaluation anxiety (8).	A shortened version of the 98-item MARS (Richardson & Suinn, 1972). It provides a more efficient degree of course-related math anxiety in undergraduate students.	EFA (PFA) Cronbach's alpha: α=.98 Correlation with the full MARS scale: *r* =.97
Math Anxiety Rating Scale-Adolescents (MARS-A; Suinn & Edwards, 1982)	A 98-item scale with two underlying factors: numerical anxiety (89) and mathematics test anxiety (9).	It measures math anxiety in junior and senior high school students (*N*=1,313).	EFA Split-half reliability: *r* = .90 Guttman's reliability: *r* = .89 Cronbach's alpha: α = .96
Math Anxiety Questionnaire (MAQ; Wigfield & Meece,	An 11-item scale with two underlying factors: negative affective reactions (7) and worry (4).	The scale comprises two factors. The former is related to the affective dimension,	EFA (PCA with Orthogonal and Oblique rotations) + CFA Cronbach's alpha for negative

1988)		whereas the latter refers to the cognitive dimension. It assesses math anxiety in 6th through 12th grade students (*N*=564).	affective reactions: α=.82 Cronbach's alpha for worry: α=.76
Abbreviated version of MARS (A-MARS; Alexander & Martray, 1989)	A 25-item scale with three underlying factors: math test anxiety, numerical test anxiety and math course anxiety.	It measures math anxiety in college students (*N*=517). Although its items refer to advanced mathematical concepts, A-MARS can be also used at high school level.	EFA Two week test-retest reliability: r = .86 Cronbach's alpha: Math test anxiety (α=.96) Numerical test anxiety (α=.86) Math course anxiety (α=.84)
Mathematics Anxiety Scale for Children (MASC; Chiu & Henry, 1990)	A 22-item scale with four underlying factors: mathematics evaluation anxiety, mathematics learning anxiety, mathematics problem solving anxiety and mathematics teacher anxiety.	It measures math anxiety in 4th to 8th grade (*N*=562).	EFA (PCA and VR) Cronbach's alpha ranged from α=.90 to α=.93 for the underlying factors
Math anxiety subscale of Escala de Actitudes hacia las Matemáticas (EAM;	A 25-item scale with five underlying factors: usefulness (5), confidence (5), anxiety (5), liking (5) and motivation (5).	It measures attitudes towards mathematics. One of the factors assesses math anxiety in middle through university	EFA (PCA and VR) Cronbach's alpha for anxiety: α=.92

Auzmendi, 1992)		students, aged 15 to 18 (*N*=1,221). Math anxiety is considered as a homogeneous factor.	
Mathematics Anxiety Survey (MAXS; Gierl & Bisanz, 1995)	The full scale comprises two subscales: test and problem solving anxiety.	It measures the level of nervousness to different situations involving mathematics in 3rd to 6th students.	EFA Cronbach's alpha ranged from α=.70 to α=.89 for the subscales
Math Anxiety Questionnaire (MAQ; Thomas & Dowker, 2000)	A 36-item scale with four underlying factors: self-perceived performance, attitudes, poor performance unhappiness and anxiety.	It rates experiences of unhappiness and worry caused by arithmetic problems in 5th to 6th grades (*N*=79).	EFA Cronbach's alpha ranged from α=.83 to α=.91 for the factors
Abbreviated Math Anxiety Scale (AMAS; Hopko, Mahadevan, Bare, & Hunt, 2003)	A 9-item scale with two underlying factors: learning math anxiety (5) and math evaluation/test anxiety (4).	It measures math anxiety in high school and college students (*N*=1,239)	EFA + CFA Test-retest reliability: *r*=.85 Cronbach's alpha: α=.90
Cuestionario para medir la ansiedad hacia las Matemáticas	A 24-item scale with five underlying factors: test anxiety (11), temporality anxiety (4), anxiety toward understanding mathematical	It measures math anxiety in Compulsory Secondary Education students aged 12	EFA Cronbach's alpha for the full scale: α=.95

(Muñoz & Mato, 2007)	problems (3), numerical anxiety (3), and anxiety toward everyday life's mathematics (3).	to 16 (*N*=1,220)	Cronbach's alpha for each underlying factor: test anxiety (α=.92), temporality anxiety (α=.96), anxiety toward understanding mathematical problems (α=.91), numerical anxiety (α=.95), anxiety toward everyday life's mathematics (α=.80)
Mathematics Anxiety Scale for Students (MASS; Ko & Yi, 2011)	A 65-item scale with four underlying factors: nature of mathematics (22), learning strategy (21), test/performance (9) and environment (13).	It measures math anxiety levels that middle and high school students experience in scholastic settings (*N*=2,339).	EFA (PCA and VR) + CFA Cronbach's alpha for the full scale: α=.77 Cronbach's alpha for each subscale: nature of Mathematics (α=.76), learning strategy (α=.73), test/performance (α=.73) and environment (α=.70)
Mathematics Anxiety Scale (MAS; Mahmood & Khatoon, 2011)	The 14-item scale consists of one homogeneous factor with 7 negatively worded items and 7 positively worded items.	It measures math anxiety in secondary students aged 15 to 17 (*N*=250). It is considered as a homogeneous	EFA Split-half reliability: r = .89 Cronbach's alpha:α = .87

		construct.	
Scale for Early Mathematics Anxiety (SEMA; Wu, Barth, Amin, Malcarne, & Menon, 2012)	A 20-item scale with two underlying factors: numerical processing anxiety (9) and situational and performance anxiety (11).	It measures math anxiety in 2^{nd} to 3^{rd} grades (N=162)	EFA (PCA and VR) Split-half reliability: r = .77 Cronbach's alpha: α=.87

Note. IQ = Intelligence Quotient; EFA = Exploratory Factor Analysis; CFA = Confirmatory Factor Analysis; PAF = Principal Axis Factoring; PCA = Principal Component Analysis; VR = Varimax Rotation.

As explained in previous section, MA was initially proposed by Gough (1954), whose hypothesis of the existence of such a content specific anxiety was first operationalized in the so-called Numerical Anxiety Scale (Dreger & Aiken, 1957). This measure was a renewed version of the existing Taylor Manifest Anxiety Scale (TMAS; Taylor, 1953), which was completed by adding three questions for measuring students' emotional responses to mathematics. This was the first instrument in literature which included specific items for assessing such type of anxiety as a compelling factor that could explain students' dropout rates in the subject.

Despite this first attempt, particularly important was the subsequent development, two decades later, of the Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972) and the less time-demanding math anxiety subscale of the set of Fennema-Sherman Mathematics Attitudes Scales (MAS; Fennema & Sherman, 1976). These instruments and their newer or revised versions, such as the Revised Math Anxiety Rating Scale (MARS-R; Plake & Parker, 1982), the Math Anxiety Rating Scale for Adolescents (MARS-A; Suinn & Edwards, 1982) and the Abbreviated Math Anxiety Rating Scale (A-MARS; Alexander & Martray, 1989) have been the most widely used measures to assess MA. To date, they have been translated into different languages and replicated in a broad range of contexts, resulting in extensive data on the reliability and validity of their scores.

Nevertheless, the factor structures both of the Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972) and of the math anxiety subscale of the set of Fennema-Sherman Mathematics Attitudes Scales (MAS; Fennema & Sherman, 1976) are still debated. Some authors (e.g., Richardson & Woolfolk,

1980) have considered MA to be a unique, homogeneous construct; whereas others (e.g., Suinn & Edwards, 1982; Alexander & Martray, 1989) have concluded the existence of more than one underlying factor. Therefore, the same instruments have yielded different structures when Exploratory Factor Analyses (henceforth, EFA) have been conducted, resulting in no agreement when defining the construct.

On other hand, since past research has considered MA as a similar construct to attitudes toward mathematics (henceforth, ATM) (Akin & Kurbanoglu, 2011), there are some instruments that have included interchangeably factors related to both constructs. That is the case for the Anxiety Toward Mathematics Scale (ATMS; Sandman, 1980) and the Mathematics Anxiety Scale for Students (MASS; Ko & Yi, 2011). Therefore, although the main target of these instruments was originally to assess MA, they also include other nature-related factors, such as, value for mathematics, enjoyment of mathematics, motivation in the subject and self-perceived performance. Nevertheless, as Evans (2006) claimed, MA and ATM are two separate subdomains of the more general domain mathematical affect. This suggests that the construct MA should have its own factor structure and its assessment should be tested separately from factors underlying ATM (i.e., value for mathematics, enjoyment of mathematics, motivation in the subject or self-perceived performance).

Similarly, the Math Anxiety Questionnaire (MAQ; Wigfield & Meece, 1988; Thomas & Dowker, 2000) includes a cognitive factor related to students' worry. Overall, MA consists of two, positively correlated components (Deffenbacher, 1980), namely, the affective and the cognitive. The former encompasses reactions of fear, nervousness, dread and discomfort; whereas the latter encompasses individuals' expectations and importance attached to mathematics. Despite this distinction, it has been widely acknowledged that the affective component not only represents a greater variance in explaining MA, but also correlates more strongly to individual's actual performance in the subject; whereas the cognitive factor correlates more strongly to individual's effort into mathematics (Wigfield & Meece, 1988). Thus, given the extensive body of research on the negative correlation between MA and the subject's mastery, it is highly interesting to isolate the affective component of MA to further analyze its own theoretical conceptualization.

Regarding measures in the Spanish literature, two instruments have been mainly used. The first is the math anxiety subscale of Escala de Actitudes hacia las Matemáticas (EAM; Auzmendi, 1992), which was considered to be a pioneering tool in the Spanish context. Its anxiety-related subscale is conceptualized as a unidimensional factor, integrated within a more general scale for assessing students' ATM. However, as previously noted, MA and ATM should be assessed separately as two separate subdomains of the more general domain mathematical affect, meaning that Auzmendi's (1992) scale has failed to successfully explain the factor structure for MA.

The second Spanish instrument is the so-called Cuestionario para medir la ansiedad ante las Matemáticas (Muñoz & Mato, 2007). In this case, MA consists of five dimensions, with an umbalanced number of items across them: the larger dimension consists of eleven items, there is another dimension comprising four items, and the remaining three dimensions comprise three items each. Although keeping a scale brief minimizes response bias by boredom or fatigue (Schmitt & Stults, 1985), there are some authors that recommend a minimum of four or five items per dimension to ensure adequate internal consistency reliability (Clark & Watson, 1995). Therefore, the number of items in some of the dimensions of Muñoz and Mato's (2007) scale appears to be inadequate to yield strong psychometric properties for the proposed underlying factors, meaning that it would be highly interesting to replicate the study and check for a more parsimonius structure.

As for the remaining instruments, little is known about the factor structure tested through confirmatory analyses. Along Table 1, only three scales have been subjected to those techniques: Math Anxiety Questionnaire (MAQ; Wigfield & Meece, 1988), Abbreviated Math Anxiety Scale (AMAS; Hopko, Mahadevan, Bare, & Hunt, 2003) and Mathematics Anxiety Scale for Students (MASS; Ko & Yi, 2011). On the one hand, both the Math Anxiety Questionnaire (MAQ; Wigfield & Meece, 1988) and the Mathematics Anxiety Scale for Students (MASS; Ko & Yi, 2011) include cognitive factors in terms of students' worry and learning strategy. However, as previously noted, due to their low contribution in explaining the variance of MA, isolating the affective component would be a highly interesting approach to better ascertain the construct in its predictive power on mathematics achievement.

On the other hand, in the Abbreviated Math Anxiety Scale (AMAS; Hopko, Mahadevan, Bare, & Hunt, 2003) a two-factor solution is proposed as a better solution to a unidimensional model, showing good psychometric properties and representing a parsimonious factor structure. However, the scale only refers to MA arousal in scholastic settings, without any reference to feelings of tension in individuals' day-to-day life's situations. Thus, following Richardson and Suinn's (1972) definition for MA, including students' feelings of tension awakened in their everyday life's mathematics-related tasks would be of great relevance in order to complete the construct.

1.5. SUMMARY

The interest for the construct MA goes back to the early 1950s, when Gough (1954) first used the term *mathemaphobia* to refer to the feelings of discomfort showed by many students during her math classes. Since then, different approaches have been proposed aiming to explain the mechanisms and factors underlying its formation and development through individuals' life.

Despite the sizeable international body of research on MA, knowledge about its factor structure is still limited. This issue, however, is relevant since the integrity of studies analyzing correlational and causal relationships between MA and mathematics achievement are contingent on the psychometric properties of the instruments used. A closer examination of the existing measures draws attention to the differing theoretical conceptualizations for the construct, leading to the conclusion that it has been tough to reach an agreement in assessing its factor structure. Specifically, three major concerns are found.

Firstly, the most widely used instruments are the Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972) and the Fennema-Sherman Mathematics Attitudes Scale (MAS; Fennema & Sherman, 1976). They were the first comprehensive instruments for assessing MA in literature, and since then, several authors have revised and adapted them into different contexts. However, subsequent research on their factor structures (e.g., Suinn & Edwards, 1982; Alexander & Martray, 1989) has resulted in differing findings.

Secondly, there are some measures (i.e., ATMS, Sandman, 1980; MAQ, Wigfield & Meece, 1988; MASS, Ko & Yi, 2011) that, although primarily set to assess MA, actually mix both attitudinal factors and MA factors. That is to say, along with MA dimensions, they also include factors such as value for mathematics or motivation in the subject. Nevertheless, MA and ATM are claimed to be two separate constructs (Evans, 2006). Consequently, each has its own factor structure and therefore, in the case of MA, measures aiming to assess it should not include attitude-based dimensions.

Thirdly, there is still scarce strong evidence of instruments for assessing MA in the Spanish literature. The two exceptions are the math anxiety subscale of the Escala de Actitudes hacia las Matemáticas (EAM; Auzmendi, 1992) and the so-called Cuestionario para medir la ansiedad hacia las matemáticas (Muñoz & Mato, 2007). In the former, MA is measured as part of a more general trait aiming to assess ATM. However, as previously noted, the distinction between these two constructs is requested. The latter casts doubts about the strength of the psychometric evidence, leading to the conclusion that a replication study would be highly interesting.

Consequently, these findings underscore the importance of developing and validating, by means of confirmatory analyses, a psychometrically sound measure for assessing MA levels. Because the phenomenon reaches peak levels at secondary level, an instrument targeting this age group may be an invaluable tool for understanding the factors underlying the construct. Undoubtedly, this measure would furnish insights within the field of mathematics education and may well become a starting point to design, plan and implement early attention measures to prevent high prevalence rates of MA among secondary students.

Chapter 2

Attitudes toward mathematics

CHAPTER

2

Attitudes toward mathematics

This chapter presents a literature review on the second key construct of the present PhD thesis, that is, attitudes toward mathematics (henceforth, ATM). To address this topic, there is a first section with the chronological evolution of the conceptualization for the general trait attitude. Indeed, the specific content construct ATM cannot be understood without referring previously to the theoretical background supporting the more general term attitude. This review supports the consideration of three main components for the construct: affective, cognitive and behavioural. That way, based upon the approach considered, there are three major theoretical approaches which are exposed and discussed in a second section. To better ascertain the origin and development of ATM as time evolves, the third section provides some evidence of recent research. To conclude, the chapter encompasses an integrative literature review on the existing instruments for assessing the construct. As in the previous chapter, this analysis provides a more in-depth look into both the factor structure proposed for the construct through relevant literature and the major limitations and concerns encountered when defining it.

2.1. DEFINITION

ATM have been studied for decades within the field of mathematical education, making their conceptualization acquire a growing importance because of their widely acknowledged impact on the learning of mathematics (Neale, 1969; McLeod, 1992). A review on their definition requires, however, a prior look into the historical development of the definition of the more general construct attitude, which goes back to the early 1930s (Thurstone, 1928; Likert, 1932; Allport, 1935).

In that period, the development of the concept attitude was closely related to the field of social psychology. Indeed, in their origins, the conceptualization of attitude became an attempt to explain and foresee individuals' choices in several contexts, such as in elections or in supermarkets. For instance, attitude was defined as:

- "the affect for or against a psychological object" (Thurstone, 1928, p. 261);

- "a certain range within which responses move" (Likert, 1932, p. 8);

- or "a mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related" (Allport, 1935, p. 810).

All three definitions, although preliminary in their origin, seem to reflect two different components of attitude. On the one hand, Thurstone's (1928) description emphasized the affective component of attitude. On the other hand, both Likert's (1932) and Allport's (1935) descriptions emphasized a behavioral component through a state of readiness.

Since then, the definition of attitude has evolved, leading to different meanings and attributed characteristics, as noted below:

- "stable or fairly stable organization of cognitive and affective processes" (Sarnoff & Katz, 1954, p.116);

- "predispositions to respond to some class of stimuli with certain classes of responses" (Rosenberg & Hovland, 1960, p. 3);

- "a relatively enduring organization of beliefs that describe, evaluate and advocate action with respect to an object or situation around an object or situation, with each belief having cognitive, affective, and behavioural components" (Rocheach, 1968, p. 132);

- "an internal state which affects an individual's choice of action toward some object, person or event" (Gagné & Briggs, 1974, p. 62);

- "general evaluations people hold in regard to themselves, other people, objects, and issues" (Petty & Cacioppo, 1986, p. 4);

- "emotional reactions to the object, behaviour toward the object, and beliefs about the object" (Hart, 1989, p. 44);

- "acts that project some topic of meaning to a position on some dimension of judgement" (McGuire, 1989, p. 39);

- "affective responses that involve positive or negative feelings of moderate intensity and reasonable stability" (McLeod, 1989, p. 249);

- "tendencies to evaluate an entity with some degree of favour or disfavour, ordinarily expressed in cognitive affective and behavioural responses" (Eagly & Chaiken, 1993, p. 155);

- "an internal state of preparation for action" (Aiken, 2002, p. 3).

If examined in detailed, three components are commonly identified in the aforedescribed definitions: the affective, the cognitive and the behavioural component. This way, based upon the components considered for their definition, descriptions for attitudes can be sorted in one of the three following main categories:

- those definitions which solely comprise positive or negative affects or emotional responses towards the attitude object (e.g., McLeod, 1989);

- those definitions which comprise both affects and beliefs or thoughts about the attitude object (e.g., Sarnoff & Katz, 1954; Rosenberg & Hovland, 1960; Gagné & Briggs, 1974; Hart, 1989; McGuire, 1989);

- and those definitions which comprise affects, beliefs and behaviours in response to the attitude object (e.g., Rokeach, 1968; Petty & Cacioppo, 1986; Eagly & Chaiken, 1993).

As seen, attitudes are always directed toward something or someone, which is known as the attitude object. According to Chaiken and Eagly (1993), every object of thought, either abstract or concrete, can become an attitude object. Thus, when attitudes relate to the specific domain of mathematics, the term is referred to as ATM. And the plausible descriptions for the construct are the same that those described above, with the unique change that 'attitude object' is replaced by 'mathematics'.

There is another important aspect, implicit in some of the definitions given before, which stresses that attitudes do not take control of behaviour on their own, but need of some kind of evaluative process (e.g., Rokeach, 1968; Petty & Cacioppo, 1986; McGuire, 1989; Eagly & Chaiken, 1993). This evaluative dimension has been extensively shown to be a key aspect in indivuals' attitude formation (Rhine, 1958; Katz, 1960; Cook & Selltiz, 1964; McGuire, 1989; Eagly & Chaiken, 1993; Olson & Zanna, 1993; Manstead, 1996).

Therefore, by extending to the field of mathematical education, students may have some knowledge about mathematics but their attitudes towards the subject form only when they evaluate their experience with mathematics, which is then operationalized in terms of affects, beliefs and/or behaviours. Taken all these considerations together, ATM are conceptualized as a tendency to evaluate mathematics, which is then expressed by students through a broad range of affective, cognitive and/or behavioural responses.

2.2. THEORETICAL FRAMEWORKS

As noted, the variety of definitions of attitude have led to three types of conceptualizations, which in turn, have supported the development of three main theoretical frameworks: the unidimensional model of attitude (Fishbein, 1963, 1967); the two-component model of attitude (Bagozzi & Burnkrant, 1979, 1980, 1985); and the tripartite model of attitude (Rosenberg & Hovland, 1960).

The unidimensional model was one of the primary frameworks reported in literature. Thurstone's (1928) research was the main reference for this model, which was then formally formulated in the 1960s through Fishbein's (1963, 1967) works. According to this, individuals' attitudes only comprise positive or negative affects, which are formed as the product of their beliefs and personal evaluation towards the attitude object. However, this theoretical framework has been extensively discussed. For example, Bonfield (1974) stated that this model provides little evidence for explaining attitudes since affects on their own are insufficient to explain individuals' motives. That is to say, considering an overall attitude, rather than an attitude comprising different components, fails to provide information about individuals' beliefs (Wilkie & Pessemier, 1973; Sheth, 1974; Bettman, Capon, & Lutz, 1975; Mazis, Ahtola, & Klippel, 1975; Tuncalp & Sheth, 1975; Hawkins, Mothersbaugh, & Best, 2007). And based on the consideration that motives trigger behaviour, affects cannot explain sucesfully individuals' attitudes.

Due to the importance of considering the behavioural component in attitude formation, Rosenberg and Hovland (1960) suggested the development of a multi-component theoretical framework. It was known as the tripartite model, whereby attitudes were referred to comprise affective, cognitive and behavioural components. This approach has been the most widely accepted (Woodsmansee & Cook, 1967; Ostrom, 1969; Kothandapani, 1971; Breckler, 1984), but since its conceptualization in the early 1960s, this model has been subsequently subjected to analysis, which have yielded two major concerns. Firstly, research on its internal structure has underscored high correlations between the three factors, casting doubts on its discriminant validity (Bagozzi, Tybout, Craig, & Sternthal, 1979; McGuire, 1989). Secondly, in some studies aiming to explain the attitude change and behavioural prediction, results have yielded a weak relationship between attitude and behaviour (Fishbein & Ajzen, 1975; Ajzen, 1989; McGuire, 1989).

Thus, given the weaknesses of the unidimensional model and the troublesome inclusion of the behavioural component in the tripartite model, the two-component model appears as an alternative theoretical framework. This approach incorporates both affective and cognitive components (Bagozzi & Burnkrant, 1979), suggesting that affective- and cognitive-based attitudes lead to behavioural intentions together, which in turn lead to overt behaviours. That is, attitudes are not predictors of behaviours, but relate to them in a complex way: "people are more likely to act according to their attitudes when these are important to their self-concepts" (Pratkanis & Greenwald, 1989, p. 272). Subsequent empirical data have supported this framework by providing evidence for convergent, discriminant and predictive validity of such a structure (Breckler & Wiggins, 1989; Millar & Millar, 1990; Esses, Haddock, & Zanna, 1993; Kraus, 1995; Verplanken, Hofstee, & Janssen, 1998; Huskinson & Haddock, 2006). Therefore, based on these considerations, the two-component model seems to be the preferred theoretical framework for the conceptualization of attitude, in general, and the conceptualization of ATM, in particular.

2.3. ATTITUDE FORMATION AND CHANGE

Once the theoretical conceptualization has been discussed, the following natural step is to further analyze the process which leads to the origin and development of individuals' attitudes. In reviewing literature, ATM are not innate but formed over time, declining significantly over the transition from upper elementary school to junior high school (Cheung, 1998; Watt, 2000). According to Halloran (1967), there are three major sources from which attitudes can be learned: direct experiences with the attitude object; explicit and implicit learning from others; and individual's personal development. However, since both attitude formation and attitude change seem to be closely interwoven in a continuous process, it is plausible to think that the previously noted sources, instead of acting individually, interact in a dynamic process (Halloran, 1967).

In such a context, socio-cognitive theories appear to be the most prominent approach that accounts for this process, according to which, as part of their socio-cognitive development, individuals form new attitudes and modify or diminish some others. Noteworthy, Kahle (1984) links this process to individuals' need of adapting themselves to the environment. Therefore, some attitudes that are adaptative in one specific context may not be at all in another one, meaning that attitudes may adopt different meanings as a function of nationality, culture and other sociodemographich variables.

Importantly, attitudes highly reliant on social heritability are less changeable than those influenced by other variables. That has been the case, for example, of the stereotype of mathematics as a male domain in some cultures. In literature, female students have been consistently found to show more negative ATM than males in all educational stages since the first grade (e.g., Fox, Engle, & Paek, 2001; Vale & Leder, 2004; Lupart, Cannon, & Telfer, 2004; Miller & Bichsel, 2004; Crombie et al., 2005, Devine, Fawcett, Szücs, & Dowker, 2012). Moreover, that difference has been reported to be more stable over time (Hembree, 1990; Ma & Xu, 2004).

A plausible explanation to this phenomenon is that offered by the gender-differentiated socialization process (Eccles & Jacobs, 1986), which tries to explain differences in terms of how males and females are socialized since childhood. Within this approach, as women are socialized, they face and endorse gender stereotypes such as that they are not good at maths or they are more willing to express their worries than boys (Friedman, 1989; Cheng & Seng, 2001; Crombie et al., 2005; Herbert & Stipek, 2005; Beilock, Gunderson, Ramirez, & Levine, 2010).

Alternatively, another plausible explanation is the so-called learned helplessness paradigm or blame the victim paradigm (Boaler, 1997), according to which, gender differences could be explained by psychological differences in attribution styles between males and females. Within this model, females are more likely to show less confidence in mathematics-related tasks as they blame themselves for failure in mathematics. Therefore, although the traditional view of mathematics as a male domain and the expression of emotions as a female domain have been decreasing over time, there are some cultures in which such factor might heavily account in the attitude formation and development.

Besides this social heritable component, as previously noted, students' attitudes are formed by previous experiences, causal attribution, processes of social comparison and appraisals from others (Marsh & Parker, 1984; Harter, 1985; Dermitzaki & Efklides, 2000; Bong & Shaalvik, 2003). Therefore, as time evolves, students' attitudes form an important part of their adjustment, becoming a critical element during adolescence. Indeed, in secondary education, students' negative attitudes are greatly due to:

- negative experiences in school transitions and unpersonalized instruction practices (Orhun, 2007; Hindal, Reid, & Badgaish, 2008);
- unsuccessful teaching techniques (Askew & William, 1995; Cornell, 1999; Butty, 2001);
- mathematics curriculum and assessment (Ponte et al., 1994; Askew & William, 1995);
- comparison with peers' accomplishments (Aiken, 2002; Tapia & Marsh, 2004),
- teachers' or parents' poor attitudes toward the subject (Johnstone & Reid, 1981; Ma, 2001; Schreiber, 2002; Mathews & Pepper, 2005; Kyriacou & Goulding, 2006);

- or previous students' own poor mathematics achievement (Kulik & Kulik, 1982; Byrne, 1986; Wixted & Ebbesen, 1991; Huberty, Dresden, & Bak, 1993; Anderman & Maehr, 1994; Bandalos, Yates, & Thorndike-Christ, 1995; Craven, Marsh, & Print, 2000).

The importance of considering ATM lies on their influence on students' perseverance (Carroll, 1963), time devoted on mathematics-related tasks (Love & McVevey, 2001) and engagement in the subject (Middleton & Toluk, 1999), which undoubtedly affect mathematics achievement (Webster & Fisher, 2000) and makes it a prominent topic in the field of mathematics education.

2.4. THE FACTOR STRUCTURE AND ASSESSMENT

As previously noted, an international body of research has suggested that ATM exert causal effects on mathematics achievement. However, the corresponding observed effect sizes have been found to be small, which might be explained as a consequence of certain psychometric limitations in the instruments designed to measure ATM. These limitations have been acknowledged by Ma and Kishor (1997), Zan, Brown, Evans, and Hannula (2006), and Lim and Chapman (2013), claiming that the factor structure of ATM remains ambiguous.

A deep look into the phychological and educational literature provides a number of differing conceptualizations for the construct ATM, which has resulted in numerous instruments targeting to measure it. Thus, as in the case of MA, a literature review on existing instruments for measuring ATM is also worth mention. Measurements for assessing attitudes towards science or statistics have not been considered in this review process because recent evidence has suggested that attitudes toward these three subjects show different trajectories over adolescence, meaning that each construct should be investigated separately (Barth et al., 2011).

The focus has been put on measures with relevant constructs based on consistent definitions, broadly cited pieces of work in the field and recent findings that present the current state of research on ATM. Additionally, studies involving secondary education students have been prioritised but those involving other cohorts were considered when relevant. Details of the review are provided in Table 2.

Table 2

Instruments for assessing attitudes toward mathematics

Instrument	Dimensions/Items	Description	Psychometric evidence
Math Attitude Scale (Aiken & Dreger, 1961)	A unidimensional 20-item scale, consisted of 10 items connoting negative feelings and 10 items connoting positive feelings.	It measures attitudes in college freshmen in mathematical courses (*N*=127)	EFA Test-retest reliability: *r*=.94
The Dutton Scale (DAS; Dutton & Blum, 1968)	A homogeneous scale consisting of 27 items that discriminate between positive and negative feelings about arithmetic.	It surveys the reasons for disliking and liking arithmetic in elementary students coming from 6th, 7th and 8th grades (*N*=346).	Spearman-Brown reliability for the full scale: *r*=.84
Enjoyment and Value Scales (E scale and V scale; Aiken, 1974)	A set of two scales, which can be used either separately or jointly: Enjoyment scale (11) and Value scale (10)	It measures enjoyment and value in freshmen at college level (*N*=190)	EFA Cronbach's alpha (for E scale): α=.95 Cronbach's alpha (for V scale): α=.85
Fennema-Sherman Mathematics Attitude Scales (FSMAS;	A set of nine subscales, which can be used either separately or jointly: mathematics anxiety scale (12), attitude toward success in mathematics scale (12),	Nine domain-specific scales measuring attitudes toward mathematics in	EFA Split-half reliability for the subscales ranged from

Fennema& Sherman, 1976)	confidence in learning mathematics scale (12), effectance motivation in mathematics scale (12), father scale (12), mother scale (12), mathematics as a male domain (12), teacher scale (12) and usefulness of mathematics scale (12).	high school age-populations (*N*=1,600).	*r*=.86 to *r*=.93
Instrument measuring certain attitudes toward mathematics (Michaels & Forsyth, 1977)	A set of four subscales: enjoyment of word problems (1), enjoyment of pictorial problems (1), appreciation of the utility of mathematics (10) and security with mathematics (10),	It measures attitudes toward mathematics in 7th grade students (*N*=299).	EFA Spearman-Brown reliability ranged from *r*=.51 to *r*=.78 for each subscale.
Mathematics Attitude Inventory (MAI; Sandman, 1980)	A set of six subscales, resulting in a total of 48 items: perception of mathematics teachers, value of mathematics, self-concept in mathematics, math anxiety, enjoyment of mathematics and motivation in mathematics.	It measures attitudes towards mathematics in secondary students (*N*=5,034).	EFA Reliability for the subscales ranged from *r*=.69 to *r*=.89
Escala de actitud de carácter verbal (Gairín, 1990)	A 22-item scale with three underlying factors: liking, usefulness, and confidence-anxiety.	It measures verbal attitudes towards mathematics in pupils aged 6 and 14 (*N*=3,637)	EFA Test-retest reliability: *r* =.77 and *r* = .93
Escala de Actitudes hacia las Matemáticas (EAM; Auzmendi,	A 25-item scale with five underlying factors: usefulness (5), confidence (5), anxiety (5), liking (5) and motivation (5).	It measures attitudes towards mathematics in middle through university	EFA (PCA and VR) Cronbach's alpha ranged from α=.50 to α=.92 for

1992)		students, aged 15 to 18 (*N*=1,221).	each dimension Cronbach's alpha for the full scale: α=.93
Escala de Actitudes hacia la Matemática-Universidad (EAHM-U; Bazán, 1997)	A 31-item scale with four underlying factors: affectivity (8), applicability (8), ability (8) and anxiety (7)	It measures attitudes toward mathematics in students entering the university (*N*=315).	EFA Cronbach's alpha ranged from α=.71 to α=.91 for the dimensions
Math Anxiety Questionnaire (MAQ; Thomas & Dowker, 2000)	A 36-item scale with four underlying factors: self-perceived performance, attitudes, poor performance unhappiness and anxiety.	It rates experiences of unhappiness and worry caused by problems in arithmetic in 5th to 6th graders (*N*=79).	EFA Cronbach's alpha ranged from α=.83 to α=.91 for the dimensions
Attitudes toward Mathematics and Mathematics Taught with Computer (AMMEC; Ursini, Sánchez & Orendain, 2004)	A 29-item scale comprising three subscales: liking for mathematics (11), liking for mathematics taught with computer (11) and self-confidence (7).	It measures attitudes toward mathematics and mathematics taught with computer in secondary students, aged 12 through 15 (*N*=439).	EFA (PCA and VR) Cronbach's alpha ranged from α=.68 to α=.81 for the subscales Cronbach's alpha for the full scale: α=.80 Split-half reliability for the full scale: r = .71
Attitudes toward	A 40-item scale with four underlying dimensions: self-	Measure students'	EFA (ML and VR) +

Mathematics Inventory (ATMI; Tapia & Marsh, 2004)	confidence (15), value (10), enjoyment (10) and motivation (5)	attitudes toward mathematics in high school students, including freshmen, sophomores, juniors, senior and 8^{th} graders (*N*=545).	CFA Cronbach's alpha ranged from α=.88 to α=.95 for the dimensions Cronbach's alpha for the full scale: α=.97 Test-retest reliability scores ranged from *r* = .70 to *r* = .88 for the dimensions Test-retest reliability for the full scale: *r* = .89
Cuestionario para medir las actitudes hacia las matemáticas en alumnos de ESO (Muñoz & Mato, 2006)	A 19-item scale with two underlying factors: liking and usefulness (9) and teacher's attitude toward mathematics perceived by the student (10)	It measures attitude towards mathematics in Compulsory Secondary Education (*N*=1,220).	EFA (PCA and VR) Cronbach's alpha for the full scale: α=.97
Scale for measuring attitudes toward mathematics in Compulsory Secondary Education (Alemany-	A 35-item scale with seven underlying factors: behavioural component (13), affective component (7), negative self-concept (5), positive self-concept (3), cognitive component (3), demotivation towards mathematics (2) and expectancy (2)	It measures attitudes toward mathematics in Compulsory Secondary Education (*N*=236).	EFA + CFA Cronbach's alpha ranged from α=.43 to α=.89 for each dimension Cronbach's alpha for the

Arrebola & Lara, 2010)			full scale: α=.92
Actitudes Matemáticas de Estudiantes Universitarios (AMADEUS; Álvarez & Soler, 2010)	A 20-item scale with three underlying dimensions: liking (9), difficulty (7) and usefulness (4).	It measures attitudes toward mathematics at university level (*N*=613).	EFA (PCA and CR) Cronbach's alpha ranged from α=.49 to α=.91 for each dimension Cronbach's alpha for the full scale: α=.96
Math and Me Survey (M&MS; Adelson & McCoach, 2011)	The 18-item M&MS consists of two subscales: mathematical self-perceptions (8) and enjoyment of mathematics (10).	It measures attitudes toward mathematics in elementary students from 3rd through 6th grades (*N*=437).	EFA + CFA Cronbach's alpha ranged from α=.92 (for the mathematical self-perceptions scale) to α=.94 (for the enjoyment of mathematics scale)
Shortened version of the Attitudes toward Mathematics Inventory (short ATMI; Lim & Chapman, 2013)	A 19-item shortened ATMI version with four subscales: enjoyment (5), motivation (4), self-confidence (5) and perceived value (5).	It measures attitudes toward mathematics in an Asian sample from pre-tertiary institutions (*N*=1,601).	EFA + CFA Cronbach's alpha ranged from α=.85 to α=.90 for each subscale Cronbach's alpha for the full scale: α=.93 Test-retest reliability for

			the full scale: .75
Cuestionario de Dominio Afectivo en la Resolución de Problemas Matemáticos (Caballero, Guerrero, & Blanco, 2014)	A 48-item scale with six underlying dimensions: beliefs about the nature and learning of mathematics (8), self-beliefs as a learner of mathematics (11), beliefs about the math teacher's role (6), beliefs drawn from the socio-familiar context (10), reactions toward mathematics (8) and value of the math training (5).	It measures affects toward mathematics at university level in a sample from Extremadura (Spain) (*N*=488)	EFA Cronbach's alpha: α=.62
Escala de Actitudes hacia las Matemáticas (EAM; Palacios, Arias & Arias, 2014)	A 32-item scale with four underlying dimensions: perception of mathematical incompetence (12), liking (12), perception of usefulness (4) and mathematical self-concept (4).	It measures the affective domain in mathematics in students from 6th to 12th grades (*N*=4,807).	EFA (PAF, ML and PR) + CFA Cronbach's alpha ranged from α=.68 to α=.93 for each dimension Cronbach's alpha for the full scale: α=.95
Short form of Mathematics Attitude Scale (Yasar, 2014)	A 19-item scale with four underlying dimensions: enjoyment (6), fear, anxiety and boredom (5), place of mathematics in life (4) and perceived mathematics success (4).	It measures attitudes towards mathematics among high school students (N=1,801).	EFA (BCA) + CFA Cronbach's alpha ranged from α=.82 to α=.89 for each dimension Cronbach's alpha for the full scale: α=.96

Note. BCA=Basic Component Analysis, CFA=Confirmatory Factor Analysis, EFA=Exploratory Factor Analysis, ML=Maximum Likelihood, PAF=Principal Axis Factoring,PCA=Principal Component Analysis, PR=Promax Rotation, VR=Varimax Rotation.

From the existing instruments, the Fennema-Sherman Mathematics Attitude Scales (FSMAS; Fennema & Sherman, 1976) have been the most widely used across all educational levels of the mathematics curriculum. Since their development, this set of nine subscales has been translated into several languages for their use with samples from different sociodemographic backgrounds. Nevertheless, throughout literature, this instrument has been criticized for several reasons. For example, O'Neal, Ernest, McLean, and Templeton (1988), by using Exploratory Factor Analysis (henceforth, EFA), obtained poor validity and reliability scores, meaning that the original subscales might not gauge properly the research construct. In line with this, Melancon, Thompson, and Becnel (1994) were unable to find a suitable model fit for the original structure proposed by Fennema and Sherman (1976). Indeed, these authors concluded that an eight-factor structure might fit data better than the original nine-factor proposal. Likewise, Mulhern and Race (1998) proposed a shortened version of six separate factors, which yielded a better internal consistency on both the whole structure and underlying subscales.

Another interesting instrument is the Attitudes Toward Mathematics Inventory (ATMI; Tapia & Marsh, 2004), which has a more distinct and cohesive factor structure, assessed by both exploratory and confirmatory analyses. However, this 40-item scale is too time demanding. Thus, in attempts to reduce the time required for its administration, Lim and Chapman (2013) developed the Shortened version of the Attitudes Toward Mathematics Inventory (short ATMI; Lim & Chapman, 2013). The confirmatory analyses yielded sound properties, but a high correlation coefficient was found between the enjoyment and motivation subscales (r = .96), suggesting that these two latent factors were statistically isomorphic. As a consequence, a reduction of the factor structure to three factors would presumably yield a better model fit to data.

On other hand, some instruments, although primarily developed to measure ATM, actually comprised in the same scale both attitudinal dimensions (e.g., motivation or perceived usefulness) and mathematics anxiety. That is the case of the Fennema-Sherman Mathematics Attitude Scales (FSMAS; Fennema & Sherman, 1976), the Mathematics Attitude Inventory (MAI; Sandman, 1980), the so-called Escala de Actitudes hacia las Matemáticas (EAM; Auzmendi, 1992), the Escala de Actitudes hacia la Matemática-Universidad (EAHM-U; Bazán, 1997) and the Short form of Mathematics Attitude Scale (Yasar, 2014). Nevertheless, as Evans (2006) claimed, ATM and math anxiety (henceforth, MA) are two separate subdomains of the more general domain mathematical affect. This means that the construct ATM should have its own factor structure and its assessments should be tested separately from MA.

Moreover, research on ATM has extensively acknowledged its multidimensional nature, having identified students' confidence as a salient underlying variable of the construct (e.g., Ruffell, Mason, & Allen, 1998; Gómez-Chacón, 2000; Hanulla, 2002; Di Martino, & Zan, 2010). In some cases, students' confidence is not included, such as in the Math Attitude Scale (Aiken & Dreger, 1961), the Dutton Scale (DAS; Dutton & Blum, 1968), the Enjoyment and Value Scales (E and V scales; Aiken, 1974), the instrument measuring certain attitudes toward mathematics (Michaels & Forsyth, 1977) and the so-called Cuestionario para medir las actitudes hacia las matemáticas en alumnos de ESO (Muñoz & Mato, 2006). Whereas in other cases, this variable appears divided into two subfactors, such as in the Scale for measuring attitudes toward mathematics in

Compulsory Secondary Education (Alemany-Arrebola & Lara, 2010) and the Escala de Actitudes hacias las Matemáticas (EAM; Palacios, Arias, & Arias, 2014). In the former, the authors distinguished between positive and negative self-concept; in the latter, the authors distinguished between the perceived mathematical incompetence and self-concept. However, upon closer examination, in both cases, the two subfactors were, in fact, constituent of the same dimension. As a result, there was not any conceptual distinction and it would be highly interesting to replicate both studies and check if a more parsimonius structure could be obtained.

As for the remaining instruments, little is known about the factor structure tested through confirmatory analyses. That is the case of the Cuestionario de Dominio Afectivo en la Resolución de Problemas Matemáticos (Caballero, Guerrero, & Blanco, 2014). Despite its relevance for having been validated in a Spanish-speaking context, the instrument was subjected only to exploratory analyses with no evidence of confirmatory consistency hitherto. Moreover, the instrument is primarily targeted at college students. Therefore, it would be necessary to adapt it in case of using other age samples, as for example, secondary education students.

2.5. SUMMARY

The body of research on the construct ATM cannot be understood without referring previously to the theoretical approaches developed in the field of social psychology. Among all the plausible definitions and corresponding frameworks, an integrative literature review leads to propose the two-component model as the preferred to explain the conceptualization for attitude. According to this, therefore, ATM is defined in the present study as a tendency to evaluate mathematics, which manifests through affective- and cognitive-based dimensions. Based on these considerations, a review on the existing instruments turns essential in order to further analyze the operationalization of the construct in empirical research. However, three conclusions may be drawn from this analysis.

Firstly, the most widely cited instruments are the Fennema-Sherman Mathematics Attitude Scales (FSMAS; Fennema & Sherman, 1976) and the Attitudes Toward Mathematics Inventory (ATMI; Tapia & Marsh, 2004), which have also been translated into several languages for their use in backgrounds with different socio-cultural characteristics. However, subsequent replication studies of these instruments (e.g., O'Neal, Ernest, McLean, & Templeton, 1988; Melancon, Thompson, & Becnel, 1994; Mulhern & Race, 1998) have obtained evidence that rebuilding some of their latent factors and shortening the scales to fewer subdomains would yield a better fit to data.

Secondly, there are some instruments, such as the Mathematics Attitude Inventory (MAI; Sandman, 1980), the Escala de Actitudes hacia las Matemáticas (EAM; Auzmendi, 1992), the Escala de Actitudes hacia la Matemática-Universidad (EAHM-U; Bazán, 1997) and the Short form of Mathematics Attitude Scale (Yasar, 2014), that, although primarily set to measure attitudes towards mathematics, actually mix both attitudinal factors and mathematics anxiety. Nevertheless, ATM and MA are claimed to be considered as two separate subdomains of the more general domain mathematical affect (Evans, 2006). This means that ATM has its own factor structure and its assessments should be tested separately from mathematics anxiety.

Thirdly, they are other measures that do not include student's self-confidence as an underlying factor (i.e., in the Math Attitude Scale, Aiken & Dreger, 1961; DAS, Dutton & Blum, 1968; E and V Scales, Aiken, 1974; Instrument measuring certain attitudes toward mathematics, Michaels & Forsyth, 1977; and Cuestionario para medir las actitudes hacia las matemáticas en alumnos de ESO, Muñoz & Mato, 2006) or that include it in such a way that remains ambiguous (i.e., in the Scale for measuring attitudes towards mathematics in Compulsory Secondary Education, Alemany-Arrebola & Lara, 2010; and EAM, Palacios, Arias & Arias, 2014).

Fourthly, there are still few instruments developed in Spanish contexts. Besides the already mentioned Cuestionario para medir las actitudes hacia las matemáticas en alumnos de ESO (Muñoz & Mato, 2006), the Scale for measuring attitudes towards mathematics in Compulsory Secondary Education (Alemany-Arrebola & Lara, 2010) and Escala de Actitudes hacia las Matemáticas (EAM; Palacios, Arias, & Arias, 2014), there is another instrument that it is worth mentioning: Cuestionario de Dominio Afectivo en la Resolución de Problemas Matemáticos (Caballero, Guerrero, & Blanco, 2014). However, its shortcoming is twofold. On the one hand, it was only assessed through exploratory analyses, with no evidence of confirmatory consistency. On the other hand, it was targeted at university level, which makes it necessary to adapt the scale in case of using with other age samples.

As a result, this lack of consistency underscores the importance of developing and validating, by means of confirmatory analyses, a psychometrically sound measure for assessing students' ATM. Because of the evidence of a turning point from upper elementary school to junior high school, an instrument targeting secondary education students may be an invaluable tool for understanding the factors underlying the construct in that scholastic stage. Undoubtedly, this measure would furnish insights within the field of mathematics education and may well become a starting point to design, plan and implement early attention measures to support students' ATM and prevent future disengagements in the subject.

Chapter 3

Mathematics achievement

CHAPTER

3

Mathematics achievement

This chapter provides a more comprehensive look into the the empirical research which has highlighted both the correlational and causal relationships between math anxiety (henceforth, MA) and overall mathematics achievement, on the one hand, and between attitudes toward mathematics (henceforth, ATM) and overall mathematics achievement, on the other hand. This review is conducted in two separate sections within this chapter. However, due to recent evidence about the intertwined relationship between MA and ATM as predictors for mathematical performance, the third section considers this jointly effect by showing the results from studies conducted with Structural Equation Modeling (henceforth, SEM) approaches.

3.1. CORRELATIONAL AND CAUSAL STUDIES BETWEEN MATH ANXIETY AND MATHEMATICS ACHIEVEMENT

Throughout literature, MA has been extensively shown to have an overall negative relationship with mathematics achievement (e.g., Ashrcraft & Krause, 2007; Legg & Locker, 2009; Geist, 2010; Young, Wu, & Menon, 2012).

However, even more impressive is the body of research that has focused on the significant negative correlation in samples comprising middle and high school students (Richardson & Suinn, 1972; Resnick, Viehe, & Segal, 1982; Wigfield & Meece, 1988; Chiu & Henry, 1990; Ashcraft & Kirk, 2001; Sheffield & Hunt, 2006; Wu, Willcutt, Escovar, & Menon, 2013). In attempts to evaluate the correlation between MA and overall mathematics achievement, Hembree (1990) and Ma (1999) conducted one meta-analysis each. The results underscored estimated correlation values of $r = -.27$ to $r = -.34$, respectively, for the previously mentioned age group (that is, secondary students).

Despite the previously noted moderate correlations, recent research has yielded small effect sizes of MA on mathematics achievement. Specifically, longitudinal studies have underscored that prior lower mathematics achievement cause higher levels of MA, but that higher levels of MA do not relate to later poorer mathematics achievement (Ma & Xu, 2004; Krizinger et al., 2009 Kyttälä & Björn, 2014). However, several authors (e.g., Ashcraft, 2002; Beilock & Carr, 2005; Ashcraft & Ridley, 2005; Ashcraft & Krause, 2007; Krinzinger, Kaufmann, & Willmes, 2009; Beilock, Gunderson, Ramírez, & Levine, 2010; Maloney, Ansari, & Fugelsang, 2011; Wu et al., 2012) claim that the development of mathematical skills are actually threatened by MA. According to this view, when performing mathematics-related tasks, MA and related worrisome thoughts tax working memory resources, which are an important predictor for mathematics achievement (Ashcraft, Kirk, & Hopko, 1998; Ashcraft & Kirk, 2001).

In line with this hypothesis, some studies have underscored reciprocal relationships between MA and mathematical performance, meaning that not only MA leads to underperformance in mathematics, but prior poor achievement also leads to later MA (Spielberg, Anton, & Bedell, 1976; Sarason, 1986; Hembree, 1990). Consequently, no agreement has been reached yet, and further analysis to test the mediating effect of MA on the relationship between prior and later math achievement is needed.

3.2. CORRELATIONAL AND CAUSAL STUDIES BETWEEN ATTITUDES TOWARD MATHEMATICS AND MATHEMATICS ACHIEVEMENT

On other hand, throughout literature, ATM have extensively demonstrated a positive relationship with mathematics achievement (e.g., Bouchey & Harter, 2005; Chipman, 2005; Anjum, 2006; Skaalvik & Skaalvik, 2006; Thomas, 2006; Samuelsson & Granstom, 2007; Barkoukis, Tsorbatzoudis, Grouios, & Sideridis, 2008; Papanastasiou, 2008; Williams & Williams, 2010; Lipnevich et al., 2011). Regarding the relationship between specific dimensions of ATM and overall mathematics achievement, Marsh et al. (2012) found correlations ranging from $r = .49$ to $r = .70$ between interest in mathematics and mathematical performance; and from $r = .27$ to $r = .49$ between math self-concept and mathematical performance. Consistently with these results, studies based on PISA datasets underscored the consistent positive associations of interest and self-concept in mathematics with mathematics achievement across countries (Chiu & Xihua, 2008; Chiu & Klassen, 2010).

Despite the previously noted moderate to strong correlation values, recent research has yielded almost inexistent effect sizes of ATM on mathematics achievement. Specifically, a meta-analysis conducted with 113 primary studies yielded a small observed effect size of the causal effect of ATM on mathematics achievement (Ma & Kishor, 1997). This finding was explained by the authors as a consequence of certain psychometric limitations in the instruments designed to measure the construct ATM. This limitation has been also acknowledged in more recent research by Zan, Brown, Evans, and Hannula (2006) and Lim and Chapman (2013), who asserted that the factor structure of ATM remains ambiguous. In fact, a deep look on the psychological literature provides a number of differing conceptualizations of the construct, which has resulted in numerous instruments targeting to measure it.

Consistently with Ma and Kishor's (1997) work, Ma and Xu (2004) conducted an analysis to determine the causal relationships between ATM and mathematics achievement in secondary education. Interestingly, results yielded a unidirectional causal predominance of achievement over ATM among those students who took calculus; whereas the relationship became reciprocal for those students who did not take calculus. All these results suggest that ATM are well known to be outcomes of previous mathematical background, but that their causal effects on later mathematics achievement are still inconclusive.

3.3. THE JOINTLY EFFECT OF MATH ANXIETY AND ATTITUDES TOWARD MATHEMATICS IN PREDICTING MATHEMATICS ACHIEVEMENT

As noted, a sizeable body of empirical research on MA on the one hand, and ATM on the other, have often been considered as separate lines within the field of mathematics education. However, there is growing evidence of a negative intertwined relationship between individuals' MA and ATM (e.g., Bessant, 1995; Bursal & Paznokas, 2006; Zakaria & Nordin, 2008; Akin & Kurbanoglu, 2011;

Klinger, 2011). For example, in the previously noted Hembree's (1990) meta-analysis, they were found negative correlations between MA and several dimensions of ATM, such as, enjoyment of mathematics (grades 5-12: r = -.75; college: r = -.47), self confidence in mathematics (grades 6-11: r = -.82; college: r = -.65), self-concept in mathematics (r = -.71); motivation in mathematics (r = -.64) and opinion about usefulness of mathematics (r = -.37). Additionally, Hembree's (1990) meta-analysis showed that MA significantly correlated with the extent of enrollment in high school mathematics (r = -.31), with the intent to enroll in college mathematics (r = -.32) and with the number of high school mathematics courses taken (r = -.45).

In line with Hembree's (1990) results, two decades later, MA has been again associated with lower levels of both self-confidence and motivation in mathematics (e.g., Chinn, 2009; Jansen et al., 2013). Indeed, compared to their peers, math anxious students show lower self-confidence as learners in mathematics, enjoy mathematics less and do not perceive the value of mathematics in their day-to-day life (Ashcraft, Krause, & Hopko, 2007; Ashcraft & Moore, 2009; Legg & Locker, 2009). Noteworthy, when focusing on both MA and math self-concept, Ahmed, Minnaert, Kuyper, and Van der Werf (2012) found that their relationship is reciprocal, although the magnitude of the path from MA to math self-concept drops to half compared with that from math self-concept to MA. This result is in line with a more general research conducted by Akin and Kurbanoglu (2011), who suggested that MA is predicted by ATM. Therefore, both constructs are not only important factors relating to math outcomes, but also desirable outcomes themselves.

In attempts to test and estimate the jointly effect of MA and ATM in predicting mathematics achievement, several structural equation approaches have been suggested through literature. Abu-Hilal and Bahri (2000) tested a SEM model including measures of primary students' self-concept, perception of the importance of mathematics, math anxiety, effort exerted in studying and mathematics achievement. Results supported that importance and effort were positively related to achievement, which in turn, predicted positively self-concept and negatively, math anxiety. These findings suggested that mathematics achievement was an important outcome, predicted by both perceived importance of mathematics and effort exerted in studying mathematics, but also a predictor of students' math self-concept and math anxiety. Overall, the hypothesized model explained 40% of the variance in mathematics achievement.

Similarly, Singh, Granville, and Dika (2010) examined the effects of 8th graders' motivation, attitudes and academic engagement on mathematics achievement. The results indicated that the three constructs had a positive effect on mathematics achievement, but the strongest effect was that of academic engagement. Another relevant work is the model developed by Palacios, Hidalgo, Maroto, and Ortega (2013), who tested the causal relationships between math anxiety, attitudes towards mathematics, academic attitudes, metacognitive strategies and mathematical performance. The results posited that attitudes toward mathematics had a positive effect on mathematical performance, through a partial mediation effect by math anxiety. Overall, the model explained 65% of mathematical performance and the strongest path coefficient was that from attitudes to math anxiety. However, the conceptualization of MA in the model is debated since the authors used an adapted version of the Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972). Although this scale and its newer revised and adapted versions are widely used to assess MA, its conceptualization for the construct has been strongly debated. Indeed, several authors (e.g., Rounds & Hendel, 1980; Suinn & Edwards, 1982; Ferguson, 1986; Alexander & Martray, 1989) have concluded the existence of more than one underlying factor, conversely to Richardson and Suinn's (1972) hypothesis.

3.4. SUMMARY

In the math education area, an impressive body of research has focused on affective and cognitive variables as salient student-related factors with a significant effect on math outcomes and future career choices (e.g., Bouchey & Harter, 2005; Chipman, 2005; Anjum, 2006; Skaalvik & Skaalvik, 2006; Ashcraft & Krause, 2007; Legg & Locker, 2009; Geist, 2010; Young, Wu, & Menon, 2012). Among these, contemporary research has drawn special attention to two constructs, namely MA and ATM, which have constituted, on their own, two separate research lines for decades.

However, students' MA and ATM are not innate but formed through individuals' life, leading them to avoid any math-related situation or task over time (e.g., Meece, Wigfield, & Eccles, 1990; Ashcraft & Krause, 2007; Jackson, 2008; Krinzinger, Kaufmann, & Willmes, 2009). Noteworthy, both MA and ATM worsen significantly over the transition from upper elementary school to junior high school (Watt, 2000), reaching peak levels among 14- to 16-year-old students (e.g., Laukenmann, Bleicher, & Fuss, 2003; Sheffield & Hunt, 2006; Wu, Willcutt, Escovar, & Menon, 2013).

Studies have often analysed the correlation relationships between MA and mathematics achievement, on the one hand, and between ATM and mathematics achievement, on the other hand. In both cases, results have consistently underscored moderate to strong relationships between these variables (e.g., Hembree, 1990; Ma, 1999; Marsh et al., 2012), making these two constructs become an essential aspect of assessment in mathematics educational programmes, particularly at secondary level. However, in recent years, the breakthrough of SEM approaches in social sciences has allowed taking a more in-depth look and test the causality between the previously noted variables. In this line, despite the still scarce evidence, drawing on previous literature, two major concerns are found.

Firstly, the inconclusive mediating effect of math anxiety on the relationship between prior and later mathematics achievement. Specifically, longitudinal research has concluded that prior mathematical performance relates to later math anxiety in a signicant way, but that math anxiety does not exert any causal effect on later mathematical performance (e.g., MA & Xu, 2004; Krinzinger et al., 2009). This would mean that math anxiety does not predict students' mathematics achievement, contrary to the growing evidence of the detrimental effect of MA in the learning and mastery of mathematics (e.g., Ashcraft & Krause, 2007; Geist, 2010; Wu & Menon, 2012).

Secondly, there are still scarce studies including, in a single model, both MA and ATM for the prediction of mathematics achievement. Two exceptions worth mentioning. The first one is that carried out by Abu-Hilal (2000), whose model explained 40% of variance in primary students' mathematics achievement by including students' self-concept, perceived importance of mathematics and math anxiety. The second one is the model proposed by Palacios, Hidalgo, Maroto, and Ortega (2013), which explained 65% of variance in eight graders' mathematics achievement by including math anxiety, attitudes toward mathematics, academic attitudes and metacognitive strategies. However, upon closer examination, the conceptualization of MA used in the model is strongly debated.

As a consequence, it would be highly interesting to expand knowledge on previous work by proposing and testing a theoretical model underlying these three key topics, that is, MA, ATM and mathematics achievement. Because mathematical affect has been shown to reach peak levels in secondary education, doing research in this age group may furnish insights for understanding the factors affecting mathematics achievement and implement early attention measures to prevent poor results in upper stages.

Chapter 4

Research objectives and method

CHAPTER

4

Research objectives and method

This chapter presents the main goal of the present PhD thesis, as well as the specific objectives underlying it. Likewise, there is a description of the method, including samples, variables and intruments used, as well as the analyses conducted to address each of the previously noted specific objectives.

4.1. RESEARCH OBJECTIVES

In the mathematics education area, contemporary research has focused on studying the factors that influence students' mathematics achievement. In such a context, two main research areas have emerged as the most prominent. On the one hand, research pertaining to math anxiety (henceforth, MA) and attitudes toward mathematics (henceforth, ATM) as relevant constructs related to students' mathematics achievement; on the other hand, research pertaining to the relationships between MA, ATM and students' mathematics achievement. In other words, the former has focused on analyzing the theoretical conceptualization and corresponding operationalization in dimensions, which subsequently are tested through factor analysis; whereas the latter has focused mainly on analyzing the correlation between the variables and more recently, on the causal effects exerted by MA and ATM on mathematics achievement.

In reviewing the research literature, despite the long-standing interest in MA and ATM, there is no a universal definition of the terms, since these vary as a function of the theoretical framework taken as the basis. Additionally, as expected, there are many factors that have been suggested as influencing students' MA and ATM, both in their formation and in their development over time. Even if there is neither consensus as to which factor is the most salient, affective-cognitive approaches have yielded, in both cases, certain theories that provide a plausible account for the phenomena. Thus, although still scarce, there is growing evidence that MA and ATM are woven tightly together and interact continuously with the student's learning process.

Therefore, as noted along previous chapters, the following major concerns are found: (a) there is a lack of consensus when defining the factor structures both for MA and for ATM; (b) there are some instruments which include, at the same time, factors related to MA and ATM, even if the main target of them is to assess solely MA or ATM; (c) the great majority of existing instruments have been psychometrically supported by EFA, with a still scarcity of confirmatory consistency; (d) there is a general lack of peer-reviewed tools for assessing both MA and ATM among secondary education students in Spanish-speaking contexts; (e) there is not any instrument adapted to Basque-speaking populations; (f) the mediating effect of MA on the relationship between prior and later mathematics achievement is still inconclusive; and (g) there are still few studies including, in a single model, the interaction of MA and ATM and its predictive power on mathematics achievement.

Based on these considerations, there is a need of further research on the factor structures of MA and ATM which serves as a basis for analyzing interactions between them and causal relationships with mathematics achievement. Because both MA and ATM have been shown to reach peak levels in secondary education, doing research in this age group will furnish insights within the field of mathematics education and may well become a starting point to design, plan and implement early attention measures.

Thus, in attempts to expand knowledge on previous literature, the main objective of this PhD thesis is to analyse Biscayan students' MA and ATM and their influence in predicting their later mathematics achievement during a mathematics course in Compulsory Secondary Education. To address it, the present research encompasses a set of specific objectives, as detailed as follows:

I. To develop and validate, by means of confirmatory analyses, the Scale for Assessing Math Anxiety in Secondary Education (SAMAS).

II. To develop and validate, by means of confirmatory analyses, the Scale for Assessing Attitudes Toward Mathematics in Secondary Education (SATMAS).

III. To create and validate a Structural Equation Model for testing both the interaction effect between math anxiety and attitudes toward mathematics and their mediation role between students' prior and later mathematical competence.

For that purpose, the present research is structured by specific objectives, each of them with its corresponding research sample, instruments and data anslyses, as summarized in Table 3.

Table 3

Specific objectives, research samples and analyses

Chapter	Specific objective	Sample	Data sources and instruments	Analyses	Software tools
5	To develop and validate, by means of confirmatory analyses, the Scale for Assessing Math Anxiety in Secondary Education (SAMAS)	n = 792	- Sociodemographic questionnaire - SAMAS - Mathematics curriculum-based questionnaire	- Descriptive statistics - CFA - Inter-item correlations - Item-total correlations - Pearson's correlations	- SPSS 22 - EQS 6.1
6	To develop and validate, by means of confirmatory analyses, the Scale for Assessing Attitudes Toward Mathematics in Secondary education (SATMAS)	n = 792	- Sociodemographic questionnaire - SATMAS - Mathematics curriculum-based questionnaire	- Descriptive statistics - CFA - Inter-item correlations - Item-total correlations - Pearson's correlations	- SPSS 22 - EQS 6.1
7	To create and validate a Structural Equation Model for testing both the interaction effect between math anxiety and attitudes toward mathematics and their mediation role between students' prior and later mathematics achievement	n = 703	- Sociodemographic questionnaire - SAMAS - SATMAS - Mathematics curriculum-based questionnaire	- Descriptive statistics - CFA - Inter-item correlations - Item-total correlations - Pearson's correlations - SEM - Two-may repeated ANOVA	- SPSS 22 - Amos 23

Note. EFA = Exploratory Factor Analysis; CFA = Confirmatory Factor Analysis; SEM = Structural Equation Modeling

4.2. METHOD

4.2.1. Participants

The target population consisted of students from Biscay (Basque Country Autonomous Region, Spain), who were enrolled in the final grade of each cycle in Compulsory Secondary Education. In such educational system, Compulsory Secondary Education is divided into two cycles. The first cycle comprises first and second grades; whereas the second cycle comprises third and fourth grades. Although mathematics is a compulsory subject for all students across this educational stage, external examiners assess the acquisition of mathematical competence only at the end of each cycle, using either the autonomous diagnostic tests (in second grade) or the international PISA assessment (in fourth grade).

Next, using the Cochran's (1973) formula and estimating a margin error of 5% and a confidence interval of 95%, a minimum sample size of 367 students was targeted. This threshold also met the Hinkin's (2005) criteria of item to response ratios of 1:10 required for the development of the scales. Thus, based on these considerations, a random sample of schools from both the public and private educational systems 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 for the study.

With this procedure, the research sample consisted of 792 secondary students (39.3% females, 60.7% males) from 36 different classes. The average age of the participants was 13.92 (*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. The pool of students was subsequently broken down by the language in which they learn mathematics at school. Thus, the following two subgroups were obtained: Math Learners in Spanish (henceforth, MLS) and Math Learners in Basque (henceforth, MLB). Table 4 summarizes the sample's distribution.

Table 4

Distribution of the original research sample

Subgroup	**Age**				**Females (*n*)**	**Males (*n*)**	**Total (*N*)**
	Min.	***Max.***	***M***	***SD***			
2nd grade	12	15	13.01	0.50	170	239	409
MLS	12	15	13.01	0.52	99	168	267
MLB	12	15	13.01	0.45	71	71	142
4th grade	14	16	14.97	0.44	167	216	383
MLS	14	16	14.95	0.45	123	173	296
MLB	14	16	15.03	0.42	44	43	87

Note. Min. = Minimum, *Max.* = Maximum, *M* = Mean, *SD* = Standard Deviation

Of the 792 secondary education students who were initially included as participants for the development and validation of the SAMAS and the SATMAS, only those who took the questionnaire both at the beginning and at the end of the mathematics course were considered for inclusion in the structural model. Indeed, this last phase required the measurement of all variables both at the beginning and at the end of the mathematics course.

Thus, based on this criterion, a total of 89 cases were discarded for the structural model (29 females and 60 males) and as a result, the research sample consisted of 703 (43.81% females, 56.19% males) secondary education students, with an average age of 13.92 (*SD* = 1.09) years, ranging from 12 to 16. Regarding the educational level, 52.77% were enrolled in second grade and 47.23% in fourth grade. Overall, as seen in Table 5, the sample distribution remained similar to that previously obtained.

Table 5

Distribution of the pruned research sample

Subgroup	**Age**				**Females (*n*)**	**Males (*n*)**	**Total (*N*)**
	Min.	***Max.***	***M***	***SD***			
2nd grade	12	15	12.99	0.50	155	216	371
MLS	12	15	12.99	0.53	93	151	244
MLB	12	15	12.99	0.45	62	65	127
4th grade	14	16	14.96	0.44	153	179	332
MLS	14	16	14.94	0.44	116	152	268
MLB	14	16	15.08	0.41	37	27	64

Note. Min. = Minimum, *Max.* = Maximum, *M* = Mean, *SD* = Standard Deviation

4.2.2. Instruments

The battery of instruments consisted of five sections: introduction, sociodemographic information sheet, the SAMAS, the SATMAS and a mathematics curriculum-based questionnaire. The introduction section stressed the voluntary nature of the study and guaranteed the anonymity of participants. The full battery of instruments, in their final version, is included in *Annex V* to *Annex VIII*.

Sociodemographic questionnaire

Survey items were included to gather participants' personal background information (age, gender, secondary grade in which they are enrolled, language in which they learn mathematics at school, number of grades retaken –either in primary education or in Compulsory Secondary Education-, and the final mark obtained in mathematics the previous year).

Scale for Assessing Math Anxiety in Secondary education (SAMAS)

The Scale for Assessing Math Anxiety in Secondary education (SAMAS) assessed secondary students' levels of math anxiety in three dimensions: everyday life's math anxiety, math learning anxiety and math test anxiety. For its development and validation, a five-step approach was followed, consisting of: 1) specification of the underlying factors and evidence about content validity; 2) data collection and prior item analyses; 3) Confirmatory Factor Analysis (CFA) and assessment of the factor structures; 4) convergent validity; and 5) test-retest reliability. The final version of the scale consists of 20 items and takes, approximately, 5 minutes to complete. The whole procedure for the development and validation of the scale is detailed in *Chapter 5*.

Scale for Assessing Attitudes Toward Mathematics in Secondary education (SATMAS)

The Scale for Assessing Attitudes Toward Mathematics in Secondary education (SATMAS) assessed secondary students' levels of attitudes toward mathematics in three dimensions: student's math self-concept, perceived usefulness and importance of mathematics and interest for mathematics. For its development and validation, a five-step approach was followed, consisting of: 1) specification of the underlying factors and evidence about content validity; 2) data collection and prior item analyses; 3) Confirmatory Factor Analysis (CFA) and assessment of the factor structures; 4) convergent validity; and 5) test-retest reliability. The final version of the scale consists of 19 items and takes, approximately, 5 minutes to complete. The whole procedure for the development and validation of the scale is detailed in *Chapter 6*.

Mathematics curriculum-based questionnaire

Since mathematics achievement is extensively referred in literature on MA to negatively correlate with it and in literature on ATM to positively correlate with it, mathematics achievement was considered not only for the development of the structural model, but also for the analises of convergent validity for both the SAMAS and the SATMAS.

For those purposes, mathematics achievement was assessed by students' score on a mathematics curriculum-based questionnaire. The basic mathematical contents were covered across each cycle and were categorized in four main domains: 1) number properties and operations; 2) measurement and geometry; 3) functions and figures; and 4) data analysis and probability. These categories, in turn, were sorted by two more general sections, named calculus skills and mathematical problem solving skills (see Table 6).

Table 6

Distribution of items in the mathematics curriculum-based questionnaire

Section	Domain	2nd grade	4th grade
Calculus skills	Number properties and operations	14	7
Mathematical problema solving skills	Measurement and geometry	9	5

	Functions and figures	4	20
	Data analysis and probability	11	3

On the one hand, calculus skills (CAL, hereafter) were assessed by students' score on a series of paper-and-pencil calculations, entirely adapted for each grade. It contained 14 items for second-grade (as for example, $(-3)^3$ x (-4) + 10) and 7 items for fourth-grade (as for example, (√5 + 2) x (√5 – 2)). These items were retrieved from two math textbooks (Colera & Gaztelu, 2012; Colera, Colera, Gaztelu, Oliveira, & Martínez, 2012). The time limit to complete this section is 5 minutes in both grades and the use of calculator is not allowed. Students need to answer correctly to get 1 point for each calculation.

On the other hand, mathematical problem solving skills (PROB, hereafter) were assessed by students' score on a series of problems presented either in a multiple choice format (one correct answer out of four alternatives) or in an open-response format. The section for second graders was entirely taken from the diagnostic tests (Gobierno Vasco, 2009, 2010), which are typically administered in second grade as an external assessment of mathematical competence at the end of the first cycle of Compulsory Secondary Education; whereas the section for fourth graders was entirely taken from the PISA assessment (Gobierno Vasco, 2011), which is administered in fourth grade as an external assessment of mathematical competence at the end of the second cycle of Compulsory Secondary Education. The time limit to complete the section is 30 minutes in both cases and the use of a calculator is allowed. For their correction, the guidelines given by their authors (Gobierno Vasco, 2009, 2010, 2011) are applied, obtaining a single composite score for each participant.

In order to obtain a unique score for mathematics achievement, a single cumulative score, based on the sum of correct answers both in calculus skills and in mathematical problem solving skills, was computed. Since the original ranging scale for second grade (0-38) was different to that for fourth grade (0-35), the raw total scores obtained were transformed to a standard score in order to place all students' scores on the same scale ranging from 0 to 10.

4.2.3. Procedure

Once the research project was approved by the Ethics Committee of University of Deusto, the principals from the selected schools were contacted via email and informed of the nature of the research (see *Annex I*). They, in turn, presented it for approval at a staff meeting. After written permission was granted by the schools, consent forms were forwarded 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 confidentially and used solely for research purposes (see *Annex II*). Principals and parents or guardians were provided with the email address in case they wanted more information about the research. 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. No incentives (e.g., academic credits) were offered in exchange for participation.

Data were collected by the PhD candidate and a purpose-trained assistant in two separate time points: October 2014 (henceforth, T1) and June 2015 (henceforth, T2). In both occasions, the battery of instruments took 55 minutes to complete and was collectively handed out to students in their usual classrooms, in the absence of the teacher. Either the PhD candidate or the trained assistant was in the classroom the entire time to explain the procedure.

Chapter 5

Development and validation of the Scale for Assessing Math Anxiety in Secondary education (SAMAS)

CHAPTER

5

Development and validation of the Scale for Assessing Math Anxiety in Secondary education (SAMAS)

5.1. DATA ANALYSIS

As detailed as follows, data analysis for the development and validation of the Scale for Assessing Math Anxiety in Secondary education (henceforth, SAMAS) was divided into five phases. Across them, a series of statistical analyses were undertaken using the software packages IBM SPSS Statistics 22 and EQS 6.1.

Phase 1. Specification of the underlying factors and evidence about content validity

The development process for the new instrument SAMAS began by specifying both the construct math anxiety (henceforth, MA) and its underlying factors. Specifically, MA in the present research was defined based on Hopko's (2003) classification and previous studies on MA (Plake & Parker, 1982; Suinn & Edwards, 1982; Alexander & Martray, 1989; Chiu & Henry, 1990; Hopko, Mahadevan, Bare, & Hunt, 2003), whereby two factors are proposed as critical elements: anxiety about the process of learning mathematics and anxiety towards math evaluation. Aiming at completing its factor structure, a third factor was proposed as relevant in explaining the construct: anxiety towards everyday life's math-related tasks. Therefore, based on previous literature and theoretical considerations, MA was conceptualized to have three latent factors: everyday life's math anxiety (henceforth, ELMA), math learning anxiety (henceforth, MLA) and math test anxiety (henceforth, MTA).

Next, as recommended by AERA, APA, and NCME (2008), existing instruments were taken as the basis for the subsequent development of the new measure, collecting a large pool of preliminary items. Those statements originally written in English were translated into Spanish. The pool was then pruned by screening out redundant items and rewording some others to provide consistency across them. Newly written items were also added to complete the item pool and complete the factor structure for MA, in such a way that they did not contain double negatives or superlatives such as "always" or "never". Efforts were made to keep statements brief, straightforward and comprehensible to the target population (Clark & Watson, 1995; DeVellis, 2012). As a result, a total of 32 items were obtained, which, in turn, were sorted as follows: ELMA (13), MLA (13) and MTA (6).

After the initial pool of items for the new instrument was developed, a review panel consisted of nine experts on research and didactics was established to provide evidence about content validity. Experts were contacted via email and asked for participation (see *Annex III*). In that email, the nature of the research was introduced, instructions to complete the task were provided and descriptions of the proposed dimensions for the constructs were described. In the content validity task, experts were asked to classify each item within just one dimension, and then rate its accuracy and clarity of writing on a scale ranging continuously from 0 to 10 (see *Annex IV*). They were also prompted to send comments or suggestions for improvement if considered necessary. When finished, experts were asked to forward the response sheet through email. All of them completed the task within two weeks' time.

Results were then analyzed according to the criteria of: (a) mean (high if $M \geq 7.50$; acceptable if $2.50 \leq M < 7.50$; low if $M < 2.50$) for both relevance and clarity of writing; (b) standard deviation (good if $SD \leq 1.00$; acceptable if $1.00 < SD < 1.50$; low if $SD > 1.50$) for both relevance and clarity of writing; and (c) the inter-judge agreement percent with respect to the modal dimension (necessary, $PA \geq 77\%$, meaning that at least 7 out of 9 experts classify the item within the theoretical dimension) (Anderson & Gerbing, 1991; Schriesheim, Powers, Scandura, Gardiner, & Lankau, 1993). As a result of the review panel, it was obtained the initial 26-item version of SAMAS. Items were distributed as follows: ELMA (11), MLA (9) and MTA (9).

As the main purpose of the SAMAS was for it to be used in subsequent studies with secondary students enrolled in Spanish-Basque bilingual scholastic settings, the corresponding Basque version was also developed. Therefore, once the initial Spanish version of the scale was obtained, translation by committee was carried out (Marin & Marin, 1991), following the recommendations of the International Test Commission (Muñiz, Elosua, & Hambleton, 2013). Three experts, whose mother tongue was Basque, was contacted and worked independently in the translation from Spanish to Basque, emphasazing the conceptual meaning of statements rather than the literal one. Two of the experts were math professors and the other one, a Basque linguist currently working as a teacher in secondary education. Once all answers were reforwarded, a review meeting was arranged between another two different researchers on didactics and the PhD candidate. In that meeting, all items were checked and discussed, one by one, against the Spanish version by ensuring the conceptual equivalence of the items and by checking for inappropiate expressions and possible misundertansdings. That way, the consensual Basque version of the scale was obtained.

The initial 26-item Spanish-Basque version of the scale was administered to participants, who were requested to rate their degree of agreement with the statements on a continuous response scale ranging from 0 (*Strongly disagree*) to 10 (*Strongly agree*). The reason for selecting this type of response format instead of a more common Likert scale is twofold. On the one hand, the reference population (i.e., students from Compulsory Secondary Education) is accustomed to this assessment style, widely used in the scholastic setting. On the other hand, rating the responses on a continuous scale enables researchers to know with higher accuracy the level of agreement or disagreement of the respondent with each statement, which in turn, makes the subsequent statistical analyses stronger and more reliable (Pett, Lackey, & Sullivan, 2003).

Phase 2. Data collection and prior item analyses

After data collection, negatively worded items were recoded, and several analyses were conducted for the accuracy of data entry, missing values and the assumptions for CFA (Tabachnick & Fidell, 2007). Specifically, tests were performed to check for univariate normality, multivariate normality and possible outliers. Firstly, univariate normality was tested through skewness and kurtosis, assuming that values above 2.30 indicate large divergence from the normal distribution (Lei & Lomax, 2005). Secondly, multivariate normality was tested via the Mardia's standardized estimator, for which the proposed threshold of 3.00 was established as criterion (Bentler, 2005; Ullman, 2006).

Next, descriptive statistics, inter-item correlations and item-total correlations were computed to identify and discard, if necessary, poor items. Thus, items with negative and/or low inter-item correlations ($r < .30$) and/or low item-total correlations ($r < .30$) were discarded. Likewise, items with extremely high inter-item correlations ($r > .80$) and item-total correlations ($r > .80$) were selected for removal (Ferketich, 1991; Nunnally & Bernstein, 1994). Based on these considerations, a total of four items were discarded because of their low inter-item correlations. The resulting 22-item SAMAS was then subjected to CFA for testing its factor structure.

Phase 3. CFA and assessments of factor structure

Confirmatory Factor Analysis (CFA) was conducted to confirm the construct validity of the factor structure theoretically proposed for MA. This approach was preferred over Exploratory Factor Analysis (EFA) since the purpose of the present study was to assess the extent to which the factor structure, previously hypothesized drawing on an integrative literature review, fitted the data (Nunnally & Bernstein, 1994; Byrne, 2001). The univariate normality obtained for all variables, the low missing values rate (< 5%) estimated in dataset and the large sample size used in the study validated the implementation of Maximum Likelihood (*ML*) estimation (Chou & Bentler, 1995; Finney & DiStefano, 2006) with listwise deletion (Brown, 1983, 2006).

Due to the multivariate non-normality of data, the parameters of the CFA were estimated using Satorra-Bentler robust corrections (S-$B_{\chi 2}$) (Satorra & Bentler, 2001; Satorra, 2003). Items were forced to load on their hypothesized factors. The variances for the first observed indicator of each latent variable were fixed to 1, and the variances for all error weights and the remaining parameters were freely estimated (Ullman, 2006).

Four a priori models for assessing MA were subjected to CFA:

- firstly, a unidimensional model in which all items were indicators of a single factor named MA;

- secondly, a three-factor model in which the items were assumed to measure three factors (that is, ELMA, MLA and MTA);

- thirdly, a second-order factor model in which the three first-order factors (that is, ELMA, MLA and MTA) loaded on a second-order general factor named MA;

- and fourthly, a mixed model consisting of a second-order construct referring to academic math anxiety, which comprised both MLA and MTA, and a first order factor referring to everyday life's math anxiety (that is, ELMA). Indeed, as theoretically noted, both MLA and MTA refer to feelings of worry or tension evoked in scholastic settings. Therefore, it is plausible that these two components could load on a second-order factor, which for reserach purposes, will be named academic math anxiety (henceforth, AMA).

Several fit indices were used to judge the adequacy of the CFA. Since the S-$B_{\chi 2}$ statistics is sensitive to sample sizes greater than 200 (Kline, 2005; Hair, Black, Babin, & Anderson, 2010), the following alternative fit indices and desirable cut-offs were used to assess model fit to data: a) the S-$B_{\chi 2}/df$ statistics should be lower than 3.00 (Bollen, 1989; Bentler, 2005); b) the Root Mean Squared Error of Approximation (RMSEA) should be lower than .08 (Hu & Bentler, 1999; Browne, MacCallum, Kim, Andersen, & Glaser, 2002) with the relative 90% confidence interval; c) the Standardized Root Mean Square Residual (SRMR) should be lower than .08 (Hu & Bentler, 1999; Kline, 2005); d) the Non-Normed Fit Index (NNFI) should be greater than .90 (Hoyle & Panter, 1995); and e) the Comparative Fit Index (CFI) should be greater than .90 (Bentler, 1990; Marsh, Hau, & Wen, 2004; Kline, 2005). In addition, the Akaike's information criterion (AIC) was used to compare the factor structures with different estimated parameters in such a way that lower values indicated higher parsimony for the model (Hu & Bentler, 1999; Kline, 2005). Among the tested structures, that model with best fit-to-data was selected.

To enact modifications representing an improvement on the final fit, the selected model was further inspected through the standardized residual covariance scores, the inter-item correlation matrix, the standardized factor loadings and the conceptual relevance of the items. Specifically, standardized residual estimates below 2.00 in absolute value were indicative of poor items. Additionally, items with standardized residual estimates below 2.00, inter-item correlations below .30 and factor loadings below .40 (Floyd & Widaman, 1995) were marked for deletion. Based on these considerations, two items were discarded, obtaining a 20-item factor structure.

Next, discriminant validty was examined through the inter-factor correlations, setting as the criterion that values below r = .85 indicate that the latent factors are not statistically isomorphic (Mahoney, Thombs, & Howe, 1995; Kline, 2005). As regards internal consistency, both the Composite Reliability (*CR*) and Cronbach's coefficient (α) were used as indicators. For the former, values above .70 were considered to be adequate (Fornell & Larcker, 1981); for the latter, values from .70 to .79 were considered to be moderate, whereas values above .80 were interpreted as high reliability (Nunnally, 1978; Cortina, 1993; Cichetti, 1994).

Phase 4. Convergent validity

Convergent validity was assessed with the Pearson correlation coefficients between MA and other construct referred in literature (i.e., mathematics achievement). Specifically, it was expected that high levels of MA would be negatively related to mathematics achievement. To interpret the results, Cohen's (1988, 1992) criteria were followed. Thus, values of $|r|$ around .10 were indicative of small correlations, $|r|$ around .30 of moderate correlations, and $|r|$ around .50 or highest of big correlations.

Phase 5. Test-retest reliability

The final version of the 20-item scale was completed by the same research sample over a seven-month period. Firstly, CFA was run again with the final version of the scale in order to confirm the factor structure for the construct MA. Secondly, test–retest reliability was assessed for each factor (that is, ELMA, MLA and MTA) by computing the Intraclass Correlation Coefficient (ICC) based on a one-way random effects model between the first and the second time points. To interpret the results, Landis and Koch's (1977) criteria were followed. Therefore, values of ICC below .20 were indicative of small reliability, ICC between .20 and .60 of moderate reliability, ICC between .60 and .80 of good reliability; and ICC above .80 of excellent reliability.

5.2. RESULTS

5.2.1. Specification of the underlying factors and evidence about content validity

The development process for the SAMAS began with defining the construct MA and specifying its underlying factors. For that purpose, MA was defined based on Hopko's (2003) classification and previous studies on MA (Plake & Parker, 1982; Suinn & Edwards, 1982; Alexander & Martray, 1989; Chiu & Henry, 1990; Hopko, Mahadevan, Bare, & Hunt, 2003), whereby two factors are proposed as critical elements of MA. On the one hand, anxiety about the process of learning mathematics, which includes affective responses that a math student may experience during different situations of the math learning process; on the other hand, anxiety towards math evaluation, which refers to worrisome feelings that a math student may experience when either preparing or doing a math test. Since both elements referred to anxiety evoked in scholastic settings, a third factor was proposed as relevant in explaining the construct: anxiety towards everyday life's math-related tasks, which to date, has been referred in only one instrument (Cuestionario para medir la ansiedad hacia las Matemáticas; Muñoz & Mato, 2007). This third factor encompasses a broad range of affective responses to individuals' common situations in their day-to-day life that require mathematical or numerical reasoning for their completion, such as doing a purchase.

Therefore, based on previous literature and theoretical considerations, MA in the present study was conceptualized to have three latent factors:

Everyday life's math anxiety: encompasses a broad range of affective responses to student's everyday situations that require mathematical reasoning (e.g., "En una compra entre varias personas, me pongo nervioso/a al calcular cuánto tiene que poner cada una" *[In a purchase among several people, I get nervous when calculating how much to put each]*). An individual who scores high on this dimension experiences feelings of tension or worry when coping with common math-related tasks in her or his day-to-day life. On the other hand, an individual scoring low in this dimension does not experience those feelings of tension or worry in everyday life's math-related tasks.

Math learning anxiety: includes affective responses that a math student may experience in several situations during the math learning process that takes place in the scholastic setting (e.g., "Me pongo nervioso/a al pensar que tengo que volver a estudiar Matemáticas el curso que viene" *[I get nervous at the thought of having to study again math next year]*). A student who scores high on this dimension experiences feelings of tension or worry which are evoked by one or more elements inherent to the learning process of academic mathematics; whereas a student scoring low in this dimensions does not experience anxiety related to the learning process of mathematics.

Math test anxiety: refers to feelings that a math student may experience when either preparing or doing a math test (e.g., "Me pongo tenso/a cuando los ejercicios del control/examen de matemáticas son distintos a los vistos en clase" *[I get tense when the exercises in the math test are different compared with those did previously in class]*). This dimension is considered different, although related to, the previous one. Indeed, it is conceivable that a student may enjoy the subject of mathematics but feel nervous about doing a math test. Therefore, an individual who scores high in this dimension experience feelings of tension or worry as a consequence of the math evaluation process. On the contrary, an individual scoring low does not experience those feelings when being evaluated in mathematics.

Next, based on the aforementioned theoretical conceptualization for MA, the preliminary pool of items for the new SAMAS was compiled. For that, the following instruments were considered potentially useful in providing the basis for its development: Revised version of the Math Anxiety Rating Scale (MARS-

R; Plake & Parker, 1982), Math Anxiety Rating Scale – Adolescents (MARS-A; Suinn & Edwards, 1982), Abbreviated version of Math Anxiety Rating Scale (A-MARS; Alexander & Martray, 1989), Math Anxiety Scale for Children (MASC; Chiu & Henry, 1990), Abbreviated Math Anxiety Scale (AMAS; Hopko, Mahadevan, Bare, & Hunt, 2003), and Cuestionario para medir la ansiedad hacia las Matemáticas (Muñoz & Mato, 2007). After removing redundant items, rewording some others and adding newly written ones, a total of 32 items were obtained and sorted as follows: ELMA (13), MLA (13) and MTA (6) (see Table 7).

Table 7

Initial pool of items for the construct MA

Factor / Item	**Content**
ELMA	
it01	Me pongo nervioso/a cuando reviso el ticket de compra
it02	Me bloqueo cuando tengo que hacer sumas sin calculadora
it03	Me bloqueo cuando tengo que hacer restas sin calculadora
it04	Me bloqueo cuando tengo que hacer multiplicaciones sin calculadora
it05	Me bloqueo cuando tengo que hacer divisiones sin calculadora
it06	Cuando compro algo, me pongo nervioso/a al comprobar las vueltas
it07	Me pongo tenso/a cuando tengo que calcular el precio final de un producto rebajado
it08	En una compra entre varias personas, me pongo nervioso/a al calcular cuánto tiene que poner cada una
it09	Cuando hacemos un bote común, me pongo nervioso/a al calcular cómo repartir lo que ha sobrado
it10	Me bloqueo cuando tengo que hacer un cálculo mental
it11	Me pongo nervioso/a cuando tengo que calcular el precio total de lo que he comprado

it12	Me pongo nervioso/a al calcular qué me puedo comprar con la paga
it13	Me pongo nervioso/a cuando estoy ante un texto (noticia, cartel publicitario, folleto informativo, etc.) con números
MLA	
it14	Me pongo nervioso/a cuando veo fórmulas en el libro de Matemáticas
it15	Me pongo tenso/a cuando veo al profesor/a resolver un ejercicio de Matemáticas en clase
it16	Me pongo nervioso/a al pensar que tengo que volver a estudiar Matemáticas el curso que viene
it17	Me siento incómodo/a cuando veo que un compañero/a sale en clase de Matemáticas a resolver un ejercicio
it18	Me pongo nervioso/a cuando toca clase de Matemáticas
it19	Me bloqueo cuando otro/a compañero/a me explica un ejercicio de Matemáticas
it20	Me pongo nervioso/a cuando tengo que explicar a la clase un problema de Matemáticas
it21	Me pongo nervioso/a cuando tengo que responder a una pregunta del profesor/a en clase de Matemáticas
it22	Me pongo nervioso/a cuando mis compañeros/as terminan de resolver un problema antes que yo
it23	Me pongo nervioso/a cuando los deberes de Matemáticas son problemas difíciles
it24	Me pongo nervioso/a ante una lista de ejercicios o problemas de Matemáticas
it25	Me pongo nervioso/a cuando me pongo a hacer los deberes de Matemáticas
it26	Me pongo nervioso/a cuando oigo al profesor/a explicar Matemáticas
MTA	
it27	Me pongo nervioso/a cuando estudio para un control/examen de Matemáticas
it28	Me pongo más nervioso/a en los controles/exámenes de Matemáticas que en los controles/exámenes de otras asignaturas
it29	Me pongo tenso/a cuando los ejercicios del control/examen de Matemáticas son distintos a los vistos en clase
it30	Durante un control/examen de Matemáticas, me pongo nervioso/a cuando mis compañeros/as terminan antes que yo

it31	Me bloqueo cuando tengo poco tiempo para hacer el control/examen de Matemáticas
it32	Durante un control/examen de Matemáticas, me bloqueo cuando no me sale algún ejercicio

Note. ELMA = Everyday Life's Math Anxiety, MLA = Math Learning Anxiety, MTA = Math Test Anxiety.

This initial pool of items was then submitted to review panel. Judges were provided with the items, presented in a random order, and worked independently in the content validity task. Descriptive statistics, as well as the comments provided by judges, are presented in Table 8. For each item, means (*M*) and standard deviations (*SD*) are given both for accuracy and clarity of writing, and the percentage of agreement (*PA*) for the theoretical dimension is indicated. For any given item, means could range from 0 to 10, and the percentage of agreement from 0% to 100%. A value below 77% would represent insufficient agreement for the research purpose.

Table 8

Results from the review panel for SAMAS

Ítem	Accuracy		Clarity		Classification			*PA*	Comments
	M	*SD*	*M*	*SD*	ELMA	MLA	MTA	(%)	
it01	9.13	0.99	8.88	1.64	9			100	Add "ticket de LA compra"
it02	9.00	1.20	7.78	3.07	3	5		33.33	Specify in the subject or in student's day-to-day life
it03	8.71	1.60	8.00	3.21	6	3		63.67	Specify in the subject or in student's day-to-day life
it04	9.25	1.16	8.75	1.83	3	5		33.33	Specify in the subject or

									in student’s day-to-day life
it05	9.00	1.60	8.13	3.09	3	4		33.33	Specify in the subject or in student’s day-to-day life
it06	9.57	0.53	9.43	0.79	8			100.00	-
it07	9.57	0.53	9.29	0.95	8			100.00	-
it08	9.43	0.79	9.29	0.95	8			100.00	-
it09	8.88	1.25	8.13	2.47	9			100.00	-
it10	9.13	1.25	7.88	3.14	8	1		88.89	Specify in the subject or in student’s day-to-day life
it11	9.50	0.93	9.13	1.46	9			100.00	-
it12	9.00	1.53	9.00	1.53	8			100.00	-
it13	9.50	0.53	9.13	1.36	9			100.00	Simplify the sentence structure by eliminating the expression “cuanto estoy”
it14	9.00	1.07	9.25	1.04		8	1	88.89	-
it15	9.00	0.93	9.13	1.36		7	2	77.78	It is not clear if anxiety is evoked by the math teacher or by the math exercises
it16	9.00	1.15	9.43	0.79		9		100.00	-
it17	9.00	1.53	8.57	2.15		8	1	88.89	The statement is confusing
it18	9.17	0.98	9.50	0.84		9		100.00	-
it19	8.88	1.36	9.25	1.04		6		66.67	The content might refer to student’s expectancy
it20	8.88	1.25	9.25	1.16		9		100.00	It is not clear if anxiety is evoked by maths or by

									having to explain in class
it21	9.29	0.95	9.57	0.79		9		100.00	It is not clear if anxiety is evoked by maths or by having to answer in class
it22	8.13	1.89	8.75	1.75		7		77.78	
it23	8.88	1.25	9.00	1.41		9		100.00	It is not clear if anxiety is evoked by maths or by the difficulty of the math problem
it24	9.57	0.79	9.43	0.98		9		100.00	-
it25	9.25	1.04	9.13	1.25		9		100.00	-
it26	9.25	1.04	9.25	1.04		9		100.00	-
it27	9.13	1.13	8.88	1.55			9	100.00	-
it28	9.50	0.76	9.50	0.76			9	100.00	-
it29	9.43	0.79	9.14	1.21			8	100.00	-
it30	8.50	1.93	8.00	3.07		1	8	88.89	It is not clear if anxiety is evoked by maths or by the fact of comparing with her/his classmates
it31	8.63	1.77	8.63	1.77		1	7	77.78	It is not clear if anxiety is evoked by the math exam or by timing
it32	9.25	0.89	9.25	1.04			9	100.00	-

Note. ELMA = Everyday Life's Math Anxiety, MLA = Math Learning Anxiety, MTA = Math Test Anxiety; PA = Percentage of Agreement.

Inspections of Table 8 revealed that overall, statements were positively evaluated in terms of accuracy and clarity of writing and were categorized into just one dimension. On over the half of all statements (62.5%) there was complete agreement among the experts (PA = 100%), and on one-fifth, approximately, of all statements (18.5%) there was almost unanimous agreement (77% < PA <

100%). There was less than 77% agreement on only six items (18.5%), without any statement showing complete lack of agreement.

Thus, the following conclusions were drawn from these results and the comments given by the experts:

- firstly, it would be necessary to reword 6 items (it01, it11, it13, it15, it21, it31);

- secondly, it would be advisable to dircard 5 items (it17, it19, it20, it22, it30);

- thirdly, it would be interesting to join it02 and it03 in a newly written unique item;

- fourthly, it would be interesting to join it04 and it05 in a newly written unique item;

- and fifthly, it would be recommended to break down it27 in two different statements.

Therefore, after examining the content contribution of these items to their theoretical dimensions and checking that the proposed changes made sense in improving the overall factor structure for MA, they were reworded, modified or deleted as suggested. Having made these modifications, the remaining 26 items, which comprised the first version of SAMAS, were distributed as follows: ELMA (11), MLA (9) and MTA (6) (see Table 9).

Table 9

Initial version of SAMAS

Factor	Original item	Final item
ELMA	it01. Me pongo nervioso/a cuando reviso el ticket de compra	**elma01. Me pongo nervioso/a cuando reviso el ticket de la compra**
	it02. Me bloqueo cuando tengo que hacer sumas sin calculadora	**elma02. Me bloqueo cuando tengo que hacer sumas o restas sin calculadora**
	it03. Me bloqueo cuando tengo que hacer restas sin calculadora	
	it04. Me bloqueo cuando tengo que hacer multiplicaciones sin calculadora	**elma03. Me bloqueo cuando tengo que hacer multiplicaciones o divisiones sin calculadora**
	it05. Me bloqueo cuando tengo que hacer divisiones sin calculadora	
	it06. Cuando compro algo, me pongo nervioso/a al comprobar las vueltas	elma04. Cuando compro algo, me pongo nervioso/a al comprobar las vueltas
	it07. Me pongo tenso/a cuando tengo que calcular el precio final de un producto rebajado	elma05. Me pongo tenso/a cuando tengo que calcular el precio final de un producto rebajado
	it08. En una compra entre varias personas, me pongo nervioso/a al calcular cuánto tiene que poner cada una	elma06. En una compra entre varias personas, me pongo nervioso/a al calcular cuánto tiene que poner cada una
	it09. Cuando hacemos un bote común, me pongo nervioso/a al calcular cómo repartir lo que ha sobrado	elma07. Cuando hacemos un bote común, me pongo nervioso/a al calcular cómo repartir lo que ha sobrado
	it10. Me bloqueo cuando tengo que hacer un cálculo mental	elma08. Me bloqueo cuando tengo que hacer un cálculo mental
	it11. Me pongo nervioso/a cuando tengo que calcular el precio total de lo que he comprado	**elma09. Me pongo nervioso/a al calcular el precio total de lo que he comprado**
	it12. Me pongo nervioso/a al calcular qué me puedo comprar con la paga	elma10. Me pongo nervioso/a al calcular qué me puedo comprar con la paga

	it13. Me pongo nervioso/a cuando estoy ante un texto (noticia, cartel publicitario, folleto informativo, etc.) con números	**elma11. Me pongo nervioso/a ante un texto (noticia, cartel publicitario, folleto informativo, etc.) con números**
MLA	it14. Me pongo nervioso/a cuando veo fórmulas en el libro de Matemáticas	mla01. Me pongo nervioso/a cuando veo fórmulas en el libro de Matemáticas
	it15. Me pongo tenso/a cuando veo al profesor/a resolver un ejercicio de Matemáticas en clase	**mla02. Me pongo nervioso/a cuando en clase se resuelve un ejercicio o problema de Matemáticas en la pizarra**
	it16. Me pongo nervioso/a al pensar que tengo que volver a estudiar Matemáticas el curso que viene	mla03. Me pongo nervioso/a al pensar que tengo que volver a estudiar Matemáticas el curso que viene
	it17. Me siento incómodo/a cuando veo que un compañero/a sale en clase de Matemáticas a resolver un ejercicio	(eliminated)
	it18. Me pongo nervioso/a cuando toca clase de Matemáticas	mla04. Me pongo nervioso/a cuando toca clase de Matemáticas
	it19. Me bloqueo cuando otro/a compañero/a me explica un ejercicio de Matemáticas	(eliminated)
	it20. Me pongo nervioso/a cuando tengo que explicar a la clase un problema de Matemáticas	(eliminated)
	it21. Me pongo nervioso/a cuando tengo que responder a una pregunta del profesor/a en clase de Matemáticas	**mla05. Me pongo nervioso/a cuando tengo que resolver un ejercicio o problema en clase de Matemáticas**
	it22. Me pongo nervioso/a cuando mis compañeros/as terminan de resolver un problema antes que yo	(eliminated)
	it23. Me pongo nervioso/a cuando los deberes de Matemáticas son problemas difíciles	mla06. Me pongo nervioso/a cuando los deberes de Matemáticas son problemas difíciles

	it24. Me pongo nervioso/a ante una lista de ejercicios o problemas de Matemáticas	mla07. Me pongo nervioso/a ante una lista de ejercicios o problemas de Matemáticas
	it25. Me pongo nervioso/a cuando me pongo a hacer los deberes de Matemáticas	mla08. Me pongo nervioso/a cuando me pongo a hacer los deberes de Matemáticas
	it26. Me pongo nervioso/a cuando oigo al profesor/a explicar Matemáticas	mla09. Me pongo nervioso/a cuando en clase se da una explicación de Matemáticas
MTA	it27. Me pongo nervioso/a cuando estudio para un control/examen de Matemáticas	mta01. Me pongo nervioso/a cuando estudio para un control/examen de Matemáticas
		mta02. Me pongo nervioso/a el día previo a un control/examen de Matemáticas
	it28. Me pongo más nervioso/a en los controles/exámenes de Matemáticas que en los controles/exámenes de otras asignaturas	mta03. Me pongo más nervioso/a en los controles/exámenes de Matemáticas que en los controles/exámenes de otras asignaturas
	it29. Me pongo tenso/a cuando los ejercicios del control/examen de Matemáticas son distintos a los vistos en clase	mta04. Me pongo tenso/a cuando los ejercicios del control/examen de Matemáticas son distintos a los vistos en clase
	it30. Durante un control/examen de Matemáticas, me pongo nervioso/a cuando mis compañeros/as terminan antes que yo	(eliminated)
	it31. Me bloqueo cuando tengo poco tiempo para hacer el control/examen de Matemáticas	**mta05. Durante un control/examen de Matemáticas, me pongo nervioso/a porque creo que tengo poco tiempo para terminarlo**
	it32. Durante un control/examen de Matemáticas, me bloqueo cuando no me sale algún ejercicio	mta06. Durante un control/examen de Matemáticas, me bloqueo cuando no me sale algún ejercicio

Note. ELMA = Everyday Life's Math Anxiety, MLA = Math Learning Anxiety, MTA = Math Test Anxiety. Statements in bold were re-written

The resulting scale was then submitted to a translation by committee. The consensual version of the Spanish-Basque bilingual scale is shown in Table 10.

Table 10

Initial Spanish-Basque bilingual SAMAS

Factor / Item	Content
ELMA	
elma01	Me pongo nervioso/a cuando reviso el ticket de la compra *Erosketa-tiketa berrikusten dudanean urduri jartzen naiz*
elma02	Me bloqueo cuando tengo que hacer sumas o restas sin calculadora *Batuketak edo kenketak kalkulagailurik gabe egin behar ditudanean trabatzen naiz*
elma03	Me bloqueo cuando tengo que hacer multiplicaciones o divisiones sin calculadora *Biderketak edo zatiketak kalkulagailurik gabe egin behar ditudanean trabatzen naiz*
elma04	Cuando compro algo, me pongo nervioso/a al comprobar las vueltas *Zerbait erosi eta gero, gainerakoak egiaztatzean urduri jartzen naiz*
elma05	Me pongo tenso/a cuando tengo que calcular el precio final de un producto rebajado *Beheratutako produktu baten salneurri finala kalkulatu behar dudanean urduri jartzen naiz*
elma06	En una compra entre varias personas, me pongo nervioso/a al calcular cuánto tiene que poner cada una *Pertsona batzuen arteko erosketa batean, gutako bakoitzak zenbat eman behar duen kalkulatzen urduri jartzen naiz*
elma07	Cuando hacemos un bote común, me pongo nervioso/a al calcular cómo repartir lo que ha sobrado *Potoa jartzen dugunean, gainontzekoa nola banatu kalkulatzean urduri jartzen naiz*

elma08	Me bloqueo cuando tengo que hacer un cálculo mental *Buruzko kalkulu bat egin behar dudanean trabatzen naiz*
elma09	Me pongo nervioso/a al calcular el precio total de lo que he comprado *Erositakoaren prezioa kalkulatzean urduri jartzen naiz*
elma10	Me pongo nervioso/a al calcular qué me puedo comprar con la paga *Aste-sariarekin zer eros dezakedan kalkulatzean urduri jartzen naiz*
elma11	Me pongo nervioso/a ante un texto (noticia, cartel publicitario, folleto informativo, etc.) con números *Zenbakiak dituen testu baten (berri baten, kartel baten, iragarki baten,…) aurrean urduri jartzen naiz*
MLA	
mla01	Me pongo nervioso/a cuando veo fórmulas en el libro de Matemáticas *Matematikako liburuan formulak ikusten ditudanean urduri jartzen naiz*
mla02	Me pongo nervioso/a cuando en clase se resuelve un ejercicio o problema de Matemáticas en la pizarra *Klasean matematikako ariketa edo buruketa bat arbelean egiten dutenean, urduri jartzen naiz*
mla03	Me pongo nervioso/a al pensar que tengo que volver a estudiar Matemáticas el curso que viene *Datorren ikasturtean Matematika berriro ere ikasi beharko dudala pentsatzean urduri jartzen naiz*
mla04	Me pongo nervioso/a cuando toca clase de Matemáticas *Matematika klasea dudan bakoitzean urduri jartzen naiz*
mla05	Me pongo nervioso/a cuando tengo que resolver un ejercicio o problema en clase de Matemáticas *Matematika klasean ariketa edo buruketa bat egin behar dudanean urduri jartzen naiz*
mla06	Me pongo nervioso/a cuando los deberes de Matemáticas son problemas difíciles *Matematikako etxerako lanak buruketa zailak direnean urduri jartzen naiz*
mla07	Me pongo nervioso/a ante una lista de ejercicios o problemas de Matemáticas *Matematikako ariketa- edo buruketa-zerrendaren aurrean urduri jartzen naiz*

mla08	Me pongo nervioso/a cuando me pongo a hacer los deberes de Matemáticas *Matematikako etxerako lanak egiten hastean urduri jartzen naiz*
mla09	Me pongo nervioso/a cuando en clase se da una explicación de Matemáticas *Klasean matematikari buruzko azalpen bat ematen dutenean urduri jartzen naiz*
MTA	
mta01	Me pongo nervioso/a cuando estudio para un control/examen de Matemáticas *Matematikako krontola/azterketarako ikasten dudanean urduri jartzen naiz*
mta02	Me pongo nervioso/a el día previo a un control/examen de Matemáticas *Matematikako krontola/azterketaren aurreko egunean urduri jartzen naiz*
mta03	Me pongo más nervioso/a en los controles/exámenes de Matemáticas que en los controles/exámenes de otras asignaturas *Matematikako krontola/azterketetan urduriago jartzen naiz gainontzeko irakasgaietako krontola/azterketetan baino*
mta04	Me pongo tenso/a cuando los ejercicios del control/examen de Matemáticas son distintos a los vistos en clase *Matematikako krontola/azterketako ariketak klasean ikusitakoekin alderatuta desberdinak direnean urduri jartzen naiz*
mta05	Durante un control/examen de Matemáticas, me pongo nervioso/a porque creo que tengo poco tiempo para terminarlo *Matematikako krontola/azterketan urduri jartzen naiz bukatzeko denbora laburra daukadalako ustean*
mta06	Durante un control/examen de Matemáticas, me bloqueo cuando no me sale algún ejercicio *Matematikako krontola/azterketan ariketaren bat ez dakidanean trabatzen naiz*

Note. ELMA = Everyday Life's Math Anxiety, MLA = Math Learning Anxiety, MTA = Math Test Anxiety. Statements in bold were re-written

This was the scale administered to the sample as part of the battery of instruments. Participants had to rate their degree of agreement with the statements on a continuous response scale ranging from 0 (*Strongly disagree*) to 10 (*Strongly agree*).

5.2.2. Data collection and prior item analyses

Prior to psychometric analyses, a series of descriptive statistics were conducted (see Table 11). The accuracy of the data entry was examined by the range of the data, ensuring that values ranged from 0 to 10 for all the items of the scale. Given the low missing data rate (< 5%), which was considered to be reasonable (Tabachnick & Fidell, 2007), the Maximum Likelihood (*ML*) estimation method was used with listwise deletion (Brown, 1983, 2006).

Table 11

Descriptive statistical data of each item in both language groups

Item	*n*	*Min.*	*Max.*	*S*	*K*	*M*	*SD*	IT correlation
elma01								
MLS	562	0	10	2.48	6.44	0.92	1.71	.56
MLB	228	0	10	2.17	5.14	1.19	1.87	.58
elma02								
MLS	560	0	10	1.43	1.34	1.89	2.40	.51
MLB	228	0	10	0.74	-0.69	3.12	2.97	.49
elma03								
MLS	563	0	10	1.06	0.21	2.33	2.63	.50
MLB	228	0	10	0.67	-0.55	3.32	2.75	.43
elma04								
MLS	562	0	10	1.59	1.95	1.55	2.23	.63
MLB	229	0	10	1.49	1.44	1.81	2.40	.58
elma05								
MLS	562	0	10	0.96	-0.11	2.34	2.61	.61
MLB	226	0	10	0.95	-0.20	2.62	2.80	.62
elma06								
MLS	560	0	10	0.89	-0.41	2.68	2.88	.55

MLB	223	0	10	0.81	-0.55	2.88	2.94	.53
elma07								
MLS	559	0	10	1.33	0.88	1.82	2.37	.72
MLB	225	0	10	0.88	-0.01	2.58	2.57	.49
elma08								
MLS	563	0	10	0.49	-0.84	3.58	2.95	.58
MLB	228	0	10	0.26	-0.09	4.23	2.85	.46
elma09								
MLS	559	0	10	1.47	1.38	1.72	2.33	.58
MLB	229	0	10	1.39	0.94	2.06	2.68	.61
elma10								
MLS	562	0	10	2.39	6.26	0.92	1.70	.46
MLB	228	0	10	1.64	2.35	1.55	2.18	.59
elma11								
MLS	562	0	10	3.01	10.06	0.66	1.45	.45
MLB	227	0	10	2.58	7.35	1.11	1.87	.47
mla01								
MLS	562	0	10	0.97	-0.15	2.57	2.88	.44
MLB	228	0	10	0.94	-0.20	2.73	2.83	.57
mla02								
MLS	562	0	10	1.19	0.53	2.23	2.67	.45
MLB	227	0	10	0.97	-0.24	2.81	3.05	.58
mla03								
MLS	563	0	10	1.17	0.10	2.40	3.13	.66
MLB	229	0	10	1.04	-0.27	2.61	3.23	.68
mla04								
MLS	562	0	10	1.70	2.18	1.55	2.33	.60
MLB	224	0	10	1.09	0.11	2.47	2.84	.62
mla05								
MLS	562	0	10	0.64	-0.68	3.19	3.00	.59
MLB	226	0	10	0.70	-0.74	3.33	3.11	.69

mla06									
	MLS	563	0	10	0.18	-1.20	4.12	3.12	.59
	MLB	228	0	10	0.50	-0.99	3.63	3.03	.57
mla07									
	MLS	559	0	10	0.43	-0.99	3.70	3.03	.69
	MLB	228	0	10	0.46	-1.00	3.91	3.07	.61
mla08									
	MLS	563	0	10	1.68	2.34	1.44	2.08	.58
	MLB	227	0	10	1.92	4.00	1.44	1.96	.66
mla09									
	MLS	562	0	10	1.04	0.09	2.18	2.49	.57
	MLB	227	0	10	1.13	0.41	2.08	2.34	.61
mta01									
	MLS	563	0	10	0.60	-0.94	3.32	3.15	.66
	MLB	229	0	10	0.57	-0.95	3.58	3.16	.66
mta02									
	MLS	562	0	10	0.41	-1.14	3.74	3.26	.69
	MLB	229	0	10	0.34	-1.25	4.11	3.30	.76
mta03									
	MLS	563	0	10	0.11	-1.48	4.43	3.63	.67
	MLB	226	0	10	0.06	-1.42	4.83	3.53	.64
mta04									
	MLS	562	0	10	-0.47	-0.98	5.95	3.11	.58
	MLB	228	0	10	-0.10	-1.14	5.15	3.02	.61
mta05									
	MLS	560	0	10	-0.40	-1.24	5.77	3.51	.61
	MLB	227	0	10	-0.61	-0.90	6.24	3.12	.55
mta06									
	MLS	561	0	10	-0.33	-1.03	5.74	3.14	.63
	MLB	229	0	10	-0.20	-0.97	5.55	2.94	.64

Note. MLS = Math Learners in Spanich, MLB = Math Learners in Basque, *Min* = Minimum, *Max* = Maximum, *S* = Skewness, *K* = Kurtosis, *M* = Mean, *SD* = Standard Deviation, IT correlation = Item-Total correlation

As seen in Table 11, considering the full SAMAS, secondary students from both language groups reported the highest mean scores on items encompassing feelings of tension as a consequence of the math evaluation process. Specifically, the highest values were obtained in:

- mta04 ("Me pongo tenso/a cuando los ejercicios del control/examen de Matemáticas son distintos a los vistos en clase" *[I get tense when the exercises in the math test are different compared with those did previously in class]*);

- mta05 ("Durante un control/examen de Matemáticas, me pongo nervioso/a porque creo que tengo poco tiempo para terminarlo" *[During a math test, I get nervous because I think that I have short time to finish it]*);

- and mta06 ("Durante un control/examen de Matemáticas, me bloqueo cuando no me sale algún ejercicio" *[During a math test, I cannot think straight when I do not know how to solve an exercise]*).

Meanwhile, students reported the lowest mean scores on items developed to assess everyday life's math anxiety. Specifically, the lowest values were obtained in:

- elma11 ("Me pongo nervioso/a ante un texto -noticia, cartel publicitario, folleto informativo, etc.- con números" *[I get nervous when dealing with a* *text (some news, an advertisements, a brochure,…) that has numerical information]*);

- elma01 ("Me pongo nervioso/a cuando reviso el ticket de la compra" *[I get nervous when checking the receipt]*);

- and elma10 ("Me pongo nervioso/a al calcular qué me puedo comprar con la paga" *[I get nervous when calculating what I can buy with the pocket money]*).

As regards the normality assumption, this was examined in two phases. First, the univariate normality was tested through skewness and kurtosis. The descriptive statistical analysis showed that the majority of items met the criteria. The three exceptions in MLS were elma01 (skewness = 2.48, kurtosis = 6.44), elma10 (skewness = 2.39, kurtosis = 6.26) and elma11 (skewness = 3.01, kurtosis = 10.06); whereas the three exceptions in MLB were elma01 (skewness = 2.15, kurtosis = 5.14), elma10 (skewness = 1.64, kurtosis = 2.35) and elma11 (skewness = 2.58, kurtosis = 7.35). However, visual inspection of the corresponding graphic distribution of scores showed that, although initially identified as outliers, they were suitable for being retained in subsequent analyses.

Second, multivariate normality was tested via the Mardia's standardized estimator, which in the current study was 72.32 ($p < .001$) in MLS and 34.07 ($p < .001$) in MLB, well above the proposed minimum value of 5.00 (Bentler, 2005; Ullman, 2006). Therefore, the violation of multivariate normality encouraged carrying out the estimations with robust methods for standard errors, statistical errors and goodness-of-fit indices (Satorra & Bentler, 2001; Satorra, 2003).

Additionally, item-total correlations were analyzed to identify poor items. Obtained values ranged from r = .44 (mla01: “Me pongo nervioso/a cuando veo fórmulas en el libro de Matemáticas” *[I get nervous when seeing formulas in the math coursebook]*) to r = .72 (elma07: ” Cuando hacemos un bote común, me pongo nervioso/a al calcular cómo repartir lo que ha sobrado” *[In a kitty, I get nervous when calculating how to divide what is left]*) in MLS, and from r = .43 (elma03: “Me bloqueo cuando tengo que hacer multiplicaciones o divisiones sin calculadora” *[I cannot think straight when I have to do multiplications or divisions without a calculator]*) to r = .76 (mta02: “Me pongo nervioso/a el día previo a un control/examen de Matemáticas” *[I get nervous the previous day of a math test]*) in MLB. No item showed values below the threshold of r = .40, and consequently, all of them were retained for subsequent analysis based on the item-total correlation criterion.

Next, inter-item correlations were computed and presented both by factors and language groups. Noteworhtly, all values were statistically significant at p < .001. Firstly, inter-item correlations for ELMA ranged from r = .19 to r = .56 in MLS, and from r = .12 to r = .66 in MLB (see Table 12).

Table 12

Inter-item correlation matrix for ELMA in both language groups

		elma 01	elma 02	elma 03	elma 04	elma 05	elma 06	elma 07	elma 08	elma 09	elma 10	elma 11
elma 01	MLS	1										
	MLB	1										
elma 02	MLS	.29	1									
	MLB	.29	1									
elma 03	MLS	.19	.44	1								
	MLB	.26	.29	1								
elma 04	MLS	.45	.33	.30	1							
	MLB	.43	.32	.33	1							
elma 05	MLS	.38	.36	.35	.51	1						
	MLB	.44	.26	.29	.51	1						
elma 06	MLS	.41	.25	.30	.38	.36	1					
	MLB	.35	.36	.14	.37	.44	1					
elma 07	MLS	.48	.40	.45	.56	.54	.50	1				
	MLB	.34	.23	.27	.36	.42	.28	1				
elma 08	MLS	.30	.46	.52	.38	.40	.39	.43	1			
	MLB	.22	.32	.42	.32	.30	.30	.26	1			
elma 09	MLS	.45	.29	.26	.37	.36	.52	.47	.36	1		
	MLB	.46	.39	.23	.37	.56	.66	.32	.28	1		
elma 10	MLS	.35	.26	.24	.42	.35	.22	.38	.23	.35	1	
	MLB	.42	.33	.40	.47	.51	.24	.52	.24	.33	1	
elma 11	MLS	.42	.19	.21	.40	.37	.25	.39	.26	.34	.39	1
	MLB	.41	.35	.24	.40	.33	.29	.32	.12	.34	.38	1

Note. All values are statistically significant at $p < .001$

Secondly, as seen in Table 13, inter-item correlations for MLA ranged from $r = .33$ to $r = .54$ in MLS, and from $r = .31$ to $r = .63$ in MLB.

Table 13

Inter-item correlation matrix for MLA in both language groups

		mla 01	mla 02	mla 03	mla 04	mla 05	mla 06	mla 07	mla 08	mla 09
mla 01	MLS	1								
	MLB	1								
mla 02	MLS	.43	1							
	MLB	.40	1							
mla 03	MLS	.48	.42	1						
	MLB	.46	.46	1						
mla 04	MLS	.41	.44	.47	1					
	MLB	.37	.44	.47	1					
mla 05	MLS	.50	.50	.43	.48	1				
	MLB	.46	.46	.52	.63	1				
mla 06	MLS	.43	.41	.34	.34	.50	1			
	MLB	.31	.39	.38	.39	.48	1			
mla 07	MLS	.44	.35	.41	.33	.54	.46	1		
	MLB	.39	.41	.49	.43	.50	.47	1		
mla 08	MLS	.48	.37	.45	.41	.42	.44	.36	1	
	MLB	.45	.43	.57	.41	.42	.46	.39	1	
mla 09	MLS	.53	.48	.42	.50	.51	.39	.40	.52	1
	MLB	.44	.37	.49	.38	.44	.40	.37	.59	1

Note. All values are statistically significant at $p < .001$

Thirdly, as seen in Table 14, inter-item correlations for MTA ranged from $r = .41$ to $r = .65$ in MLS, and from $r = .33$ to $r = .67$ in MLB.

Table 14

Inter-item correlation matrix for MTA in both language groups

		mta01	mta02	mta03	mta04	mta05	mta06
mta01	MLS	1					
	MLB	1					
mta02	MLS	.65	1				
	MLB	.67	1				
mta03	MLS	.60	.61	1			
	MLB	.57	.59	1			
mta04	MLS	.41	.44	.47	1		
	MLB	.49	.58	.38	1		
mta05	MLS	.44	.47	.45	.45	1	
	MLB	.33	.46	.41	.40	1	
mta06	MLS	.44	.47	.46	.50	.57	1
	MLB	.43	.53	.48	.51	.51	1

Note. All values are statistically significant at $p < .001$

Overall, most items were moderately correlated. No value exceeded the threshold of $r = .80$, meaning that there was not any problem of multicollineality. However, upon a closer examination of the matrices, the following four items were proposed to be discarded because of their low inter-item correlations:

- elma02 ("Me bloqueo cuando tengo que hacer sumas o restas sin calculadora" *[I cannot think straight when I have to do additions or subtractions without a calculator]*);

- elma03 ("Me bloqueo cuando tengo que hacer multiplicaciones o divisiones sin calculadora" *[I cannot think straight when I have to do multiplications or divisions without a calculator]*);

- elma08 ("Me bloqueo cuando tengo que hacer un cálculo mental" *[I cannot think straight when I have to do a mental calculation]*);

- and elma11 ("Me pongo nervioso/a ante un texto -noticia, cartel publicitario, folleto informativo, etc.- con números" *[I get nervous when dealing with a text (some news, an advertisements, a brochure,…) that has numerical information]*).

Thus, the version of the scale to be subjected to CFA consisted of 22 items, as shown in Table 15.

Table 15

22-item SAMAS for being subjected to CFA

Factor / Item	Content
ELMA	
elma01	Me pongo nervioso/a cuando reviso el ticket de la compra *Erosketa-tiketa berrikusten dudanean urduri jartzen naiz*
elma04	Cuando compro algo, me pongo nervioso/a al comprobar las vueltas *Zerbait erosi eta gero, gainerakoak egiaztatzean urduri jartzen naiz*
elma05	Me pongo tenso/a cuando tengo que calcular el precio final de un producto rebajado *Beheratutako produktu baten salneurri finala kalkulatu behar dudanean urduri jartzen naiz*
elma06	En una compra entre varias personas, me pongo nervioso/a al calcular cuánto tiene que poner cada una *Pertsona batzuen arteko erosketa batean, gutako bakoitzak zenbat eman behar duen kalkulatzen urduri jartzen naiz*
elma07	Cuando hacemos un bote común, me pongo nervioso/a al calcular cómo repartir lo que ha sobrado

	Potoa jartzen dugunean, gainontzekoa nola banatu kalkulatzean urduri jartzen naiz
elma09	Me pongo nervioso/a al calcular el precio total de lo que he comprado
	Erositakoaren prezioa kalkulatzean urduri jartzen naiz
elma10	Me pongo nervioso/a al calcular qué me puedo comprar con la paga
	Aste-sariarekin zer eros dezakedan kalkulatzean urduri jartzen naiz
MLA	
mla01	Me pongo nervioso/a cuando veo fórmulas en el libro de Matemáticas
	Matematikako liburuan formulak ikusten ditudanean urduri jartzen naiz
mla02	Me pongo nervioso/a cuando en clase se resuelve un ejercicio o problema de Matemáticas en la pizarra
	Klasean matematikako ariketa edo buruketa bat arbelean egiten dutenean, urduri jartzen naiz
mla03	Me pongo nervioso/a al pensar que tengo que volver a estudiar Matemáticas el curso que viene
	Datorren ikasturtean Matematika berriro ere ikasi beharko dudala pentsatzean urduri jartzen naiz
mla04	Me pongo nervioso/a cuando toca clase de Matemáticas
	Matematika klasea dudan bakoitzean urduri jartzen naiz
mla05	Me pongo nervioso/a cuando tengo que resolver un ejercicio o problema en clase de Matemáticas
	Matematika klasean ariketa edo buruketa bat egin behar dudanean urduri jartzen naiz
mla06	Me pongo nervioso/a cuando los deberes de Matemáticas son problemas difíciles
	Matematikako etxerako lanak buruketa zailak direnean urduri jartzen naiz
mla07	Me pongo nervioso/a ante una lista de ejercicios o problemas de Matemáticas
	Matematikako ariketa- edo buruketa-zerrendaren aurrean urduri jartzen naiz
mla08	Me pongo nervioso/a cuando me pongo a hacer los deberes de Matemáticas
	Matematikako etxerako lanak egiten hastean urduri jartzen naiz
mla09	Me pongo nervioso/a cuando en clase se da una explicación de Matemáticas
	Klasean matematikari buruzko azalpen bat ematen dutenean urduri jartzen naiz

MTA	
mta01	Me pongo nervioso/a cuando estudio para un control/examen de Matemáticas *Matematikako krontola/azterketarako ikasten dudanean urduri jartzen naiz*
mta02	Me pongo nervioso/a el día previo a un control/examen de Matemáticas *Matematikako krontola/azterketaren aurreko egunean urduri jartzen naiz*
mta03	Me pongo más nervioso/a en los controles/exámenes de Matemáticas que en los controles/exámenes de otras asignaturas *Matematikako krontola/azterketetan urduriago jartzen naiz gainontzeko irakasgaietako krontola/azterketetan baino*
mta04	Me pongo tenso/a cuando los ejercicios del control/examen de Matemáticas son distintos a los vistos en clase *Matematikako krontola/azterketako ariketak klasean ikusitakoekin alderatuta desberdinak direnean urduri jartzen naiz*
mta05	Durante un control/examen de Matemáticas, me pongo nervioso/a porque creo que tengo poco tiempo para terminarlo *Matematikako krontola/azterketan urduri jartzen naiz bukatzeko denbora laburra daukadalako ustean*
mta06	Durante un control/examen de Matemáticas, me bloqueo cuando no me sale algún ejercicio *Matematikako krontola/azterketan ariketaren bat ez dakidanean trabatzen naiz*

Note. ELMA = Everyday Life's Math Anxiety, MLA = Math Learning Anxiety, MTA = Math Test Anxiety.

5.2.3. CFA and assessments of factor structure

Four models were tested and compared to yield the best and most parsimonious factor structure for SAMAS: (1) a one-factor model (unidimensional), in which all items were indicators of a global factor (MA); (2) a three first-order factor model (multidimensional), in which the items were assumed to measure the three principal factors of the scale (that is, ELMA, MLA and MTA); (3) a second-order model (hierarchical), in which the three first-order factors (ELMA, MLA, and MTA) loaded on a second-order factor (MA), and (4) a hierarchical model, comprising a first order factor (ELMA) and a second-order factor (on which both MLA and MTA loaded on a second-order factor named AMA).

After these alternative models were proposed, the goodness-of-fit indices were computed and compared in order to select the most parsimonius and interpretable factor structure for MA (see Table 16).

Table 16.

Goodness-of-fit indices for the four alternative models, split down by language

CFA model	S-B$_{\chi^2}$	*df*	RMSEA (90% CI)	SRMR	NNFI	CFI	AIC	ΔS-B$_{\chi^2}$ (Δ*df*)
Single factor								
Spanish version	1039.08	209	.086 (.081, .091)	.083	.78	.80	621.08	/
Basque version	556.43	209	.090 (.081, .099)	.089	.76	.79	138.43	/
Three-factor model								
Spanish version	501.27	206	.052 (.046, .057)	.047	.92	.93	89.28	537.81*** (3)
Basque version	358.70	206	.060 (.050, .071)	.062	.89	.91	-53.30	197.73*** (3)
Second-order model								
Spanish version	513.94	206	.053 (.047, .059)	.050	.92	.93	101.94	525.14*** (3)
Basque version	370.80	206	.063 (.052, .073)	.066	.89	.90	-41.20	185.63*** (3)
Mixed model								
Spanish version	513.94	206	.053 (.047, .059)	.050	.92	.93	101.94	525.14*** (3)
Basque version	370.80	206	.063 (.052, .073)	.066	.89	.90	-41.20	185.63*** (3)

Note. RMSEA = Root Mean Square Error of Approximation, SRMR = Standardized , NNFI =, CFI = Comparative Fit Index, AIC = Akaike Information Index
***$p < .001$

An seen, the single factor did not reach adequate goodness-of-fit indices, showing values for RMSEA and SRMR above .08, and values for NNFI and CFI below .90. In contrast, both the three-factor model and the second-order factor showed an overall adequate fit-to-data, with very similar values for all goodness-of-fit indices considered in the analysis. However, the three components in the three-factor model were strongly correlated both in MLS (r = .49 - .86) and in MLB (r = .46 - .83). Specifically, the strong correlation between MLA and MTA (r = .86 in MLS and r = .83 in MLB) suggested potential model redundancy and casted doubts on the discriminant validity between these two factors.

Therefore, the mixed model, which attempted to model this strong correlation among these two factors by loading them on a second-order factor (AMA), was a significantly better fit-to-data, compared to the three-factor model both in Spanish version ($\Delta\chi^2$ = 525.14, Δdf = 3, p < .001) and in Basque version ($\Delta\chi^2$ = 185.63, Δdf = 3, p < .001). In addition, the AIC value of the mixed model was lower than that corresponding to the single-factor model. Based on these results and the principle of parsimony, the mixed model model emerged as the preferred structure for the construct MA.

Next, based on the considerations for covariance scores, inter-item correlations and factor loadings, two items were selected for removal: mla07 ("Me pongo nervioso/a ante una lista de ejercicios o problemas de Matemáticas" [*Matematikako ariketa- edo buruketa-zerrendaren aurrean urduri jartzen naiz*]) and mta05 ("Durante un control/examen de Matemáticas, me pongo nervioso/a porque creo que tengo poco tiempo para terminarlo" [*Matematikako* *krontola/azterketan urduri jartzen naiz bukatzeko denbora laburra daukadalako ustean*]).

After their deletion, the re-specified model yielded good to excellent values for the goodness-of-fit indices both in Spanish version (χ^2 (167, N = 563) = 355.22, p < .001; RMSEA = .046 (.039, .052); SRMR = .046; NNFI = .94; CFI = .95) (see Figure 1) and in Basque version (χ^2 (167, N = 229) = 291.71, p < .001; RMSEA = .061 (.049, .072); SRMR = .064; NNFI = .90; CFI = .91) (see Figure 2).

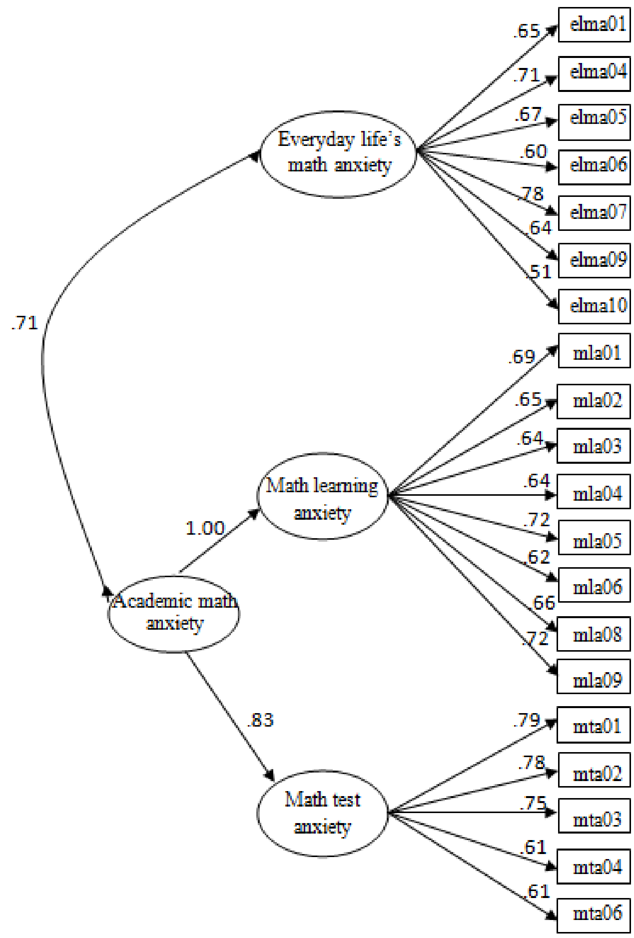


Figure 1. Confirmatory factor analysis of SAMAS in Spanish version (N = 563).

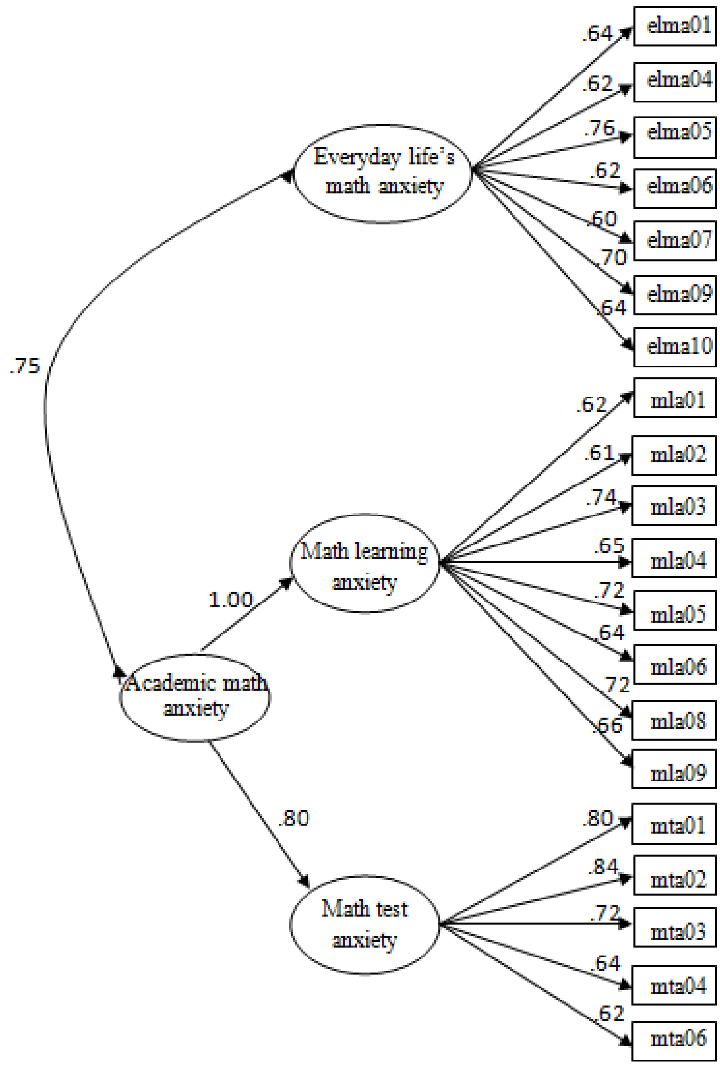


Figure 2. Confirmatory factor analysis of SAMAS in Basque version (*N* = 229).

In these re-specificied models, the first-order factors MLA and MTA strongly loaded on the second-order factor AMA ($p < .05$). Furthermore, all standardized factor loadings were statistically significant ($p < .05$). Specifically:

- the standardized factor loadings for ELMA ranged from λ = .51 (elma10: "Me pongo nervioso/a al calcular qué me puedo comprar con la paga") to λ = .78 (elma07: "Cuando hacemos un bote común, me pongo nervioso/a al calcular cómo repartir lo que ha sobrado") in Spanish version, and from λ = .60 (elma07: "Potoa jartzen dugunean, gainontzekoa nola banatu kalkulatzean urduri jartzen naiz") to λ = .76 (elma05: "Beheratutako produktu baten salneurri finala kalkulatu behar dudanean urduri jartzen naiz") in Basque version;

- the standardized factor loadings from MLA ranged from λ = .62 (mla06: "Me pongo nervioso/a cuando los deberes de Matemáticas son problemas difíciles") to λ = .72 (mla05: "Me pongo nervioso/a cuando tengo que resolver un ejericio o problema en clase de Matemáticas") in Spanish version, and from λ = .61 (mla02: "Klasean matematikako ariketa edo buruketa bat arbelean egiten dutenean, urduri jartzen naiz") to λ = .74 (mla03: "Datorren ikasturtean Matematika berriro ere ikasi beharko dudala pentsatzean urduri jartzen naiz") in Basque version;

- and the standardized factor loadings for MTA ranged from λ = .61 (mta04: "Me pongo tenso/a cuando los ejercicios del control/examen de Matemáticas son distintos a los vistos en clase" and mta06: "Durante un control/examen de Matemáticas, me bloqueo cuando no me sale algún ejercicio") to λ = .79 (mta01: "Me pongo nervioso/a cuando estudio para un control/examen de Matemáticas") in Spanish version and from λ = .62 (mta06: "Matematikako krontola/azterketan ariketaren bat ez dakidanean trabatzen naiz”) to λ = .84 (mta02: “Matematikako krontola/azterketaren aurreko egunean urduri jartzen naiz”) in Basque version.

Additional properties of the final 20-item SAMAS were assessed with the Composite Reliability (*CR*) and Cronbach’s alpha (α) of each factor. The reliability analyses showed good internal consistency for ELMA (*CR* = .80 and α = .83 in Spanish version; *CR* = .79 and α = .83 in Basque version), MLA (*CR* = .83 and α = .86 in both Spanish and Basque versions) and MTA (*CR* = .78 and α = .84 in Spanish version; *CR* = .80 and α= .85 in Basque version).

Also, the squared multiple correlation (R^2) was estimated for each observed variable. The values ranged from R^2 = .27 (elma10: “Me pongo nervioso/a al calcular qué me puedo comprar con la paga”) to R^2 = .63 (mta01: “Me pongo nervioso/a cuando estudio para un control/examen de Matemáticas”) in Spanish version, and from R^2 = .36 (elma07: “Cuando hacemos un bote común, me pongo nervioso/a al calcular cómo repartir lo que ha sobrado”) to R^2 = .71 (mta02: “Me pongo nervioso/a el día previo a un control/examen de Matemáticas”) in Basque version, which indicated acceptable proportions of variance. Results are summarized in Table 17.

Table 17

Standardized factor loadings, Composite Reliability scores and Cronbach’s alpha values

Spanish version	**λ**	**R^2**	**Basque version**	**λ**	**R^2**
ELMA (α = .83, *CR* = .80)			ELMA (α = .83, *CR* = .79)		
elma01	.65	.42	elma01	.64	.41

elma04	.71	.50	elma04	.62	.39
elma05	.67	.45	elma05	.76	.58
elma06	.60	.36	elma06	.62	.39
elma07	.78	.60	elma07	.60	.36
elma09	.64	.41	elma09	.70	.49
elma10	.51	.27	elma10	.64	.42
MLA (α = .86, *CR* = .83)			MLA (α = .86, *CR* = .83)		
mla01	.69	.47	mla01	.62	.39
mla02	.65	.42	mla02	.61	.37
mla03	.64	.41	mla03	.74	.55
mla04	.64	.41	mla04	.65	.42
mla05	.72	.52	mla05	.72	.52
mla06	.62	.38	mla06	.64	.41
mla08	.66	.44	mla08	.72	.52
mla09	.72	.52	mla09	.66	.43
MTA (α = .84, *CR* = .78)			MTA (α = .85, *CR* = .80)		
mta01	.79	.63	mta01	.80	.63
mta02	.78	.60	mta02	.84	.71
mta03	.75	.56	mta03	.72	.51
mta04	.61	.37	mta04	.64	.41
mta06	.61	.37	mta06	.62	.39

Note. ELMA = Everyday Life's Math Anxiety, MLA = Math Learning Anxiety, MTA = Math Test Anxiety, α = Cronbach's alpha, *CR* = Comporsite Reliability

5.2.4. Convergent validity

As regards convergent validity, this was assessed by the Pearson correlation coefficients between math anxiety and the most referred construct in literature. Specifically, the dimensions of math anxiety were related to mathematics achievement (e.g., Hembree, 1990; Suinn & Edwards, 1982; Meece, Wigfield, & Eccles, 1990; Ma, 1999; Ho et al., 2000).

As shown in Table 18, moderate negative correlations were found between math learning anxiety and mathematics achievement both in MLS (r = -.25, p < .01) and in MLB (r = -.18, p < .01); likewise, moderate negative correlations were found between math test anxiety and mathematics achievement both in MLS (r = -.25, p < .01) and in MLB (r = -.25, p < .01). However, a low correlation score was found between everyday life's math anxiety and mathematics achievement both in MLS (r = -.18, p < .01) and in MLB (r = -.16, p < .01).

Table 18

Correlation coefficients between math anxiety and math achievement

		ELMA	MLA	MTA	MACH
ELMA	MLS	1			
	MLB	1			
MLA	MLS	.60**	1		
	MLB	.65**	1		
MTA	MLS	.42**	.72**	1	
	MLB	.40**	.71**	1	
MACH	MLS	-.18**	-.25**	-.25**	1
	MLB	-.16*	-.18*	-.25**	1

Note. ELMA = Everyday Life's Math Anxiety, MLA = Math Learning Anxiety, MTA = Math Test Anxiety, MACH = Math Achievement
**p < .01, *p < .05

5.2.5. Test-retest reliability

Finally, the replication study was carried out by comparing responses to the final version of SAMAS among 512 (90.94%) secondary students who completed the Spanish version of the scale after a seven-month period, and among 191

(83.41%) secondary students who did it with the corresponding Basque version. CFA was run again in order to confirm the factor structure emerged in previous steps. Table 19 summarizes the goodness-of-fit indices obtained.

Table 19

Goodness-of-fit indices for the replication study, split down by language

Language group	**S-B$_{\chi 2}$**	***df***	**RMSEA (90% CI)**	**SRMR**	**NNFI**	**CFI**	**AIC**
MLS							
pre	355.22	167	.046 (.039, .052)	.046	.94	.95	21.22
post	358.29	167	.048 (.041, .055)	.053	.94	.94	24.29
MLB							
pre	291.71	167	.061 (.049, .072)	.064	.90	.91	-42.29
post	263.18	167	.057 (.044, .070)	.063	.92	.93	-70.82

Note. RMSEA = Root Mean Square Error of Approximation, SRMR = Standardized , NNFI =, CFI = Comparative Fit Index, AIC = Akaike's Information Index
***p < .001

On other hand, test-retest reliabilities were computed as Intraclass Correlations Coefficients (ICC) with 95% confidence interval (see Table 20). Results revealed good test-retest realibilities for ELMA (ICC = .78 (.74 - .82) in Spanish version and ICC = .76 (.67 - .82) in Basque version), excellent test-retest reliabilities for MLA (ICC = .82 (.79 - .85) in Spanish version and ICC = .80 (.73 -. 85) in Basque version) and good to excellent test-retest reliabilities for MTA (ICC = .83 (.80 - .86) in Spanish version and ICC = .79 (.72 - .84) in Basque version). The factor with the lowest median reliability was ELMA; whereas both MLA and MTA showed the highest median reliabilities. These results underscored the reproductibility of the scale over time.

Table 20

Test-retest reliabilities for SAMAS

Factor	*n*	Pre		Post		ICC (95% CI)
		M	*SD*	*M*	*SD*	
ELMA						
MLS	512	1.74	1.62	1.52	1.55	.78 (.74, .82)
MLB	191	2.13	1.84	1,82	1.65	.76 (.67, .82)
MLA						
MLS	512	2.48	1.97	2.29	1.88	.82 (.79, .85)
MLB	191	2.69	2.09	2.53	2.09	.80 (.73, .85)
MTA						
MLS	512	4.73	2.55	4.48	2.48	.83 (.80, .86)
MLB	191	4.66	2.61	4.33	2.35	.79 (.72, .84)

Note. ELMA = Everyday Life's Math Anxiety, MLA = Math Learning Anxiety, MTA = Math Test Anxiety, *M* = Mean, *SD* = Standard Deviation, ICC = Intraclass Correlation Coefficient, CI = Confidence Interval

5.3. DISCUSSION

Throughout literature, there has been a growing interest in individuals' math anxiety because of its adverse effects on the engagement in- and mastery of mathematics (e.g., Meece, Wigfield, & Eccles, 1990; Ma & Kishor, 1997; Bouchey & Harter, 2005; Anjum, 2006; Skaalvik & Skaalvik, 2006; Ashcraft & Krause, 2007; Samuelsson & Granstom, 2007; Krinzinger, Kaufmann, & Willmes, 2009; Williams & Williams, 2010; Lipnevich, MacCann, Krumm, Burrus, & Roberts, 2011). However, research on math anxiety is undoubtedly contingent on the psychometric properties of the measures for assessing the construct.

In this context, a review on the existing instruments warrants cautious considerations about the lack of agreement on the factor structure for math anxiety, mainly due to the still scarcity of confirmatory consistency on the measures. Moreover, it is found that some instruments originally targeted at measuring math anxiety, contrary to Evan's (2006) recommendations, also include factors related to attitudes toward mathematics. Therefore, the main goal of this study was to develop and validate a new measure, called Scale for Assessing Math Anxiety in Secondary education (SAMAS), which attempted to furnish insights into the factor structure of MA by suggesting three factors drawn from an integrative literature review: everyday life's math anxiety, math learning anxiety and math test anxiety.

In order to test which structure best fitted the data, four models were subjected to analysis. The mixed model, comprising at the same time a second-order factor (comprising both math learning anxiety and math test anxiety) and a first-order factor (comprising everyday life's math anxiety), emerged as the best structure for math anxiety. Results provide evidence of good to excellent psychometric properties for the final version of the instruments (i.e., content validity, construct validity, discriminant validity, convergent validity), which guarantees its use both with samples of math learners in Spanish and math learners in Basque. All standardized factor loadings of items were statistically significant and results of reliability analyses suggested that the items were internally consistent in representing the corresponding factors.

This validation evidence yielded very important implications. On the one hand, the mixed factor model fitted significantly better than both the unidimensional model and the three-factor model. This suggests the existence of an academic math anxiety factor beyond the math learning anxiety and math test anxiety, which, in turn, is correlated with a first order factor assessing everyday life's math anxiety. Such structure for assessing math anxiety has been first proposed in literature, contrary to two-factor (Wigfield & Meece, 1988; Hopko, Mahadevan, Bare, & Hunt, 2003) or four-factor (Ko & Yi, 2011) models tested through confirmatory approaches in previous research, which makes it a great contribution to literature on the area.

Assessments of convergent validity underscored negative moderate correlations between math learning anxiety and mathematics achievement, as well as between math test anxiety and mathematics achievement. These results were consistent with previous studies wherein math anxiety, operationalized by feelings of tension evoked only in scholastic settings, was negatively correlated to mathematics achievement (e.g., Suinn & Edwards, 1982; Meece, Wigfield, & Eccles, 1990; Tocci & Engelhard, 1991; Ho et al., 2000). To this respect, it is important to highlight the results of the meta-analyses conducted by Hembree (1990) and Ma (1999), who estimated correlations from r = -.27 to r = -.34 between math anxiety and mathematics achievement among secondary students. As a result, the Pearson's correlations obtained in the present study are appropriate compared to the results from previous literature considering the same variables. Interestingly, when everyday life's math anxiety is considered, its correlation with mathematics achievement is smaller, which makes sense as it is the only factor referring to feelings of tension and worry evoked in math-related situations outside the scholastic setting. No previous result has been found in this line in previous research, which encourages to further investigate this relationship.

Despite the promising findings, there are also some limitations to take into account in the present study. Indeed, because validation is a continuous process (Clark & Watson, 1995), future studies should continue to examine and improve the validity of SAMAS. Specifically, data were collected using a cluster-sampling method, which means that the results are not entirely generalizable. Although the resulting sample group was representative and large enough for the research purposes, future research is needed using larger samples from different sociodemographic contexts to further assess the invariance of the factor structure. Second, the participants in the study were limited to secondary education students from Biscay (Basque Country Autonomous Region, Spain). Therefore, there is a need for adapting and validating the scales with other populations (i.e., primary school students and university students) in order to monitor the changes in math anxiety levels as time evolves.

To conclude, this study has allowed taking a more in-depth look into the factor structure of MA in secondary education, as well as having developed a psychometrically sound instrument for its assessment. Indeed, given the reliability and validity evidence gathered, the 20-item SAMAS proves to be a promising tool for its use either in math educational research or in scholastic settings with secondary education students who learn mathematics either in Spanish or in Basque. Noteworthy, the developed scale is easy to administer and not time-demanding, as this short form takes, approximately, 5 minutes to complete. Therefore, either school counselors or educators might use it to monitor students' levels of math anxiety, identify those individuals with extreme scores in one or some of the underlying factors and provide early attention measures to alleviate those levels. This might be of great interest particularly for those students showing strong mathematical skills but struggling with, for example, high math anxiety levels, which put them at risk of disengagement in mathematics and mathematics-related pathways. In fact, since math anxiety has shown to worsen from upper elementary school to junior high school, developing and validating measurements targeting secondary students furnishes insights within the field of mathematics education, becoming a starting point to identify and prevent those dropout risky situations at mathematics classrooms. On other hand, researchers might use it as the starting point to identify the key domains of math anxiety affecting the mathematics achievement and further investigate the variables which affect their prevalence. In fact, assessing the dimensions underlying this construct is critical to gain knowledge about the plausible factors that affect mathematics achievement.

Chapter 6

Development and validation of the Scale for Assessing Attitudes toward Mathematics in Secondary education (SATMAS)

CHAPTER

6

Development and validation of the Scale for Assessing Attitudes Toward Mathematics in Secondary education (SATMAS)

6.1. DATA ANALYSIS

As detailed as follows, data analysis for the development and validation of the Scale for Assessing Attitudes Toward Mathematics in Secondary education (henceforth, SATMAS) was divided into five phases. Across them, a series of statistical analyses were undertaken using the software packages IBM SPSS Statistics 22 and EQS 6.1.

Phase 1. Specification of the underlying factors and evidence about content validity

The development process for the new instrument SATMAS began by specifying both the construct attitudes toward mathematics (henceforth, ATM) and its underlying factors. Specifically, ATM was defined based on the so-called Self-Determination Theory (henceforth, SDT) (Ryan & Deci, 1985, 2000), whereby four factors are proposed as critical elements: student's math self-concept (henceforth, SMSC), perceived usefulness of mathematics (henceforth, PUM), importance of mathematics (henceforth, IoM) and interest for mathematics (henceforth, IfM). These served as the basic components for the conceptualization of ATM in the present research.

Next, as recommended by AERA, APA and NCME (2008), existing instruments were taken as the basis, collecting a large pool of preliminary items. Those statements originally written in English were translated into Spanish. The pool was then pruned by screening out redundant items and rewording some others to provide consistency across them. In order to complete the factor structure for ATM, newly written items were also added to complete the item pool, in such a way that they did not contain double negatives or superlatives such as "always" or "never". Efforts were made to keep statements brief, straightforward and comprehensible to the target population (Edwards, 1957; Clark & Watson, 1995; DeVellis, 2003, 2012). As a result, a total of 32 items were obtained, which, in turn, were sorted as follows: SMSC (12), PUM (10), IoM (4) and IfM (12).

After the initial pool of items for the new instrument was developed, a review panel consisted of nine experts on research and didactics was established to provide evidence about content validity. Experts were contacted via email and asked for participation (see *Annex III*). In that email, the nature of the research was introduced, instructions to complete the task were provided and descriptions of the proposed dimensions for the constructs were described. In the content validity task, experts were asked to classify each item within just one dimension, and then rate its accuracy and clarity of writing on a scale ranging continuously from 0 to 10 (see *Annex IV*). They were also prompted to send comments or suggestions for improvement if considered necessary. When finished, experts were asked to forward the response sheet through email. All of them completed the task within two weeks' time.

Results were then analyzed according to the criteria of: (a) mean (high if $M \geq 7.50$; acceptable if $2.50 \leq M < 7.50$; low if $M < 2.50$) for both relevance and clarity of writing; (b) standard deviation (good if $SD \leq 1.00$; acceptable if $1.00 < SD < 1.50$; low if $SD > 1.50$) for both relevance and clarity ofwriting; and (c) the inter-judge agreement percent with respect to the modal dimension (necessary, $PA \geq 77\%$, meaning that at least 7 out of 9 experts classify the item within the theoretical dimension) (Anderson & Gerbing, 1991; Schreisheim, Powers, Scandura, Gardiner, & Lankau, 1993). As a result of the review panel, the first decision was to join the PUM and the IoM components in just one, which was renamed perceived usefulness and importance of mathematics (henceforth, PUIM). After this first modification, results from the review panel were re-estimated, obtaining an initial 23-item version of SATMAS, with the following item distribution: SMSC (7), PUIM (9) and IfM (7).

As the main purpose of developing SATMAS was for it to be used in subsequent studies with secondary students enrolled in Spanish-Basque bilingual scholastic settings, the corresponding Basque version was also obtained. Therefore, once the initial Spanish version of the scale was obtained, translation by committee was carried out (Marin & Marin, 1991), following the recommendations of the International Test Commission (Muñiz, Elosua, & Hambleton, 2013). Three experts, whose mother tongue was Basque, was contacted and worked independently in the translation from Spanish to Basque, emphasazing the conceptual meaning of statements rather than the literal one. Two of the experts were math professors and the other one, a Basque linguist currently working as a teacher in a secondary school. Once all answers were reforwarded, a review meeting was arranged between another two different researchers on didactics and the PhD candidate. In that meeting, all items were checked and discussed, one by one, against the Spanish version by ensuring the conceptual equivalence of the items and by checking for inappropiate expressions and possible misundertansdings. That way, the consensual Basque version of the scale was obtained.

The initial 23-item Spanish-Basque version of the scale was administered to participants, who were requested to rate their degree of agreement with the statements on a continuous response scale ranging from 0 (*Strongly disagree*) to 10 (*Strongly agree*).The reason for selecting this type of response format instead of a more common Likert scale is twofold. On the one hand, the reference population (i.e., students from Compulsory Secondary Education) is accustomed to this assessment style, widely used in the scholastic setting. On the other hand, rating the responses on a continuous scale makes the subsequent statistical analyses stronger and more reliable (Pett, Lackey, & Sullivan, 2003).

Phase 2. Data collection and prior item analyses

After data collection, negatively worded items were recoded, and several analyses were conducted for the accuracy of data entry errors, missing values and the assumptions for CFA (Tabachnick & Fidell, 2007). Specifically, tests were performed to check for univariate normality, multivariate normality and possible outliers. Firstly, univariate normality was tested through skewness and kurtosis, assuming that values above 2.30 indicate large divergence from the normal distribution (Lei & Lomax, 2005). Secondly, multivariate normality was tested via the Mardia's standardized estimator, for which the proposed threshold of 3.00 was established as criterion (Bentler, 2005; Ullman, 2006).

Next, descriptive statistics, inter-item correlations and item-total correlations were computed to identify and discard, if necessary, poor items. Thus, items with negative and/or low inter-item correlations (r < .30) and/or low item-total correlations (r < .30) were discarded. Likewise, items with extremely high inter-item correlations (r > .80) and item-total correlations (r > .80) were selected for removal (Ferketich, 1991; Nunnally & Bernstein, 1994). Based on these considerations, one item was discarded because of its low item-total correlation and another two were removed because of their low inter-item correlations. As a result, the version of SATMAS that was subjected to CFA in the following step consisted of 20 items.

Phase 3. CFA and assessments of factor structure

Confirmatory Factor Analysis (CFA) was conducted to confirm the construct validity of the factor structures theoretically proposed for ATM. This approach was preferred over Exploratory Factor Analysis (EFA) since the purpose of the present study was to assess the extent to which the factor structures, previously hypothesized drawing on an integrative literature review, fitted the data (Nunnally & Bernstein, 1994; Byrne, 2001). The univariate normality obtained for all variables, the low missing data rate (< 5%) estimated in the dataset and the large sample size used in the study validated the implementation of Maximum Likelihood (*ML*) estimation (Chou & Bentler, 1995; Finney & DiStefano, 2006) with listwise deletion (Brown, 1983, 2006).

Due to the multivariate non-normality of data, the parameters of the CFA were estimated using Satorra-Bentler robust corrections (S-$B_{\chi 2}$) (Satorra & Bentler, 2001; Satorra, 2003). Items were forced to load on their hypothesized factors. The variances for the first observed indicator of each latent variable were fixed to 1, and the variances for all error weights and the remaining parameters were freely estimated (Ullman, 2006).

Three a priori models for assessing ATM were subjected to CFA:

- firstly, a unidimensional model in which all items were indicators of a single factor, named ATM;

- secondly, a three-factor model in which the items were assumed to measure three factors (that is, SMSC, PUIM and IfM);

- and thirdly, a second-order factor model in which the three first-order factors (that is, SMSC, PUIM and IfM) loaded on a second-order general factor (that is, ATM).

Several fit indices were used to judge the adequacy of the CFA. Since the S-$B_{\chi 2}$ statistics is sensitive to sample sizes greater than 200 (Kline, 2005; Hair, Black, Babin, & Anderson, 2010), the following alternative fit indices and desirable cut-offs were used to assess model fit to data: a) the S-$B_{\chi 2}/df$ statistics should be lower than 3.0 (Bollen, 1989; Bentler, 2005); b) the Root Mean Squared Error of Approximation (RMSEA) should be lower than .08 (Hu & Bentler, 1999; Browne, MacCallum, Kim, Andersen, & Glaser, 2002) with the relative 90% confidence interval; c) the Standardized Root Mean Square Residual (SRMR) should be lower than .08 (Hu & Bentler, 1999; Kline, 2005); d) the Non-Normed Fit Index (NNFI) should be greater than .90 (Hoyle & Panter, 1995); and e) the Comparative Fit Index (CFI) should be greater than .90 (Bentler, 1990; Marsh, Hau, & Wen, 2004; Kline, 2005). In addition, the Akaike's information criterion (AIC) was used to compare the factor structures with different estimated parameters in such a way that lower values indicated higher parsimony for the model (Hu & Bentler, 1999; Kline, 2005). Among the tested structures, that model with best fit-to-data was selected.

To enact modifications representing an improvement on the final fit, the selected model was further inspected through the standardized residual covariance scores, the inter-item correlation matrix, the standardized factor loadings and the conceptual relevance of the items. Specifically, standardized residual estimates below 2.00 in absolute value were indicative of poor items. Additionally, items with standardized residual estimates below 2.00, inter-item correlations below .30 and factor loadings below .40 (Floyd & Widaman, 1995) were marked for deletion. Based on these considerations, one item was discarded, obtaining a 19-item factor structure for ATM.

Next, discriminant validty was examined through the inter-factor correlations, setting as the criterion that values below r = .85 indicate that the latent factors are not statistically isomorphic (Mahoney, Thombs, & Howe, 1995; Kline, 2005). As regards internal consistency, both the Composite Reliability (*CR*) and Cronbach's coefficient (α) were used as indicators. For the former, values above .70 were considered to be adequate (Fornell & Larcker, 1981); for the latter, values from .70 to .79 were considered to be moderate, whereas values above .80 were interpreted as high reliability (Nunnally, 1978; Cortina, 1993; Cichetti, 1994).

Phase 4. Convergent validity

Convergent validity was assessed with the Pearson correlation coefficients between ATM and other construct referred in literature (i.e., mathematics achievement). Specifically, it was expected that high levels of ATM would be negatively related to mathematics achievement. To interpret the results, Cohen's (1988, 1992) criteria were followed. Thus, values of $|r|$ around .10 were indicative of small correlations, $|r|$ around .30 of moderate correlations, and $|r|$ around .50 or highest of big correlations.

Phase 5. Test-retest reliability

The final version of the 19-item scale was completed by the same research sample over a seven-month period. Firstly, CFA was run again with the final version of the scale in order to confirm the factor structure for the construct ATM. Secondly, test–retest reliability was assessed for each factor (that is, SMSC, PUIM and IfM) by computing the Intraclass Correlation Coefficient (ICC) based on a one-way random effects model between the first and the second measurement points. To interpret the results, Landis and Koch's (1977) criteria were followed.

Therefore, values of ICC below .20 were indicative of small reliabilities, ICC between .20 and .60 of moderate reliabilities, and ICC between .60 and .80 of good reliabilities and ICC above .80 of excellent reliabilities.

6.2. RESULTS

6.2.1. Specification of the underlying factors and evidence about content validity

The SDT (Ryan & Deci, 1985, 2000) is primarily used as the general framework to support the development of the new instrument SATMAS. According to this approach, students' achievement-related outcomes in mathematics are influenced by their feelings towards the subject, their interest in it, their perceived value and their beliefs in their own cognitive skills to cope with math-related tasks. Indeed, international body of research has supported this theory, showing that students who feel themselves competent and value those tasks at hand are more likely to engage in the subject, take more mathematics courses and work hard within their learning process (e.g., Crombie et al., 2005; Grootenboer & Hemmings, 2007; Malmivouri, 2007).

Thus, based on these considerations, four factors were proposed as critical elements of ATM and taken as the basis for the construct conceptualization in the present chapter:

Student's math self-concept: encompasses a broad range of student's responses about her or his ability to learn and perform mathematically (e.g., "Soy incapaz de resolver problemas matemáticos" [*I am unable to solve math problems*]). An individual who scores high on this dimension believes that she or he has the ability to understand and solve math-related tasks. On the contrary, an individual scoring low in this dimension does not believe that she or he has the ability to understand and do mathematics.

Perceived usefulness of mathematics: refers to the student's extrinsic utility value of mathematics, as defined by Eccles and Wigfield (2002). That is to say, this dimension measures student's beliefs about the applicability of mathematics for their current and future goals and in relation to school, career and everyday life (e.g., "Saber matemáticas aumentará mis posibilidades de encontrar trabajo" [*Learning math will increase my future job opportunities*]). Therefore, an individual who scores high in this dimension finds mathematics very useful for both their current and future goals; whereas an individual scoring low finds it useless for both their current and future goals.

Importance of mathematics: includes student's attributed importance to mathematics as a core element both in her or his personal development and in several areas of society (e.g., "Las matemáticas son importantes porque favorecen el avance de la sociedad" [*Math is important for fostering the society development*]). Therefore, an individual who scores high on this dimension thinks that learning mathematics is relevant not only for herself or himself but also for society development; whereas an individual scoring low finds it irrelevant for her or his life and thinks that society progress can easily do without it.

Interest for mathematics: refers to the amount of interest or enjoyment students have in learning and doing mathematics (e.g., "Se me pasa el tiempo volando cuando resuelvo ejercicios/problemas de Matemáticas" [*Time just flies by when I am solving math problems]).* An individual who scores high in this dimension enjoy and has high interest in learning and doing mathematics. On the other hand, an individual scoring low dislikes mathematics, finds it boring and does not take pleasure from learning and doing mathematics.

Next, based on the aforementioned theoretical conceptualization for ATM, the preliminary pool of items was collected from all the examined instruments described in Table 2. Indeed, it was observed that the same factor could be in several instruments under different names. Therefore, it was important to consider all items and closely examine their conceptual meaning. Those items referring to factors different from ATM were discarded, and the remaining items were redistributed, considering their content and definition of the constructs, in the previously noted four theoretical dimensions. After removing redundant items, rewording some others and adding a few newly written ones, a final pool of 36 items was obtained and sorted as follows: SMSC (12), PUM (10), IoM (4) and IfM (12) (see Table 21). As in the SAMAS development, the rules of keeping them brief, clear and as comprehensible as possible were also applied for the development process of the SATMAS (Edwards, 1957; Clark & Watson, 1995).

Table 21

Initial pool of items for the construct ATM

Factor / Item	Content
SMSC	
it01	En Matemáticas me cuesta decidir qué tengo que hacer
it02	Soy incapaz de resolver problemas matemáticos
it03	Tengo dificultades con las matemáticas
it04	Me siento más torpe en Matemáticas que la mayoría de mis compañeros/as
it05	Las matemáticas me confunden
it06	Siempre he tenido problemas con las matemáticas
it07	Haga lo que haga saco notas bajas en Matemáticas
it08	Cuando hago matemáticas me quedo con la mente en blanco
it09	No sé estudiar Matemáticas
it10	Aunque me esfuerce, no entiendo las Matemáticas
it11	Siempre será difícil para mí aprender Matemáticas
it12	No nací para aprender Matemáticas
PUM	
it13	Las matemáticas son necesarias para mis estudios
it14	Todas las personas necesitan saber matemáticas
it15	Las matemáticas son muy útiles
it16	Sólo deberían estudiar Matemáticas aquellos/as que las vayan a utilizar en sus trabajos
it17	Guardaré mis cuadernos y libros de Matemáticas por si los tengo que utilizar más adelante
it18	En Matemáticas sólo deberían enseñarse las cosas prácticas que utilizamos fuera del coles
it19	Las Matemáticas son útiles para entender las demás asignaturas
it20	Las matemáticas son necesarias para la vida
IoM	
it21	Las matemáticas son importantes para desenvolverse en la vida
it22	Saber matemáticas es importante para mi futuro trabajo

it23	Las matemáticas son importantes porque favorecen el desarrollo tecnológico
it24	Saber matemáticas aumentará mis posibilidades de encontrar trabajo
IfM	
it25	Estudiar Matemáticas es divertido
it26	Me gusta estudiar Matemáticas
it27	Puedo pasarme horas estudiando Matemáticas
it28	Puedo pasarme horas resolviendo ejercicios de Matemáticas
it29	Si las Matemáticas fueran optativas, las eligiría
it30	Lo que estudiamos en Matemáticas es interesante
it31	Las Matemáticas son aburridas
it32	Me gustan las Matemáticas
it33	Las Matemáticas son un “rollo”
it34	Toca clase de Matemáticas, ¡qué horror!
it35	No soporto estudiar Matemáticas
it36	Las Matemáticas son entretenidas

Note. SMSC = Student’s Math Self-Concept, PUM = Perceived Usefulness of Mathematics, IoM = Importance of Mathematics, IfM = Interest for Mathematics.

Next, this initial pool of items was forwarded to the review panel, which consisted of the same experts requested for the content validity of the Scale for Assessing Math Anxiety in Secondary Education (SAMAS). The procedure followed was exactly the same. The results were analyzed in terms of accuracy, clarity of writing and percentage of agreement. Comments and suggestions were also considered for improvement. Results are summarized in Table 22.

Table 22

Results from the review panel for SATMAS

Ítem	**Accuracy**		**Clarity of writing**			**Classification**			***PA* (%)**	**Comments**
	M	***SD***	***M***	***SD***	**SMSC**	**PUM**	**IoM**	**IfM**		

it01	8.67	1.51	8.33	1.97	2				28.57	Confusing statement
it02	9.25	1.04	9.13	1.25	8				88.89	-
it03	8.88	1.46	8.71	1.70	8				88.89	It not clear the meaning of “to have difficulties”
it04	9.00	1.51	7.88	2.90	6				66.67	Adjective “torpe” could sounds quite aggressive
it05	7.43	3.26	7.29	3.35	2			1	25.00	Confusing statement
it06	8.83	1.83	9.17	1.33	7				77.78	-
it07	9.38	0.92	9.00	1.41	8				88.89	-
it08	8.43	1.40	7.57	1.62	2				25.00	It is not clear the meaning of “hacer matemáticas”
it09	8.75	1.58	8.00	3.07	4				44.44	The majority would sort in a category of strategies
it10	9.00	1.51	9.13	1.25	8				88.89	-
it11	8.75	1.67	8.63	1.69	8				88.89	-
it12	9.00	1.07	9.00	1.41	8			1	88.89	-
it13	8.57	1.81	9.00	1.53		5	3		62.50	It is difficult to distinguish importance from uselfulness
it14	8.00	2.00	8.29	1.89		2	6		75.00	It is difficult to distinguish importance from uselfulness

it15	9.25	1.04	9.25	1.49		8	1	88.89	-
it16	8.71	1.25	8.71	1.25		7	1	87.50	-
it17	8.29	1.38	9.43	1.13		2	4	22.22	It is difficult to distinguish if this statement refers to interest, importance or usefulness
it18	8.13	2.03	8.63	1.60		8	1	88.89	-
it19	8.88	1.36	8.75	1.28	1	7	1	77.78	-
it20	9.38	0.92	8.88	1.73		6	3	66.67	It is difficult to distinguish if this statement refers to importance or usefulness
it21	9.14	1.21	9.43	0.79		4	5	55.56	It is difficult to distinguish if this statement refers to importance or usefulness
it22	8.75	1.28	9.25	1.16		5	4	44.44	It is difficult to distinguish if this statement refers to importance or usefulness
it23	8.50	2.00	8.38	2.00		2	6	66.67	Confusing statement
it24	9.25	1.04	9.50	0.76		9		0.00	It is difficult to distinguish if this statement refers to importance or

										usefulness
it25	9.00	1.20	9.38	1.06	1			8	88.89	-
it26	9.38	0.92	9.25	1.04	1			8	88.89	-
it27	8.50	1.93	8.50	1.77				8	88.89	It is not clear of the expression “puedo” refers to interest or ability
it28	8.83	1.33	8.50	1.76			1	6	85.71	It is not clear of the expression “puedo” refers to interest or ability
it29	8.13	1.89	8.63	1.85	1		2	6	66.67	This statement could be sorted in different categories
it30	9.25	1.04	9.00	1.51		1		7	77.78	Very similar to it31
it31	9.29	0.76	9.00	1.53			1	8	88.89	-
it32	9.38	0.74	9.63	0.74			1	8	88.89	Very similar to it33
it33	9.29	0.76	8.86	1.57			1	8	88.89	It could refer to math test anxiety
it34	8.25	2.05	8.25	2.25				5	55.56	It could refer to math test anxiety
it35	8.25	1.75	8.38	1.77					55.56	-
it36	9.00	1.20	8.75	1.16	1			7	77.78	-

Note. SMSC = Student’s Math Self-Concept, PUM = Perceived Usefulness of Mathematics, IoM = Importance of Mathematics, IfM = Interest for Mathematics.

Inspections of Table 22 revealed that the most recurrent comment given by experts was that concerning the difficulty to sort those statements referring to either PUM or IoM in just one of these two dimensions. Thus, the first decision was to join these two factors and create a new unique dimension called perceived usefulness and importance of mathematics (henceforth, PUIM). This change also affected the percentage of agreement for those statements initially categorized either in PUM or in IoM. Considering these modifications, the results for the original PUM and IoM were re-estimated in a unique factor called PUIM and summarized in a new table (see Table 23):

Table 23

Results from the review panel for SATMAS after joining PUM and IoM

Item	Accuracy		Clarity of writing		Classification			*PA*(%)	Comments
	M	*SD*	*M*	*SD*	SMSC	PUIM	IfM		
it13	8.57	1.81	9.00	1.53		8		100.00	
it14	8.00	2.00	8.29	1.89		8		100.00	
it15	9.25	1.04	9.25	1.49		9		100.00	-
it16	8.71	1.25	8.71	1.25		8		100.00	-
it17	8.29	1.38	9.43	1.13		6		66.67	It is difficult to distinguish if this statement refers to interest or importance-usefulness
it18	8.13	2.03	8.63	1.60		9		100.00	-
it19	8.88	1.36	8.75	1.28	1	8		88.89	-
it20	9.38	0.92	8.88	1.73		9		100.00	
it21	9.14	1.21	9.43	0.79		9		100.00	
it22	8.75	1.28	9.25	1.16		9		100.00	
it23	8.50	2.00	8.38	2.00		8		88.89	Confusing statement
it24	9.25	1.04	9.50	0.76		9		100.00	

Note. SMSC = Student's Math Self-Concept, PUIM = Perceived Usefulness and Importance of Mathematics, IfM = Interest for Mathematics.

As shown in Table 23, after this re-specification, most statements were positively evaluated in terms of accuracy and clarity of writing and could be categorized into just one dimension. On exactly one-fourth of all statements (25%) the agreement was complete among the experts (PA = 100%), and on half of all statements (50%) there was almost unanimous agreement (77% < PA < 100%). There was less than 77% agreement on only nine items (25%), although no statement had a complete lack of agreement.

Thus, the following conclusions were drawn from these results and the comments given by the experts:

- on the one hand, it is necessary to reword 4 items (it04, it23, it27, it28);

- on the other hand, it is advisable to discard 13 items (it01, it05, it06, it08, it09, it13, it17, it21, it29, it30, it31, it34, it35).

Therefore, after examining the content contribution of these items to their theoretical dimensions and checking that the proposed changes made sense in improving the overall factor structure for ATM, they were reworded or deleted as suggested. Having made these modifications, the remaining 23 items, which comprised the first version of SATMAS, were distributed as follows: SMSC (7), PUIM (9) and IfM (7) (see Table 24).

Table 24

Initial version of SATMAS

Factor	Original item	Final item
SMSC	it01. En Matemáticas me cuesta decidir qué tengo que hacer	(eliminated)
	it02. Soy incapaz de resolver problemas matemáticos	smsc01. Soy incapaz de resolver problemas matemáticos
	it03. Tengo dificultades con las Matemáticas	smsc02. Tengo dificultades con las Matemáticas
	it04. Me siento más torpe en Matemáticas que la mayoría de mis compañeros/as	**smsc03. Me siento más torpe que mis compañeros/as resolviendo ejercicios y problemas de Matemáticas**
	it05. Las Matemáticas me confunden	(eliminated)
	it06. Siempre he tenido problemas con las Matemáticas	(eliminated)
	it07. Haga lo que haga saco notas bajas en Matemáticas	smsc04. Haga lo que haga saco notas bajas en Matemáticas
	it08. Cuando hago Matemáticas me quedo con la mente en blanco	(eliminated)
	it09. No sé estudiar Matemáticas	(eliminated)
	it10. Aunque me esfuerce, no entiendo las Matemáticas	smsc05. Aunque me esfuerce, no entiendo las Matemáticas
	it11. Siempre será difícil para mí estudiar Matemáticas	smsc06. Siempre será difícil para mí estudiar Matemáticas
	it12. No nací para aprender Matemáticas	smsc07. No nací para aprender Matemáticas
PUIM	it13. Las Matemáticas son necesarias para mis estudios	(eliminated)
	it14. Todas las personas necesitan saber matemáticas	puim01. Todas las personas necesitan saber matemáticas
	it15. Las matemáticas son muy útiles	puim02. Las matemáticas son muy útiles

	it16. Sólo deberían estudiar matemáticas aquellos/as que las vayan a utilizar en sus trabajos	puim03. Sólo deberían estudiar matemáticas aquellos/as que las vayan a utilizar en sus trabajos
	it17. Guardaré mis cuadernos y libros de Matemáticas por si los tengo que utilizar más adelante	(eliminated)
	it18. En Matemáticas sólo deberían enseñarse las cosas prácticas que utilizamos fuera del cole	puim04. En Matemáticas sólo deberían enseñarse las cosas prácticas que utilizamos fuera del cole
	it19. Las Matemáticas son útiles para entender las demás asignaturas	puim05. Las Matemáticas son útiles para entender las demás asignaturas
	it20. Las matemáticas son necesarias para la vida	puim06. Las matemáticas son necesarias para la vida
	it21. Las matemáticas son importantes para desenvolverse en la vida	(eliminated)
	it22. Saber Matemáticas es importante para mi futuro trabajo	puim07. Saber matemáticas es importante para mi futuro trabajo
	it23. Las matemáticas son importantes porque favorecen el desarrollo tecnológico	**puim08. Las matemáticas son importantes porque favorecen el avance de la sociedad**
	it24. Saber Matemáticas aumentará mis posibilidades de encontrar trabajo	puim09. Saber Matemáticas aumentará mis posibilidades de encontrar trabajo
IfM	it25. Estudiar Matemáticas es divertido	ifm01. Estudias Matemáticas es divertido
	it26. Me gusta estudiar Matemáticas	ifm02. Me gusta estudiar Matemáticas
	it27. Puedo pasarme horas estudiando Matemáticas	**ifm03. Se me pasa el tiempo volando cuando estudio Matemáticas**
	it28. Puedo pasarme horas resolviendo ejercicios de Matemáticas	**ifm04. Se me pasa el tiempo volando cuando resuelvo ejercicios y problemas de**

		Matemáticas
	it29. Si las Matemáticas fueran optativas, las eligiría	(eliminated)
	it30. Lo que estudiamos en Matemáticas es interesante	(eliminated)
	it31. Las Matemáticas son aburridas	(eliminated)
	it32. Me gustan las Matemáticas	ifm05. Me gustan las Matemáticas
	it33. Las Matemáticas son un "rollo"	ifm06. Las Matemáticas son un "rollo"
	it34. Toca clase de Matemáticas, ¡qué horror!	(eliminated)
	it35. No soporto estudiar Matemáticas	(eliminated)
	it36. Las Matemáticas son entretenidas	ifm07. Las Matemáticas son entretenidas

Note. SMSC = Student's Math Self-Concept, PUIM = Perceived Usefulness and Importance of Mathematics, IfM = Interest for Mathematics.

The resulting scale was then submitted to a translation by committee. The consensual version of the Spanish-Basque bilingual scale is shown in Table 25.

Table 25

Initial Spanish-Basque bilingual SATMAS

Factor / Item	**Content**
SMSC	
smsc01	Soy incapaz de resolver problemas matemáticos *Ez naiz buruketak ebazteko gai*
smsc02	Tengo dificultades con las Matemáticas *Matematikarekin arazoak dauzkat*
smsc03	Me siento más torpe que mis compañeros/as resolviendo ejercicios y problemas de Matemáticas *Ikaskideekin alderatuta, problema eta ariketa matematikoak ebazterakoan motelagoa naizela uste dut*
smsc04	Haga lo que haga saco notas bajas en Matemáticas

	Egiten dudana egiten dudala, Matematikan emaitza baxuak ateratzen ditut
smsc05	Aunque me esfuerce, no entiendo las Matemáticas
	Nahiz eta ahalegindu, ez dut Matematika ulertzen
smsc06	Siempre será difícil para mi aprender Matemáticas
	Matematika ulertzea zaila egingo zait beti
smsc07	No nací para aprender Matemáticas
	Ez nintzen Matematika ulertzeko jaio
PUIM	
puim01	Todas las personas necesitan saber Matemáticas
	Pertsona guztiek Matematika jakin behar dute
puim02	Las Matemáticas son muy útiles
	Matematika oso erabilgarria da
puim03	Sólo deberían estudiar Matemáticas aquellos/as que las vayan a utilizar en sus trabajos
	Matematika beren lanbideetan erabiliko dutenek soilik ikasi beharko lukete
puim04	En Matemáticas sólo deberían enseñarse las cosas prácticas que utilizamos fuera del cole
	Matematikan eskolaz kanpo erabalgarriak diren gauza praktikoak soilik irakatsi beharko lirateke
puim05	Las Matemáticas son útiles para entender las demás asignaturas
	Matematika erabilgarria da gainontzeko irakasgaiak ulertzeko
puim06	Las Matemáticas son necesarias para la vida
	Matematika beharrezkoa da bizitzarako
puim07	Saber Matemáticas es importante para mi futuro trabajo
	Matematika jakitea garrantzitsua da nire etorkizuneko lanarako
puim08	Las Matemáticas son importantes porque favorecen el avance de la sociedad
	Matematika garrantzitsua da gizartearen garapena errazten baitu
puim09	Saber Matemáticas aumentará mis posibilidades de encontrar trabajo *Matematika jakiteak lana aurkitzeko aukera gehiago emango dizkit*
IfM	
ifm01	Estudiar Matemáticas es divertido

	Matematika ikastea dibertigarria da
ifm02	Me gusta estudiar Matemáticas
	Matematika ikastea gustuko dut
ifm03	Se me pasa el tiempo volando cuando estudio Matemáticas
	Matematika ikasten dudanean denbora di-da batean igarotzen zait
ifm04	Se me pasa el tiempo volando cuando resuelvo ejercicios y problemas de Matemáticas
	Ariketa edo problema matematikoak egiten ditudanean denbora di-da batean igarotzen zait
ifm05	Me gustan las Matemáticas
	Matematika gustuko dut
ifm06	Las Matemáticas son un “rollo”
	Matematika oso aspergarria da
ifm07	Las Matemáticas son entretenidas
	Matematika entretenigarria da

Note. SMSC = Student’s Math Self-Concept, PUIM = Perceived Usefulness and Importance of Mathematics, IfM = Interest for Mathematics.

This was the scale administered to the sample as part of the battery of instruments. Participants had to rate their degree of agreement with the statements on a continuous response scale ranging from 0 (*Strongly disagree*) to 10 (*Strongly agree*).

6.2.2. Data collection and prior item analyses

Prior to psychometric analyses, a series of descriptive statistics were conducted and summarized in Table 26. The accuracy of the data entry was examined by the range of the data, ensuring that values ranged from 0 to 10 for all the items of the scale. Given the low missing data rate (< 5%), which was considered to be reasonable (Tabachnick & Fidell, 2007), the Maximum Likelihood (*ML*) estimation method was used with listwise deletion (Brown, 1983, 2006).

Table 26

Descriptive statistical data of each item in both language groups

Item	***n***	***Min.***	***Max.***	***S***	***K***	***M***	***SD***	**IT correlation**
smsc01								
MLS	555	0	10	-1.03	-0.07	7.49	2.94	.68
MLB	226	0	10	-0.90	-0.25	7.02	2.97	.58
smsc02								
MLS	555	0	10	-0.29	-1.21	5.69	3.44	.84
MLB	229	0	10	-0.42	-1.13	5.99	3.28	.75
smsc03								
MLS	555	0	10	-0.38	-1.18	6.07	3.31	.74
MLB	228	0	10	-0.08	-1.07	5.33	3.00	.57
smsc04								
MLS	555	0	10	-0.58	-0.92	6.50	3.34	.77
MLB	227	0	10	-0.54	-0.82	6.50	2.96	.65
smsc05								
MLS	555	0	10	-0.90	-0.41	7.12	3.06	.82
MLB	227	0	10	-0.88	-0.17	7.04	2.88	.73
smsc06								
MLS	555	0	10	-0.56	-1.06	6.41	3.45	.83
MLB	228	0	10	-0.53	-0.94	6.22	3.20	.76
smsc07								
MLS	555	0	10	-0.74	-0.77	6.62	3.41	.71
MLB	229	0	10	-0.48	-1.07	6.19	3.36	.68
puim01								
MLS	553	0	10	-1.50	2.15	8.36	2.01	.52
MLB	228	0	10	-1.33	1.13	7.64	2.67	.52

puim02								
MLS	553	0	10	-1.74	3.45	8.30	2.07	.55
MLB	228	0	10	-1.35	1.22	8.02	2.29	.60
puim03								
MLS	553	0	10	-1.03	-0.06	7.44	2.97	.47
MLB	226	0	10	-0.98	-0.03	7.40	2.80	.42
puim04								
MLS	553	0	10	0.27	-1.04	4.28	3.19	.35
MLB	226	0	10	0.21	-1.15	4.55	3.27	.27
puim05								
MLS	553	0	10	-0.19	-0.92	5.15	2.97	.44
MLB	227	0	10	-0.29	-0.80	5.45	2.83	.47
puim06								
MLS	553	0	10	-1.60	2.50	8.36	2.12	.60
MLB	227	0	10	-1.58	2.30	8.16	2.28	.72
puim07								
MLS	553	0	10	-1.26	1.07	7.81	2.50	.54
MLB	226	0	10	-1.11	0.53	7.49	2.71	.57
puim08								
MLS	553	0	10	-1.19	1.41	7.84	2.07	.55
MLB	222	0	10	-1.00	0.57	7.47	2.37	.65
puim09								
MLS	553	0	10	-1.48	2.06	8.11	2.23	.51
MLB	226	0	10	-1.06	0.50	7.64	2.45	.66
ifm01								
MLS	563	0	10	0.12	-1.16	4.19	3.14	.82
MLB	228	0	10	0.04	-1.10	4.36	3.01	.85
ifm02								
MLS	562	0	10	-0.41	-0.94	5.42	3.05	.80
MLB	228	0	10	-0.25	-1.22	5.09	3.22	.81

ifm03									
	MLS	563	0	10	0.02	-1.18	4.68	3.21	.53
	MLB	227	0	10	0.10	-1.21	4.39	3.19	.59
ifm04									
	MLS	562	0	10	-0.16	-1.00	5.18	3.02	.63
	MLB	226	0	10	0.01	-1.07	4.79	3.04	.62
ifm05									
	MLS	563	0	10	-0.55	-0.95	5.87	3.32	.83
	MLB	228	0	10	-0.34	-1.30	5.44	3.47	.84
ifm06									
	MLS	561	0	10	-0.42	-1.01	5.83	3.29	.74
	MLB	227	0	10	-0.54	-0.91	5.92	3.25	.63
ifm07									
	MLS	563	0	10	-0.22	-1.14	5.08	3.21	.82
	MLB	229	0	10	-0.15	-1.23	4.89	3.23	.82

Note. Min = Minimum, *Max* = Maximum, *S* = Skewness, *K* = Kurtosis, *M* = Mean, *SD* = Standard Deviation, IT correlation = Item-Total correlation

As seen in Table 26, considering the full SATMAS, secondary students from both language groups reported the highest mean scores on items encompassing students' beliefs about the applicability of mathematics. Specifically, the highest values were obtained in:

- puim06 ("Las matemáticas son necesarias para la vida" [*Math is necessary for life*]);

- puim01 ("Todas las personas necesitan saber matemáticas"*[Everybody needs to learn math]*);

- and puim02 ("Las matemáticas son muy útiles"*[Math is very useful]*).

Meanwhile, students reported the lowest mean scores on items referring both to extrinsic utility value of mathematics and to their interest in learning and doing mathematics. Specifically, the lowest values were obtained in:

- ifm01 ("Estudiar Matemáticas es divertido" [*Studying math is fun*]);

- puim04 ("En Matemáticas solo deberían enseñarse las cosas practices que utilizamos fuera del cole" [*Only practical stuff, which we use outside school, should be taught in math classes*]);

- and ifm03 ("Se me pasa el tiempo volando cuando estudio Matemáticas"[*Time just flies when I am studying math*]).

As regards the normality assumption, this was examined in two phases. First, the univariate normality was tested through skewness and kurtosis. The descriptive statistical analysis showed that the majority of items met the criteria. The two exceptions in MLS were puim02 (skewness = -1.74, kurtosis = 3.45), and puim06 (skewness = -1.60, kurtosis = 2.50); whereas the only exception in MLB was puim06 (skewness = -1.58, kurtosis = 2.30). However, their values for kurtosis were borderline, which in addition to the visual inspection of the corresponding graphic distribution of scores, showed that they could be suitable for being retained in subsequent analyses.

Second, multivariate normality was tested via the Mardia's standardized estimator, which in the current study was 45.04 ($p < .001$) in MLS and 27.46 ($p < .001$) in MLB, well above the proposed minimum value of 5.00 (Bentler, 2005; Ullman, 2006). Therefore, the violation of multivariate normality encouraged carrying out the estimations with robust methods for standard errors, statistical errors and goodness-of-fit indices (Satorra & Bentler, 2001; Satorra, 2003).

Additionally, item-total correlations were analyzed to identify poor items. Obtained values ranged from $r = .35$ (puim04: "En Matemáticas sólo deberían enseñarse las cosas prácticas que utilizamos fuera del cole" [*Only practical stuff, which we use outside school, should be taught in math classes*]) to $r = .84$ (smsc02: "Tengo dificultades con las matemáticas" [*I have difficulties with math*]) in MLS, and from $r = .27$ (puim04: "Matematikan eskolaz kanpo erabalgarriak diren gauza praktikoak soilik irakatsi beharko lirateke" [*Only practical stuff, which we use outside school, should be taught in math classes*]) to $r = .85$ (ifm01: "Matematika ikastea dibertigarria da"[*Studying math is fun*]) in MLB. Only one item showed an item-total correlation below the threshold of $r = .40$ in both language groups. Specifically, it was pum04 ($r = .35$ in MLS and $r = .27$ in MLB), which was consequently, removed for subsequent analyses.

Next, inter-item correlations were computed and presented both by factors and language groups. Noteworhtly, all values were statistically significant at $p < .001$. Firstly, as shown in Table 27, inter-item correlations for SMSC ranged from $r = .53$ to $r = .79$ in MLS, and from $r = .40$ to $r = .68$ in MLB.

Table 27

Inter-item correlation matrix for SMSC items in both language groups

		smsc01	smsc02	smsc03	smsc04	smsc05	smsc06	smsc07
smsc01	MLS	1						
	MLB	1						
smsc02	MLS	.56	1					
	MLB	.48	1					
smsc03	MLS	.59	.69	1				
	MLB	.40	.53	1				
smsc04	MLS	.57	.74	.62	1			
	MLB	.47	.54	.47	1			
smsc05	MLS	.59	.79	.65	.70	1		
	MLB	.52	.64	.43	.52	1		
smsc06	MLS	.61	.76	.63	.70	.74	1	
	MLB	.47	.68	.51	.53	.60	1	
smsc07	MLS	.53	.63	.55	.56	.62	.70	1
	MLB	.42	.58	.36	.51	.63	.67	1

Note. All values are statistically significant at $p < .001$

Secondly, as seen in Table 28, inter-item correlations for PUIM ranged from $r = .21$ to $r = .58$ in MLS, and from $r = .14$ to $r = .68$ in MLB.

Table 28

Inter-item correlation matrix for PUIM items in both language groups

		puim 01	puim 02	puim 03	puim 05	puim 06	puim 07	puim 08	puim 09
puim01	MLS	1							
	MLB	1							
puim02	MLS	.40	1						

	MLB	.48	1						
puim03	MLS	.36	.31	1					
	MLB	.21	.27	1					
puim05	MLS	.26	.29	.21	1				
	MLB	.33	.35	.14	1				
puim06	MLS	.54	.54	.36	.31	1			
	MLB	.57	.56	.40	.42	1			
puim07	MLS	.27	.36	.28	.29	.39	1		
	MLB	.27	.42	.29	.30	.43	1		
puim08	MLS	.42	.41	.25	.33	.46	.42	1	
	MLB	.48	.60	.28	.39	.67	.41	1	
puim09	MLS	.30	.31	.22	.32	.39	.58	.43	1
	MLB	.48	.38	.31	.39	.54	.68	.51	1

Note. All values are statistically significant at $p < .001$

Thirdly, as seen in Table 29, inter-item correlations for IfM ranged from $r = .39$ to $r = .83$ in MLS, and from $r = .34$ to $r = .87$ in MLB.

Table 29

Inter-item correlation matrix for IfM items in both language groups

		mta01	mta02	mta03	mta04	mta05	mta06	ifm07
ifm01	MLS	1						
	MLB	1						
ifm02	MLS	.71	1					
	MLB	.77	1					
ifm03	MLS	.51	.42	1				
	MLB	.54	.49	1				
ifm04	MLS	.55	.51	.55	1			
	MLB	.57	.49	.60	1			
ifm05	MLS	.72	.83	.40	.52	1		

	MLB	.78	.87	.50	.50	1		
ifm06	MLS	.67	.65	.39	.48	.72	1	
	MLB	.60	.58	.34	.39	.60	1	
ifm07	MLS	.77	.73	.45	.54	.78	.69	1
	MLB	.79	.72	.49	.53	.79	.63	1

Note. All values are statistically significant at $p < .001$

Overall, most items were moderately correlated. No value exceeded the threshold of $r = .80$, meaning that there was not any problem of multicollineality. However, upon a closer examination of the matrices, the following two items were proposed to be discarded because of their low inter-item correlations:

- puim03 ("Sólo deberían aprender Matemáticas aquellos/as que las vayan a utilizar en sus trabajos" [*Math should be learned only by those who will use it in their jobs*]),

- and puim05 ("Las Matemáticas son útiles para entender las demás asignaturas" [*Math is useful for understanding the rest of subjects*]).

Thus, the version of the scale to be subjected to CFA consisted of 20 items, as shown in Table 30.

Table 30

20-item SATMAS for being subjected to CFA

Factor / Item	**Content**
SMSC	
smsc01	Soy incapaz de resolver problemas matemáticos

		Ez naiz buruketak ebazteko gai
	smsc02	Tengo dificultades con las Matemáticas
		Matematikarekin arazoak dauzkat
	smsc03	Me siento más torpe que mis compañeros/as resolviendo ejercicios y problemas de Matemáticas
		Ikaskideekin alderatuta, problema eta ariketa matematikoak ebazterakoan motelagoa naizela uste dut
	smsc04	Haga lo que haga saco notas bajas en Matemáticas
		Egiten dudana egiten dudala, Matematikan emaitza baxuak ateratzen ditut
	smsc05	Aunque me esfuerce, no entiendo las Matemáticas
		Nahiz eta ahalegindu, ez dut Matematika ulertzen
	smsc06	Siempre será difícil para mi aprender Matemáticas
		Matematika ulertzea zaila egingo zait beti
	smsc07	No nací para aprender Matemáticas
		Ez nintzen Matematika ulertzeko jaio
PUIM		
	puim01	Todas las personas necesitan saber Matemáticas
		Pertsona guztiek Matematika jakin behar dute
	puim02	Las Matemáticas son muy útiles
		Matematika oso erabilgarria da
	puim06	Las Matemáticas son necesarias para la vida
		Matematika beharrezkoa da bizitzarako
	puim07	Saber Matemáticas es importante para mi futuro trabajo
		Matematika jakitea garrantzitsua da nire etorkizuneko lanarako
	puim08	Las Matemáticas son importantes porque favorecen el avance de la sociedad
		Matematika garrantzitsua da gizartearen garapena errazten baitu
	puim09	Saber Matemáticas aumentará mis posibilidades de encontrar trabajo
		Matematika jakiteak lana aurkitzeko aukera gehiago emango dizkit
IfM		
	ifm01	Estudiar Matemáticas es divertido
		Matematika ikastea dibertigarria da

ifm02	Me gusta estudiar Matemáticas *Matematika ikastea gustuko dut*
ifm03	Se me pasa el tiempo volando cuando estudio Matemáticas *Matematika ikasten dudanean denbora di-da batean igarotzen zait*
ifm04	Se me pasa el tiempo volando cuando resuelvo ejercicios y problemas de Matemáticas *Ariketa edo problema matematikoak egiten ditudanean denbora di-da batean igarotzen zait*
ifm05	Me gustan las Matemáticas *Matematika gustuko dut*
ifm06	Las Matemáticas son un “rollo” *Matematika oso aspergarria da*
ifm07	Las Matemáticas son entretenidas *Matematika entretenigarria da*

Note. SMSC = Student’s Math Self-Concept, PUM = Perceived Usefulness of Mathematics, IfM = Interest for Mathematics.

6.2.3. CFA and assessments of factor structure

Three models were tested and compared to yield the best and most parsimonious factor structure for SATMAS: (1) a one-factor model (unidimensional), in which all items were indicators of a global factor (ATM); (2) a three first-order factor model (multidimensional), in which the items were assumed to measure the three principal factors of the scale (that is, SMSC, PUIM and IfM); and (3) a second-order model (hierarchical), in which the three first-order factors (SMSC, PUIM, and IfM) loaded on a second-order factor (ATM). After these alternative models were proposed, the goodness-of-fit indices were computed and compared in order to select the most parsimonious and interpretable factor structure for ATM (see Table 31).

Table 31

Goodness-of-fit indices for the three alternative models, split down by language

CFA model	**S-B$_{\chi^2}$**	***df***	**RMSEA (90% CI)**	**SRMR**	**NNFI**	**CFI**	**AIC**	**ΔS-B$_{\chi^2}$ (Δ*df*)**
Single factor								
Spanish version	1807.51	170	.133 (.128, .139)	.083	.68	.71	1467.51	/
Basque version	917.61	170	.146 (.137, .155)	.146	.63	.67	577.61	/
Three-factor model								
Spanish version	574.28	167	.067 (.061, .073)	.059	.92	.93	240.28	1233.23*** (3)
Basque version	340.45	167	.071 (.060, .082)	.066	.91	.92	6.45	577.16*** (3)
Second-order model								
Spanish version	574.27	167	.067 (.061, .073)	.059	.92	.93	240.27	1233.34*** (3)
Basque version	344.24	167	.072 (.061, .082)	.071	.91	.92	10.24	573.37*** (3)

Note. RMSEA = Root Mean Square Error of Approximation, SRMR = Standardized , NNFI =, CFI = Comparative Fit Index, AIC = Akaike's Information Index
***p< .001

An seen, the single factor fitted data poorly, showing values for RMSEA and SRMR above .08, and values for NNFI and CFI well below .90. In contrast, both the three-factor model and the second-order model showed an overall and significantly better fit-to.data compared to the unidimensional model, with very similar values for all goodness-of-fit indices considered for the study. Moreover, in this case, the three-factor structure did not show any model redundancy, since its inter-factor correlations ranged from $r = .36$ (between SMSC and PUIM) to $r = .72$ (between SMSC and IfM) in MLS, and from $r = .21$ (between SMSC and PUIM) to $r = .65$ (between SMSC and IfM) in MLB, which ensured discriminant validity. As regards AIC, although very similar in both models, the corresponding Basque version yielded lower values, as occurred with the value of SRMR. Therefore, based on these results and the principle of parsimony, the three-factor model emerged as the preferred structure for the construct ATM in the present study.

Next, based on the considerations for covariance scores, inter-item correlations and factor loadings, another item was selected for removal: puim09 ("Saber matemáticas aumentará mis posibilidades de encontrar trabajo" [*Matematika jakiteak lana aurkitzeko aukera gehiago emango dizkit*]). After its deletion, the re-specified model yielded good to excellent values for the goodness-of-fit indices both in Spanish version (χ^2 (149, $N = 563$) = 477.19, $p < .001$; RMSEA = .064 (.057, .070); SRMR = .056; NNFI = .93; CFI = .94) (see Figure 3) and in Basque version (χ^2 (149, $N = 229$) = 262.66, $p < .001$; RMSEA = .061 (.048, .072); SRMR = .061; NNFI = .94; CFI = .95) (see Figure 4).

In these re-specificied models, all standardized factor loadings were statistically significant at $p < .05$. Specifically:

- the standardized factor loadings for SMSC ranged from $\lambda = .68$ (smsc01: "Soy incapaz de resolver problemas matemáticos") to $\lambda = .89$ (smsc02: "Tengo dificultades con las matemáticas") in Spanish version, and from $\lambda = .64$ (smsc03: "Ikaskideekin alderatuta, problema eta ariketa matematikoak ebazterakoan motelagoa naizela uste dut") to $\lambda = .88$ (smsc07: "Ez nintzen Matematika ulertzeko jaio") in Basque version;

- the standardized factor loadings from PUIM ranged from $\lambda = .55$ (puim07: "Saber matemáticas es importante para mi futuro trabajo") to $\lambda = .77$ (puim06: "Las matemáticas son necesarias para la vida") in Spanish version, and from $\lambda = .59$ (puim07: "Matematika jakitea garrantzitsua da nire etorkizuneko lanarako") to $\lambda = .86$ (puim06: "Matematika beharrezkoa da bizitzarako") in Basque version;

- and the standardized factor loadings for IfM ranged from $\lambda = .53$ (ifm03: "Se me pasa el tiempo volando cuando estudio Matemáticas") to $\lambda = .91$ (ifm05: "Me gustan las matemáticas") in Spanish version, and from $\lambda = .54$ (ifm03: "Matematika ikasten dudanean denbora di-da batean igarotzen zait") to $\lambda = .95$ (ifm05: "Matematika gustuko dut") in Basque version.

Additional properties of the final 19-item SATMAS were assessed with the Composite Reliability (*CR*) and Cronbach's alpha (α) of each factor. The reliability analyses showed good internal consistency for SMSC (*CR* = .88 and α = .93 in Spanish version; *CR* = .84 and α= .88 in Basque version), PUIM (*CR* = .74 and α = .78 in Spanish version; *CR* = .78 and α = .82 in Basque version) and IfM (*CR* = .87 and α = .91 in Spanish version; *CR* = .87 and α= .91 in Basque version).

Also, the squared multiple correlation (R^2) was estimated for each observed variable. The values ranged from R^2 = .28 (ifm03: "Se me pasa el tiempo volando cuando estudio Matemáticas") to R^2 = .83 (ifm05: "Me gustan las matemáticas") in Spanish version, and from R^2 = .29 (ifm03: "Matematika ikasten dudanean denbora di-da batean igarotzen zait") to R^2 = .90 (ifm05: "Matematika gustuko dut") in Basque version, which indicated acceptable proportions of variance. Results are summarized in Table 32.

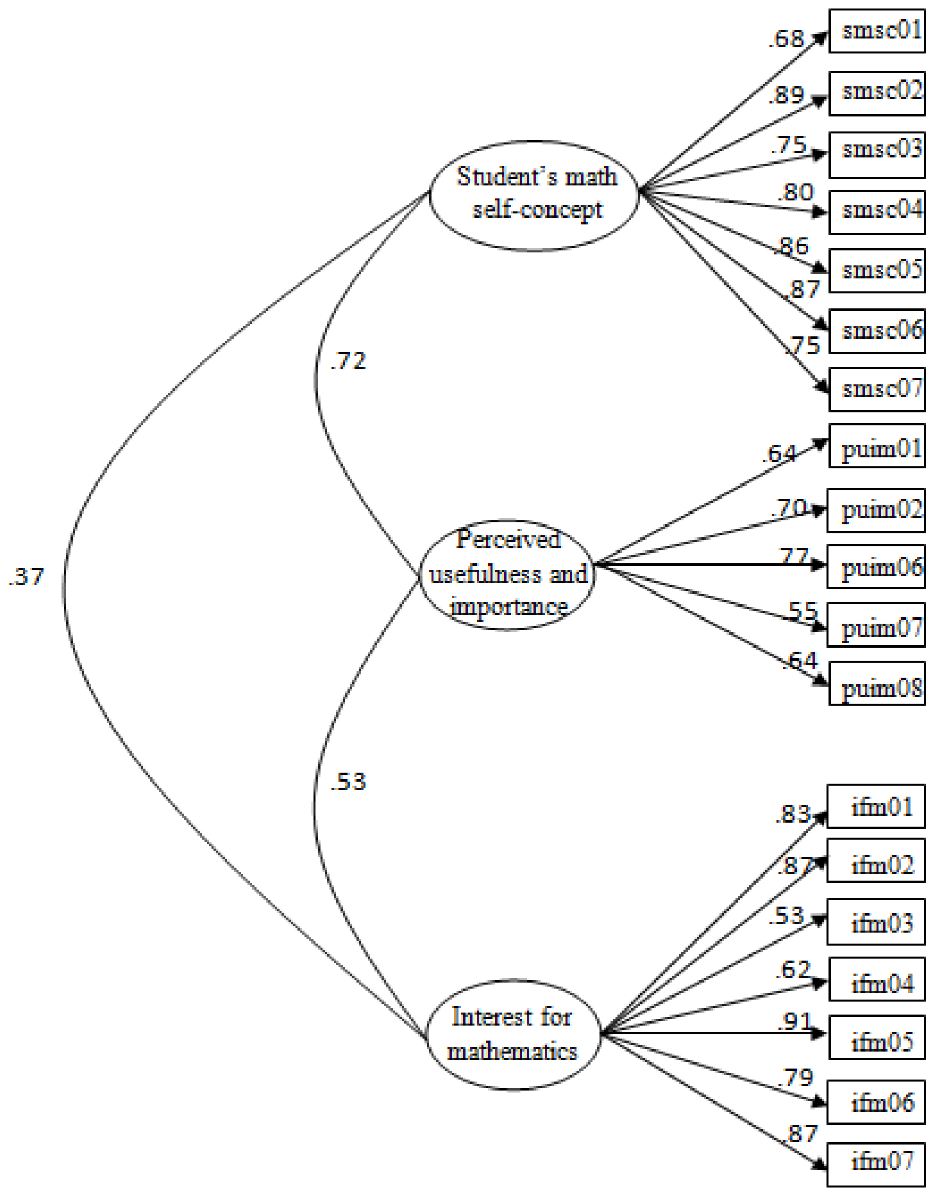


Figure 3. Confirmatory factor analysis of SATMAS in Spanish version (N = 563).

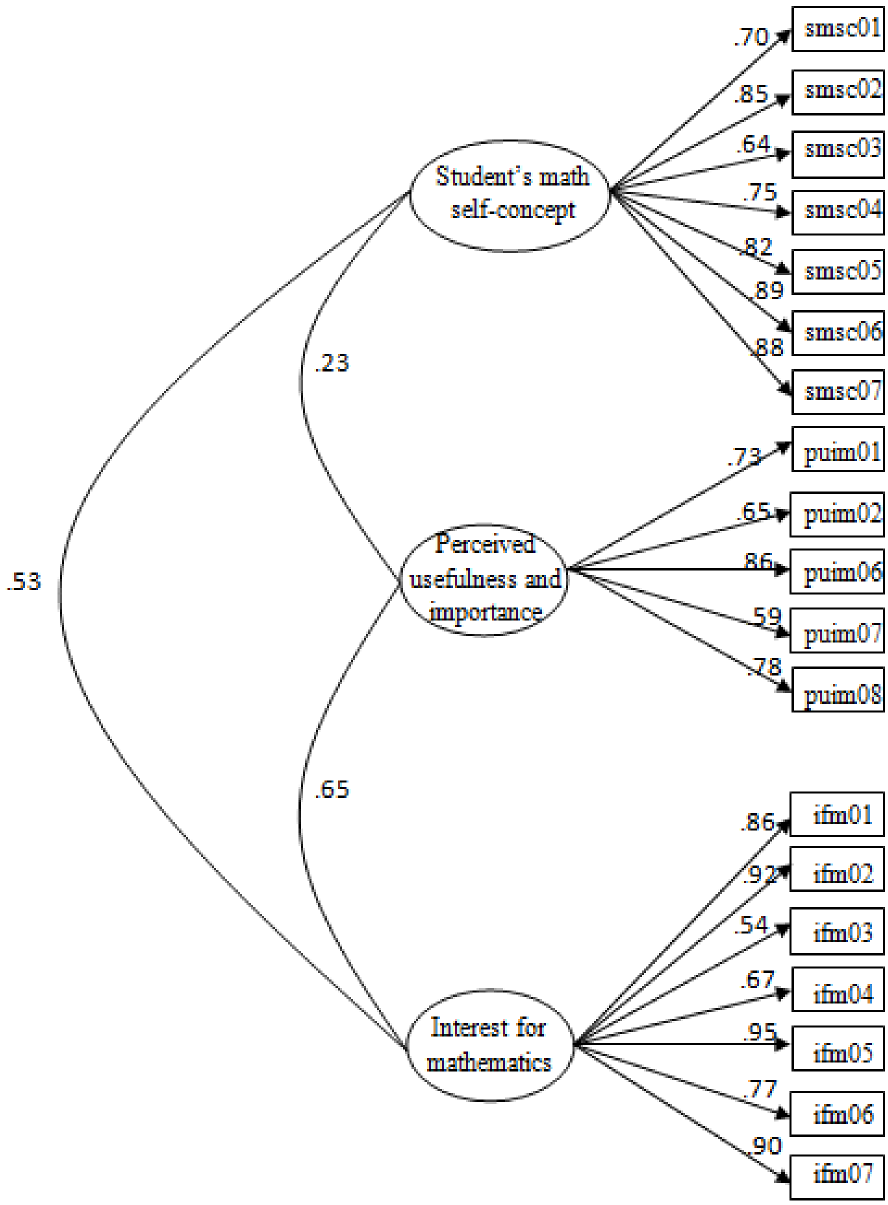


Figure 4. Confirmatory factor analysis of SATMAS in Basque version (N = 229).

Table 32

Standardized factor loadings, Composite Reliability scores and Cronbach's alpha values

Spanish version	**λ**	**R^2**	**Basque version**	**λ**	**R^2**
SMSC (α = .93, *CR* = .88)			SMSC (α = .88, *CR* = .84)		
smsc01	.68	.46	smsc01	.70	.49
smsc02	.89	.79	smsc02	.85	.73
smsc03	.75	.56	smsc03	.64	.41
smsc04	.80	.64	smsc04	.75	.57
smsc05	.86	.74	smsc05	.82	.67
smsc06	.87	.76	smsc06	.89	.79
smsc07	.75	.56	smcs07	.88	.78
PUIM (α = .78, *CR* = .74)			PUIM (α = .82, *CR* = .78)		
puim01	.64	.41	puim01	.73	.53
puim02	.70	.49	puim02	.65	.42
puim06	.77	.59	puim06	.86	.74
puim07	.55	.30	puim07	.59	.35
puim08	.64	.41	puim08	.78	.61
IfM (α = .91, *CR* = .87)			IfM (α = .91, *CR* = .87)		
ifm01	.83	.69	ifm01	.86	.74
ifm02	.87	.75	ifm02	.92	.85
ifm03	.53	.28	ifm03	.54	.29
ifm04	.62	.39	ifm04	.67	.44
ifm05	.91	.83	ifm05	.95	.90
ifm06	.79	.62	ifm06	.77	.60
ifm07	.87	.75	ifm07	.90	.80

Note. SMSC = Student's Math Self-Concept, PUIM = Perceived Usefulness and Importance of Mathematics, IfM = Interest for Mathematics, α = Cronbach's alpha, *CR* = Comporsite Reliability

6.2.4. Convergent validity

As regards convergent validity, this was assessed by the Pearson correlation coefficients between attitudes toward mathematics and the most referred construct in literature. Specifically, the dimensions of attitudes toward mathematics were related to mathematics achievement (e.g., Ma & Kishor, 1997; Bouchey & Harter, 2005; Anjum, 2006; Skaalvik & Skaalvik, 2006; Samuelsson & Granstom, 2007; Kadijevich, 2008; Williams & Williams, 2010; Lipnevich, MacCann, Krumm, Burrus, & Roberts, 2011).

Results (see Table 33) yielded moderate positive correlations between student's math self-concept and mathematics achievement both in MLS (r = .28, p < .01) and in MLB (r = .34, p < .01); moderate positive correlations between perceived usefulness and importance of mathematics and mathematics achievement both in MLS (r = .22, p < .01) and in MLB (r = .25, p < .01); and low-moderate positive correlations between interest for mathematics and mathematics achievement both in MLS (r = .21, p < .01) and in MLB (r = .29, p < .01).

Table 33

Correlation coefficients between attitudes towards math and math achievement

		SMSC	PUIM	IfM	MACH
SMSC	MLS	1			
	MLB	1			
PUIM	MLS	.35**	1		
	MLB	.16*	1		
IfM	MLS	.66**	.47**	1	

	MLB	.55**	.44**	1	
MACH	MLS	.28**	.22**	.21**	1
	MLB	.34**	.25**	.29**	1

Note. SMSC = Student's Math Self-Concept, PUIM = Perceived Utility and Importance of Mathematics, IfM = Interest for Mathematics, MACH = Math Achievement
$^{**}p < .01$, $^{*}p < .05$

6.2.5. Test-retest reliability

Finally, the replication study was carried out by comparing responses to the final version of SATMAS among 512 (90.94%) secondary students who completed the Spanish version of the scale after a seven-month period, and among 191 (83.41%) secondary students who did it with the corresponding Basque version. CFA was run again in order to confirm the three-factor structure emerged in previous steps. Table 34 summarizes the goodness-of-fit indices obtained.

Table 34

Goodness-of-fit indices for the replication study, split down by language

Language group	**S-B$_{\chi^2}$**	***df***	**RMSEA (90% CI)**	**SRMR**	**NNFI**	**CFI**	**AIC**
MLS							
pre	477.19	149	.064 (.057, .070)	.056	.93	.94	179.19
post	520.83	149	.072 (.065, .078)	.064	.92	.93	222.83
MLB							
pre	262.66	149	.061 (.048, .072)	.061	.94	.95	-35.34
post	314.90	149	.080 (.067, .092)	.069	.92	.93	16.90

Note. RMSEA = Root Mean Square Error of Approximation, SRMR = Standardized , NNFI =, CFI = Comparative Fit Index, AIC = Akaike's Information Index
$^{***}p< .001$

On other hand, test-retest reliabilities were computed as Intraclass Correlations Coefficients (ICC) with 95% confidence interval (see Table 35). Results revealed excellent test-retest reliabilities for SMSC (ICC = .87 (.85 - .89) in Spanish version and ICC = .88 (.84 - .91) in Basque version), good test-retest reliabilities for PUIM (ICC = .74 (.68 - .78) in Spanish version and ICC = .78 (.70 -. 83) in Basque version) and excellent test-retest reliabilities for IfM (ICC = .84 (.81 - .87) in Spanish version and ICC = .87 (.83 - .90) in Basque version). The factor with the lowest median reliability was PUIM; whereas both SMSC and IfM showed the highest median reliabilities. These results underscored the reproductibility of the scale over time.

Table 35

Test-retest reliabilities for SATMAS

Factor	***n***	**Pre**		**Post**		**ICC (95% CI)**
		M	***SD***	***M***	***SD***	
SMSC						
MLS	512	6.49	2.74	6.50	2.64	.87 (.85, .89)
MLB	191	6.21	2.51	6.25	2.54	.88 (.84, .91)
PUIM						
MLS	512	8.17	1.56	7.91	1.77	.74 (.68, .78)
MLB	191	7.80	1.87	7.74	1.89	.78 (.70, .83)
IfM						
MLS	512	5.17	2.56	5.04	2.61	.84 (.81, .87)
MLB	191	4.90	2.62	4.69	2.68	.87 (.83, .90)

Note. SMSC = Student's Math Self-Concept, PUIM = Perceived Usefulness and Importance of Mathematics, IfM = Interest for Mathematics, *M* = Mean, *SD* = Standard Deviation, ICC = Intraclass Correlation Coefficient, CI = Confidence Interval

6.3. DISCUSSION

Over the past years, there has been a growing interest in studying the students' attitudes towards mathematics because of their important role in the engagement in and mastery of mathematics (e.g., McLeod, 1992; Goldin, 2002; Grootenboer & Hemmings, 2007; Malmivouri, 2007). Nevertheless, correlational research on attitudinal variables and mathematical achievement has been contingent on the psychometric properties of the measurements for measuring the construct attitudes towards mathematics.

Drawing on the so-called Self-Determination Theory (Ryan & Deci, 1985, 2000) and after gathering evidence about content validity through a review panel, three latent factors are proposed as main constituents of the attitudes towards mathematics: students' math self-concept, perceived usefulness and importance of mathematics and interest for mathematics. In order to test which structure best fitted the data, three alternative models were subjected to analysis. The three first-order factor model emerged as the best structure for the construct ATM. Results provide evidence of good to excellent psychometric properties for the final version of the instruments (i.e., content validity, construct validity, discriminant validity, convergent validity), which guarantees its use both with samples of math learners in Spanish and math learners in Basque. All standardized factor loadings of items were statistically significant and results of reliability analyses suggested that the items were internally consistent in representing the corresponding factors. This validation evidence provided additional evidence of the previously noted Self-Determination Theory (Ryan & Deci, 1985, 2000) for explaining students' achievement-related outcomes, contributing in this way to expand knowledge on the field.

Assessments of convergent validity underscored positive moderate correlations between each dimension of attitudes toward mathematics and mathematics achievement, which is consistent with previous studies (e.g., Bouchey & Harter, 2005; Chipman, 2005; Anjum, 2006; Skaalvik & Skaalvik, 2006; Thomas, 2006; Chiu & Xihua, 2007; Samuelsson & Granstom, 2007; Barkoukis, Tsorbatzoudis, Grouios, & Sideridis, 2008; Kadijevich, 2008; Papanastasiou, 2008; Chiu & Klassen, 2010; Williams & Williams, 2010; Lipnevich et al., 2011). Specifically, Marsh et al. (2012) underscored correlations ranging from $r = .49$ to $r = .70$ between interest in mathematics and mathematics achievement; and from $r = .27$ to $r = .49$ between math self-concept and mathematics achievement. Compared with results obtained in the present research, the correlation scores are found to be small, which might be due to the different conceptualization of construct attitudes toward mathematics both in previous research and in the present study. Indeed, attitudes towards mathematics, along with its underlying components, have been conceptualized according to the Self-Determination Theory (Ryan & Deci, 1985, 2000). However, this is not the unique theory that can serve as a basis for the development of the contruct, meaning that the same attitudinal factors may well be operationalized differently according to the theoretical framework that serves as starting point.

Despite the promising findings, since both the SAMAS and the SATMAS followed the same procedure with the same research sample for their development and validation, the methodological limitations described in Chapter 5 were also found in Chapter 6. That is, although the research sample was representative and large enough for the research purpose in Chapter 6, this was not completely probabilistic and therefore, results are not entirely generalizable outside of a Basque population. In this line, future research using larger samples from different sociodemographic contexts would be necessary to further assess the invariance of the factor structure. Also, given the relevance of attitudes toward mathematics in the engagement in and mastery of mathematics, it would be highly interesting to adapt and validate the new developed instrument with other propulations (i.e., primary school students and university students) in order to monitor the changes in levels of attitudes toward mathematics as time evolves.

To conclude, given the reliability and validity evidence gathered, the 19-item SATMAS proves to be a promising instrument for assessing secondary students' attitudes toward mathematics both in math learners in Spanish and in math learners in Basque. On the one hand, the results largely supported the theoretical conceptualization according to which attitudes towards mathematics is a multidimensional construct with a non-hierarchized structure consisting of the three aforementioned first-order factors (namely, student's math self-concept, perceived usefulness and importance of mathematics and interest for mathematics). On the other hand, the developed scale is easy to administer and not time-demanding, since this short form takes secondary students 5 minutes to complete. Therefore, either school counselors or educators might use it to monitor students' attitudes towards mathematics, identify those individuals with low mathematical self-concept or motivation and provide early attention measures to improve these levels. On other hand, researchers might use it as the starting point to identify the key domains of attitudes towards mathematics affecting the mathematical achievement and further investigate the variables which affect their prevalence. Noteworthy, the theoretical framework for the development of SATMAS has been the Self-Determination Theory, but this does not mean that future versions of the scale do not include additional components from other approaches that could complement the conceptualization of the construct and improve the validity of the SATMAS. Indeed, assessing the dimensions underlying attitudes toward mathematics, along with those underlying math anxiety, is critical to gain knowledge about the plausible non-cognitive factors that affect mathematics achievement.

Chapter 7

Factors influencing secondary education students' mathematical competence: A structural model

CHAPTER

7

Factors influencing secondary education students' mathematical competence: A structural model

7.1. DATA ANALYSIS

As detailed as follows, the data analysis section for the development and assessment of the structural model was divided into five phases. Across them, a series of statistical analyses were undertaken using the software packages IBM SPSS Statistics 22 and Amos 23 (Arbuckle, 2013).

Phase 1. Specification of the theoretical model and preliminary analyses for SEM assumptions

A theoretical model was proposed to be tested by Structural Equation Modeling (henceforth, SEM) in the research sample during a mathematics course. For that, relationships between math anxiety (henceforth, MA), attitudes toward mathematics (henceforth, ATM), calculus skills (henceforth, CAL) and mathematical problem solving skills (henceforth, PROB) were hypothesized. All these variables were measured both at the beginning and at the end of the mathematics course. As detailed in Chapter 5 and Chapter 6, a set of CFA was conducted for the Scale for Assessing Math Anxiety in Secondary education (henceforth, SAMAS) and the Scale for Assessing Attitudes Toward Mathematics in Secondary education (henceforth, SATMAS) to test the fit of their factor structures in both measurement times and their standardized factor loadings. Given the reliability and validity evidence gathered, both instruments were adequate for their use in the development and validation of the subsequent structural model, addressed in the present chapter. Next, a set of preliminary analyses were performed to test if dataset met the assumptions required for SEM.

Firstly, missing data rate and accurate input were tested for all the variables considered in the theoretical model. A percentage of 10% was established as threshold for missing data rate, since a value below this cut-off supports employing mean imputation method for conducting the SEM (Kline, 1998).

Secondly, descriptive statistics were computed. Specifically, means and standard deviations were displayed for each variable and results were analyzed for the identification of potential outliers. Thus, those scores with standard deviations which were both above 3.00 and far from their closest neighboring scores were selected for removal.

Thirdly, the absolute values of skewness and kurtosis were computed for testing univariate normality. Values for both absolute skewness and kurtosis below 1.96 were indicators of univariate normality (Byrne, 2010; Arbuckle, 2013). And fourthly, the standardized Mardia's multivariate kurtosis coefficient was analyzed, setting a benchmark for the critical ratio of c.r. < 7.13 for multivariate normality. Since several studies have shown that most data in social sciences has non-normal distributions (Bentler & Chou, 1987; Barnes, Cote, Cudeck, & Malthouse, 2001), an unfulfillment of the assumption of multivariate normality encourages to confirm the robustness of the theoretical model through bootstrapping (Byrne, 2001). In fact, this technique allows reducing bias in parameter estimates with no power loss in the model, showing even better results for SEM than the Satorra-Bentler scaled chi-square (Finney & DiStefano, 2006). Thus, this method was conducted with an 95% confidence interval and 2,000 bootstrapped samples.

Phase 2. Measurement and structural models

The SEM was then performed following the two-step approach (Anderson & Gerbing, 1988). First, the measurement model, with all latent variables freely correlated, was run to preliminarily assess the adequacy of the hypothesized model and evaluate the bivariate correlations between variables. Those variables which underperformed at this step were selected for removal for subsequent analyses. Next, in the second step of this approach, two models were tested: 1) the saturated model, in which hypothesized path connections between the latent constructs were assessed, setting later mathematical competence as the exogenous or outcome variable; and 2) the pruned model, in which all the statistically non-significant paths at $p < .05$ were trimmed gradually from the saturated model, following the MacCallum's (1986) procedure. The pruned model was then analyzed to determine if it accounted for a significant improvement for fit-to-data in comparison with the saturated model. For that purpose, the chi-square difference test was performed.

All above mentioned structural models were tested using the Maximum Likelihood (*ML*) estimation on the variance-covariance matrix. For model identification purposes, the loading for the first indicator on its corresponding latent variable was set to 1 and the variances for all error weights and remaining parameters were freely estimated (Ullman, 2006). Since the χ^2 statistics is sensitive to sample sizes greater than 200 (Hair et al., 2010; Jöreskog & Soborn, 1993; Raykov & Marcoulides, 2006), the following alternative fit indices and desirable cut-offs were used to assess model fit to data: a) the χ^2/df statistics should be lower than 5.00 (Wheaton, Muthén, Alwin, & Summers, 1977; Schumacker & Lomax, 2010); b) the Root Mean Squared Error of Approximation (RMSEA) should be lower than .08 (Browne & Cudeck, 1993; MacCallum, Browne, & Sugawara, 1996; Hu & Bentler, 1999) with the relative 90% confidence interval; c) the Goodness-of-Fit Index (GFI) should be greater than .90 (Garson, 2001); and d) the Comparative Fit Index (CFI) should be greater than .90 (Bentler, 1990, Garson, 2001).

Phase 3.Testing for mediation relationships

Next, in order to support the mediation relationshipss included in the pruned model and determine which type of mediation occurred, the standards of Kenny, Kashy, and Bolger (1998) were considered. According to these authors, these analyses should be performed following four steps: 1) the hypothesis testing for the regression coefficient from the independent variable to the dependent variable (in absence of the mediator) should be statistically significant; 2) the hypothesis testing for the regression coefficient from the independent variable to the mediator (in absence of the dependent variable) should be statistically significant; 3) the hypothesis testing for the regression coefficients from the independent variable to the dependent variable (both directly and indirectly through the moderator) should be statistically significant; and 4) the direct and indirect effects obtained in the third stage should be analyzed to determine if the mediation is full or partial. Thus, for a full mediation, the direct effect of the independent variable on the dependent variable should be statistically non-significant when the mediator enters the model; whereas for a partial mediation, the direct effect of the independent variable on the dependent variable should remain significant when the mediator enters the model.

Once the types of mediation were assessed for the pruned model, boostrapping was conducted to confirm the findings (MacKinnon, Lockwood, & Williams, 2004; MacKinnon, 2008). Therefore, direct and indirect effects were estimated for 2,000 bootstrapped samples and the 95% confidence interval was computed. Finally, the effect size of the corresponding mediators was assesed. To interpret the results, Cohen's (1988) benchmarks were considered, according to which, values of R^2 below .13 were indicative of small effect size, R^2 ranging from .13 to .26 of moderate effect size, and R^2 above .26 of large effect size.

Phase 4. Testing the moderation effect of educational grade

The pruned model was further analyzed to test whether there was a moderation effect of educational level on the relationship between final levels of math anxiety and mathematical competence. For that, the difference in chi-square value ($\Delta\chi^2$) between the constrained and unconstrained models was estimated considering two student subgroups: students enrolled in second-grade and students enrolled in fourth-grade. In case of a significant difference, the unconstrained models would be re-run separately to determine in which educational grade the previously noted path was stronger.

Phase 5. Interaction effects on math anxiety

Next, in order to better ascertain the interaction effect of several independent variables both on the combined components of math anxiety and on each component of the construct, a 2x2 mixed ANOVA was conducted with time (T1/T2) as the within-subjects factor, and the educational level (second/fourth), student's gender (female/male) and the language in which the student learns mathematics at school (Spanish/Basque) as the between-subjects factors. Only those interactions which were statistically significant were detailed, meaning that those results which were not displayed in the corresponding section of results were statistically non-significant, and therefore, not included.

Phase 6. Interaction effects on attitudes toward mathematics

Next, in order to better ascertain the interaction effect of several independent variables both on the combined components of attitudes toward mathematics and on each component of the construct, a 2x2 mixed ANOVA was conducted with time (T1/T2) as the within-subjects factor, and the educational level (second/fourth), student's gender (female/male) and the language in which the student learns mathematics at school (Spanish/Basque) as the between-subjects factors. Only those interactions which were statistically significant were detailed, meaning that those results which were not displayed in the corresponding section of results were statistically non-significant, and therefore, not included.

7.2. RESULTS

7.2.1. Specification of the theoretical model and preliminary analyses for SEM assumptions

Having reviewed the evidence and main concerns from previous literature, the model proposed in the present research (see Figure 5) posits that: 1) prior calculus skills and mathematical problem solving skills are reciprocally related over time; 2) math anxiety and attitudes toward mathematics are reciprocally related over time; 3) final levels of math anxiety and attitudes toward mathematics mediate the relationship between prior and later calculus skills and prior and later mathematical problem solving skills; and 4) later calculus skills has a significant effect on later mathematical problem solving skills..

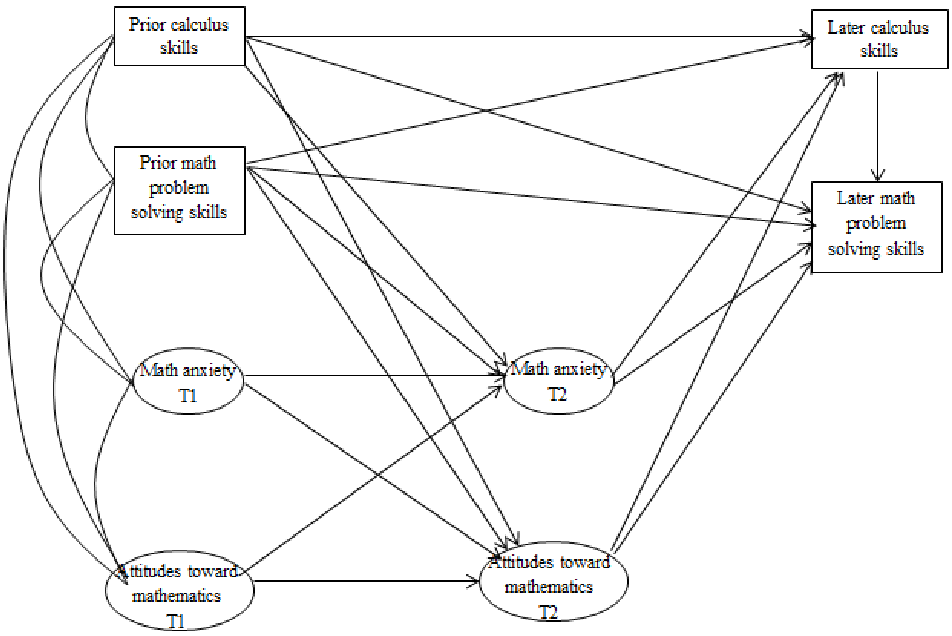


Figure 5. The initially hypothesized model

For SEM purposes, the scales were divided into parcels, in such a way that each dimension corresponded to one parcel and corresponding respondents' scores on each dimension were averaged. Therefore, possible score ranges were 0 through 10 for each parcel of the SAMAS and the SATMAS, as well as for calculus skills and mathematical problem solving skills. The accuracy of the data entry was examined by this previously noted range of the data, resulting in all variables ranging from 0 to 10. Additionally, given the low missing data rate (<5%), well below the threshold of 10% previously set, the Maximum Likelihood (*ML*) estimation method was used with mean imputation method (Kline, 1998). Descriptive data and reliability coefficients were then computed for all variables (see Table 36).

Table 36

Descriptive statistical data and reliability coefficients of each variable

Variable	***n***	***Min.***	***Max.***	***S***	***K***	***M***	***SD***
CAL-T1	703	0.00	10.00	-0.01	-0.99	4.90	2.80
PROB-T1	703	0.00	5.42	0.30	-0.10	2.21	0.90
ELMA-T1	703	0.00	7.93	1.00	0.46	1.84	1.66
MLA-T1	703	0.00	9.88	0.76	0.03	2.54	2.00
MTA-T1	703	0.00	10.00	0.05	-0.92	4.71	2.56
SMSC-T1	703	0.00	10.00	-0.50	-0.73	6.42	2.67
PUIM-T1	703	0.00	10.00	-1.24	2.08	8.07	1.65
IfM-T1	703	0.00	10.00	-0.19	-0.83	5.10	2.57
CAL-T2	703	0.00	10.00	-0.25	-1.01	5.44	2.89
PROB-T2	703	0.00	6.25	0.28	0.16	2.64	1.02
ELMA-T2	703	0.00	8.57	1.20	1.21	1.60	1.58
MLA-T2	703	0.00	9.50	0.85	0.19	2.35	1.93
MTA-T2	703	0.00	10.00	0.09	-0.81	4.44	2.44

SMSC-T2	703	0.00	10.00	-0.49	-0.61	6.43	2.61
PUIM-T2	703	0.00	10.00	-1.13	1.43	7.87	1.79
IfM-T2	703	0.00	10.00	-0.12	-0.89	4.95	2.62

Note. *Min* = Minimum, *Max* = Maximum, *S* = Skewness, *K* = Kurtosis, *M* = Mean, *SD* = Standard Deviation, CAL = Calculus skills, PROB = Problem solving skills, ELMA = Everyday life's math anxiety, MLA = Math learning anxiety, MTA = Math test anxiety, SMSC = Student's math self concept, PUIM = Perceived usefulness and importance of mathematics, IfM = Interest for mathematics, T1 = Measurement point at the beginning of the mathematics course, T2 = Measurement point at the end of the mathematics course.

As seen, no outliers were identified, meaning that all cases were retained for subsequent analyses. Additionally, results underscored that overall, research sample showed moderate levels of math test anxiety (henceforth, MTA); whereas levels of everyday life's math anxiety (henceforth, ELMA) and math learning anxiety (henceforth, MLA) were considered to be low. Indeed, levels of MTA-T1 (M = 4.71, SD = 2.56) and MTA-T2 (M = 4.44, SD = 2.44) were relatively high, compared to levels of ELMA-T1 (M = 1.84, SD = 1.66), MLA-T1 (M = 2.35, SD = 1.93), ELMA-T2 (M = 1.60, SD = 1.58) and MLA-T2 (M = 2.35, SD = 1.93).

Regarding components of attitudes toward mathematics, research sample showed high positive attitudes in terms of math self-concept (henceforth, SMSC) and perceived usefulness and importance of mathematics (henceforth, PUIM), but their levels of interest for mathematics (henceforth, IfM) only were moderate. Indeed, participants reported more positive scores on SMSC-T1 (M = 6.42, SD = 2.67), PUIM-T1 (M = 8.07, SD = 1.65), SMSC-T2 (M = 6.43, SD = 2.61) and PUIM-T2 (M = 7.87, SD = 1.79) than the corresponding scores on IfM-T1 (M = 5.10, SD = 2.57) and IfM-T2 (M = 4.95, SD = 2.62).

Next, dataset was examined through normality tests. First, univariate distributions of all variables were analyzed based on suggested cut-offs of ±1.96 for skewness and kurtosis. As shown in Table 36, measurement values for skewness ranged from -1.24 (PUIM-T1) to 1.20 (ELMA-T2), which met the aforementioned criteria of $|S| < 1.96$.

Regarding scores of kurtosis, all values met the criteria of $|k| < 1.96$, with the only exception of PUIM-T1 (k = 2.08). However, this result supported no appreciable distorsion. Second, Mardia's multivariate kurtosis coefficient indicated severe non-normality (c.r. = 12.19, $p < .05$) (Bentler, 2005; Ullman, 2006). Thus, in order to discard a significant influence of multivariate non-normality on estimators and confirm the robustness of the model, a bootstrapping was perfomed, using the Maximum Likelihood (*ML*) method, a 95% confidence interval and 2,000 bootstrap samples randomly obtained by re-sampling (Byrne, 2010; Arbuckle, 2013). Results indicated that none of the confidence intervals for the bias included zero and that only a difference in the third decimal occurred. Therefore, discrepancies between estimators were minimal, suggesting that results were robust enough and not affected by a lack of multivariate normality (Byrne, 2001). Consequently, these findings allowed both retaining all cases for subsequent analyses and implementing the Maximum Likelihood (*ML*) method for SEM (Finney & DiStefano, 2006).

7.2.2. Measurement and structural models

The pooled measurement model was tested prior to fit the structural model. Results yielded an acceptable fit to data (χ^2/df = 5.79, RMSEA = .083 (90% CI:

.075, .090), GFI = .93, CFI = .95). Also, the correlation matrix underscored significant correlations at $p < .05$ between all variables (see Table 37).

The signs were consistent with those initially hypothesized. Thus, those students who reported higher levels of math anxiety were associated with poorer math outcomes, both in calculus skills and mathematical problem solving skills; those students who reported more positive attitudes toward mathematics were associated with better math outcomes, both in calculus skills and mathematical problem solving skills; those students who reported higher levels of math anxiety were associated with more negative attitudes toward mathematics; and vice versa, those students who reported more positive attitudes toward mathematics were associated with lower levels of math anxiety. As expected, CAL-T1 and CAL-T2 (r = .72), PROB-T1 and PROB-T2 (r = .50), ELMA-T1 and ELMA-T2 (r = .63), MLA-T1 and MLA-T2 (r = .69) and MTA-T1 and MTA-T2 (r = .57) were among the highest correlations.

Consequently, acccording with these results, no relevant problems were encounter to estimate the fit of the structural model. First, the saturated model was proposed to be tested with SEM (see Figure 6). The estimation of the saturated model yielded an overall adequate fit to data (χ^2/df = 7.57, RMSEA = .097 (90% CI: .089, .104), GFI = .91, CFI = .93), with the exception of the value for RMSEA, which exceeded the recommended threshold of .08, and the value for the ratio χ^2/df, which was above the benchmark of 5.

Table 37

Correlation matrix for the latent constructs considered for SEM

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.	CAL-T1	1															
2.	PROB-T1	.39[a]	1														
3.	ELMA-T1	-.21[a]	-.10b	1													
4.	MLA-T1	-.21[a]	-.18[a]	.62[a]	1												
5.	MTA-T1	-.21[a]	-.21[a]	.41[a]	.72[a]	1											
6.	SMSC-T1	.25[a]	.26[a]	-.39[a]	-.71[a]	-.71[a]	1										
7.	PUIM-T1	.21[a]	.18[a]	-.14[a]	-.17[a]	-.09[b]	.31[a]	1									
8.	IfM-T1	.20[a]	.21[a]	-.08[b]	-.38[a]	-.45[a]	.64[a]	.47[a]	1								
9.	CAL-T2	.72[a]	.39[a]	-.15[a]	-.15[a]	-.13[a]	.20[a]	.18[a]	.15[a]	1							
10.	PROB-T2	.48[a]	.50[a]	-.16[a]	-.20[a]	-.18[a]	.24[a]	.18[a]	.17[a]	.55[a]	1						
11.	ELMA-T2	-.24[a]	-.16[a]	.63[a]	.45[a]	.30[a]	-.35[a]	-.16[a]	-.12[a]	-.20[a]	-.23[a]	1					
12.	MLA-T2	-.25[a]	-.19[a]	.50[a]	.69[a]	.53[a]	-.55[a]	-.17[a]	-.31[a]	-.19[a]	-.25[a]	.66[a]	1				
13.	MTA-T2	-.23[a]	-.22[a]	.34[a]	.57[a]	.70[a]	-.54[a]	-.14[a]	-.38[a]	-.15[a]	-.22[a]	.44[a]	.69[a]	1			
14.	SMSC-T2	.29[a]	.25[a]	-.37[a]	-.58[a]	-.56[a]	.77[a]	.31[a]	.58[a]	.24[a]	.28[a]	-.44[a]	-.68[a]	-.65[a]	1		
15.	PUIM-T2	.23[a]	.14[a]	-.13[a]	-.14[a]	-.09[b]	.26[a]	.60[a]	.37[a]	.20[a]	.23[a]	-.12[a]	-.18[a]	-.11[a]	.32[a]	1	
16.	IfM-T2	.23[a]	.19[a]	-.14[a]	-.31[a]	-.32[a]	.50[a]	.42[a]	.74[a]	.20[a]	.21[a]	-.14[a]	-.35[a]	-.35[a]	.63[a]	.49[a]	1

Note. CAL = Calculus skills, PROB = Problem solving skills, ELMA = Everyday life's math anxiety, MLA = Math learning anxiety, MTA = Math test anxiety, SMSC = Student's math self concept, PUIM = Perceived usefulness and importance of mathematics, IfM = Interest for mathematics, T1 = Measurement point at the beginning of the mathematics course, T2 = Measurement point at the end of the mathematics course

[a]$p < .01$, [b]$p < .05$

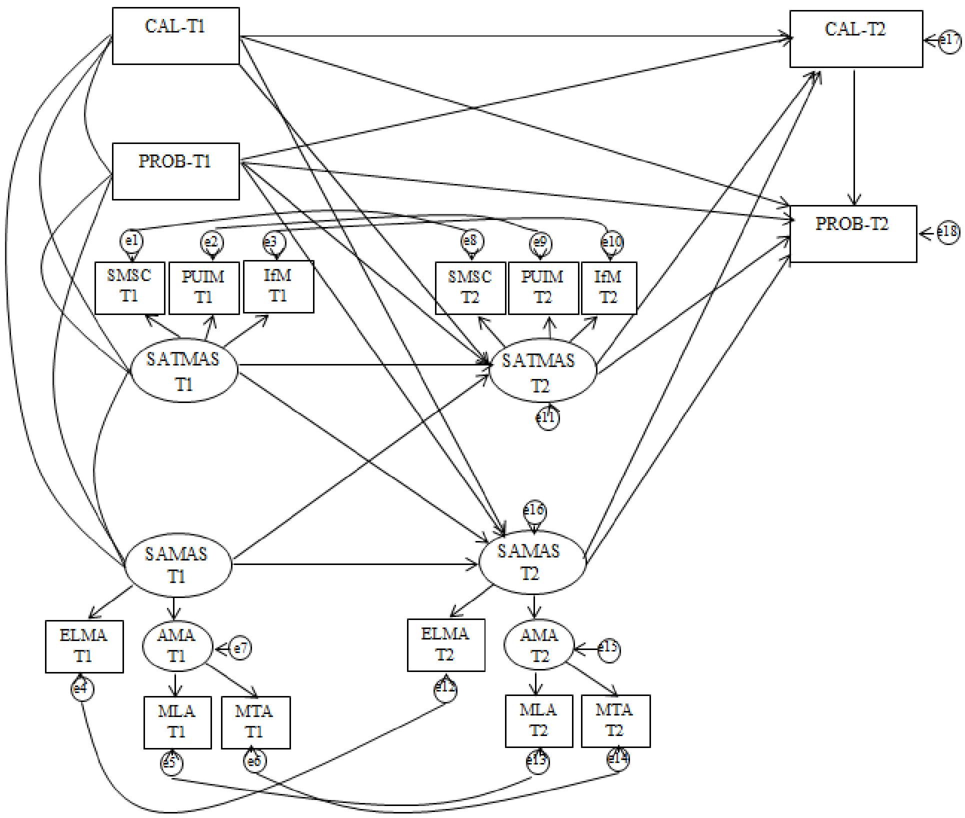


Figure 6. The saturated model

However, results suggested that this model was not the most interpretable one. Path coefficients from PROB-T1 to SATMAS-T2 (β = .01, *SE* = .033, *p* = .788), from SATMAS-T2 to PROB-T2 (β = .02, *SE* = .025, *p* = .553), from PROB-T1 to SAMAS-T2 (β = .02, *SE* = .031, *p* = .492), from SAMAS-T2 to CAL-T2 (β = -.09, *SE* = .116, *p* = .474), from SATMAS-T2 to CAL-T2 (β = .03, *SE* = .062, *p* = .401), from CAL-T1 to SATMAS-T2 (β = .04, *SE* = .015, *p* = .204) and from CAL-T1 to PROB-T2 (β = .08, *SE* = .016, *p* = .081) were non-significant. Consequently, these paths were removed gradually in order to obtain the pruned model (see Figure 7).

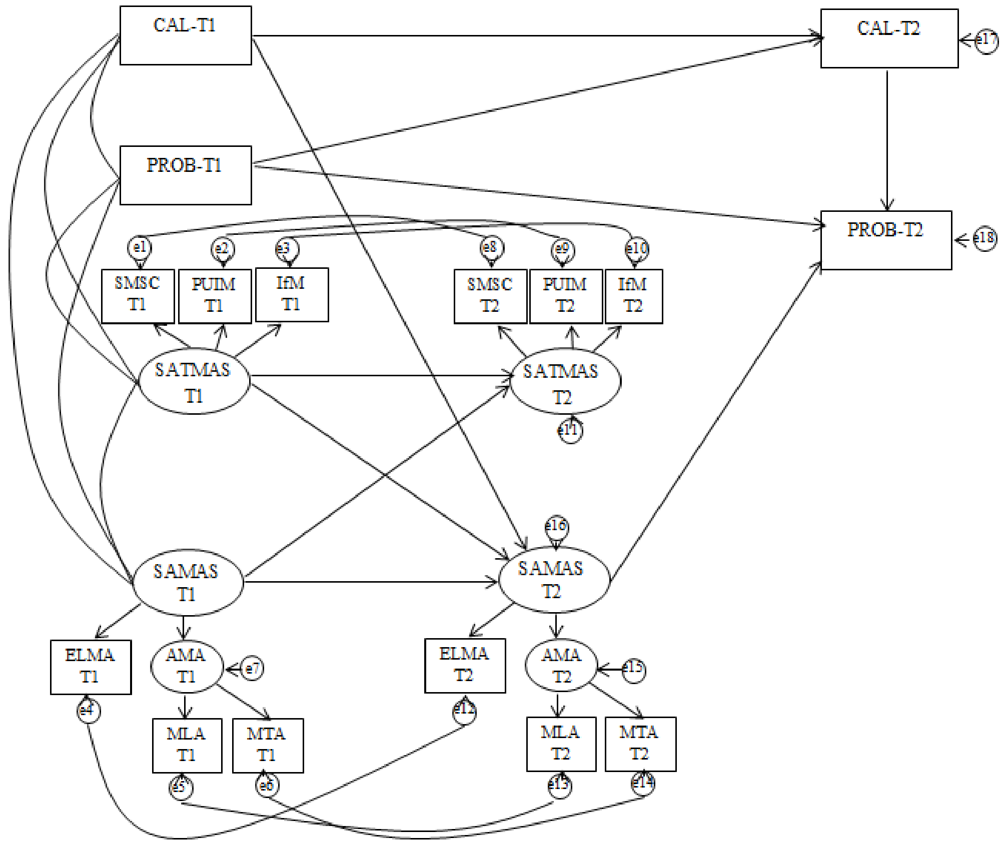


Figure 7. The pruned model

The goodness-of-fit indices for the pruned model yielded a good to excellent fit to data (χ^2/df = 5.13, RMSEA = .077 (90% CI: .070, .084), GFI = .93, CFI = .95). Noteworthy, all path coefficients were statistically significant at $p < .001$, with the exception of the path from SATMAS-T1 to SAMAS-T2, which was statistically significant at $p = .004$ (see Figure 8).

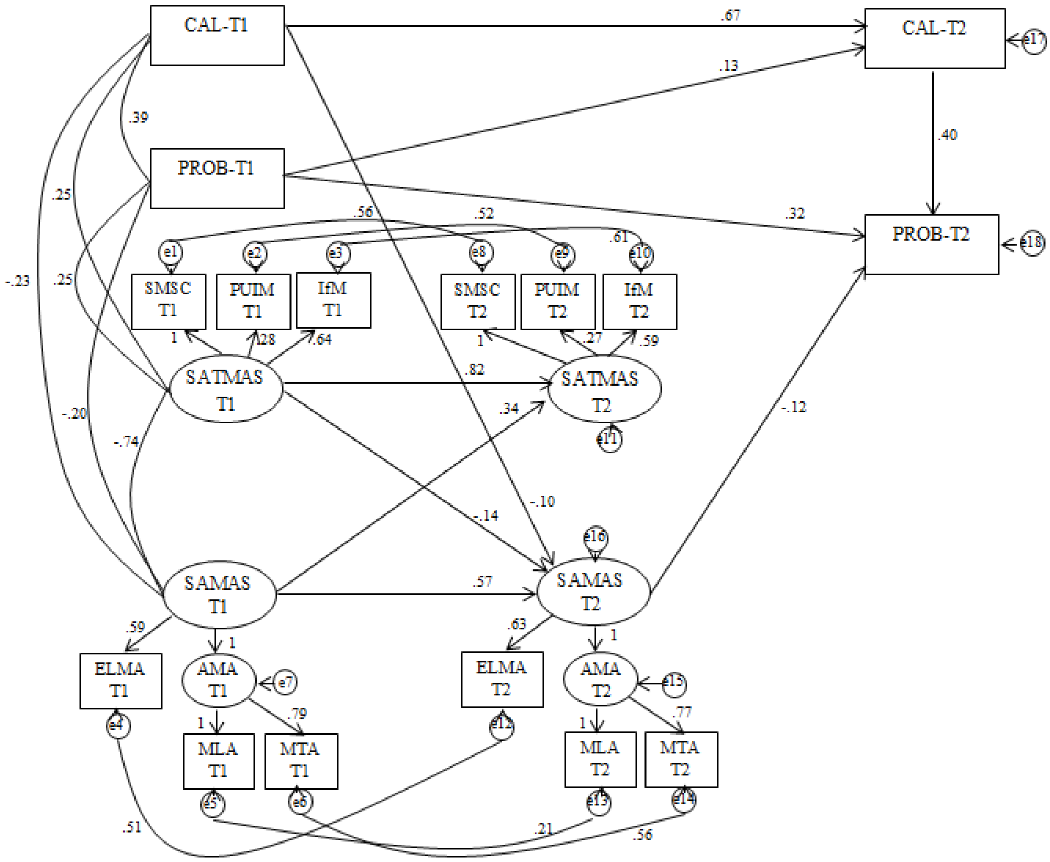


Figure 8. The pruned model with standardized parameters

Table 38 summarizes detailed information about the standardized path coefficients shown in Figure 8.

Table 38

Standardized path coefficients in the pruned model

Latent pair	Standardized estimate	S.E.	C.R.	*p*
SAMAS-T1 – SAMAS-T2	.57	.056	10.06	< .001
CAL-T1 – SAMAS-T2	-.10	.010	-3.65	< .001
SATMAS-T1 – SAMAS-T2	-.14	.030	-2.86	.004

PROB-T1 – CAL-T2	.13	.090	4.51	< .001
SATMAS-T1 – SATMAS-T2	.82	.052	14.71	< .001
SAMAS-T1 – SATMAS-T2	.34	.075	6.95	< .001
CAL-T1 – CAL-T2	.67	.029	23.84	< .001
CAL-T2 – PROB-T2	.40	.011	12.74	< .001
SAMAS-T2 – MC-T2	-.12	.033	-3.77	< .001
PROB-T1 – PROB-T2	.32	.036	10.19	< .001

Note. S.E. = Standard error, C.R. = Critical ratio, CAL = Calculus skills, PROB = Problem solving skills, SAMAS = Scale for Assessing Math Anxiety in Secondary education, SATMAS = Scale for Assessing Attitudes Toward Mathematics in Secondary education, T1 = Measurement point at the beginning of the mathematics course, T2 = Measurement point at the end of the mathematics course.

Since the pruned model was nested within the saturated model, chi-square difference test was performed between them (see Table 39). Model comparison resulted statistically significant ($\Delta\chi^2 = 152.30$, $df = 6$, $p < .001$), meaning that the pruned model was more parsimonious and interpretable than the corresponding saturated structure. As a result, the pruned model was selected as the preferred.

Table 39

Model comparison between the saturated and the pruned models

Model	χ^2	***df***	**RMSEA (90% CI)**	**GFI**	**CFI**	$\Delta\chi^2(\Delta df)$
Saturated model	568.02	75	.097 (.089, .104)	.91	.93	/
Pruned model	420.66	82	.077 (.070, .084)	.93	.95	152.30*** (6)

Note. RMSEA = Root Mean Square Error of Approximation, GFI = Goodness of Fit Index, CFI = Comparative Fit Index
***p< .001

Next, standardized direct, indirect and total effects for the pruned model were estimated (see Table 40). As expected, a strong direct relationship was found between prior and later calculus skills (.67), which in turn was directlty related to later mathematical problem solving skills (.40). Also, the direct relationship between prior and later mathematical problem solving skills was considered to be moderate (.32). On other hand, attitudes toward mathematics at the beginning of the mathematics course was the strongest predictor of attitudes toward the subject at the end of the course (.88), although initial levels of math anxiety also exerted a moderate effect on attitudes at the end (.34). In the case of math anxiety at the end of the mathematics course, this was affected not only by student's math anxiety levels at the beginning (.57), but also by student's initial levels of attitudes toward the subject (.14). Although their effect was referred as small, the corresponding effect resulted statistically significant, and therefore, accounted for explaining the path. Finally, it was noteworthy that final levels of math anxiety had a direct effect on later mathematical problem solving skills (-.12), which underscored the effect of mathematical affect on explaning the achievement in the subject.

Table 40

Standardized direct, indirect and total effects for the pruned model

		CAL T1	**PROB T1**	**SATMAS T1**	**SAMAS T1**	**SATMAS T2**	**SAMAS T2**	**CAL T2**
SATMAS T2	Dir.	-	-	.88	.34	-	-	-
	Ind.	-	-	-	-	-	-	-
	Total	-	-	.88	.34	-	-	-
SAMAS T2	Dir.	-.10	-	-.14	.57	-	-	-
	Ind.	-	-	-	-	-	-	-
	Total	-.10	-	-.14	.57	-	-	-
CAL T2	Dir.	.67	.13	-	-	-	-	-
	Ind.	-	-	-	-	-	-	-
	Total	.67	.13	-	-	-	-	-

PROB	Dir.	-	.32	-	-	-	-.12	.40
T2	Ind.	.28	.05	.02	-.07	-	-	-
	Total	.28	.37	.02	-.07	-	-.12	.40

Note. CAL = Calculus skills, PROB = Problem solving skills, SAMAS = Scale for Assessing Math Anxiety in Secondary education, SATMAS = Scale for Assessing Attitudes Toward Mathematics in Secondary education, T1 = Measurement point at the beginning of the mathematics course, T2 = Measurement point at the end of the mathematics course.

Noteworthy, squared multiple correlations (R^2) indicated that this model explained 53% and 42% of the variance in later calculus skills and mathematical problem solving skills, respectively; and 81% and 51% of the variance in final levels of attitudes toward mathematics and math anxiety, respectively.

7.2.3. Testing the mediation relationships

Information about standardized direct, indirect and total effects between variables was re-structured in order to show clearly the partial and total mediation paths supported by the pruned model (see Table 41).

Table 41

Mediation paths in the pruned model

Type of mediation	Total effect	Direct effect	Indirect effect
Full mediation			
CAL-T1→PROB-T2 (through CAL-T2 and SAMAS-T2)	.28	-	.28
SAMAS-T1 → PROB-T2 (through SAMAS-T2)	-.07	-	-.07
SATMAS-T1 → PROB-T2 (through SAMAS-T2)	.02	-	.02
Partial mediation			
PROB-T1→ PROB-T2 (through CAL-T2)	.37	.32	.05

Note. CAL = Calculus skills, PROB = Problem solving skills, SAMAS = Scale for Assessing Math Anxiety in Secondary education, SATMAS = Scale for Assessing Attitudes Toward Mathematics in Secondary education, T1 = Measurement point at the beginning of the mathematics course, T2 = Measurement point at the end of the mathematics course.

On the one hand, final math anxiety mediated the relationships between prior calculus skills and later mathematical problem solving skills, initial math anxiety and later mathematical problem solving skills and initial attitudes toward mathematics and later mathematical problem solving skills. Additionally, later calculus skills were found to mediate the relationship between prior calculus skills and later mathematical problem solving skills. In all these cases, as previously noted, the direct effects resulted statistically non-significant, and therefore, were discarded for research purposes. However, the corresponding indirect and total effects remained significant, which underscored the full mediation paths between these variables.

On the other hand, only one partial mediation was found in the pruned model. Specifically, later calculus skills mediated the relationship between prior and later mathematical problem solving skills. Indeed, based on Figure 8 and Table 38, the standardized regression coefficient between prior mathematical problem solving skills and later calculus skills ($\beta = .13$, $p < .001$) was statistically significant, as was the standardized coefficient between later calculus skills and later mathematical problem solving skills ($\beta = .40$, $p < .001$). Since the indirect effect ($\beta = .05$) was lower than the direct effect ($\beta = .32$), but the direct effect was still significant after mediation entered the model, the relationship between prior and later mathematical problem solving skills was partially mediated by later calculus skills.

Next, boostrapping was conducted to confirm these findings (see Table 42). Direct and indirect effects were estimated for 2,000 bootstrapped samples and the 95% confidence interval was computed. Results indicated that the aforementioned full and partial mediations were supported, consistently with the above results using normal testing procedures.

Table 42

The bootstrapping results

		Indirect effect *p*-value	**Direct effect *p*-value**
CAL-T1→ PROB-T2 (through CAL-T2)	Bootstrapping *p-value*	< .001	na
	Result	Significant	na
	Type of mediation	Total mediation since indirect effect is significant	
CAL-T1→ PROB-T2 (through SAMAS-T2)	Bootstrapping *p-value*	< .001	na
	Result	Significant	na
	Type of mediation	Total mediation since indirect effect is significant	
SAMAS-T1 → PROB-T2 (through SAMAS-T2)	Bootstrapping *p-value*	< .001	na
	Result	Significant	na
	Type of mediation	Total mediation since indirect effect is significant	
SATMAS-T1 → PROB-T2 (through SAMAS-T2)	Bootstrapping *p-value*	< .001	na
	Result	Significant	na
	Type of mediation	Total mediation since indirect effect is significant	
PROB-T1→ PROB-T2 (through CAL-T2)	Bootstrapping *p-value*	< .001	< .001
	Result	Significant	Significant
	Type of mediation	Partial mediation since both direct and indirect effects are significant	

Note. CAL = Calculus skills, PROB = Problem solving skills, SAMAS = Scale for Assessing Math Anxiety in Secondary education, SATMAS = Scale for Assessing Attitudes Toward Mathematics in Secondary education, T1 = Measurement point at the beginning of the mathematics course, T2 = Measurement point at the end of the mathematics course.
na = not applicable.

Finally, the effect size of the mediators was calculated (see Table 43). According to Cohen's (1988) benchmarks, the mediated effect size of final math anxiety in the relationship between prior calculus skills and later mathematical problem solving skills (R^2 = .40) was large; the mediated effect size of final math anxiety in the relationship between initial math anxiety and later mathemartical problem solving skills (R^2 = .40) was large; the mediated effect size of final math anxiety in the relationship between initial attitudes and later mathematical problem solving skills (R^2 = .41) was large; the mediated effect size of later calculus skills in the relationship between prior and later mathematical problem solving skills (R^2 = .35) was large; whereas the mediated effect size of later calculus skills in the relationship between prior calculus skills and later mathematical problem solving skills (R^2 = .19) was moderate.

Table 43

Amount of variance explained in the mediation model

Mediation path	**Individual path**	**r^2**	**R^2 effect size**
CAL-T1→ PROB-T2 (through CAL-T2)	CAL-T1→ PROB-T2	.28	.19
	CAL-T2→ PROB-T2	.33	
	CAL-T1→ PROB-T2 (through CAL-T2)	.42	
CAL-T1→ PROB-T2 (through SAMAS-T2)	CAL-T1→ PROB-T2	.41	.40
	SAMAS-T2 → PROB-T2	.41	
	CAL-T1→ PROB-T2 (through SAMAS-T2)	.42	
SAMAS-T1 → PROB-T2 (through SAMAS-T2)	SAMAS-T1 → PROB-T2	.41	.40
	SAMAS-T2 → PROB-T2	.41	
	SAMAS-T1 → PROB-T2 (through SAMAS-T2)	.42	
SATMAS-T1 → PROB-T2 (through SAMAS-T2)	SATMAS-T1 → PROB-T2	.41	.41
	SAMAS-T2 → PROB-T2	.42	
	SATMAS-T1 → PROB-T2 (through SAMAS-T2)	.42	

PROB-T1→ PROB-T2 (through CAL-T2)	PROB-T1→ PROB-T2	.36	.35
	CAL-T2→ PROB-T2	.41	
	PROB-T1→ PROB-T2 (through CAL-T2)	.42	

Note. r^2 = Squared partial correlation, CAL = Calculus skills, PROB = Problem solving skills, SAMAS = Scale for Assessing Math Anxiety in Secondary education, SATMAS = Scale for Assessing Attitudes Toward Mathematics in Secondary education, T1 = Measurement point at the beginning of the mathematics course, T2 = Measurement point at the end of the mathematics course.

7.2.4. Testing the moderation effect of educational grade

To conclude, the relationship between math anxiety at the end of the mathematics course and later mathematical problem solving skills was further analyzed in order to test whether there was a moderation effect of educational grade. The difference in chi-square value ($\Delta\chi^2$) between the constrained and unconstrained models was estimated considering two student subgroups, split down by educational grade (see Table 44). Results showed that educational level did moderate the relationship between final levels of math anxiety and later mathematical problem solving skills.

Table 44

The moderation test for secondary education, split down by grade

Grade		Constrained model	Unconstrained model	$\Delta\chi^2$ (Δdf)	Result on moderation	Result on hypothesis
2nd grade	χ^2	416.41	263.22	153.319	Significant at $p < .001$	Supported
	df	83	82	(1)		
4th grade	χ^2	427.20	238.78	188.42	Significant at $p < .001$	Supported
	df	83	82	(1)		

Note. χ^2 = Chi-square, *df* = Degrees of freedom.

To determine in which educational grade the path was more pronounced, the unconstrained models were re-run separately (see Table 45). The standardized parameter estimate for second grade (β = -.10, p = .023) was smaller than the estimate for fourth grade (β = -.18, p < .001), meaning that the effect of final levels of math anxiety on later mathematical problem solving skills comes stronger as time evolves. As both estimates resulted significant, the moderation was partial.

Table 45

The standardized regression weights and their significance, split down by educational grade

Grade	Sub-hypothesis statement	β	*p*-value	Result
2nd grade	SAMAS-T2 has a significant effect on PROB-T2	-.10	.023	Significant
4th grade	SAMAS-T2 has a significant effect on PROB-T2	-.18	< .001	Significant

Note. SAMAS = Scale for Assessing Math Anxiety in Secondary education, SATMAS = Scale for Assessing Attitudes Toward Mathematics in Secondary education, T2 = Measurement point at the end of the mathematics course.

7.2.5. Interaction effects on math anxiety

In order to further analyze whether there was any interaction effect of educational grade, gender and language on the math anxiety scores during the mathematics course, a two-way repeated measured ANOVA was conducted. Thus, the dependent variables were the components of SAMAS, whilst the within-subjects factor was time and the between-subjects factors were the educational grade, the language in which students learned mathematics and student's gender. Only those interactions which were statistically significant either in the combined components of math anxiety or individually are detailed next, meaning that those results which are not displayed in this section resulted statistically non-significant, and therefore, were not included.

Overall, there was a main effect of time on the combined components of math anxiety (F(3, 693) = 5.79, p = .001, Wilk's Λ= .976), which resulted in a statistically significant decrease of scores for ELMA (F(1,701) = 11.33, p = .001, η^2_p = .016), MLA (F(1,701) = 4.44, p = .035, η^2_p = .006) and MTA (F(1,701) = 10.97, p = .001, η^2_p = .016), from the beginning to the end of the mathematics course (see Table 46). The strongest interactions occurred with everyday life's math anxiety and math test anxiety, in which time accounted for 16% of the variance in such components. As for math learning anxiety, the time effect only accounted for 6% of the variance in the component.

Table 46

Tests of between-subject contrasts for the effect of time on SAMAS components

Measure	**T1** *M (SD)*	**T2** *M (SD)*	***F***	***df***	***p***	η^2_p
ELMA	1.84 (1.66)	1.60 (1.58)	13.65	1	< .001	.019
MLA	2.54 (2.00)	2.35 (1.93)	5.86	1	.016	.008
MTA	4.71 (2.56)	4.44 (2.44)	1.33	1	.250	.002

Note. ELMA = Everyday life's math anxiety, MLA = Math learning anxiety, MTA = Math test anxiety, T1 = Measurement point at the beginning of the mathematics course, T2 = Measurement point at the end of the mathematics course, *M* = Mean, *SD* = Standard Deviation

Additionally, there was a statistically significant interaction effect between time and educational grade on the combined components of math anxiety (F(3, 693) = 4.80, p = .003, Wilk's Λ= .980). Specifically, when analyzed by components, results only tended to be significant with ELMA (F(1,701) = 13.65, p< .001, η^2_p = .019) and MLA (F(1,701) = 5.86, p = .016, η^2_p = .008), remaining non-significant with MTA (F(1,701) = 1.33, p = .250, η^2_p = .002) (see Table 47). These findings indicated that the magnitude of the decrease both in everyday life's math anxiety and in math learning anxiety over time was consistent across the two educational grades. Nevertheless, the time by grade interaction accounted for only 8% and 2% of the variance in everyday life's math anxiety and math learning anxiety, respectively.

Table 47

Tests of between-subject contrasts for the interaction effect of grade by time on SAMAS components

Measure	**Grade**	**T1** *M (SD)*	**T2** *M (SD)*	***F***	***df***	***p***	η^2_p
ELMA	2nd grade	1.91 (1.72)	1.51 (1.55)	13.65	1	< .001	.019
	4th grade	1.76 (1.59)	1.69 (1.61)				
MLA	2nd grade	2.56 (2.06)	2.30 (1.94)	5.86	1	.016	.008
	4th grade	2.52 (1.93)	2.41 (1.93)				
MTA	2nd grade	4.58 (2.64)	4.23 (2.42)	1.33	1	.250	.002
	4th grade	4.86 (2.45)	4.67 (2.44)				

Note. ELMA = Everyday life's math anxiety, MLA = Math learning anxiety, MTA = Math test anxiety, T1 = Measurement point at the beginning of the mathematics course, T2 = Measurement point at the end of the mathematics course, M = Mean, SD = Standard Deviation

On other hand, it was found a non-significant interaction effect between time, gender and educational grade on the combined components of math anxiety (F(3, 693) =0.28, p = .844, Wilk's Λ= .999). However, when analyzed by components, it was found that this interaction effect only tended to be statistically significant in the case of MTA (F(1,701) = 3.84, p = .050, η^2_p = .006). Therefore, this result suggested that the magnitude of the decrease in math test anxiety over time was consistent both across gender and the two educational grades. However, as seen in

Table 48, the time by grade and gender interaction accounted for only 6% of the variance in this component of math anxiety.

Table 48

Tests of between-subject contrasts for the interaction effect of grade by time and gender on SAMAS components

Measure	**Grade**	**Gender**	**T1** *M (SD)*	**T2** *M (SD)*	***F***	***df***	***p***	η^2_p
ELMA	2nd grade	Females	2.20 (1.80)	1.71 (1.66)	2.47	1	.117	.004
		Males	1.70 (1.63)	1.37 (1.45)				
	4th grade	Females	1.95 (1.68)	2.00 (1.78)				
		Males	1.60 (1.50)	1.43 (1.39)				
MLA	2nd grade	Females	3.04 (2.27)	2.60 (2.16)	3.13	1	.077	.004
		Males	2.21 (1.82)	2.09 (1.73)				
	4th grade	Females	2.82 (2.06)	2.76 (2.03)				
		Males	2.26 (1.78)	2.11 (1.79)				
MTA	2nd grade	Females	5.07 (2.77)	4.54 (2.58)	3.84	1	.050	.006
		Males	4.22 (2.50)	4.00 (2.28)				
	4th grade	Females	5.38 (2.37)	5.24 (2.34)				
		Males	4.41 (2.44)	4.18 (2.42)				

Note. ELMA = Everyday life's math anxiety, MLA = Math learning anxiety, MTA = Math test anxiety, T1 = Measurement point at the beginning of the mathematics course, T2 = Measurement point at the end of the mathematics course, *M* = Mean, *SD* = Standard Deviation

Finally, it was found a non-significant interaction effect between time, language and educational grade on the combined components of math anxiety (F(3, 693) =2.30, p = .076, Wilk's Λ= .010). However, when analyzed by components, it was found that this interaction effect only tended to be statistically significant in MLA (F(1,701) = 5.27, p = .022, η^2_p = .008). This result suggested that the magnitude of the decrease in math learning anxiety over time was consistent both across the language groups and the educational grades. However, as seen, the time by grade and language interaction accounted for only 8% of the variance in this component of math anxiety.

Table 49

Tests of between-subject contrasts for the interaction effect of grade by time and language on SAMAS components

Measure	**Grade**	**Language**	**T1** *M (SD)*	**T2** *M (SD)*	***F***	***df***	***p***	η^2_p
ELMA	2nd grade	Spanish	1.74 (1.67)	1.42 (1.51)	3.77	1	.053	.005
		Basque	2.23 (1.78)	1.69 (1.62)				
	4th grade	Spanish	1.73 (1.56)	1.60 (1.58)				
		Basque	1.88 (1.72)	2.08 (1.66)				
MLA	2nd grade	Spanish	2.43 (2.03)	2.24 (1.89)	5.27	1	.022	.008
		Basque	2.81 (2.08)	2.41 (2.03)				
	4th grade	Spanish	2.54 (1.90)	2.33 (1.86)				
		Basque	2.44 (2.06)	2.73 (2.15)				
MTA	2nd grade	Spanish	4.49 (2.69)	4.19 (2.52)	0.28	1	.598	.000
		Basque	4.74 (2.56)	4.29 (2.23)				
	4th grade	Spanish	4.94 (2.39)	4.73 (2.40)				
		Basque	4.51 (2.71)	4.41 (2.58)				

Note. ELMA = Everyday life's math anxiety, MLA = Math learning anxiety, MTA = Math test anxiety, T1 = Measurement point at the beginning of the mathematics course, T2 = Measurement point at the end of the mathematics course, *M* = Mean, *SD* = Standard Deviation

7.2.6. Interaction effects on attitudes toward mathematics

In order to further analyze whether there was any interaction effect of educational grade, gender and language on the attitudes toward mathematics scores during the mathematics course, a two-way repeated measured ANOVA was conducted. Thus, the dependent variables were the components of SATMAS, whilst the within-subjects factor was time and the between-subjects factors were the educational grade, the language in which students learned mathematics and student's gender. Only those interactions which were statistically significant either in the combined components of attitudes toward mathematics or individually are detailed next, meaning that those results which are not displayed in this section resulted statistically non-significant, and therefore, were not included.

Noteworthy,the interaction effect between time and educational grade on the combined components of attitudes toward mathematics ($F(3, 693) = 1.81$, p = .144, Wilk's Λ= .992) was non-significant. However, when analyzed by components, the interaction effect tended to be statistically significant with SMSC ($F(1,701) = 3.91$, $p = .048$, $\eta^2_p = .006$) (see Table 50). This result underscored that the magnitude of the change in students' math self-concept over time was consistent across the educational grades. Nevertheless, the time by grade interaction accounted for only 6% of the variance in student's math self-concept. Interestingly, scores on math self-concept increased from the beginning (M = 6.40, SD = 2.77) to the end (M = 6.50, SD = 2.66) of the mathematics course only among second graders, since its scores decreased from the starting point (M = 6.43, SD = 2.57) to the end (M = 6.36, SD = 2.55) among fourth graders.

Table 50

Tests of between-subject contrasts for the interaction effect of grade by time on SATMAS components

Measure	**Grade**	**T1** *M (SD)*	**T2** *M (SD)*	***F***	***df***	***P***	η^2_p
SMSC	2nd grade	6.40 (2.77)	6.50 (2.66)	3.91	1	.048	.006
	4th grade	6.43 (2.57)	6.36 (2.55)				
PUIM	2nd grade	8.32 (1.68)	8.15 (1.77)	0.88	1	.350	.001
	4th grade	7.79 (1.58)	7.56 (1.77)				
IfM	2nd grade	5.31 (2.62)	5.10 (2.68)	0.00	1	.979	.000
	4th grade	4.87 (2.50)	4.78 (2.55)				

Note. SMSC = Student's math self-concept, PUIM = Perceived Usefulness and importance of mathematics, IfM = Interest for mathematics, T1 = Measurement point at the beginning of the mathematics course, T2 = Measurement point at the end of the mathematics course, *M* = Mean, *SD* = Standard Deviation

No significant results were found in the research sample for the remaining interaction effects.

7.3. DISCUSSION

This study examined an integrated model whereby both cognitive and non-cognitive variables were hypothesized as potential predictors of later mathematical competence during an entire mathematics course in secondary education. Specifically, calculus skills, mathematical problem solving skills, math anxiety and attitudes toward mathematics were considered for their inclusion in the model and measured in two separate time points during the course.

As expected, prior calculus skills and prior mathematical problem solving skills were the strongest predictors for later calculus skills ($\beta = .67$, $p < .001$) and later mathematical problem solving skills (β = .32, p < .001), respectively. Likewise, initial levels of math anxiety and attitudes toward mathematics were the strongest predictors for final levels of math anxiety (β = .57, p < .001) and attitudes (β = .82, p < .001), respective. However, these non-cognitive variables were reciprocally related over time, meaning that initial levels of math anxiety had a significant effect on final levels of attitudes (β = -.34, p < .001), and vice versa, initial levels of attitudes toward mathematics had a significant effect on final levels of math anxiety (β = -.14, p < .001). This result is considered a great contribution to the growing evidence of a close and negative relationship between individuals' math anxiety and attitudes toward mathematics (e.g., Bursal & Paznokas, 2006; Zakaria & Nordin, 2008; Akin & Kurbanoglu, 2011; Klinger, 2011; Ahmed, Minnaert, Kuyper, & Van der Werf, 2012), by the time that extents knowledge on previous work by Akin and Kurbanoglu (2011), who suggested that the prediction path only occurred in the direction from attitudes to math anxiety.

Additionally, it was found that final levels of math anxiety had a statistically significant effect only on later mathematical problem solving skills (β = -.12, p < .001). This result complements evidence supported by Ma and Xu (2004), Krizinger et al. (2009) and Kyttälä and Björn (2014). These authors suggested that prior mathematics achievement predicted math anxiety, but that math anxiety did not relate to later mathematics achievement. A plausible explanation to the finding in the present research might be found in the distinction between calculus skills and mathematical problem solving skills, both as constituent of the more general mathematics achievement, conversely to overall mathematics achievement considered in previous literature. Guerrero and Blanco (2004) claimed that higher levels of math anxiety seem to affect heavily those math-related tasks demanding creativity. In this study, such type of mathematical tasks are covered in the second section of the mathematics curriculum-based questionnaire, which aimed at assessing students' mathematical problem solving skills. And, as previously noted, this variable was that significantly affected by math anxiety. Therefore, this finding might be consistent with the suggestion by Guerrero and Blanco (2004). Nevertheless, further analysis about the effect of math anxiety on different types of achievement (e.g., calculus skills, mathematical problem solving skills) would be needed in order to provide additional evidence to this hypothesized distinct effect of math anxiety as a function of the mathematical task.

Regarding descriptive statistics, it was noteworthy that the highest scores for math anxiety were reported on math test anxiety, concluding that in general, secondary students showed moderate anxiety levels toward mathematics evaluation. Given the significant effect of math anxiety on later mathematical problem solving skills, it would be of interest to consider carefully these results and suggest educational interventions that support highly math test anxious students by, for instance, taking into account other evaluation tools different from the exam.

Additionally, mean scores were higher in all math anxiety components among those math learners who studied the subject in Basque. This finding underscores the close relationship between language and mathematics at the time of learning mathematical content, which, in turn, could be intensified by the student's language proficiency as it affects the efficiency of retrieving the needed resources for, for instance, solving a math problem (Frenck-Mestre & Vaid, 1993; Elston-Guttler, Paulmann, & Kotz, 2005). In the case of the participant sample, although enrolled in a bilingual scholastic setting, it mainly came from Spanish-speaking contexts. Therefore, those students from a Spanish-speaking context which learned mathematics in Basque might experience feelings of worry or tension in those situations demanding mathematical reasoning when (a) the math learning language differs from their lingua franca and moreover, when (b) the language proficiency in which mathematics are learned at school is not as good as expected (Dehane, 1997; Dehaene, Spelke, Pinel, Stanescu, & Tsivkin, 1999; Spelke & Tsivkin, 2001; Salillas & Wicha, 2012). In this line, further experimental research using longitudinal datasets from early primary stages onwards would provide more in-depth evidence both of the role played by language proficiency when accessing mathematical knowledge and of the mechanisms underlying these between-group differences.

Notably, the present study also provides evidence of the moderating effect of educational level on the relationship between math anxiety and later mathematical problem solving skills, meaning that the higher the educational level, the stronger the negative impact of math anxiety on mathematical problem solving skills (e.g., Laukenmann, Bleicher, & Fuss, 2003; Sheffield & Hunt, 2006; Wu, Willcutt, Escovar, & Menon, 2013). As for interaction effects, it was remarkable that scores on math self-concept increased from the beginning to the end of the mathematics course in second grade; whereas it experienced an overall decrease during the mathematics course in fourth grade.This is worrisome as fourth graders with low math self-concept might be at risk of underperforming and/or disengaging in mathematics (e.g., Marsh & Hau, 2004; Trautwein, Lüdtke, Marsh, Köller, & Baumert, 2006; Dermitzaki, Leondari, & Goudas, 2009; Ireson & Hallam, 2009; Viljaranta, Lerkkanen, Poikkeus, Aunola, & Nurmi, 2009). Therefore, taken together, these findings emphasize the interaction of multiple aspects in a mathematics course and warrant cautious considerations about the important role of mathematical affect in math education, particularly at secondary school.

From this conclusion, some pedagogical implications can be derived with the aim of enhancing attitudes toward mathematics while alleviating levels of math anxiety. Since development in students' mathematical competence depends not only on mathematical knowledge, but also on students' mathematical affect, math-focused instructional interventions should be re-thought. Firstly, it might be useful to arrange exercises aimed at mastering basic math ability required during the course and also in their day-to-day life. Indeed, it is important that students are familiar with rudimentary mathematics, requested to solve several math-related situations. This does not mean that the assessment of mathematical competence depends solely on rudimentary mathematics, but these are necessary for students to keep in touch with mathematics so as to facilitate them to solve common math-related tasks.

Secondly, given the mediating effect of students' mathematical affect, instructional interventions should also be aimed at reducing math anxiety levels and enhancing positive attitudes toward mathematics. For that purpose, it might be relevant to promote the importance and applicability of mathematics in different areas, for example, through mainstreaming mathematical contents in a wide range of examples taken from common situations. In this line, it is necessary to make students recognize that mathematics are no more an isolated subject in the curricular program, but an embedded content also present in non-mathematical subjects. This practice could benefit students, especially if complemented with cooperative activities in which they interact each other within small groups while performing specific tasks. Recent literature has shown that cooperative learning in mathematics classrooms might alleviate math anxiety levels and improve students' self-confidence (Millis, 2010; Furner & González-DeHass, 2011; Lavasani & Khandan, 2011; Emamjomeh & Bahrami, 2015). Therefore, if these actions were implemented, improvement in students' mathematical competence could be an attainable goal. Future research would furnish insights into the effectiveness of these pedagogical issues.

Despite the promising findings, there are also some methodological limitations to be addressed in future research. First, although the study has considered changes in calculus skills, mathematical problem solving skills, math anxiety and attitudes toward mathematics from the beginning to the end of the mathematics course, longitudinal designs would be desirable to obtain evidence about intra-course changes and better ascertain the interactions among factors. Second, although the sample was representative and large enough for research purposes, it is not entirely generalizable. Replicating the model in other contexts would provide evidence of definitive causality. Third, data were collected using self-report measures, which might have led to subjective social desirability bias. Future studies should, therefore, include other measurement strategies, such as peer reports or observation, which could complement the information.

Consequently, this study has allowed taking a more in-depth look into the impact of calculus skills, prior mathematical problem solving skills, math anxiety and attitudes toward mathematics on later mathematical problem solving skills during a mathematics course in secondary education. More specifically, results show that although prior mathematical problem solving skills are a usual proxy to predict later mathematical problem solving skills, the importance of calculus skills, math anxiety and attitudes toward mathematics should not be diminished. Specifically, math anxiety and attitudes toward mathematics have been proved not only to be important factors relating to mathematics outcomes, but also desirable outcomes themselves. That is to say, math-focused instructional interventions are unlikely to completely explain the development of students' mathematical competence. This has a very important implication for math educators, since they could improve students' mathematical competence not only by focusing on building mathematical contents, but also by mastering rudimentary mathematics, fostering their positive attitudes towards the subject and alleviating their levels of math anxiety. For that purpose, the arrangement of a wide range of exercises taken from common situations, aimed at mastering mathematical contents from a cooperative learning approach, might be a useful intervention. Also, implementing evaluation tools different from the exam could support, particularly, those students reporting moderate to high levels of anxiety toward mathematics evaluation. As a result, this study provides a foundation for future longitudinal research on collecting evidence about the impact of several pedagogical strategies in both cognitive and non-cognitive factors in order to monitor their changes and engagements in mathematical competence.

Chapter 8

General conclusions and discussion

CHAPTER

8

General conclusions and discussion

This last chapter summarizes the main findings of the present PhD thesis, along with the conclusions and educational implications supported by those results and previous literature on mathematics achievement, math anxiety and attitudes toward mathematics. Since this information has been provided separately along the research, this chapter allows taking an integrative overview of the present research as a whole. To conclude, the methodological considerations encountered are described and additional issues are suggested for future research to address.

The main objective of the present PhD thesis was to analyse Biscayan students' math anxiety and attitudes toward mathematics and their influence in predicting their later mathematical competence (in terms of problem solving skills and calculus skills) during a mathematics course in Compulsory Secondary Education. For that purpose, this PhD thesis comprised three specific objectives:

I. To develop and validate, by means of confirmatory analyses, the Scale for Assessing Math Anxiety in Secondary education (SAMAS).

II. To develop and validate, by means of confirmatory analyses, the Scale for Assessing Attitudes Toward Mathematics in Secondary education (SATMAS).

III. To create and validate a Structural Equation Model for testing both the interaction effect between math anxiety and attitudes toward mathematics and their mediation role between students' prior and later mathematical competence.

The participants in the research were limited to Biscayan students from 36 group-classes in Compulsory Secondary Education, and more specifically, from the second- and the fourth-grades of that educational stage.

8.1. MAIN FINDINGS OF THE DEVELOPMENT AND VALIDATION OF THE SCALE FOR ASSESSING MATH ANXIETY IN SECONDARY EDUCATION (SAMAS)

The development and validation of the Spanish-Basque bilingual SAMAS provides sound evidence of its good psychometric properties: content validity through a review panel, good to excellent goodness-of-fit indices tested by Confirmatory Factor Analysis (CFA), strong internal consistency, high seven-month test-retest reliability and convergent validity in line with previous literature in the field. This study has been necessary to further understand the factor structure of the still debated construct math anxiety and to make sure that math anxiety will be measured with a psychometrically sound instrument when assessing the structural model for the prediction of students' mathematical competence during a course in Compulsory Secondary Education.

Interestingly, confirmatory analyses show that the best and most parsimonious structure is a mixed model, consisting of a two-order factor and a first-order factor. The former refers to academic math anxiety, and comprises both math test anxiety and math learning anxiety; whereas the latter refers to everyday life's math anxiety. The resulting factor structure includes, therefore, feelings of worry or tension about academic and everyday life's mathematics. This proposal is aligned with the description for math anxiety supported by previous literature, and specifically, with the definition taken as the basis for the present PhD thesis: "Mathematics anxiety involves feelings of tension and worry that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551).

On other hand, examinations of the mean scores in the final 20-item SAMAS reveal that the main source of math anxiety for participants in the research comes from math evaluation. Indeed, students from both language groups report the highest levels of math anxiety in mta04 ("Me pongo tenso/a cuando los ejercicios del control/examen de Matemáticas son distintos a los vistos en clase" [*I get tense when the exercises in the math test are different compared with those dis previously in class*]) and mta06 ("Durante un control/examen de Matemáticas, me bloqueo cuando no me sale algún ejercicio" [*During a math tets, I cannot think straight when I do not know how to solve and exercise*]).

On the contrary, feelings of worry or tension from everyday life's tasks involving mathematical thinking seem not to evoke much math anxiety in participants. This is indicated by the fact that items with the lowest mean scores are elma01 ("Me pongo nervioso/a cuando revise el ticket the compra" [*I get nervous when checking the receipt*]) and elma10 ("Me pongo nervioso/a al calcular qué me puedo comprar con la paga" [*I get nervous when calculating what I can buy with the pocket money*]). Despite these results, the overall mean scores for each factor comprising the SAMAS suggest that the reported levels of math anxiety could be considered, in their whole, as lower-moderate in both language groups.

8.2. MAIN FINDINGS OF THE DEVELOPMENT AND VALIDATION OF THE SCALE FOR ASSESSING ATTITUDES TOWARD MATHEMATICS IN SECONDARY EDUCATION (SATMAS)

The development and validation of the Spanish-Basque bilingual SATMAS provides sound evidence of its good psychometric properties: content validity through a review panel, good to excellent goodness-of-fit indices tested by confirmatory factor analysis, strong internal consistency, high seven-month test-retest reliability and convergent validity in line with previous literature in the field. This study has been necessary to further understand the factor structure of the still debated construct attitudes toward mathematics and to make sure that this variable will be measured with a psychometrically sound instrument when assessing the structural model for the prediction of students' mathematical competence during a course in Compulsory Secondary Education.

In this case, the confirmatory analyses show that the best and most parsimonious structure is a three-factor model, consisting of three first order factors, named student's math self-concept, perceived usefulness and importance of mathematics, and interest for mathematics. This resulting factor structure is multidimensional and strongly supports the two-component model for explaining attitudes proposed in literature, consisting of both affective and cognitive components (Bagozzi & Burnkrant, 1979, 1980, 1985). Specifically, the resulting structure includes one affective factor, referring to interest for mathematics, and two cognitive factors, referring to student's math self-concept and perceived usefulness and importance of mathematics. Moreover, the strong correlation between all three components of math anxiety and student's math self-concept, supported later on, suggests the relevance of this cognitive-based factor when predicting individual's later behaviour. As noted in previous research: "people are more likely to act according to their attitudes when these are important to their self-concepts" (Pratkanis & Greenwald, 1989, p. 272).

On other hand, examinations of the mean scores in the final 19-item SATMAS reveal that overall, students show upper-moderate positive attitudes toward mathematics. Noteworthy, students agree that mathematics is a useful and important subject for both their current personal life and future professional career by scoring high in this dimension. But their attitude in terms of interest in learning and doing mathematics is just moderate. Indeed, upon closer observation, the individual items with highest mean scores are puim06 ("Las matemáticas son necesarias para la vida" [*Math is necessary for life*]) and puim01 ("Todas las personas necesitan saber matemáticas" [*Everybody needs to learn math*]); meanwhile, the items with lowest mean scores were ifm01 ("Estudiar Matemáticas es divertido" [*Studying math is fun*]) and ifm03 ("Se me pasa el tiempo volando cuando studio Matemáticas" [*Time just flies when I am studying math*]). These findings reveal the need for making mathematics a more enjoyable and interesting subject for students.

8.3. MAIN FINDINGS OF THE FACTORS INFLUENCING SECONDARY EDUCATION STUDENTS' MATHEMATICAL COMPETENCE: A STRUCTURAL MODEL

A structural model was proposed to further investigate the intertwined relationship between math anxiety and attitudes toward mathematics, as well as their role in predicting later mathematical competence during a mathematics course in Compulsory Secondary Education. Specifically, the proposed model hypothesizes, on the one hand, that the strongest predictor for later calculus skills and mathematical problem solving skills are prior calculus skills and problem solving skills, respectively; and on the other hand, that the chain consisted of math anxiety and attitudes toward mathematics mediates those relationships.

In order to better ascertain the relationships between variables and enact modifications representing an improvement in the final model, prior bivariate correlations are computed, followed by a two-step procedure consisting of a measurement model and a pruned model. The goodness-of-fit indices for the pruned model yield a good to excellent fit-to-data, by explaining 53% and 42% of the variance in final calculus skills and mathematical problem solving skills, respectively; and 81% and 51% of the variance in final levels of attitudes toward mathematics and math anxiety, respectively.

Notably, mediation analyses, subsequently supported by boostrapping, yield several results. On the one hand, final levels of math anxiety fully mediate the relationships between prior calculus skills and later mathematical problem solving skills, initial levels of math anxiety and later mathematical problem solving skills, and initial attitudes toward mathematics and later mathematical problem solving skills. Also, later calculus skills fully mediate the link between prior calculus skills and later mathematical problem solving skills. On the other hand, later calculus skills are found to partially mediate the relationship between prior and later mathematical problem solving skills. All these mediation paths are considered to be large, with the exception of the partial mediation exerted by later calculus skills, which is considered to be moderate.

Additionally, bivariate correlations between variables highlight the negative relationship between math anxiety and mathematical competence (in terms of mathematical problem solving skills and calculus skills) and the positive relationship between attitudes toward mathematics and mathematical competence (in terms of problem solving skills and calculus skills). These results, as expected, are completely in line with previous research (e.g., Hembree, 1990; Ho eta al., 2000; Ashrcraft & Kirk, 2001; Ashcraft & Krause, 2007).

Moreover, math anxiety is found to relate negatively with attitudinal variables, meaning that positive attitudes are consistently related to lower levels of math anxiety, and vice versa (Wood, 1988; Hembree, 1990; Ma, 1999). Among these, it is necessary to mention the prominent correlation between academic math anxiety and student's math self-concept. This finding has been addressed in previous studies (Pajares & Miller, 1994; Bursal & Paznokas, 2006; Swars, Daane, & Giesen, 2006; Gresham, 2009), suggesting that the most relevant attitudinal dimension when predicting individual's behaviour is that referring to students' beliefs in their own skills as learners in mathematics.

When this close relationship between mathematics anxiety and attitudes toward mathematics is further assessed through Structural Equation Modeling, a significant intertwined chain is found over time. That is, previous attitudes exert a significant causal effect on later math anxiety, and prior math anxiety exert a significant causal effect on later attitudes. This result underscores that, although traditionally treated as separate variables, both math anxiety and attitudes towards mathematics are inexorably linked (Bursal & Paznokas, 2006; Zakaria & Nordin, 2008; Akin & Kurbanoglu, 2011; Klinger, 2011; Ahmed, Minnaert, Kuyper, & Van der Werf, 2012).

Moreover, later math anxiety appears to exert a significant effect on later mathematical problem solving skills, which is considered to be a great contribution in the field. Indeed, previous studies have underscored that mathematics achievement predicts math anxiety (Ma & Xu, 2004; Krinzinger et al., 2009; Kyttälä & Björn, 2014), but no empirical evidence was found supporting a causal effect of math anxiety on later mathematics achievement. Thus, this result encourages to further analyze this causality by replicating the model with other research samples.

Noteworthy, besides prior mathematical problem solving skills, later calculus skills also appear to be a strong predictor for final mathematical problem solving skills. Consequently, students with lower prior mathematical competence (in terms of calculus skills and problem solving skills) tend to experience higher levels of math anxiety and more negative attitudes toward mathematics, which contributes to a worsening in later math anxiety and therefore, in final mathematical problem solving skills. Additionally, the present study also provides evidence of the moderating effect of educational level on the link between math anxiety and later problem solving skills. Indeed, a significantly moderate moderation effect is found based upon secondary grade, meaning that the higher the educational level, the stronger the negative impact of math anxiety on final mathematical problem solving skills. This phenomenon has been extensively studied through literature (e.g., Sheffield & Hunt, 2006; Wu, Willcutt, Escovar, & Menon, 2013), supporting the hypotheses of causation between both affective and cognitive variables when predicting the mathematical competence at the end of an entire mathematics course in Compulsory Secondary Education.

Among math anxiety components, math test anxiety is found to arouse higher levels of anxiety in females than males, tending to be statistically significant both in second- and in fourth-grade. This result is consistent with previous literature (Hyde, Fennema, Ryan, Frost, & Hopp, 1990; Baloglu & Kocak, 2006), and warrants cautious considerations because of its implication in females' future enrollment intentions and career choices. Regarding attitudinal dimensions, no significant gender differences are found, which is partially in line with previous studies (e.g., Ma & Kishor, 1997). Indeed, there are some authors who claim that gender differences do exist when assessing attitudes towards mathematics (e.g., Lipnevich, MacCann, Krumm, Burrus, & Roberts, 2011). This differing evidence leads, therefore, to make gender issue a still unresolved topic in academic research.

Getting back on overall math anxiety, visual inspections of data show that fourth graders report higher levels in all components of math anxiety when measured at the end of the mathematics course; meanwhile, those same fourth graders experience a decrease in all components of attitudes toward mathematics at the same measurement point. This result is consistent with previous literature, by showing that both math anxiety and attitudes toward mathematics are not static but worsen as time evolves (e.g., Meece, Wigfield, & Eccles, 1990; Sheffield & Hunt, 2006; Ashcraft & Krause, 2007; Jackson, 2008; Krinzinger, Kaufmann, & Willmes, 2009; Wu, Willcutt, Escovar, & Menon, 2013). Although the reported mean scores appear not to be extremely worrisome, there is a need of taking them into account because of their relation with individuals' mathematical outcomes and future career choices.

Among all these factors, special attention deserves everyday life's math anxiety and math learning anxiety. Indeed, tests of between-subjects contrasts suggest a significant interaction effect between time and educational grade on the corresponding levels of everyday life's math anxiety and math learning anxiety. That is to say, the previously noted increase in mean scores for both factors over time is significantly consistent across the two educational grades. Additionally, when language enters the analysis, it is shown a significant effect between time, language and educational grade on math learning anxiety. This results in math learners in Basque reporting higher levels of math learning anxiety compared with math learners in Spanish. Although not extensively studied in previous literature, a plausible reason that might explain this finding is the moderation effect that language proficiency may exert on the close relationship between language and mathematics at the time of learning mathematical content (Frenck-Mestre & Vaid, 1993; Elston-Guttler, Paulmann, & Kotz, 2005). Therefore, although considered to be lower-moderate in their self-reported scores on math learning anxiety, students might experience feelings of worry or tension when the math learning language differs from their communicating one and moreover, when the language proficiency is not as good as expected.

8.4. EDUCATIONAL IMPLICATIONS

Along this PhD thesis, it has been provided information about the underlying dimensions of math anxiety and attitudes toward mathematics, as well as the causal relationships between both affective and cognitive variables in predicting secondary education students' mathematical competence.

On the one hand, further analysing the reported scores on the SAMAS and SATMAS has highlighted math test anxiety and math self-concept as salient factors with a relevant effect when assessing students' levels of the more general constructs mathematics anxiety and attitudes toward mathematics. On the other hand, the proposed structural model has demonstrated the impact of math anxiety, attitudes toward mathematics and prior mathematical competence on later mathematical competence during a secondary mathematics course. As seen, the significant paths obtained between variables have underscored the need of considering the intertwined chain of mathematics anxiety and attitudes towards mathematics when assessing mathematics achievement. It is also recommended to pay attention to the need of breeding calculus skills because of its significant effect on predicting later mathematical problem solving skills. Therefore, based on the evidence gathered along this PhD thesis, there are some educational implications and recommendations that might be proposed.

Firstly, colleges and universities should provide pre-service teachers with strategies and professional formation specific both to support their future students' attitudes towards mathematics and to alleviate mathematics anxiety. Public exposure to embarrassment and failure in mathematics has been suggested as potential reasons for math anxiety arousal (Ashcraft et al., 2007; Bekdemir, 2010), which underscores the importance of making future teachers recognize the potential of methodologies that focus on the learning process instead of such environmental exposure. For example, cooperative learning has been shown to alleviate students' levels of mathematics anxiety by the time they help them to improve their self-confidence (Ma & Xu, 2004; Millis, 2010; Furner & González-DeHass, 2011; Lavasani & Khandan, 2011; Emamjomeh & Bahmari, 2015). Indeed, in such a learning environment, students are not compared with their classmates but supported to learn through asking and collaborating with others, which helps them not to attribute their lack of ability to a lack of knowledge or condition.

Secondly, mathematics teachers should make use of quantitative and/or qualitative measures to monitor their students' levels of math anxiety and attitudes toward mathematics. For that purpose, the developed SAMAS and SATMAS may be invaluable tools, little-time demanding, which inform teachers about the reported scores of secondary education students in the corresponding underlying factors. Thus, pinpointing extremely high or low scores on one or several factors would be of great importance not only to detect potential at-risk students but also to design and implement, as early as possible, strategies or methodologies aiming at strengthening the weaknesses detected.

Thirdly, mathematics evaluation should consist of multiple methods rather than high stakes timed exams (Miller & Mitchel, 1994; Faust et al., 1996; Geist, 2010). This would mean including, in a frequent basis during the course, a broad range of tools and formats (e.g., short quizzes, writing activities and oral questions) so that teachers could assess their students' integral learning of mathematical content and mathematical thinking. Likewise, mathematics course should include exercises aimed at mastering basic numeracy ability since these skills have demonstrated to have a significant effect of overall mathematical performance. This does not mean that mathematical competence should exclude the proper use of computers and calculators for solving problems, but numeracy ability is necessary for facing common mathematics-related tasks, such as doing a purchase.

In line with this, there would be a need of mainstreaming the applicability of and interest for mathematics, stressing that it is no longer an isolated curricular subject but an embedded content present in all areas. For that purpose, it would be highly interesting to identify students' learning styles and propose interdisciplinary projects requiring a number of mathematical ideas and procedures, which in turn, would help to facilitate the previously noted variety of evaluation sources.

As a summary, Table 51 relates the main findings encountered along the research with the corresponding educational implications described in the present section.

Table 51

Main findings and educational implications for the specific objectives I-III

Objective	Main findings	Educational implications
I	Math anxiety may be divided into two dimensions: academic math anxiety and everyday life's math anxiety. The math learning anxiety and the test math anxiety may form a second-order factor, namely academic math anxiety.	The developed SAMAS may be used as a little time demanding and psychometrically sound instrument for assessing and monitoring secondary education students' levels of math anxiety in bilingual Spanish-Basque scholastic settings. Its use would allow detecting potential at-risk students and consequently, design and implement, from early stages, strategies aimining at alleviating detected levels of math anxiety.
	The most prominent factor in the research sample has been math test anxiety.	Evaluation in mathematics should consist of multiple methods rather than high stakes timed exams or unique paper-pencil exams.
II	Attitudes toward mathematics may be divided into three dimensions: student's math self-conceot, perceived usefulness and importance of mathematics, and interest for mathematics.	The developed SATMAS may be used as a little time demanding and psychometrically sound instrument for assessing and monitoring attitudes toward mathematics in bilingual Spanish-Basque scholastic settings. Its use would allow detecting potential at-risk students and consequently, design and implement, from early stages, strategies aimining at fostering end enhancing their attitudes.
	The poorest factor in the research sample has been interest for mathematics.	There is a need for making mathematics a more enjoyable subject, by, for example, proposing interdisciplinary projects requiring a number of mathematical ideas.

III	There is a significant intertwined relationship between math anxiety and attitudes toward mathematics, which remains significant from the beginning to the end of the course. Moreover, later levels of math anxiety exert a significant effect on final mathematical problem solving skills.	Universities should provide pre-service teachers with strategies and professional formation specific both to support their future students' attitudes towards mathematics and to alleviate mathematics anxiety, as for example, cooperative learning techniques.
	Besides prior problem solving skills, calculus skills appear as a strong predictor of later problem solving skills.	Mathematics course should include exercises aimed at mastering basic numeracy ability, which would facilitate students having to face common mathematical situations, such as doing a purchase.
	There is a significant interaction effect between time and educational grade on math learning anxiety and everyday life's math anxiety.	Mathematics course should include a number of exercises and problems requiring a several mathematical procedures to match the students' different learning styles. Moreover, it would be highly interesting that these tasks would be taken from common situations in order to promote mathematics as an embedded content present in all areas, including those from day-to-day life.

8.5. METHODOLOGICAL CONSIDERATIONS

This research acknowledges that bilingualism of the Biscayan scholastic setting should be taken into account when conducting research on mathematics education. Therefore, througout the different studies comprising this PhD thesis, one challenge has been to develop and validate the scales not only in Spanish, but also in Basque, while providing good-quality quantitative research. The scales were, therefore, submitted to translation by committee (Marin & Marin, 1991) and followed the recommendations of the International Test Commission (Muñiz, Elosua, & Hambleton, 2013). Despite validation processes yield very similar results between Spanish and Basque versions in both scales, it would have been interesting to complete a more in-depth translation process, through, for example, the committee-based Translation, Review, Adjudication, Pre-testing and Documentation (TRAPD) approach, recommended by the European Social Survey (2014). This issue will be addressed in future research.

As noted, this PhD thesis focuses on one province of the Basque Country Autonomous Region (Spain), namely Biscay. This fact warrants cautious considerations in generalizing the results and findings to Basque population in general. Regarding data collection, a cluster-sampling method was used after a number of schools, from both the public and private educational systems, was ramdomly extracted. This technique does not allowed generalizing the results outside the research sample. Nevertheless, some indicators suggest that it is possible to rely on the quality of the data gathered. On the one hand, the participating schools were previously selected via a simple random sampling method. On the other hand, the characteristics and descriptive statistics of the resulting sample showed a profile very similar to that of the reference population according to the official enrollment data (Eustat, 2016). Thus, the research sample was representative and large enough for the purposes of the present research. But it was not entirely probabilistic in case of wanting to generalize the findings outside Biscay (Basque Country Autonomous Region, Spain). In this line, it would be desirable to further validate both scales using larger representative samples from all provinces in Basque Country Autonomous Region (Spain), and next, from other sociodemographic contexts outside this region.

After participants' data was collected, scores was coded into digital format and tested for univariate and multivariate normality assumptions. At an early stage of the analysis, it became clear that both the SAMAS and the SATMAS did not fulfill multivariate normality, which encouraged computing the estimations with robust methods for standard errors, statistical errors and goodness-of-fit indices (Satorra & Bentler, 2001; Satorra, 2003) during the validation process of both scales through Confirmatory Factor Analysis (CFA). Next, during the Structural Equation Modeling (SEM), the same shortcoming occurred by showing a multivariate non-normal distribution of data. In this case, the unfulfillment of the assumption of multivariate normality led to confirm the robustness of the model through bootstrapping (Byrne, 2001). This technique has been shown to reduce bias in parameter estimates with no power loss in the model, showing even better results for SEM than the Satorra-Bentler scaled chi-square ($S\text{-}B_{\chi 2}$) (Finney & DiStefano, 2006). In both steps, that is, in the validation of the factor structures of math anxiety and attitudes toward mathematics and in the validation of the model proposed for predicting mathematical competence, there was a violation of the assumption for multivariate normality. Nevertheless, this result, which may be primarily considered as a limitation, has been shown to be very common in most data in social sciences (Bentler & Chou, 1987; Barnes, Cote, Cudeck, & Malthouse, 2001) and can be overcome through different techniques and approaches, such as the previously noted robust statistics or bootstrapping.

On other hand, to address specific objectives I and II, confirmatory approaches were used to test the structural validity of the SAMAS and SATMAS. For that purpose, the following goodness-of-fit indices were used: S-$B_{\chi 2}$, RMSEA (90% CI), SRMR, NNFI, CFI and AIC. Results indicated good to excellent model fits. The only exception in both studies was the significance level of the Satorra-Bentler chi-square statistics, which initially would suggest the rejection of the corresponding models for math anxiety and attitudes toward mathematics. However, the chi-square test has been widely shown to be highly sensitive to sample size, in such a way that sample sizes greater than 200 tend to yield a significant score even if the remaining goodness-of-fit indices yield good or excellent results (Fan, Thompson, & Wang, 1999; Munro, 2005). Therefore, despite this shortcoming, validation tests support good adequate structural validities for the SAMAS and the SATMAS in both language groups. Additionally, the reliability scores of all dimensions was above $\alpha = .78$. This result can be considered more than adequate reliability for so relatively short instruments, and even more important, for newly developed measures (Nunnally & Bernstein, 1994).

To conclude, the structural model was entirely tested by using self-reported measures when assessing math anxiety and attitudes toward mathematics. As noted, scores on these constructs were entirely collected through the newly developed SAMAS and SATMAS. The main disadvantage of using only self-reporting instruments is that referring to subjective social desirability bias. This fact, along with the gender-differentiated socialization process (Eccles & Jacobs, 1986) might lead to compute gender differences in several variables. Indeed, within the gender-differentiated socialization approach, girls would endorse gender stereotypes such as that they are more willing to express their worries (Friedman, 1989; Cheng & Seng, 2001; Crombie et al., 2005; Herbert & Stipek, 2005; Beilock, Gunderson, Ramirez, & Levine, 2010), which in turn, might explain higher levels of math anxiety or less self-confidence in such self-reported instruments. Thus, future studies should include other measurement strategies, such as peer reports or observation sheets, which could complement and support the information collected in the scales and provide more accurate evidence of the phenomena.

8.6. DIRECTIONS FOR FUTURE RESEARCH

As discussed in Chapter 5 and Chapter 6, the development and validation of the 20-item SAMAS and 19-item SATMAS have been considered to be a great contribution in the fields of math anxiety and attitudes towards mathematics, respectively. Apart from further analysing the corresponding factor structures of the constructs, these studies have provided two Spanish-Basque bilingual instruments for their use either in scholastic settings or in academic research. However, future research should continue to further assess the validity and invariance of the new scales, by using larger samples from different sociodemographic contexts from Basque Country Autonomous Region.

Additionally, due to research purposes, both SAMAS and SATMAS have been initially developed for their use with secondary education participants. It would be highly interesting, therefore, to adapt and validate the scales with other populations, as for example, primary education or college students. Indeed, since math anxiety and attitudes toward mathematics experience a deep change in the transition from upper elementary school to junior high school, investigating this turning point with psychometrically sound instruments would be of great relevance.

On other hand, the Structural Equation Modeling tested in Chapter 7 has relied heavily on math anxiety, attitudes toward mathematics, calculus skills and mathematical problem solving skills, which have been assessed both at the beginning and at the end of the course. The main goal of that chapter has been, in fact, to test the relationships between these variables, as well as assess the significance level of possible mediation and moderation effects. However, drawing on literature, there are many factors which might contribute to the formation and development of math anxiety and attitudes toward mathematics, as for example, past negative mathematics-related experiences (e.g., Ashcraft et al., 2007; Hindal, Reid, & Badgaish, 2008; Bekdemir, 2010), teachers' own math anxiety and attitudes toward mathematics (e.g., Swars, Daane, & Giesen, 2006; Al-Himali, 2008; Beilock, Gunderson, Ramirez, & Levine, 2010), comparison with peers (Aiken, 2002; Tapia & Marsh, 2004), inadequate teaching techniques and high stakes timed evaluations (e.g., Turner et al., 2002). Thus, it would be interesting to further analize the influence of other variables on predicting later mathematical competence by gathering longitudinal data from early educational stages onwards. Indeed, such a methodological design would allow monitoring intra-course changes and interactions between variables as time evolves. Additionally, future research would furnish insights into the effectiveness of pedagogical issues, such as cooperative learning, in alleviating math anxiety and supporting attitudes toward mathematics, and consequently, in improving students' development of mathematical competence.

To conclude, when comparing scores on all variables between groups, it has been found significant mean differences in math learning anxiety based upon the language in which participants learn mathematics. This result has suggested the existence of a close relationship between language and mathematics learning in the bilingual scholastic setting considered in the present PhD thesis, whereby the great majority students' lingua franca has been different from the language for the mathematics learning. A plausible explanation given for the phenomenon has been found in the fact that bilingualism seems to overload both working memory and abstract reasoning capacity resources (Van den Noort, Bosch, & Hugdahl, 2006; Adesope, Lavin, Thompson, & Ungerleider, 2010), which in turn, can make it difficult to perform well mathematically. This fact, together with the plausible effect that language proficiency may exert on the close relationship between language and mathematics learning (Frenck-Mestre & Vaid, 1993; Elston-Guttler, Paulmann, & Kotz, 2005), suggests an interesting future research line. Thus, further experimental designs using longitudinal datasets from early primary stages onwards would provide more in-depth evidence both of the role played by language proficiency when accessing mathematical knowledge and of the mechanisms underlying these between-group differences.

References

References

Abu-Hilal, M.M. & Bahri, T.M. (2000). Self-concept: The generalizability of research on the SDQ. Marsh/Shavelson model and I/E frame of reference model to United Arab Emirates students. *Social Behavior and Personality, 28*(4), 309-332.

Adelson, J.L. & McCoach, D.B. (2011). Development and Psychometric Properties of the Math and Me Survey: Measuring Third through Sixth Graders' Attitudes Toward Mathematics. *Measurement and Evaluation in Counseling and Development, 44*(4), 225-247.

Adesope, O.O., Lavin, T., Thompson, T., & Ungerleider, C. (2010). A systematic review and meta-analysis of the cognitive correlates of bilingualism. Review of Educational Research, 80(2), 207-245. doi: 10.3102/0034654310368803

Ahmed, W., Minnaert, A., Kuyper, H., & van der Werf, G. (2010). Reciprocal relationships between math self-concept and math anxiety. Learning and Individual Differences, 22(3), 385-389. doi: 10.1016/j.lindif.2011.12.004

Aiken, L.R. (1974). Two scales of attitude toward mathematics. *Journal for Research in Mathematics Education,* 5, 67-71. doi: 10.2307/748616

Aiken, L.R. (2002). *Attitudes and related psychosocial constructs: Theories, assessment, and research*. Thousand Oaks: Sage Publications.

Aiken, L.R. & Dreger, R.M. (1961). The effect of attitude on performance in mathematics. *Journal of Educational Psychology*, 52, 19-24. doi: 10.1037/h0041309

Ajzen, I. (1989). Attitude structure and behavior. In A.R. Pratkanis, S.J. Beckler, & A.G. Greenwald (Eds.), Attitude structure and function (pp. 241-274). Hillsdale, NJ: Lawrence Erlbaum.

Akin, A. & Kurbanoglu, I.N. (2011). The relationships between math anxiety, math attitudes, and self-efficacy: A structural equation model. *Studia Psychologica, 53*(3), 263-273. doi: 10.1007/s10212-014-0239-0

Alemany-Arrebola, I., & Lara, A.I. (2010). Las actitudes hacia las matemáticas en el alumnado de ESO: un instrumento para su medición. *Publicaciones, 40*, 49-71.

Alexander, L. & Martray, C. (1989).The development of an abbreviated version of the Mathematics Anxiety Rating Scale.*Measurement and Evaluation in Counseling and Development, 22*(3), 143-150.

Allport, G.W. (1935). Attitudes. In C.M. Murchison (Ed.), *Handbook of Social Psychology* (pp. 348-388). Winchester, MA: Clark University Press.

Álvarez, Y. & Soler, M. (2010). Actitudes hacia las matemáticas en estudiantes de ingeniería en universidades autónomas venezolanas. *Revista de Pedagogía, 89*(31), 225-249.

American Educational Research Association, American Psychological Association, & National Council on Measurement in Educacion (2008). *Standards for educational and psychological testing*. Washington, DC: American Educational Research Association.

Anderman, E.M. & Maehr, M.L. (1994). Motivation and schooling in the middle grades. *Review of Educational Research, 64,* 287-309.

Anderson, J.C., & Gerbing, D.W. (1991). Predicting the performance of measures in a confirmatory factor analysis with a pretest assessment of their substantive validities. *Journal of Applied Psychology*, 76, 732-740. doi: 10.1037/0021-9010.76.5.732

Anjum, R. (2006). The role of self-concept in mathematics achievement of primary school children. *Pakistan Journal of Social and Clinical Psychology, 4*, 21-38.

Arbuckle, J. (2013). *AMOS 22. User's Guide*. Chicago: Smallwaters Corporation.

Arem, C.A. (2009). Conquering Math Anxiety (3rd Ed.). Belmont, CA: Cengage Learning.

Ashcraft, M. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions In Psychological Science, 11*(5), 181-185. doi: 10.1111/1467-8721.00196

Ashcraft, M.H. & Faust, M.W. (1994). Mathematics anxiety and mental arithmetic performance: An exploratory investigation. *Cognition and Emotion*, 8, 97-125. doi: 10.1080/02699939408408931

Ashcraft, M. & Kirk, E. (2001). The relationships among working memory, math anxiety, and performance. *Journal Of Experimental Psychology-General, 130*(2), 224-237. doi: 10.1037/0096-3445.130.2.224

Ashcraft, M.H., Kirk, E. P., & Hopko, D. (1998). On the cognitive consequences of mathematics anxiety. In C. Donlan (Ed.), *The development of mathematical skills*, 175-196. East Sussex, Great Britain: Psychology Press.

Ashcraft, M. & Krause, J. (2007).Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review, 14*(2), 243-248. doi: 10.3758/bf03194059

Ashcraft, M.H., Krause, J.A., & Hopko, D.R. (2007). Is math anxiety a mathematic a mathematical learning disability? In D.B. Berch & M.M.M. Mazzocco (Eds.), *Why is math so hard for some children? The nature and the origins of mathematical learning difficulties and disabilities* (pp. 329-348). Baltimore: Brookes.

Ashcraft, M. H., & Moore, A. M. (2009). Mathematics anxiety and the affective drop in performance. *Journal of Psychoeducational Assessment*, 27, 197–205. doi: 10.1177/0734282908330580

Ashcraft, M. & Ridley, K. (2005). Math anxiety and its cognitive consequences: A tutorial review. In Campbell, J. (2005). *Handbook of mathematical cognition* (315-327). Hove, East Sussex: Psychology Press.

Askew, M. & Wiliam, D. (1995). *Recent research in mathematics education 5–16*. London: OFSTED.

Austin, S., Wadlington, E., & Bitner, J. (1992). Effects of beliefs about mathematics on math anxiety and math self-concept in elementary teachers. *Education, 112*(3), 390-396.

Auzmendi, E. (1992). *Las actitudes hacia la matemática-estadística en las enseñanzas medias y universitaria: Características y medición*. Bilbao: Mensajero.

Bagozzi, R.P., & Burnkrant, R.E. (1979). Attitude measurement and behavior change: A reconsideration of attitude organization and its relationship to behavior. In W.L. Wilkie (Ed.), *Advances in Consumer Research*, vol.6, (pp. 295-302). Ann Arbor, MI: Association for Consumer Research.

Bagozzi, R.P., & Burnkrant, R.E. (1980). Single component versus multicomponent models of attitude: Some cautions and contingencies for their use. In J. Olson (Ed.), *Advances in Consumer Research*, vol.7, (pp. 339-344). Ann Arbor, MI: Association for Consumer Research.

Bagozzi, R.P., & Burnkrant, R.E. (1985). Attitudes Organization and the attitude-behavior relation: A reply to Dillon and Kumar. *Journal of Personality and Social Psychology, 49*(1), 47-57.

Bagozzi, R. P., Tybout, A. M., Craig, C. S., & Sternthal, B. (1979). *The Construct Validity of the Tripartite Classification of Attitudes. Journal of Marketing Research*, *16*, 88-95.

Baloğlu, M. & Koçak, R. (2006). A multivariate investigation of the differences in mathematics anxiety. *Personality and Individual Differences*, 40, 1325-1335.

Bandalos, D.L., Yates, K., & Thorndike-Christ, T. (1995). The effects of math-self-concept, perceived self-efficacy, and attributions for success and failure on test anxiety. *Journal of Educational Psychology*, 87(4), 611-624.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215. doi: 10.1037/0033-295X.84.2.191

Barkoukis, V., Tsorbatzoudis, H., Grouios, G., & Sideridis, G. (2008). The assessment of intrinsic and extrinsic motivation and amotivation: Validity and reliability of the Greek version of the academic motivation scale. *Assessment in Education: Principles, Policy & Practice, 15*(1), 39-55. doi: 10.1080/09695940701876128

Barnes, J., Cote, J., Cudeck, R., & Malthouse, E. (2001). Factor analysis: Checking assumptions of normality before conducting factor analysis. *Journal of Consumer Psychology, 10*(1,2), 79-81.

Barth, J.M., Todd, B., McCallum, D.M., Goldston, M., Guadagno, R.E., Roskos, B., & Burkhalter, C. (2011). *Effects of engaging classroom strategies and teacher support on student outcomes over school transitions*. Proceedings of the American Society for Engineering Education.

Bazán, J.L. (1997). Metodología estadística de construcción de pruebas. Una aplicación al estudio de actitudes hacia las matemáticas en la UNALM. UNALM: Lima (tesis).

Beilock, S., & Carr, T. (2005).When high-powered people fail - Working memory and "choking under pressure" in math. *Psychological Science, 16*(2), 101-105. doi: 10.1111/j.0956-7976.2005.00789.x

Beilock, S.L., Gunderson, E.A., Ramirez, G., & Levine, S.C. (2010). Female teachers' math anxiety affects girls' math achievement. Proceedings of the National Academic of Sciences, 1075, 1060-1063.

Bekdemir, M. (2010). The pre-service teachers' mathematics anxiety related to depth of negative experiences in mathematics classroom while they were students. *Educational Studies in Mathematics*, 75 (3), 311-328.

Bentler, P.M. (1990). Comparative Fit Indexes in Structural Models. *Psychological Bulletin, 107*(2), 238-246.

Bentler, P.M. (2005). *EQS Structural equations program manual*. Encino, CA: Multivariate Software, Inc.

Bentler, P.M. & Chou, C.P. (1987). Practical Issues in Structural Modeling. Sociological Methods Research, 16, 78-117. doi: 10.1177/0049124187016001004

Bessant, K.C. (1995). Factors associated with types of mathematics anxiety in college students. *Journal for Research in Mathematics Education*, 26, 327-345.

Bettman, J., Capon, N., and Lutz, R. (1975). Multiattribute measurement models and multiattribute attitude theory: A test of construct validity. *Journal of Consumer Research, 1*(4), 1-15.

Breckler, S. J., & Wiggins, E. C. (1989). Affect versus evaluation in the structure of attitudes. *Journal of Experimental Social Psychology*, 25, 253-271.

Boaler, J. (1997). *Experiencing school mathematics: Teaching styles, sex and settings*. Buckingham: Open University Press.

Bollen, K.A. (1989). *Structural equations with latent variables.* New York, NY: John Wiley & Sons.

Bonfield, E.H. (1974). Attitude, social influence, personal norms, and intention interactions as related to brand purchase behavior. *Journal of Marketing Research, 11*(4), 379-389. doi: 10.2307/3151284

Bong, M. & Shaalvik, E.M. (2003) Academic Self-Concept and Self-Efficacy: How different are they really? *Educational Psychology Review, 15*(1), 1-40.

Bouchey, H.A., & Harter, S. (2005). Reflected appraisals, academic perceptions, and math/science performance during early adolescence. *Journal of Educational Psychology, 97*(4), 673-686. doi: 10.1037/0022-0663.97.4.673

Breckler, S.J. (1984). Empirical validation of affect, behavior, and cognition as distinct components of attitude. *Journal of Personality and Social Psychology*, 47, 1191 -1205.

Brown, C.H. (1983). Asymptotic comparison of missing data procedures for estimating factor loadings. *Psychometrika, 48*(2), 269-292.

Brown, T. (2006). *Confirmatory factor analysis for applied research.* New York: Guildford.

Browne, M.W. & Cudeck, R. (1993). Alternative ways of assessing model fit. In Bollen, K.A. & Long, J.S. [Eds.] Testing structural equation models. Newbury Park, CA: Sage, 136–162.

Browne, M.W., MacCallum, R.C., Kim, C.T., Andersen, B.L., & Glaser, R. (2002). When fit indices and residuals are incompatible. *Psychological Methods, 7*(4), 403-421. doi: 10.1037//1082-989X.7.4.403

Bruner, J.S. (1960). The process of education. Cambridge: Harvard University Press.

Bursal, M. & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics, 106*(4), 173-180. doi: 10.1111/j.1949-8594.2006.tb18073.x

Burton, G. (1979). Getting comfortable with mathematics. *The Elementary School Journal, 79*(3), 129-135. doi: 10.1086/461142

Bush, W.S. (1991). Factors related to changes in elementary students' mathematics anxiety. *Focus on Learning Problems in Mathematics*, 13, 33-43.

Butty, J. L. (2001). Teacher instruction, student attitudes, and mathematics performance among 10th and 12th grade black and Hispanic students. *Journal of Negro Education, 70*(1/2), 19-37.

Byrne, B.M. (1986). Self-concept/academic achievement relations: An investigation of dimenionality, stability, and causality. Canadian Journal of Behavioural Science, 18, 173-186.

Byrne, B.M. (2001*). Structural equation modeling with AMOS: Basic concepts, applications, and programming*. Mahwah, NJ: Rawrence Erlbaum Associates, Publishers.

Byrne, B.M. (2010*). Structural equation modeling with AMOS* (2nd ed.). New York: Routledge.

Caballero, A., Guerrero, E., & Blanco, L.J. (2014). Construcción y administración de un instrumento para la evaluación de los afectos hacia las matemáticas. *Campo Abierto, 33*(1), 47-71. doi: 10.1787/9789264091450-en

Carroll (1963). A model of school learning. *Teachers College Record*, 64, 723-733.

Cemen, P.B. (1987). The nature of mathematics anxiety. Stillwater, OK: Oklahoma State University.

Chavez, A. & Widmer, C.C. (1982). Math anxiety: Elementary teachers speak for themselves. *Educational Leadership, 39*(5), 387-388.

Cheng, S. K., & Seng, Q. K. (2001). Gender differences in TIMSS mathematics achievement of four Asian nations: A secondary analysis. *Studies in Educational Evaluation, 27*(4), 331–340.

Cheung, K. C. (1998). Outcomes of Schooling: Mathematics achievement and attitudes towards mathematics learning in Hong Kong. *Educational Studies in Mathematics, 19*(2), 209-219.

Chinn, S. (2009). Mathematics anxiety in secondary students in England. *Dislexia, 15*(1), 61-68. doi: 10.1002/dys.381

Chipman, S.F. (2005). Research on the women and mathematics issue: A personal case history. In A.M. Gallagher & J.C. Kaufman (Eds.), *Gender differences in mathematics: An integrative psychological approach* (1-24). Cambridge, England: Cambridge University Press.

Chiu, L. & Henry, L. L. (1990). Development and validation of the mathematics anxiety scale for children. *Measurement & Evaluation In Counseling & Development*, *23*(3), 121-127.

Chiu, M. M., & Klassen, R. M. (2010). Relations of mathematics self-concept and its calibration with mathematics achievement: cultural differences among fifteen-year-olds in 34 countries. *Learning and Instruction*, *20*(1), 2-17. doi: 10.1016/j.learninstruc.2008.11.002

Chiu, M. M. & Xihua, Z. (2008). Family and motivation effects on mathematics achievement: Analyses of students in 41 countries. *Learning and Instruction, 18*(4), 321–336.

Chou, C.P., & Bentler, P.M. (1995). Estimates and tests in structural equation modeling. In R.H. Hoyle (Ed.), *Structural equation modeling: Concepts, issues, and applications*. Thousand Oaks, CA: Sage Publications, Inc.

Cicchetti, D.V. (1994). Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology. *Psychological Assessment*, 6, 284-290. doi: 10.1037/1040-3590.6.4.284

Clark, L. A., & Watson, D. (1995). Construct validity: Basic issues in objective scale development. *Psychological Assessment, 7(3)*, 309-319.

Cochran, W.G. (1973). *Sampling Techniques* (2nd Ed.). New York, NY: John Wiley and Sons, Inc.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd Ed.). New Jersey, NJ: Lawrence Erlbaum .

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112*(1), 155-159. doi: 10.1037/0033.2909.112.1.155

Colera, J. & Gaztelu, I. (2012). Matemáticas 2º E.S.O. Madrid: Grupo Editorial Anaya.

Colera, J., Gaztelu, I., Oliveira, M.J., Colera, L., & Martínez, M.M. (2012). Matemáticas 4º E.S.O. Madrid: Grupo Editorial Anaya.

Cook, S.W. & Selltiz, C. (1964). A multiple-indicator approacg to attitude measurement. *Psychological Bulletin*, 62, 36-55.

Cornell, C. (1999). I hate math! I couldn't learn it, and I can't teach it! *Childhood education, 75*(4), 225-230.

Cortina, J.M. (1993). What is Coefficient Alpha? An examination of theory and applications. *Journal of Applied Psychology, 78*(1), 98-104.

Craven, R.G., Marsh, H.W. & Print, M. (2000). Selective, streamed and mixed ability programs for gifted students: Impact on self-concept, motivation, and Achievement. *Australian Journal of Education*, 44, 51–75.

Crombie, G., Sinclair, N., Silverthorn, N., Byrne, B.M., Dubois, D. L., & Trinneer, A. (2005). Predictors of young adolescents' math grades and course enrolment intentions: Gender similarities and differences. *Sex Roles, 52*(5/6), 351–367.

Deffenbacher, J.L. (1980). Worry and emotionality in test anxiety. In G.Sarason (Ed.), *Test anxiety: Theory, research and applications* (pp. 111-128). Hillsdale, NJ: Erlbaum.

Dehaene, S. (1997). *The number sense*. Oxford, England: Oxford University Press.

Dehaene, S., Spelke, E., Pinel, P., Stanescu, R., & Tsivkin, S. (1999). Sources of mathematical thinking: Behavioural and brain-imaging evidence, *Science, 284*, 970-974. doi: 10.1126/science.284.5416.970

Dermitzaki, I. & Efklides, A. (2000). Aspects of self-concept and their relationship with language performance and verbal reasoning abilty. *American Journal of Psychology*, 113, 643–659.

Dermitzaki, I., Leondari, A., & Goudas, M. (2009). Relations between young students'strategic behaviours, domain-specific self-concept, and performance in a problem-solving situation. *Learning and Instruction*, 19, 144-157.

DeVellis, R.F. (2012). *Scale development: Theory and applications* (3rd ed.). Thousands Oaks, CA: Sage Publications, Inc.

Devine, A., Fawcett, K., Szücs, D., & Dowker, A. (2012). Gender differences in mathematics anxiety and the relation to mathematics performance while controlling for test anxiety. *Behavioural and Brain Functions*, 8, 33. doi: 10.1186/1744-9081-8-33

Dew, K.H., Galassi, J.P., & Galassi, M.D. (1984). Math anxiety: Relation with situational test anxiety, performance, physiological arousal, and math avoidance behavior. *Journal of Counseling Psychology, 31*(4), 580-583. doi: 10.1037/0022-0167.31.4.580

Di Martino, P., & Zan, R. (2010). 'Me and maths': Towards a definition of attitude grounded on students' narratives. *Journal of Mathematics Teacher Education, 13*, 27-48. doi: 10.1007/s10857-009-9134-z

Dossel, S. (1993). Math anxiety. *Australian Teacher, 49*(11), 4-8.

Dreger, R.M. & Aiken, L.R.Jr. (1957). The identification of number anxiety in a college population. *Journal of Educational Psychology, 48*(6), 344-351. doi: 10.1037/h0045894

Dutton, W.H. & Blum, M.P. (1968). The measurement of attitudes toward arithmetic with a Likert-type test. *Elementary School Journal*, 68, 259-264. doi: 10.1086/460443

Eagly, A.H. & Chaiken, S. (1993). The psychology of attitudes. Orlando, FL: Harcourt Brace Jovanovich.

Eccles, J.S. & Jacobs, J.E. (1986). Social forces shape math attitudes and performance. *Signs: Journal of Women in Culture and Society,* 11, 367-380.

Elston-Guttler, K.E., Paulmann, S., & Kotz, S.A. (2005). Who's in control? Proficiency and L1 influence on L2 processing. *Journal of Cognitive Neuroscience, 17*, 1593-1610. doi: 10.1162/089892905774597245

Emamjomeh, S.M. & Bahrami, M. (2015). Effect of a supportive-educative program in the math class for stress, anxiety, and depression in female students in the third level of junior high school: An action research. *Journal of Education and Health Promotion*, 23, 4-10. doi: 10.4103/2277-9531

Engle, R.W. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science*, 11, 19-23.

Esses, V.M., Haddock, G., & Zanna, M.P. (1993). Assessing the structure of prejudicial attitudes: The case of attitudes toward homosexuals. *Journal of Personality and Social Psychology, 65*(6), 1105-1118. doi: 10.1037/0022-3514.65.6.1105

Eustat (2016, February 2016). Alumnado matriculado en enseñanzas de régimen general no universitarias en la C.A. de Euskadi por ámbitos territoriales, según nivel de enseñanza y modelo lingüístico. 2014-15. Retrieved from https://goo.gl/w758Cq

Evans, J. (2006). Affect and Emotion in Mathematical Thinking and Learning. The Turn to the Social: Sociocultural Approaches Introduction: Recent Developments in Research on Affect. In J.Maasz, W.Schloeglmann (Eds.), *New mathematics education research and practice* (pp.203-208). Rotterdam: Sense Publishers.

European Social Survey (2014). *ESS round 7 translation guidelines*. Mannheim, Germany: European Social Survey, GESIS.

Eysenck, M. & Calvo, M.G. (1992). Anxiety and performance: The processing Efficiency Theory. *Cognition and Emotion, 6*(6), 409-434. doi: 10.1080/02699939208409696

Fan, X., Thompson, B., & Wang, L. (1999). The effects of sample size, estimation methods, and model specification on SEM fit indices. *Structural Equation Modeling*, 6, 56–83.

Faust, M.W., Ashcraft, M.H., & Fleck, D.E. (1996). Mathematics anxiety effects in simple and complex addition. *Mathematical Cognition*, 2, 25-62. doi: 10.1080/135467996387534

Fennema, E., & Sherman, J.A. (1976). Fennema-Sherman Mathematics Attitudes Scales: Instruments designed to measure attitudes toward the learning of Mathematics by females and males. *Journal of Research in Mathematics Education, 7*(5), 324-326.

Ferguson, R. (1986). Abstraction anxiety: A factor of mathematics anxiety. *Journal of Research in Mathematics Education, 17*(2), 145-150.

Ferketich, S. (1991). Focus on psychometrics: Aspects of item analysis. *Nursing Reseach, 39*(1), 59-62.

Finney, S.J., & DiStefano, C. (2006).Non-normal and categorical data in SEM.In G.R.Hancock & R.O.Mueller (Eds). Structural equation modeling: A second course (pp. 269-314). Greenwich, CT: Information Age Publishing.

Fishbein, M. (1963). An investigation of the relationship between beliefs about an object and the attitude toward that object. *Human Relations*, 16, 233-240.

Fishbein, M. (1967). A behavior theory approach to the relations between beliefs about an object and the attitude toward the object. In M. Fishbein (Ed.), Readings in attitude theory and measurement (pp. 389-400). New York: Wile.

Fishbein, M. & Ajzen, I. (1974). Attitudes toward objects as predictors of single and multiple behavioral criteria. *Psychological Review, 81*(1), 59-74.

Floyd, F.J., & Widaman, K. (1995). Factor analysis in the development and refinement of clinical assessment instruments. *Psychological Bulletin, 7*, 286-299.

Fornell, C. & Larcker, D.F. (1981).Evaluating structural equation models with unobservable variables and measurement error.*Journal of Marketing Research, 18*(1), 39-50.

Fox, L.H., Engle, J.L., & Paek, P. (2001). An exploratory study of social factors and mathematics achievement among high-scoring students: Cross-cultural perspectives from TIMSS. *Gifted and Talented International, XV1*, 7-15.

Frenck-Mestre, C., & Vaid, J. (1993). Activation of number facts in bilinguals. *Memory & Cognition, 21*, 809-818. doi: 10.3758/BF03202748

Friedman, L. (1989). Mathematics and the gender gap: A meta-analysis of recent studies on sex differences in mathematical tasks. *Review of Educational Research, 59*(2), 185-213.

Furner, J. & Berman, B. (2003). Math anxiety: Overcoming a major obstacle to the improvement of student math performance. Childhood Education, 79(3), 170-174. doi: 10.1080/00094056.2003.10522220

Furner, J.M., & González-DeHass, A. (2011). How do students' mastery and performance goals relate to math anxiety? Eurasia Journal of Mathematics, Science and Technology Education, *7*(4), pp. 227-242. doi: 10.12973/eurasia.2019

Gagné, R. M. & Briggs, L. J. (1974). *The principles of instructional design* (1st ed.). New York, NY: Holt.

Gairín, J. (1990). Las actitudes en educación. Un estudio sobre la educación matemática. Barcelona: Boixareu Universitaria.

Garson, G.D. (2001). *PA 765 Statnotes: An Online Textbook*. Raleigh, NC: North Carolina State University.

Geist, E. (2010). The Anti-Anxiety Curriculum: Combating Math Anxiety in the Classroom. *Journal Of Instructional Psychology*, *37*(1), 24-31.

Gierl, M., & Bisanz, J. (1995). Anxieties and Attitudes Related to Mathematics in Grades 3 and 6. *Journal of Experimental Education,63*(2), 139-58. doi: 10.1080/00220973.1995.9943818

Gil, N., Blanco, L.J., & Guerrero, E. (2006). The affective domain in mathematics learning. *International Electronic Journal of Mathematics Education, 1*(1), 16-32.

Gobierno Vasco (2009). *Competencia matemática. 2º curso de Educación Secundaria Obligatoria*. Bilbao: ISEI-IVEI.

Gobierno Vasco (2010). *Competencia matemática. 2º curso de Educación Secundaria Obligatoria*. Bilbao: ISEI-IVEI.

Gobierno Vasco (2011). *PISA: Matemáticas y resolución de problemas*. Bilbao: ISEI-IVEI.

Goldin, (2002). Affect, meta-affect, and mathematical belief structures. In G. Leder, E. Pehkonen, & G. Törner (Eds.), Beliefs: A hidden variable in mathematics education? Dordrecht: Kluwer.

Gómez-Chacón, I.M. (2000). Affective influences in the knowledge of mathematics. *Educational Studies in Mathematics, 43*(2), 149-168.

Greenwood, J. (1984). My anxieties about math anxiety. *Mathematics Teacher*, 77, 662-663.

Gresham, G. (2009). Examining the relationship between pre-service elementary teachers' experience of mathematics anxiety and their efficacy for teaching mathematics. Journal of Classroom Interaction 44(2), 22-38.

Grootenboer, P. & Hemmings, B. (2007). Mathematics performance and the role played by affective and background factors. Mathematics Education Research Journal, 19(3), 3-20. doi: 10.1007/BF03217459

Guerrero, E. & Blanco, L.J. (2004). Diseño de un programa psicopedagógico para la intervención en los trastornos emocionales en la enseñanza y aprendizaje de las matemáticas. *Revista Iberoamericana de Educación, 33*(5). Retrieved from http://rieoei.org/psi_edu13.htm

Hadfield, O.D. & McNeil, K. (1994). The relationship between Myers-Briggs personality type and mathematics anxiety among preservice elementary teachers. *Journal of Instructional Psychology, 21*(4), 375-384.

Hair, J.F., Black, W.C., Babin, B.J., & Anderson, R.E. (2010).*Multivariate data analysis* (7thed.). Upper Saddke River, NJ: Prentice Hall.

Halloran, J.D. (1967). *Attitude Formation and Change*. Great Britain: Leicester Press.

Hannula, M.S. (2002). Attitude towards mathematics: Emotions, expectations and values. *Educational Studies in Mathematics, 49*(1), 25-46.

Harper, N. & Daane, C. (1998). Causes and reductions of math anxiety in pre-service elementary teachers. *Action in Teacher Education, 19*(4), 29-38.

Hart, L. (1989). Describing the Affective Domain: Saying What we Mean. In D.B. McLeod and V.M. Adams (Eds.), *Affect and Mathematical Problem-Solving: A New Perspective* (pp. 37-45). New York: Springer-Verlag.

Harter, S. (1985). *Manual for de Self-Perception Profile for Children*. Denver: University of Denver.

Hawkins, D. I., Mothersbaugh, D. L., & Best, R. J. (2007). *Consumer behavior: Building marketing strategy*. Boston: McGraw-Hill/Irwin.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21*(1), 33-46. doi: 10.2307/749455

Herbert, T.P. & Furner, J.M. (1997). Helping high ability students overcome mathematics anxiety through bibliotherapy. *Journal of Secondary Gifted Educaion, 8*(4), 164-179. doi: 10.1177/1932202X9700800403

Herbert, J. & Stipek, D.T. (2005). The emergence of gender differences in children's perceptions of their academic competence. *Applied Developmental Psychology*, 26, 276–295.

Hindal, H, Reid, N., & Badgaish, M. (2008). Working Memory, Performance and Learner Characteristics. *Research in Science and Technological Education, 27*(2), 187-204.

Hinkin, T. (2005). Scale Development Principles and Practices. In R.A. Swanson & E.F. Holton (Eds.). *Research in Organizations: Foundations and Methods of Inquiry*. San Francisco: Berrett-Koehler Press.

Ho, H.Z., Senturk, D., Lam, A.G., Zimmer, J.M., Hong, S., & Okamoto, Y. (2000). The affective and cognitive dimensions of math anxiety: A cross-national study. *Journal for Research on Mathematics Education*, 331, 362-379. doi: 10.2307/749811

Hopko, D.R. (2003). Confirmatory factor analysis of the Math Anxiety Rating Scale-Revised.*Educational and Psychological Measurement, 63*(2), 336-351.

Hopko, D.R., Mahadevan, R, Bare, R.L., & Hunt, M.K. (2003). The Abbreviated Math Anxiety Scale (AMAS): Construction, validity and reliability. *Assessment, 10*(2), 178-182. doi: 10.1177/1073191103010002008

Hopko, D.R., McNeil, D.W., Zvolensky, M.J., & Eifert, G.H. (2001). The relation between anxiety and skill in performance-based anxiety disorders: A behavioral formulation of social phobia. *Behavior Therapy, 32*(1), 185-207. doi: 10.1016/S0005-7894(01)80052-6

Hoyle, R.H. & Panter, A.T. (1995). Writing about structural equation models in structural equation modeling. In R.H. Hoyle (Ed.), *Structural Equation Modeling: Concepts. Issues and Applications* (pp. 158-176). Thousand Oaks, CA: Sage Publications, Inc.

Hu, L.T. & Bentler, P.M. (1999). Cutoff criteria for fit indices in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Quotation Modeling*, 6, 1-55. doi: 10.1080/10705519909540118

Huberty, C. J., Dresden, J., & Bak, B. (1993). Relations among dimensions of statistical knowledge. *Educational and Psychological Measurement*, 53, 523-532.

Hunsley, J. (1987). Cognitive processes in mathematics anxiety and test anxiety: The role of appraisals, internal dialogue, and attributions. Journal of Educational Psychology, 79, 388-392. doi: 10.1037/0022-0663.79.4.388

Huskinson, T.L.H. & Haddock, G. (2006). Individual Differences in Attitude Structure and the Accessibility of the Affective and Cognitive Components of Attitude. Social Cognition, 24(4), 453-468. doi: 10.1521/soco.2006.24.4.453

Hyde, J., Fennema, E., Ryan, M., Frost, L. A., & Hopp, C. (1990). Gender comparisons of mathematics attitude and affect. *Psychology Of Women Quarterly, 14*(3), 299-324.

Ireson, J. & Hallam, S. (2005). Pupils' liking for school: ability grouping, self-concept and perceptions of teaching. *British Journal of Educational Psychology,75*(2), 297–311.

Jackson, E. (2008). Mathematics anxiety in student teachers. *Practitioner Research in Higher Education, 2*(1), 36-42.

Jackson, C. & Leffingwell, R. (1999). The role of instructors in creating math anxiety in students from kindergarten through college. *Mathematics Teacher, 92*(7), 583-587.

Jansen, B.R.J., Louwerse, J., Straatemeier, M., Van der Ven, S.H.G., Klinkenberg, S., & Van der Maas, S.H.G. (2013). The influence of experiencing success in math on math anxiety, perceived math competence, and math performance. Learning and Individual Differences, 24, 190-197. doi: 0.1016/j.lindif.2012.12.014

Johnstone, A. H. & Reid, N. (1981). Towards a model for attitude change. *European Journal of Science Education, 3*(2), 205-212.

Kahle, L. (1984). *Attitudes and Social Adaptation: A Person-Situation Interaction Approach*. Oxford: Pergamon Press.

Katz, D. (1960). The functional approach to the study of attitudes. *Public Opinion Quarterly*, 24, 163-204.

Kenny, D. A., Kashy, D., & Bolger, N. (1998). Data analysis in social psychology. In D. Gilbert, S.Fiske, & G. Lindzey (Eds.), Handbook of social psychology (4th Ed), 233-265. New York: McGraw-Hill.

Kline, R. B. (1998). *Principles and practices of structural equation modeling*. New York: Guilford.

Kline, R.B. (2005). *Principles and practice of structural equation modeling* (2nd ed.). New York, NY: The Guilford Press.

Klinger, C.M. (2011). 'Connectivism': A new paradigm for the mathematics anxiety challenge? *Adult Learning Mathematics: An International Journal, 6*(1), 7-19.

Ko, H.K., & Yi, H.S. (2011). Development and validation of a mathematics anxiety scale for students. *Asia Pacific Education Review*, 12, 509-521. doi: 10.1007/s12564-011-9150-4.

Kothandapani, V. (1971). Validation of feeling, belief, and intention to acr as three components of attitude and their contribution to prediction of contraceptive behavior. *Journal of Personality and Social Psychology*, 19, 321-333.

Kraus, S.J. (1995). Attitudes and Prediction of Behaviour: A meta-analysis of the empirical literature. *Personality and Social Psychology Bulletin, 21*(1), 58-75.

Krinzinger, H., Kaufmann, L., & Willmes, K. (2009). Math Anxiety and Math Ability in Early Primary School Years. *Journal of Psychoeducational Assessment*, *27*(3), 206–225. doi:10.1177/073428290833058

Kulik, C.L.C. & Kulik, J.A. (1982). Effects of ability grouping on secondary school students: A meta-analysis of evaluation findings. *American Educational Research Journal*, 19, 415-428.

Kyriacou, C. & Goulding, M. (2006). *A systematic review of strategies to raise pupils' motivational effort in Key Stage 4 Mathematics*. London: EPPI-Centre.

Kyttälä, M. & Björn, P.M. (2014). The role of literacy skills in adolescents' mathematics word problem performance: Controlling for visuo-spatial ability and mathematics anxiety. *Learning and Individual Differences*, 29, 59-66. doi: 10.1016/j.lindif.2013.10.010

Landis, J.R. & Koch, G.G. (1977). The measurement of observed agreement for categorical data. Biometrics, 33, 159-174.

Lavasani, M.G. & Khandan, F. (2011). Mathematic anxiety, help seeking behavior and cooperative learning. *Cypriot Journal of Educational Sciences*, 2, 61-74. doi: 0.1016/j.sbspro.2011.03.085

Lazarus, M. (1974). Mathephobia: Some personal speculations. *National Elementary Principal*, 53, 16-22.

Legg, A.M. & Locker J.L. (2009). Math performance and its relationship to math anxiety and metacognition. *North American Journal of Psychology, 11*(3), 471-486.

Lei, M., & Lomax, R.G. (2005). The effect of varying degrees of nonnormality in structural equation modeling. *Structural Equation Modeling: A Multidisciplinary Journal, 12*, 1-27. doi: 10.1207/s15328007sem1201_1

Likert, R. (1932). A Technique for the Measurement of Attitudes. *Archives of Psychology*, 140, 1–55.

Lim, S.Y. & Chapman, E. (2013). Development of a short form of the attitudes toward mathematics inventory. *Educational Studies in Mathematics, 83*, 145-164. doi: 10.1007/s10649-012-9414-x

Lipnevich, A.A., MacCann, C., Krumm, S., Burrus, J., & Roberts, R.D. (2011). Mathematics attitudes and mathematics outcomes of U.S. and Belarusian Middle School Students. *Journal of Educational Psychology, 103*(1), 105-108. doi: 10.1037/a0021949

Love, R. & McVevey, M. (2001). The role of parents, teachers, and peers in promoting girls' mathematics achievement. *Research in Education*, 65, 99-100.

Lupart, J.L., Cannon, E., & Telfer, J.A. (2004). Gender differences in adolescent academic achievement, interests, values and life-role expectations. *High Ability Studies, 15*(1), 25-42. doi: 10.1080/1359813042000225320

Lyons, I.M. & Beilock, S.L. (2012). When math hurts: Math anxiety predicts pain network activation in anticipation of doing math. *PLoS ONE, 7*(10), e48076. doi:10.1371/journal.pone.0048076

Ma, X. (1999). A meta-analysis of the relationship between anxiety toward Mathematics and achievement in Mathematics. *Journal of Research in Mathematics Education, 30*(5), 520-540. doi: 10.2307/749772

Ma, X. (2001). Participation in Advanced Mathematics: Do Expectation and Influence of Students, Peers, Teachers, and Parents Matter? *Contemporary educational psychology, 26*(1), 132–146. doi:10.1006/ceps.2000.1050

Ma, X. & Kishor, N. (1997). Assessing the relationship between attitudes towards mathematics and achievement in mathematics: A meta-analysis. *Journal for Research in Mathematics Education, 28*(1), 26-47. doi: 10.2307/749662

Ma, X. & Xu, J. (2004). The causal ordering of mathematics anxiety and mathematics achievement: A Longitudinal panel analysis. *Journal of Adolescence, 27*(2), 165-179.

Ma, X. & Xu, J. (2004). Determining the causal ordering between attitude toward mathematics and achievement in mathematics. *American Journal of Education, 110*(3), 256-281.

MacCallum, R.C. (1986). Specification searches in covariance structure modeling. *Psychological Bulletin,* 100, 107–120.

MacCallum, R. C., Browne, M. W., & Sugawara, H. M. (1996). Power analysis and determination of sample size for covariance structure modeling. *Psychological Methods*, *1*, 130-149.

MacKinnon, D. P. (2008). Introduction to Statistical Mediation Analysis. Mahwah, NJ: Erlbaum.

MacKinnon D.P., Lockwood, C.M., Williams. J. (2004). Confidence Limits for the Indirect Effect: Distribution of the Product and Resampling Methods. *Multivariate Behavioral Research, 39*(1), 99-128.

Mahmood, S., & Khatoon, T. (2011).Development and validation of the Mathematics Anxiety Scale for Secondary and Senior Secondary school students. *British Journal of Arts and Social Sciences, 2(*2), 169-179.

Mahoney, C.A., Thombs, D.L., & Howe, C.Z. (1995).The art and science of scale development in health education research. *Health Education Research,* 10, 1-10. doi: 10.1093/her/10.1.1-a

Malinsky, M., Ross, A., Pannells, T., & McJunkin, M. (2006). Math anxiety in pre-service elementary school teachers. *Education, 127*(2), 274-279.

Malmivouri, M. (2006). Affect and self-regulation. *Educational Studies in Mathematics*, 63, 149-164.

Maloney, E. A., Ansari, D., & Fugelsang, J. A. (2011). The effect of mathematics anxiety on the processing of numerical magnitude. *The Quarterly Journal of Experimental Psychology*, 64, 10-16.

Manstead, A.S.R. (1996). Attitudes and Behaviour. In G.R. Semin & K. Fiedler (Eds.), *Applied Social Psychology*. London: Sage Publications.

Marin, G., & Marin, B.V. (1991). *Research with Hispanic populations*. Newbury Park, CA: Sage Publications, Inc.

Marsh, H. W. & Hau, K. T. (2004). Explaining paradoxical relations between academic self-concepts and achievements: Cross-cultural generalizability of the internal-external frame of reference predictions across 26 countries. *Journal of Educational Psychology*, 96, 56-67.

Marsh, H.W., Hau, K.T., & Wen, Z. (2004). In search of golden rules: Comment on hypothesis-testing approaches to setting cutoff values for fit indexes and dangers in overgeneralizing Hu and Bentler's findings. *Structural Equation Modeling, 11*, 320-341. doi: 10.1207/s15328007sem1103_2

Marsh, H.W., Lüdtke, O., Nagengast, B., Trautwein, U., Morin, A.J., Abduljabbar, A.S. et al. (2012). Classroom climate and contextual effects: Conceptual and methodological issues in the evaluation of group-level effects. *Educational Psychologist, 47*(2), 106-124. Doi: 10.1080/00461520.2012.670488

Marsh, H.W. & Parker, J. (1984). Determinants of student self-concept: Is it better to be a relatively large fish in a small pong even if you don't learn to swim as well? *Journal of Personality and Social Psychology*, 47, 213-231.

Martinez, J.G.R. & Martinez, N.C. (1996). Math without fear. Needhan Heights, MA: Allyn and Bacon.

Matthews, A. & Pepper, D. (2005). *Evaluation of participation in A-level Mathematics*. London: Qualifications and Curriculum Agency (QCA).

Mazis, M.B., Ahtola, O.T., & Klippel, R.E. (1975). A comparison of four multi-attribute models in the prediction of consumer attitudes. *Journal of Consumer Research, 2*(1), 38-52. doi: 10.1086/208614

McGuire, W.J. (1989). Theoretical foundations of campaigns. In R.Rice & C.Atkin (Eds.), *Public communication campaigns* (pp. 43-65). Newberry Park, CA: Sage.

McLeod, D.B. (1989). Beliefs, attitudes, and emotions: New view of affect in mathematics education. In D.B. McLeod & V.M. Adams (Eds.), *Affect and Mathematical Problem Solving: A New Perspective* (pp. 245-258). New York: Springer-Verlag.

McLeod, D.B. (1992). Research on affect in mathematics education: A reconceptualization. In D.A. Grows (Ed.), Handbook of research on mathematics teaching and learning (pp. 575-596). New York: MacMillan.

Meece, J., Wigfield, A., & Eccles, J. (1990). Predictors of math anxiety and its influence on young adolescents course enrollment intentions and performance in Mathematics. *Journal of Educational Psychology, 82*(1), 60-70. doi: 10.1037/0022-0663.82.1.60

Melancon, J.G., Thomson, B., & Becnel, S. (1994). Measurement integrity of scores from the Fennema-Sherman Mathematics Attitudes Scales: The attitudes of public school teachers. *Educational and Psychological Measurement, 54*, 187-192. doi: 10.1177/0013164494054001024

Michaels, L.A., & Forsyth, R.A. (1977). Construction and validation of an instrument measuring certain attitudes toward mathematics. *Educational and Psychological Measurement, 37*(4), 1043-1049. doi: 10.1177/001316447703700429

Middleton, J. & Toluk, Z. (1999). First steps in the development of adaptative theory of motivation. *Educational Psychologist, 34*(2), 99-112.

Miller, H., & Bichsel, J. (2004). Anxiety, working memory, gender, and math performance. *Personality and Individual Differences*, 37, 591-606. doi: 10.1016/j.paid.2003.09.029

Millar, M. G. & Millar, K. U. (1990). Attitude change as a function of attitude type and argument type. *Journal of Personality and Social Psychology*, 59, 217-228.

Miller, L. D. & Mitchell, C. E. (1994). Mathematics anxiety and alternative methods of evaluation. *Journal of Instructional Psychology, 21*(4), 353-359.

Millis,B. (2010). Cooperative learning in high education: Across the discplines, across the academy. Sterling, VA: Stylus Publishing.

Miyake, A. & Shah, P. (Eds.) (1999). *Models of working memory: Mechanisms of active maintenance and executive control*. New York: Cambridge University Press.

Morris, J. (1981). Mathematics anxiety: Teaching to avoid it. *Mathematics Teacher*, 74, 413-417.

Mulhern, F., & Race, G. (1998). Development of a shortened form of the Fennema-Sherman Mathematics Attitudes Scales. *Educational and Psychological Measurement, 58*, 295-306. doi: 10.1177/0013164498058002012

Munro, B.H. (2005). *Statistical Methods for Health Care Research*. Philadelphia: Lippincott Williams and Wilkins.

Muñiz, J., Elosua, P., & Hambleton, R.K. (2013). Directrices para la traducción y adaptación de los tests: Segunda edición. *Psicothema, 25*, 149-155.

Muñoz, J.M., & Mato, M.D. (2006). Diseño y validación de un cuestionario para medir las actitudes hacia las matemáticas en alumnos de ESO. *Revista galego-portuguesa de psicoloxía e educación*, 13, 413-424.

Muñoz, J.M., & Mato, M.D. (2007). Elaboración y estructura factorial de un cuestionario para medir la ansiedad hacia las Matemáticas en alumnos de Educación Secundaria Obligatoria. *Revista galego-portuguesa de Psicoloxía e Educación*, 14, 221-231.

Neale, D. (1969). The role of attitudes in learning mathematics. *The Arithmetic Teacher, 16*(8), 631-640.

Newstead, K. (1998). Aspects of children's mathematics anxiety. *Educational Studies in Mathematics, 36*(1), 53-71.

Norwood, K.S. (1994). The effects of instructional approach on mathematics anxiety and achievement. *School Science and Mathematics*, 94(5), 248-254. doi: 10.1111/j.1949-8594.1994.tb15665.x

Nunnally, J.C. (1978). *Psychometric theory* (2nd ed.). New York, NY: McGraw-Hill.

Nunnally, J.C., & Bernstein, I.H. (1994). *Psychometric theory* (3rd ed.). New York, NY: McGraw-Hill.

Olson, J.M. & Zanna, M.P. (1993). Actitudes y cambio de actitudes. Annual Review of Psychology, 44, 117-154.

O'Neal, M.R., Ernest, P.S., McLean, J.E., & Templeton, S.M. (1988, November). Factorial validity of the Fennema-Sherman Mathematics Attitude Scales. Paper presented at the annual meeting of the Mid-South Educational Research Association, Louisville, KY.

Orhun, N. (2007). An investigation into the mathematics achievement and attitude towards mathematics with respect to learning style according to gender. *International Journal of Mathematical Education in Science and Technology, 38*(3), 321-333.

Osborne, J.W. (2001). Testing stereotype threat: Does anxiety explain race and sex differences in achievement? *Contemporary Educational Psychology*, 26, 291-310.doi: 10.1006/ceps.2000.1052

Osborne, J.W. & Costello, A.B. (2004). Sample size and subject to item ratio in principal components analysis. *Practical Assessment, Research & Evaluation*, 9(11).

Ostrom, T.M. (1969). The Relationship Between the Affective, Behavioral, and Cognitive Components of Attitude. *Journal of Experimental Social Psychology*, 5, 12-30.

Pajares, F. & Miller, M.D. (1994). The role of self-efficacy and self-concept beliefs in mathematical problema-solving: A path analysis. *Journal of Educational Psychology*, 86, 193-203.

Palacios, A., Arias, V., & Arias, B. (2014). Attitudes Towards Matheamtics: Construction and Validation of a Measurement Instrument. *Journal of Psicodidactics, 19*(1), 67-91. doi: 10.1387/RevPsicodidact.8961

Palacios, A., Hidalgo, S., Maroto, A., & Ortega, T. (2013). Causas y consecuencias de la ansiedad matemática mediante un modelo de ecuaciones estructurales. *Revista de investigación y experiencias didácticas, 31*(2), 93-111.

Papalia, D. & Olds, S. (1992). Desarrollo Humano (4th Ed.). Santa Fe de Bogotá: McGraw Hill.

Papanastasiou, C. (2008). A residual analysis of effective schools and effective teaching in mathematics.*Studies in Educational Evaluation, 34*, 24-30. doi: 10.1016/j.stueduc.2008.01.005

Parsons, J.E., Kaczala, C.M., & Meece, J.L. (1982). Socialization of achievement attitudes and beliefs: Classroom influences. *Child development*, 53, 322-339.

Petty, R.E. & Cacioppo, J.T. (1986). *Communication and persuasion: Central and peripheral routes to attitude change*. New York: Springer-Verlag.

Plake, B., & Parker, C. (1982).The development and validation of a revised version of the Mathematics Anxiety Rating Scale.*Educational and Psychological Measurement, 42*(2), 551-557. doi: 10.1177/001316448204200218

Pratkanis, A. R. & Greenwald, A.G. (1989) A sociocognitive model of attitude structure and function. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (pp. 245-286). San Diego: Academic Press

Pett, M.A., Lackey, N.R., & Sullivan, J.J. (2003). *Making sense of factor analysis: The use of factor analysis for instrument development in health care research*. Thousand Oaks, CA: Sage Publications, Inc.

Ponte, J., Matos, J.F., Guimaräes, H.M., Leal, L.C., & Canavarro, A.P. (1994). Teachers' and students' views and attitudes towards a new mathematics curriculum: A case study. *Educational Studies in Mathematics, 26*(4), 347-365.

Raykov, T., & Marcoulides, G. A. (2006). On Multilevel Model Reliability: Estimation From the Perspective of Structural Equation Modeling. *Structural Equation Modeling*, 13, 130-141.

Resnick, H., Viehe, J. & Segal, L. H. (1982). Is math anxiety a localphenomenon? A study of prevalence and dimensionality. *Journal of Counseling Psychology*, 29, 39-47.

Rhine, R.J. (1958). A concept formation approach to attitude acquisition. *Psychological Review, 65*(6), 362-370.

Richardson, F.C. & Suinn, R.M. (1972). The Mathematics Anxiety Rating Scale: Psychometric data. *Journal of Counseling Psychology, 19*(6), 551-554. doi: 10.1037/h0033456

Richardson, F.C., & Woolfolk, R.L. (1980).Mathematics anxiety. In I.G. Sarason (Ed.).*Test anxiety: Theory, research, and applications*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Rokeach, M. (1968). *Beliefs, attitudes, and values*. San Francisco: Jossey-Bass.

Rosenberg, M.J. & Hovland, C.I. (1960). Cognitive, affective and behavioral components of attitudes. In M.J. Rosenberg, C.I. Hovland, W.J. McGuire, R.P. Abelson, & J.W. Brehm (Eds.), *Attitude Organization and Change: An Analysis of Consistency Among Attitude Components*. New Haven: Yale University Press.

Rounds, J., & Hendel, D. (1980).Measurement and Dimensionality of Mathematics Anxiety.*Journal of Counseling Psychology,27*(2), 138-49. doi: 10.1037/0022-0167.27.2.138

Ryan, R.M., & Deci, E.L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*, 68-78.

Ryan, R.M., & Deci, E.L. (2009). Promoting self-determined school engagement: Motivation, learning, and well-being. In K.R. Wentzel & A. Wigfield (Eds.), *Handbook of motivation at school* (pp. 171-196). New York, NY: Routledge.

Ruffell, M., Mason, J., & Allen, B. (1988). Studying attitude to mathematics. *Educational Studies in Mathematics, 35*, 1-18.

Salillas, E., & Wicha, N.Y.Y. (2012). Early learning shapes the memory networks for arithmetic: Evidence from brain potentials in bilinguals. *Psychological Science, 23*(7), 745-755. doi: 10.1177/0956797612446347

Samuelsson, J., & Granstom, K. (2007). Important prerequisite for students' mathematical achievement. *Journal of Theory and Practice in Education, 3*(2), 150-170.

Sandman, R.S. (1980). The Mathematics Attitude Inventory: Instrument and user's manual. *Journal of Research in Mathematics Education, 11*(2), 148-149.

Sarason, I.G. (1986). Test anxiety, worry, and cognitive interference. In R. Schwarzer (Ed.), *Self-related cognitions in anxiety and motivation*, 19-33. Hillsdale, NJ: Erlbaum.

Sarnoff, D. & Katz, D. (1954). The motivational bases of attitude change. *Journal of Abnormal and Social Psychology, 49*(1), 115-124.

Satorra, A. (2003). Power of chi-square Goodness-of-fit test in structural equation models: the case of non-normal data. In H. Yanai, A. Okada, K. Shigemasu, Y. Kano & J. J. Meulman (Eds.). *New developments of psychometrics* (57-68). Tokio: Springer Verlag.

Satorra, A., & Bentler, P.M. (2001). A scaled difference chi-square test statistic for moment structure analysis. *Psychometrika,* 66(4), 507-514. doi: 10.1007/BF02296192

Scarpello, G. (2007). Helping Students Get Past Math Anxiety. *Techniques: Connecting Education and Careers, 82*(6), 34-35.

Scherer, M. (2002). Do students care about learning? *Educational Leadership, 60*(1), 12-17.

Schmitt, N. & Stults, D.M. (1985). Factors defined by negatively keyed items: The result of careless respondents?. *Applied Psychological Measurement*, 9, 367-373. doi:10.1177/014662168500900405

Schreiber, J.B. (2002). Institutional and student factors and their influence on advanced mathematics achievement. *The Journal of Educational Research, 95*(5), 274-286.

Schriesheim, C.A., Powers, K.J., Scandura, T.A., Gardiner, C.C., & Lankau, M.J. (1993). Improving construct measurement in management research. Comments and quantitative approach for assessing the theoretical adequacy of paper-and-pencil and survey-type instruments. *Journal of Management*, 19, 385-417. doi: 10.1177/014920639301900208

Schumacker, R. E., & Lomax, R. G. (2010). *A beginner's guide to structural equation modeling* (3rd ed.). New York: Routledge.

Sheffield, D., & Hunt, T. (2006). How does anxiety influence maths performance and what can we do about it? *MSOR Connections, 6*(4), 19-23. doi: 10.11120/msor.2006.06040019

Sheth, J.N. (1974). A field study of attitude structure and attitude-behavior relationship, in J.N. Sheth (Ed.), *Models of Buyer Behavior* (pp. 242-268). New York: Harper and Row.

Skaalvik, E.M. & Skaalvik, S. (2006). Self-concept and self-efficacy in mathematics: Relation with mathematics motivation and achievement. In A.P. Prescott (Ed.), *The concept of self in education, family and sports* (51-74). New York, NY: Nova Science.

Singh, K., Granville, M., & Dika, S. (2002). Mathematics and science achievement: Effects of motivation, interest and academic engagement. *The Journal of Educational Research, 95,* 323-332. doi: 10.1080/00220670209596607

Sloan, T., Daane, C., & Giesen, J. (2002). Mathematics anxiety and learning styles: What is the relationship in elementary preservice teachers? *School Science & Mathematics, 102*(2), 84.

Spelke, E.S., & Tsivkin, S. (2001). Language and number: A bilingual training study. *Cognition, 78*, 45-88. doi: 10.1016/S0010-0277(00)00108-6

Spielberger C.D., Anton, W.D., & Bedell, J. (1976). The nature and treatment of test anxiety. In M. Zuckerman & C.D. Spielberger (Eds.), *Emotions and anxiety: New concepts, methods, and applications*, 317-345. New York: Eribaum/Wiley.

Steele, E. & Arth, A. (1998). Lowering anxiety in the math curriculum. *Education Digest, 63*(7), 18-24.

Steiger, J.H. & Lind, J.C. (1980, May 30, 1980). Statistically-based tests for the number of common factors. Paper presented at the Annual Spring Meeting of the Psychometric Society, Iowa City.

Stuart, V.B. (2000). Math course or math anxiety? *Teaching Children Mathematics, 6*(5), 330.

Suinn, R., & Edwards. (1982). The measurement of mathematics anxiety: The mathematics anxiety rating scale for adolescents-MARS-A. *Journal of Clinical Psychology,38*(3), 576-580.

Swars, S.L., Daane, C.J., & Giesen, J. (2006). Mathematics anxiety and mathematics teacher efficacy: What is the relationship in elementary preservice teachers? *School Science and Mathematics, 106*(7), 306-315.

Swetman, D.L. (1994). Fourth grade math: The beginning of the end? *Reading Improvement, 31*(3), 173-176.

Tabachnick, B.G., & Fidell, L.S. (2007). *Using multivariate statistics* (5th ed.). Boston, MA: Allyn & Bacon.

Tapia, M. & Marsh, G. E. (2004). An Instrument to Measure Mathematics Attitudes. *Academic Exchange Quarterly, 8*(2), 16-21.

Taylor, J.A. (1953). A personality scale of manifest anxiety. *Journal of Abnormal Psychology, 48*(2), 285-290. doi: 10.1037/h0056264

Thomas, J. (2006). The effects on student's achievements and attitudes using integrated learning systems with co-operative pairs. *Journal Educational Technology Research and Development, 45*, 51-64.

Thomas, G., & Dowker, A. (2000, September).*Mathematics anxiety and related factors in young children*. Paper presented at the British Psychological Society Developmental Section Conference, Bristol.

Thorndike, E. L. (1905). *The elements of psychology*. New York: A. G. Seiler.

Thurstone, L.L. (1928) . Attitudes Can Be Measured. *American Journal of Sociology,* 33, 529-554.

Tobias, S. (1978). Overcoming math anxiety. Boston: Houghton Mifflin.

Tobias, S. (1990). Math anxiety: An update. *NACADA Journal, 10*(1), 47-50.

Tocci, C.M., & Engelhard, G. (1991).Achievement, parental support, and gender differences in attitudes toward mathematics. *Journal of Educational Research, 84*(5), 280-286. doi: 10.1080/00220671.1991.10886028

Trautwein, U., Lüdtke, O., Marsh, H.W., Köller, O., & Baumert, J. (2006). Tracking, grading, and student motivation: Using group composition and status to predict self-concept and interest in ninth grade mathematics. *Journal of Educational Psychology*, 98, 788-806.

Triandis, H. C. (1977). *Interpersonal behavior.* Monterey, CA: Brooks/Cole Publishing.

Tuncalp, S. & Sheth, J.N. (1975). Prediction of attitudes: A comparative study of Rosenberg, Fishbein, and Sheth models. In M.J. Schlinger (Ed.), *Advances in consumer research* (vol.2). Chicago: Association for Consumer Research.

Turner, J.C., Midgley, C., Meyer, D.K., Gheen, M., Anderman, E.M., Kang, Y., & Patrick, H. (2002). The classroom environment and students' reports of avoidance strategies in mathematics: A multimethod study. *Journal of Educational Psychology, 94*(1), 88-106. doi: 10.1037/0022-0663.94.1.88

Ullman, J.B. (2006). Structural equation modeling.InB.G.Tabachnick & L.S.Fidell (Eds.).*Using multivariate statistics* (5th ed., pp. 653-771). Boston: MA: Allyn & Bacon.

Ursini, S., Sánchez, G., & Orendain, M. (2004). Validación y confiabilidad de una escala de Actitudes hacia las Matemáticas y hacia las Matemáticas Enseñadas con Computadora. *Educación Matemática, 16*(3), 59-78.

Vale, C., & Leder, G. (2004). Student views of computer-based mathematics in the middle years: does gender make a difference? *Educational Studies in Mathematics*, 56, 287–312.

Van den Noort, M.W.M.L., Bosch, P., & Hugdahl, K. (2006). Foreign language proficiency and working memory capacity. *European Psychologist, 11*(4), 289-329. doi: 10.1027/1016-9040.11.4.289

Verplanken, B., Hofstee, G., & Janssen, H. J. W. (1998). Accessibility of affective versus cognitive components of attitudes. European Journal of Social Psychology, 28, 23–35.

Viljaranta, J., Lerkkanen, M.K., Poikkeus, A.M., Aunola, K., & Nurmi, J.E. (2009). Cross-lagged relations between task motivation and performance in arithmetic and literacy in kindergarten. *Learning and Instruction*, 19, 335-344.

Vinson, B.M. (2001). A comparison of preservice teachers' mathematics anxiety before and after a methods class emphasizing manipulatives. *Early Childhood Education Journal, 29*(2), 89-94.

Vukovic, R.K., Kieffer, M.J., Bailey, S.P., & Harari, R.R. (2013). Mathematics anxiety in young children: Concurrent and longitudinal associations with mathematical performance. *Contemporary Educational Psychology*, 38, 1-10. doi: 10.1016/j.cedpsych.2012.09.001

Wang, Z., Hart, S.A., Kovas, Y., Lukowski, S., Soden, B., Thompson, L.A., Plomin, R., McLoughlin, G., Bartlett, C.W., Lyons, I.M. & Petrill, S.A. (2014). Who is afraid of math? Two sources of genetic variabce for mathematical anxiety. *Journal of Child Psychology and Psychiatry, 55*(9), 1056-1064. doi: 10.1111/jcpp.12224

Watt, H.M.G. (2000). Measuring attitudinal change in mathematics and English over the first year of junior high school: A multidimensional analysis.

Journal of Experimental Education, 68, 331-361. doi: 10.1080/00220970009600642

Webster, B. & Fisher, F. (2000). Accounting for variations in Science and mathematics achievement: A multilevel analysis of Australian data. *School Effectiveness and School Improvement, 11*(3), 229-360.

Wheaton, B., Muthén, B., Alwin, D., & Summers, G. (1977). Assessing reliability and stability in panel models. In D. R. Heise (Ed.), *Sociological Methodology* (pp. 84-136). San Francisco: Jossey-Bass, Inc.

Wigfield, A., & Meece, J.L. (1988). Math Anxiety in Elementary and Secondary School Students. *Journal of Educational Psychology, 80*(2), 210-216. doi: 10.1037/0022-0663.80.2.210

Wilkie, W.L. & Pessemier, E.A. (1973). Issues in marketing's use of multi-attribute models. *Journal of Marketing Research*, 10, 428-441.

Williams, V. (1988). Answers to questions about math anxiety. *School Science and Mathematics*, 88, 95–104.

Williams, T., & Williams, K. (2010). Self-efficacy and performance in mathematics: Reciprocal determinism in 33 nations. *Journal of Educational Psychology, 102*, 453-466. doi: 10.1037/a0017271

Wixted, J. T., & Ebbesen, E. B. (1991). On the form of forgetting. *Psychological Science*, 2, 409-415.

Wood, E. (1988). Math anxiety and elementary teachers. What does research tell us? *For the Learning of Mathematics*, 86, 8-13.

Woodmansee, J.J. & Cook, S.W. (1967). Dimensions of verbal racial attitudes: Their identification and measurement. *Journal of Personality and Social Psychology*, 7, 240-250.

Wu, S. S., Barth, M., Amin, H., Menon, V., & Malcarne, V. (2012). Math anxiety in second and third graders and its relation to mathematics achievement. *Frontiers in Psychology*, 3. doi: 10.3389/fpsyg.2012.00162

Wu, S., Willcutt, E., Escovar, E., & Menon, V. (2013). Mathematics achievement and anxiety and their relation to internalizing and externalizing behaviors. *Journal of Learning Disabilities,47*(6), 503-514. doi: 10.1177/0022219412473154

Yasar, M. (2014). Short form of Mathematics Attitude Scale: Its psychometric properties. *Pakistan Journal of Statistics, 30*(6), 1267-1277.

Yee, D.K. & Eccles, J.S. (1988). Parent perceptions and attributions for children's math achievement. *Sex Roles*, 19, 317–33. doi: 10.1007/BF00289840

Young, C., Wu, S., & Menon, V. (2012). The Neurodevelopmental Basis of Math Anxiety. *Psychological Science, 23*(5), 492-501. doi: 10.1177/0956797611429134

Zakaria, E., & Nordin, N.M. (2008). The effects of mathematics anxiety on matriculation students as related to motivation and achievement. *Eurasia Journal of Mathematics, Science & Technology Education, 4*(1), 27-30.

Zan, R., Brown, L., Evans, J., & Hannula, M. S. (2006). Affect in mathematics education: An introduction. *Educational Studies in Mathematics, 63*(2), 113-121.

Zettle, R.D. & Raines, S.J. (2000). The relationship of trait and test anxiety with mathematics anxiety. *College Student Journal, 34*(2), 246-258.

Annexes

Annex I

Written permission sent to schools

Autorización del centro educativo

Estimado/a:

Mi nombre es Lara Yáñez, investigadora predoctoral del equipo de Desarrollo de Competencias y Valores (DECOMVA) de la Facultad de Psicología y Educación de la Universidad de Deusto. El motivo de este mensaje es informarle de una investigación que estamos realizando en el equipo, avalada por la Facultad y dirigida por la Dra. Lourdes Villardón, catedrática del Dpto. de Didáctica y Desarrollo Curricular.

Es conocida la preocupación generalizada en nuestro entorno por el nivel competencial de los estudiantes de Educación Secundaria en Matemáticas. Partiendo de esta realidad, se está realizando una investigación para conocer los factores que influyen en el aprendizaje de las Matemáticas con el fin de proporcionar propuestas educativas que mejoren esta situación. Se pretende analizar el efecto de las actitudes y la ansiedad hacia las Matemáticas en el rendimiento.

En este estudio se va a medir el nivel en matemáticas al inicio y al final del curso académico 2014/15 de los estudiantes de 2º y 4º E.S.O. Estas mediciones se realizarán a través de unos cuestionarios y pruebas diseñados, adaptados y validados para tal fin. La cumplimentación de dichas pruebas solo llevará una sesión de la clase de matemáticas y se realizará en dos momentos, en octubre de 2014 y en mayo de 2015.

A continuación le informo sobre la naturaleza de la investigación:

1º LOS ESTUDIANTES SERÁN INFORMADOS DE LAS CARACTERÍSTICAS DEL ESTUDIO Y DEL CARÁCTER VOLUNTARIO DE SU PARTICIPACIÓN. El procedimiento de información y de solicitud de participación se llevará a cabo de la forma en que el centro estime oportuna.

2º LA INFORMACIÓN RECOGIDA SERÁ TRATADA DE FORMA CONFIDENCIAL Y SERÁ ANALIZADA SIEMPRE DE FORMA AGRUPADA. La información será utilizada exclusivamente para los fines de la investigación, respetando así el Informe del Comité de Ética y la Ley de Secreto Profesional y de Protección de Datos.

3º EN TODO MOMENTO SE PRESERVARÁ EL ANONIMATO DEL CENTRO Y DE LOS ESTUDIANTES PARTICIPANTES.

4º EL CENTRO RECIBIRÁ UN INFORME CON LOS RESULTADOS PRINCIPALES DE LA INVESTIGACIÓN Y CON LAS RECOMENDACIONES QUE SE DERIVEN DE LOS MISMOS.

5º DURANTE TODO EL PROCESO, LA INVESTIGADORA Y LA DIRECTORA DE LA INVESTIGACIÓN ESTARÁN DISPONIBLES PARA CUALQUIER COMENTARIO O DUDA.

En el convencimiento de que los resultados de esta investigación tendrán importantes implicaciones para la mejora de la enseñanza de las matemáticas, le agradeceríamos enormemente la colaboración de su centro, facilitando el acceso a la recogida de información en los dos momentos indicados y en los dos cursos señalados.

La información de contacto la puede encontrar al final del mensaje. Agradeciendo el tiempo dedicado a este tema y esperando que la propuesta sea de su interés, reciba un cordial saludo,

Lara Yáñez Marquina
Investigadora Predoctoral de la Universidad de Deusto
Doctorado en Educación
Facultad de Psicología y Educación
Teléfono: +34 944 139 000 (Ext.: 2114)
Correo electrónico: lara.yannez@deusto.es

http://www.research.deusto.es/cs/Satellite/deustoresearch/es/centros-equipos-e-investigadores/equipos-de-investigacion/desarrollo-de-competencias-y-valores/equipoinvestiga

Autorización del centro educativo

Yo, D./Dª. (nombre y apellidos), en calidad de (cargo/función) de (nombre del centro educativo), autorizo a Lara Yáñez Marquina, doctoranda de la Universidad de Deusto, a aplicar las escalas de medición de actitudes hacia las Matemáticas y pruebas de rendimiento matemático a los estudiantes de 2º y 4º de E.S.O. de acuerdo a las condiciones y términos recogidos en la presente comunicación.

Y para que así conste y surta los efectos oportunos, firmo la presente autorización.

En …(LUGAR)…, a …(DÍA)… de …(MES)… de …(AÑO)…

Firmado y sellado:

Annex II

Consent form sent to students' parents or guardians

Autorización padre / madre / tutor
Guraso- / tutorearen baimena

Estimado/a padre/madre o tutor/a:

Mi nombre es Lara Yáñez, investigadora predoctoral del equipo de Desarrollo de Competencias y Valores (DECOMVA) de la Facultad de Psicología y Educación de la Universidad de Deusto. El motivo de este mensaje es informarle de una investigación que estamos realizando en el equipo, cuyo objetivo es conocer los factores que influyen en el aprendizaje de las Matemáticas y poder proporcionar propuestas educativas de mejora.

Para ello, en el estudio se va a medir tanto las actitudes hacia las Matemáticas como el rendimiento en la asignatura al inicio y al final del curso académico 2014/15 con estudiantes de 2º E.S.O. y 4º E.S.O. Estas mediciones se realizarán a través de unos cuestionarios y pruebas diseñados, adaptados y validados para tal fin. La cumplimentación de dichas pruebas solo llevará una sesión de la clase de matemáticas y se realizará en dos momentos, en octubre de 2014 y en mayo de 2015.

Es importante destacar los siguientes aspectos:

1. **LA INFORMACIÓN RECOGIDA SERÁ TRATADA DE FORMA CONFIDENCIAL.**

2. **EN TODO MOMENTO SE PRESERVARÁ EL ANONIMATO DEL CENTRO Y DE LOS ESTUDIANTES PARTICIPANTES.**

3. **EL CENTRO RECIBIRÁ UN INFORME CON LOS RESULTADOS PRINCIPALES DE LA INVESTIGACIÓN Y CON LAS RECOMENDACIONES QUE SE DERIVEN DE LOS MISMOS.**

En el convencimiento de que los resultados de esta investigación tendrán importantes implicaciones para la mejora de la enseñanza de las matemáticas, se ha solicitado previamente al centro la participación de los estudiantes de 2º y 4º de E.S.O. Ahora, a través de este comunicado quisiéramos también contar con su autorización para la participación de su hijo/a en la citada investigación.

Agradeciendo de antemano el apoyo y colaboración que pueda brindar al desarrollo de la investigación, reciba un cordial saludo,

Lara Yáñez Marquina
Investigadora Predoctoral de la Universidad de Deusto
Doctorado en Educación
Facultad de Psicología y Educación
Teléfono: +34 944 139 000 (Ext.: 2114)
Correo electrónico: lara.yannez@deusto.es

Autorización padre / madre / tutor
Guraso- / tutorearen baimena

Guraso edo tutore agurgarria,

Nire izena Lara Yáñez da, eta Deustuko Unibertsitateko Psikologia eta Hezkuntza Fakultateko "Gaitasunen eta Balioen Garapena" izeneko taldeko Doktorego ikertzailea naiz. Mezu honen bidez taldeko ikerketa baten berri eman nahi dizuegu, Matematikako ikaskuntzan parte hartzen duten faktoreak jakinaraztea eta hobetzeko hezkuntza-proposamenak ematea helburu dituena.

Horretarako, ikerketan DBH-ko 2.maila- eta 4-mailako ikasleriaren Matematikan jarrerak eta Matematika-erredimendua neurtuko ditugu 2014/15 ikasturteko hasieran eta bukaeran. Neurketa hauek guztiak diseinatu, egokitu eta balioztatu ditugun galdera-sorta eta froga batzuen bidez jasoko ditugu, aipatutako helburuak lortzeko. Frogak egiteak Matematikako eskola bat bakarrik eskatuko digu, eta bi momentutan egingo ditugu: bata, 2014ko urrian eta bestea, 2015ko maiatzean.

Hurrengo gakoak azpimarratu nahiko genituzke:

1. **JASOTAKO INFORMAZIOA KONFIDENTZIALTASUNEZ ERABILIKO DUGU.**

2. **BETI IKASTETXE- ETA IKASLERIAREN ANONIMATUA BABESTUKO DUGU.**

3. **IKASTETXEAK IKERKETAKO KONKLUSIOAK ETA HEZKUNTZA-PROPOSAMENAK DITUEN TXOSTEN BAT JASOKO DU.**

Ikerketako emaitzek Matematikako iraskaskuntza hobetzeko ondorio garrantzitsuak izango dituzten uste osoarekin, aldez aurretik DBK-ko ikasleriaren partaidetza eskatu diogu ikastetxeari. Hori egin eta gero, agiri honen bidez, zure seme/alabaren partaidetza-baimena ere eskatu nahiko genizueke.

Aldez aurretik ikerketaren garapenean eskaini ahal diguzuen laguntza eta partaidetza eskertuz,

Agur bero bat,

Lara Yáñez Marquina
DeustukoUnibertsitatekoDoktoregoIkertzailea
HezkuntzanDoktoregaia
Psikologia eta HezkuntzaFakultatea
Telefonoa: +34 944 139 000 (Ext.: 2114)
Helbide-elektronikoa: lara.yannez@deusto.es

Autorización padre / madre / tutor
Guraso- / tutorearen baimena

D./Dª…………………………………………………………………………………………….
autorizo a mi hijo/a…………………………………………………………………………
a participar en la investigación sobre los factores que influyen en el aprendizaje de las Matemáticas, que está llevando a cabo la doctoranda Lara Yáñez Marquina en la Universidad de Deusto.

Y para que así conste y surta los efectos oportunos, firmo la presente autorización.

Ç

Firmado (padre/madre/tutor) ___

…………………………………………………………………………………………jaun/andreak
nire seme/alaba……………………………………………………………………..……-ren
partaidetza baimentzen dut Deustuko Unibertsitateko Lara Yáñez doktoregaiak egiten duen Matematikako ikaskuntzan eragiten duten faktoreei buruzko ikerketarako.

Eta dagozkion xedeetarako, eta idatziz jasota egoteko, baimen-agiri hau sinatzen dut,

Sinadura (Guraso edo tutorea) ___

Annex III

Request for participation in review panel

myDeusto

Lara Yáñez Marquina <lara.yannez@deusto.es>

Solicitud de participación en juicio de expertos

Lara Yáñez Marquina <lara.yannez@deusto.es> 2014(e)ko uztailak 16 09:11

Buenos días:

Me pongo en contacto con vosotros para solicitar vuestra colaboración como expertos en la validación del instrumento adjunto a este correo. Dicho instrumento será aplicado a una muestra conformada por estudiantes de 2º E.S.O. y 4º E.S.O. de la provincia de Bizkaia y tendrá como finalidad recoger información sobre las actitudes hacia las matemáticas y ansiedad matemática, una línea de estudio que se enmarca dentro de la tesis doctoral en la que investigamos los factores influyentes en el aprendizaje de las matemáticas con el fin de proporcionar propuestas didácticas de mejora.

Vuestras respuestas, así como las observaciones y/o sugerencias relativas a la formulación, pertinencia, claridad o cualquier otro aspecto de mejora del diseño del instrumento nos resultarán de gran utilidad. Por tanto, en primer lugar os agradeceríamos que leyerais las instrucciones recogidas en la primera hoja del libro Excel. Una vez leídas, podréis proceder a la evaluación del instrumento, que se encuentra en la segunda hoja. En esta última se muestran los ítems, las dimensiones del instrumento propuestas, y las columnas correspondientes a evaluación de pertinencia, claridad y observaciones.

Finalmente, comentaros que este proceso no os llevará más de 30 minutos de vuestro tiempo, y que es fundamental que lo realicéis de manera individual. La fecha límite para recibir vuestras respuestas será el próximo miércoles 23 de julio, respondiendo a este mail. Os sugiero que nombréis el archivo rellenado de la siguiente forma: nombrearchivoorigen_apellidoexperto, por ejemplo, juiciodeexpertosmatematicas_yañez.

Si tuvierais algún problema para descargaros el fichero adjunto, no dudéis en contactar conmigo para enviaros el documento en otro formato que resulte compatible.

Agradecemos de antemano vuestra colaboración y el tiempo dedicado a esta tarea.

Recibid un cordial saludo,

Lara Yáñez

Annex IV

Content validity task sent to review panel

En la siguiente pestaña (Tabla) se presenta una serie de ítems relacionados con actitudes hacia las Matemáticas. Por favor:

1. Marca con una X a qué dimensión crees que corresponde cada ítem (marcar **UNA** sola dimensión) (definición de cada dimensión, abajo)
2. Puntúa del 0-10 lo pertinente que crees que es el ítem en la dimensión escogida
3. Puntúa del 0-10 la claridad y corrección en la formulación del ítem
4. Cualquier comentario, sugerencia, propuesta de reformulación del ítem, etc. que quieras realizar, la puedes escribir en la columna "observaciones"

¡Muchas gracias por tu colaboración!

A continuación se describen brevemente las dimensiones de las que consta la tabla de ítems:

Expectativas (Exp.): autoconcepto que el estudiante tiene de sí mismo como aprendiz de matemáticas, y expectativas de logro en la asignatura
Utilidad (Ut.): utilidad que tiene para el estudiante el conocimiento matemático
Importancia (Imp.): importancia que el estudiante concede a las matemáticas y su aprendizaje
Interés (Int.): interés y motivación que siente el estudiante hacia el aprendizaje de las matemáticas
Estrategias de aprendizaje (Estr.): estrategias de aprendizaje que el estudiante emplea en la asignatura de matemáticas
Ansiedad ante los números y las situaciones matemáticas de la vida cotidiana (A.numreal.): tensión y miedo del estudiante al trabajar y enfrentarse a las matemáticas de la vida real
Ansiedad ante las matemáticas como asignatura (A.asign.): tensión y miedo del estudiante ante aspectos de la clase de matemáticas
Ansiedad a la evaluación (A.ev.): tensión y miedo del estudiante ante los exámenes de matemáticas

	ÍTEM	DIMENSIÓN							PERTI-NENCIA	CLARIDAD	OBSERVACIONES
		Exp.	Ut.	Imp.	Int.	A.numreal	A.asign	A.ev	De 0 a 10	De 0 a 10	Comentarios, sugerencias, propuestas de reformulación del ítem, etc.
1	Me siento más torpe en matemáticas que la mayoría de mis compañeros/as										
2	Me bloqueo cuando tengo que hacer multiplicaciones sin calculadora										
3	Me pongo nervioso/a cuando me toca clase de matemáticas										
4	Guardaré mis cuadernos y libros de matemáticas por si los tengo que utilizar más adelante										
5	Durante un control/examen de matemáticas, me pongo nervioso/a cuando mis compañeros/as terminan antes que yo										
6	Me pongo nervioso/a al pensar que tengo que volver a estudiar matemáticas el curso que viene										
7	Siempre he tenido problemas con las matemáticas										
8	Cuando hago matemáticas me quedo con la mente en blanco										
9	Siempre será difícil para mí aprender matemáticas										
10	Me pongo nervioso/a cuando estoy ante un texto (noticia, cartel publicitario, folleto informativo, etc.) con números										
11	Las matemáticas son útiles para entender las demás asignaturas										
12	Me pongo nervioso/a cuando reviso el ticket de compra										

13	Me gusta estudiar matemáticas										
14	Las matemáticas son entretenidas										
15	Me pongo nervioso/a ante una lista de ejercicios o problemas de matemáticas										
16	Las matemáticas me confunden										
17	Me pongo nervioso/a cuando estudio para un control/examen de matemáticas										
18	Si las matemáticas fueran optativas, las eligiría										
19	Aunque me esfuerce, no entiendo las matemáticas										
20	Me pongo nervioso/a cuando los deberes de matemáticas son problemas difíciles										
21	Me pongo nervioso/a al calcular el precio total de lo que he comprado										
22	Me bloqueo cuando tengo que hacer un cálculo mental										
23	Me bloqueo cuando tengo que hacer restas sin calculadora										
24	Las matemáticas son útiles										
25	Lo que estudiamos en matemáticas es interesante										
26	Las matemáticas son un "rollo"										
27	Las matemáticas son aburridas										
28	Saber matemáticas es importante para mi futuro trabajo										
29	No nací para aprender matemáticas										
30	Me bloqueo cuando tengo poco tiempo para hacer el control/examen de matemáticas										
31	Me bloqueo cuando tengo que hacer sumas sin calculadora										
32	Me pongo nervisoso/a cuando veo tantas										

	fórmulas en del libro de matemáticas										
33	Las matemáticas son importantes porque favorecen el desarrollo tecnológico										
34	Toca clase de matemáticas, ¡qué horror!										
35	No sé estudiar matemáticas										
36	Puedo pasarme horas estudiando matemáticas										
37	En matemáticas sólo deberían enseñarse las cosas prácticas que utilizamos fuera del cole										
38	Me bloqueo cuando tengo que hacer divisiones sin calculadora										
39	Tengo dificultades con las matemáticas										
40	Soy incapaz de resolver problemas matemáticos										
41	Me gustan las matemáticas										
42	Me pongo tenso/a cuando veo al profesor/a resolver un ejercicio de matemáticas en clase										
43	Durante un control/examen de matemáticas, me bloqueo cuando no me sale algún ejercicio										
44	Me siento incómodo/a cuando veo que un compañero/a sale en clase de matemáticas a resolver un ejercicio										
45	Me pongo nervioso/a cuando tengo que explicar a la clase un problema de matemáticas										
46	Cuando hacemos un bote común, me pongo nervioso/a al calcular cómo repartir lo que ha sobrado										
47	Las matemáticas son importantes para desenvolverse en la vida										
48	Haga lo que haga saco notas bajas en matemáticas										
49	No soporto estudiar matemáticas										

50	Me pongo más nervioso/a en los controles/exámenes de matemáticas que en los controles/exámenes de otras asignaturas										
51	Me pongo tenso/a cuando oigo al profesor explicar matemáticas										
52	Me pongo nervioso/a cuando me pongo a hacer los deberes de matemáticas										
53	Me pongo nervioso/a cuando mis compañeros/as terminan de resolver un problema antes que yo										
54	Me bloqueo cuando otro compañero/a me explica un ejercicio de matemáticas										
55	Estudiar matemáticas es divertido										
56	Me pongo nervioso/a cuando tengo que responder a una pregunta del profesor/a en clase de matemáticas										
57	Saber matemáticas aumentará mis posibilidades de encontrar trabajo										
58	Las matemáticas son necesarias para la vida										
59	Cuando compro algo, me pongo nervioso/a al comprobar las vueltas										
60	Me pongo tenso/a cuando tengo que calcular el precio final de un producto rebajado										
61	En matemáticas me cuesta decidir qué tengo que hacer										
62	Sólo deberían estudiar matemáticas aquellos/as que las vayan a utilizar en sus trabajos										
63	En una compra entre varias personas, me pongo nervioso/a al calcular cuánto tiene que poner cada una										
64	Me pongo nervioso/a al calcular qué me puedo comprar con la paga										
65	Me pongo tenso/a cuando los ejercicios del control/examen de matemáticas sin distintos a los										

	vistos en clase											
66	Las matemáticas son necesarias para mis estudios											
67	Puedo pasarme horas resolviendo ejercicios de matemáticas											
68	Todas las personas necesitan saber matemáticas											

Annex V

The battery of instruments in Basque for second grade

KOADERNOA

2014/15 Ikasturtea

DBH-ko Lehen Zikloa

IKASLEA

Ikerketan zehar zure anonimatua eta datu-konfidentzialtasuna bermatzeko, jarraian identifikazio-kode bat emango dizugu. Kode hau gogoratu behar duzu maiatzean egingo duzun hurrengo frogarako.

Horrela, zure izen-abizenez bidez identifikatu beharrean, zuk bakarrik jakingo duzun kode baten bidez identifikatu zaitugu. Horretarako, hurrengo laukiak bete beharko dituzu:

☐ Aitaren izeneko iniziala (jakinezean, utzi hutsean)

☐ Amaren izeneko iniziala (jakinezean, utzi hutsean)

☐ Zure urtebetetzeko eguna (eguna soilik, ez hila) (idatzi zenbakia(k))

☐ Zure lehen abizeneko iniziala

INFORMAZIO PERTSONALA

☐ Mutila ☐ Neska

- ✓ Taldea……………………………Adina (urteak)……………………………
- ✓ Jaiotze-data (urtea / hila / eguna)……………………………………
- ✓ Ikastetxea……………………………………………………………
- ✓ Irakasgaiko hizkuntza: ☐ gaztelania ☐ euskara ☐ ingelesa
- ✓ Pasaden ikasturtean Matematikan aterariko azken emaitza (hurrengo aukeren artean, hautatu bat):

Suspentsua	Nahikoa	Oso ongi	Bikaina
(0 - 4.9)	(5 - 6.9)	(7 - 8.9)	(9 - 10)
☐	☐	☐	☐

- ✓ Errepikatu duzu Lehen Hezkuntzako ikasturterik? ☐ Bai ☐ Ez
  Erantzuna "Bai" bada, zein Lehen Hezkuntzako ikasturte errepikatu duzu?……………………………………
- ✓ Errepikatu duzu Derrigorrezko Bigarren Hezkuntzako ikasturterik? ☐ Bai ☐ Ez
  Erantzuna "Bai" bada, zein Lehen Hezkuntzako ikasturte errepikatu duzu?……………………………………

I. ATALA

ARGIBIDEAK

Koaderno honetako hurrengo orridaldeetan Matematikari buruzko iritziarekin erlazionatutako galderak erantzun beharko dituzu.

Kontuan izan:

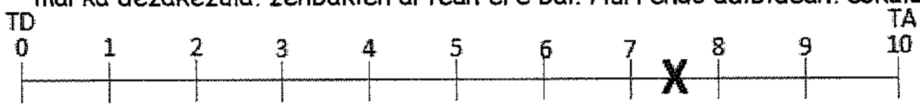
- Galdera-sorta hau erantzutea **GUZTIZ BORONDAZTEKOA ETA ANONIMOA** da. Hau da, inork ez ditu zure erantzunak jakingo.

- **EZ DA AZTERKETA BAT**, eta honen ondorioz, ez dago erantzun onik ezta txarrik ere.

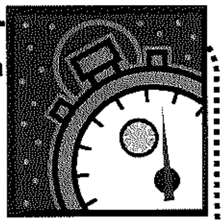
- **ERANTZUN ZINTZOTASUNEZ.**

ADI !

- Erantzun **GALDERA GUZTIAK.**
- Erantzun esaldiak **ERANTZUN BAKAR BATEKIN** .Esaldi bakoitzarako, markatu behin.
- Esaldi bakoitzarako, **MARKATU "X" BATEKIN ZURE ADOSTASUN-MAILA.** Gogoratu 0-ak "Guztiz desadostasunean" (GD) eta 10-ak "Guztiz adostasunean" (GA) adieratzen dutela, eta eskalan zehar edozein puntu marka dezakezula. zenbakien artean ere bai. Hurrenao adibidean. eskalan



Galderaren bat sortuz gero, altxatu eskua eta itxaron ikasgelan arduraduna zure eserlekura hurbildu arte.



Isilik lan egin, arin eta denborarik galdu gabe, mesedez.

Ez ahaztu koadernoko lehenengo orridaldean zure datu-pertsonalak idazteaz.

It	Esaldia	Adostasun-maila
1	Pertsona batzuen arteko erosketa batean, gutako bakoitzak zenbat eman behar duen kalkulatzean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
2	Matematika ikastea gustuko dut	TD 0 1 2 3 4 5 6 7 8 9 10 TA
3	Matematikako ariketa- edo buruketa-zerrendaren aurrean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
4	Erositakoaren prezioa kalkulatzean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
5	Matematika oso erabilgarria da	TD 0 1 2 3 4 5 6 7 8 9 10 TA
6	Batuketak edo kenketak kalkulagailurik gabe egin behar ditudanean trabatzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
7	Ikaskideekin alderatuta, problema eta ariketa matematikoak ebazterakoan motelagoa naizela ustea dut	TD 0 1 2 3 4 5 6 7 8 9 10 TA
8	Matematikako krontola/azterketako ariketak klasean ikusitakoekin alderatuta desberdinak direnean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
9	Matematikako etxerako lanak buruketa zailak direnean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
10	Nahiz eta ahalegindu, ez dut Matematika ulertzen	TD 0 1 2 3 4 5 6 7 8 9 10 TA
11	Pertsona guztiek Matematika jakin behar dute	TD 0 1 2 3 4 5 6 7 8 9 10 TA
12	Matematikarekin arazoak dauzkat	TD 0 1 2 3 4 5 6 7 8 9 10 TA
13	Matematika krontola/azterketarako ikasten dudanean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
14	Matematika gustuko dut	TD 0 1 2 3 4 5 6 7 8 9 10 TA
15	Matematikan eskolaz kanpo erabalgarriak diren gauza praktikoak soilik irakatsi beharko lirateke	TD 0 1 2 3 4 5 6 7 8 9 10 TA
16	Matematika beren lanbideetan erabiliko dutenek soilik ikasi beharko lukete	TD 0 1 2 3 4 5 6 7 8 9 10 TA
17	Erosketa-tiketa berrikusten dudanean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
18	Matematika ikasten dudanean denbora di-da batean igarotzen zait	TD 0 1 2 3 4 5 6 7 8 9 10 TA
19	Matematika beharrezkoa da bizitzarako	TD 0 1 2 3 4 5 6 7 8 9 10 TA
20	Matematika ikastea dibertigarria da	TD 0 1 2 3 4 5 6 7 8 9 10 TA
21	Ariketa edo problema matematikoak egiten ditudanean denbora di-da batean igarotzen zait	TD 0 1 2 3 4 5 6 7 8 9 10 TA
22	Matematika garrantzitsua da gizartearen garapena errazten baitu	TD 0 1 2 3 4 5 6 7 8 9 10 TA

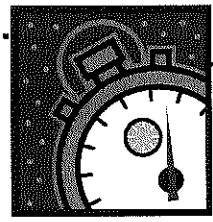
23	Matematika klasea dudan bakoitzean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
24	Matematika klasean ariketa edo buruketa bat egin behar dudanean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
25	Matematikako krontola/azterketetan urduriago jartzen naiz gainontzeko irakasgaietako krontola/azterketeetan baino	TD 0 1 2 3 4 5 6 7 8 9 10 TA
26	Buruzko kalkulu bat egin behar dudanean trabatzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
27	Matematikako krontola/azterketaren aurreko egunean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
28	Ez nintzen Matematika ulertzeko jaio	TD 0 1 2 3 4 5 6 7 8 9 10 TA
29	Potoa jartzen dugunean, gainontzekoa nola banatu kalkulatzean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
30	Matematikako krontola/azterketan ariketaren bat ez dakidanean trabatzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
31	Beheratutako produktu baten salneurri finala kalkulatu behar dudanean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
32	Ez naiz buruketak ebazteko gai	TD 0 1 2 3 4 5 6 7 8 9 10 TA
33	Datorren ikasturtean Matematika berriro ere ikasi beharko dudala pentsatsean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
34	Aste-sariarekin zer eros dezakedan kalkulatzean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
35	Matematika entretenigarria da	TD 0 1 2 3 4 5 6 7 8 9 10 TA
36	Zerbait erosi eta gero, gainerakoak egiaztatzean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
37	Egiten dudana egiten dudala, Matematikan emaitza baxuak ateratzen ditut	TD 0 1 2 3 4 5 6 7 8 9 10 TA
38	Matematika jakiteak lana aurkitzeko aukera gehiago emango dizkit	TD 0 1 2 3 4 5 6 7 8 9 10 TA
39	Matematika oso aspergarria da	TD 0 1 2 3 4 5 6 7 8 9 10 TA
40	Matematika jakitea garrantzitsua izango da nire etorkizuneko lanarako	TD 0 1 2 3 4 5 6 7 8 9 10 TA
41	Klasean matematikako ariketa edo buruketa bat arbelean egiten dutenean, urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
42	Zenbakiak dituen testu baten (berri baten, kartel baten, iragarki batean,...) aurrean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
43	Matematikako etxerako lanak egiten hastean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
44	Biderketak edo zatiketak kalkulagailurik gabe egin behar ditudanean trabatzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
45	Matematikako liburuan formulak ikusten ditudanean	TD 0 1 2 3 4 5 6 7 8 9 10 TA

	urduri jartzen naiz	
46	Matematikako krontola/azterketan urduri jartzen naiz bukatzeko denbora laburra daukadalako ustean	TD 0 1 2 3 4 5 6 7 8 9 10 TA
47	Klasean matematikari buruzko azalpen bat ematen dutenean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
48	Matematika ulertzea zaila egingo zait beti	TD 0 1 2 3 4 5 6 7 8 9 10 TA
49	Matematika erabilgarria da gainontzeko irakasgaiak ulertzeko	TD 0 1 2 3 4 5 6 7 8 9 10 TA

II. ATALA

ADI !

- **BOLIGRAFOZ** idatzi erantzun guztiak.
- **EZ** erabili **KALKULAGAILUA**.
- Erantzun **GALDERA GUZTIAK**.



Orain **5 MINUTU** edukiko dituzu froga egiteko.

Galderaren bat sortuz gero, altxatu eskua era itxaron ikasgelan dagoen arduraduna zure eserlekura hurbildu arte.

Isilik lan egin, arin eta denborarik galdu gabe.

Ez ahaztu koadernoaren lehenengo orrialdean eta folioan zure datu pertsonalak idazteaz.

A

HASTEKO...

Egin hurrengo eragiketak, erantzunak taulako azken zutabean idatziz..

01

	Eragiketa	Erantzuna
A.	3^4	
B.	$(-2)^2$	
C.	$\frac{3}{4}+\frac{1}{2}$	
D.	5,05 + 7,5	
E.	$(3+2)^2$	
F.	$(-3)^3 \times (-4) + 10$	
G.	(-3) x 4 + (-5)	
H.	(-3) x [(-4) + (-5)]	
I.	$\sqrt{16}+\sqrt{4}$	
J.	$(\sqrt{16})^2$	
K.	100^3	
L.	10^2	
M.	$100^3 \times 10^2$	
N.	$100^3 + 10^2$	

- Ariketa hau egitean, zelan sentitu duzu zeure burua?

____

____

____

____

III. ATALA

ARGIBIDEAK

Erantzun koaderno honetako galderak, mesedez. Litekeena da atal batzuk errazak gertatzen zaizkizula, eta beste batzuk, ordea, zailagoak. Ez da azterketa bat, hots, ez dizute kalifikaziorik ipiniko. Gogoratu anonimoa dela, eta honen ondorioz, inork ez ditu zure erantzunak jakingo.

Galdera-mota desberdinak egongo dira:

- Batzuek 4 erantzun posible edukiko dituzte. Zuzena aukeratu beharko duzu, eta dagokion letra inguratu. Hurrengo adibideak galdera-mota hau erakusten du.

EJEMPLO 1

¿Cuántos meses tiene un año? Rodea la opción correcta.

A.- 2 meses

B.- 17 meses

C.- 12 meses

D.- 11 meses

Gaizki erantzun eta erantzuna aldatu nahi baduzu, "X" batekin ezabatu eta erantzun berria inguratu, hurrengo adibidean agertzen den moduan. Adibidean lehenengoz erantzun A aukeratu zen, eta gero eman nahi zen erantzuna 'C' zela aukeratu zen.

EJEMPLO 2

¿Cuántos meses tiene un año? Rodea la opción correcta.

A.- 2 meses

B.- 17 meses

C.- 12 meses

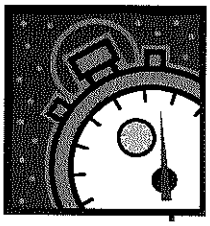
D.- 11 meses

- Azkenik, galdera batzuetan grafika bat marraztu beharko duzu. Eskuz irudikatu, marrazki-tresnarik erabili gabe.

ADI !

- **BOLIGRAFOZ** idatzi erantzun guztiak.
- **KALKULAGAILUA** erabil dezakezu.
- Eragiketak egitekotan, erabili koadernoarekin batera emandako **FOLIOA**. Froga bukatu ondoren, bai koadernoa bai folioa entregatu beharko dituzu.
- Erantzun **GALDERA GUZTIAK**, mesedez.

Orain **30 MINUTU** edukiko dituzu froga egiteko.



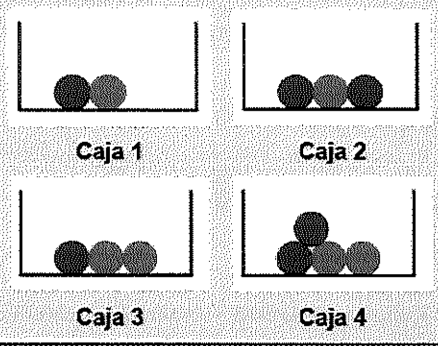
Galderaren bat sortuz gero, altxatu eskua eta itxaron ikasgelan dagoen arduraduna zure eserlekura hurbildu arte.

Isilik lan egin, arin eta denborarik galdu gabe.

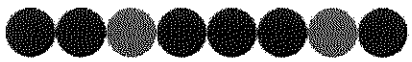
Ez ahaztu koadernoaren lehenengo orrialdean eta folioan zure datu pertsonalak idazteaz.

B PROBABILITATE KONTUETAN

Hurrengo lau kutxa hauek ditugu, bola gorri eta berdeekin:



1 Andres-ek kutxa hauetako bat hartu zuen eta jolasean ibili zen. Bola bat hartu, bere kolorea idatzi eta berriro kutxara bueltatu zuen. Hona hemen emaitza:



Zein kutxarekin ibili zen Andres jolasean aurreko emaitza lortzeko?

A. Lehenengo kutxarekin
B. Bigarren kutxarekin
C. Hirugarren kutxarekin
D. Laugarren kutxarekin

Andres-ek 2.kutxa hartu zuen eta beronekin jolasean ibili zen. Bola bat hartu, bere kolorea idatzi eta berriro kutxara bueltatu zuen. Zein izan zen hurrengo emaitza lortzeko probablitatea?:

A. 0
B. 1/4
C. 1/2
D. 3/4

C

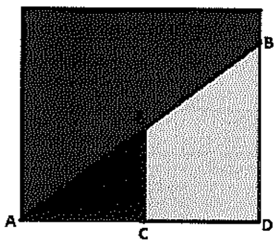
ARKATZ-KUTXA

Lagun-talde batek arkatz-kutxak egin eta saltzen ditu ikasketa-bidaiarako dirua lortzeko asmoz. Kutxek ez dute taparik eta kubo itxura dute. Kutxa-multzo handia egin nahi dutenez eta aldi berean, diru gutxi gastatu, tamainarik egokiena 9 cm-ko arista daukana dela konturatu dira

01 Behin kutxa eginda, zenbatekoa izango da bere kapazitatea?

A. 729 cm^3-koa
B. 405 cm^3-koa
C. 486 cm^3-koa
D. 324 cm^3-koa

02 Kutxa politagoa izan dadin, lagunek kutxaren azal bakoitza horrela margoztea erabaki dute:



CE segmentua aristaren erdibitzailetik eginda badago, eta AB segmentuak 10 cm-ko luzeera badu, zenbatekoa da AE segmentuaren luzeera?

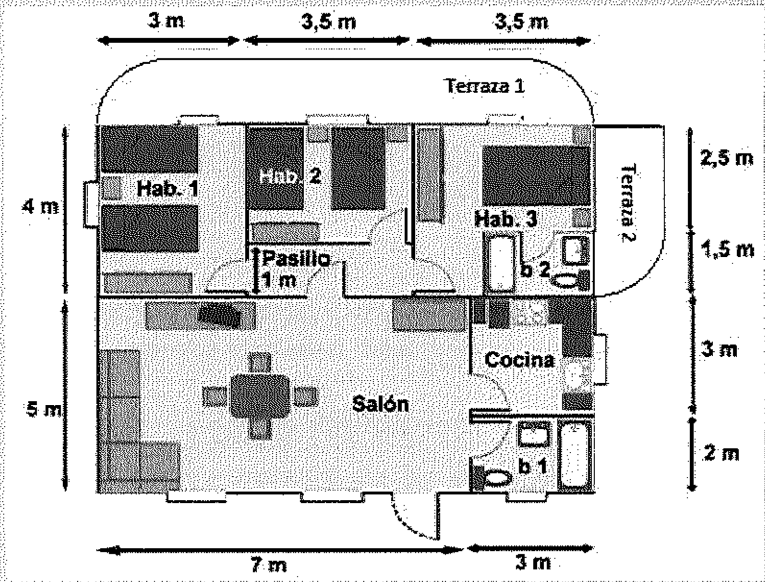
A. 9 cm-koa
B. 6 cm-koa
C. 5 cm-koa
D. 4,5 cm-koa

03 Eta EC segmentuarena?:

A. 4,75 cm-koa
B. 2,2 cm-koa
C. 4,5 cm-koa
D. 2,5 cm-koa

D ETXEBIZITZA BATEKO PLANOA

Etxebizitza bateko planoa erakutsiko dizuet egin nahi ditugun erreforma batzuk egiten lagun diezaguzun. Planoan gela eta pasilloko dimentsioak ikus ditzakezu.



01	Terraza 1-eko azala deskonposa daiteke...

A. Laukizuzen batean eta zirkulu batean
B. Laukizuzen batean eta zirkunferentzia erdi batean
C. Laukizuzen batean eta zirkunferentzia batean
D. Laukizuzen batean eta zirkulu erdi batean

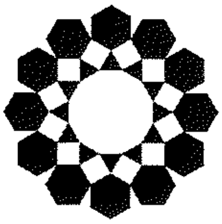
02 Terraza 2-ko kanpoko perimetroa zerratu nahi dugu. Zenbateko luzeerako hesia erosi behar dugu?:

A. 17,42 m-ko luzeerako hesia
B. 7,855 m-ko luzeerako hesia
C. 6,355 m-ko luzeerako hesia
D. 9,355 m-ko luzeerako hesia

03 Bainugelako zorua aldatu nahi dugu (planoan, b1) eta horretarako baldosa-mota berbera erabiliko dugu. Bainuontziko zoruak 0,80 m-ko zabalera du eta honetan ez dugu baldosarik ipiniko. Zenbat baldosako m^2 erosi beharko dugu?

A. 1,6 m^2
B. 4,4 m^2
C. 4,5 m^2
D. 6 m^2

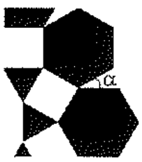
04 Baldosa-mota desberdinak ikusi ondoren, hurrengoa erostea erabaki dugu:



Nola deitzen diogu erdiko figurari?

A. Dodekaedroa
B. Dekagonoa
C. Zirkulua
D. Dodekagonoa

05 Hurrengo irudian baldosako zati bat xehetasun handiagoz ikus daiteke:



Zenbatekoa da α angelua?:

A. 15°-koa
B. 30°-koa
C. 45°-koa
D. 60°-koa

06 Aurreko irudiaren α angeluaren erdikaria eginez gero, zenbatekoa izango litzateke sortutako angelu bakoitza?

A. 15°-koa
B. 30°-koa
C. 7,5°-koa
D. 22,5°-koa

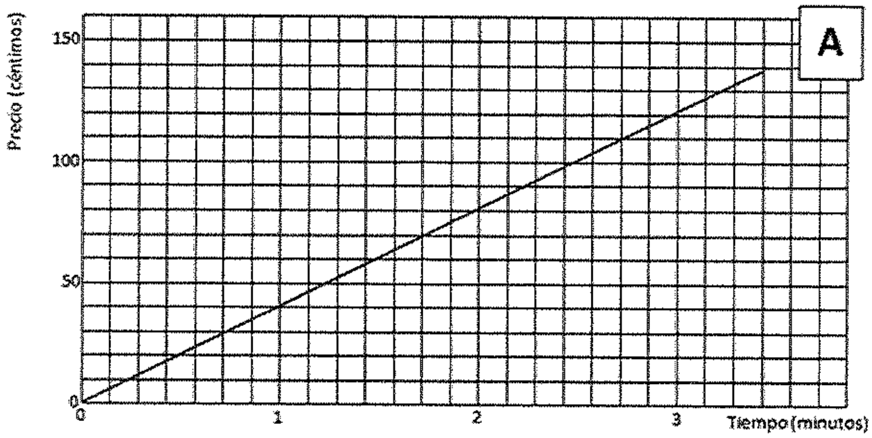
E

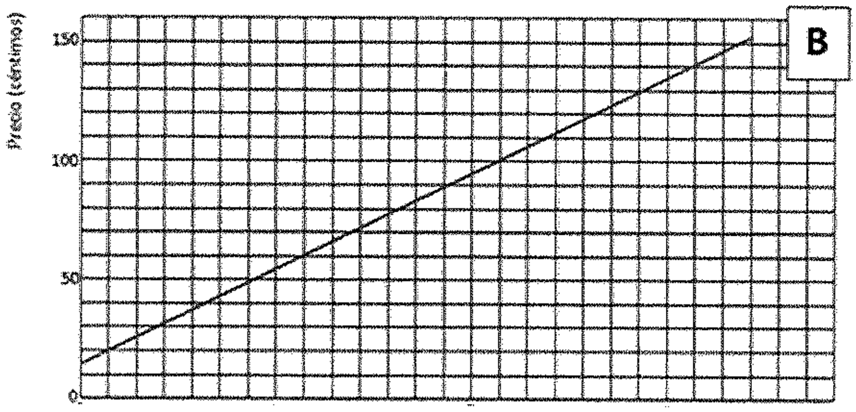
MUGIKORRAREN GASTUA

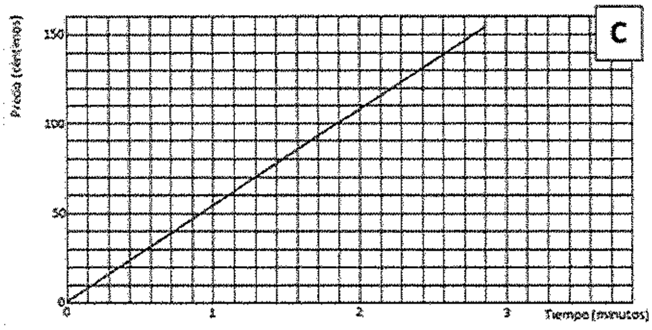
Jon-ek mugikorrean dirutza gastatzen duela uste duenez, operadorezk aldatzea erabaki du. Aukera ugari analisatu ondoren, Jon-ek hurrengo tarifa aukeratu du:

- 40 zentimo/minutu edozein lekutarako deietan, dei-establezimenturik gabe.
- 15 zentimo/sms

01 Jon-ek hautatutako tarifari dagokionez, hurrengo grafikoen artean, zeinek erakusten du dei bakoitzako kostearen (euroko zentimoetan adierazita) eta dei-iraupenaren (minutuetan adierazita) arteko dependentzia?







A. Grafika A
B. Grafika B
C. Grafika C
D. Ezer ez

02 Jon-en tarifaren kasurako, zein da prezioaren (euroko zentimoetan adierazita) eta dei-iraupenaren (minutuetan adierazita) arteko proportzionaltasun-konstantea?:

A. r = 40
B. r = 0.40
C. r = 4
D. r = 0.040

03 Jon-en tarifaren kasurako, hautatu eguneko kostea adierazten duen formula, Jon-ek "a" sms bidaltzen dituela eta "b" dei egiten dituela kontuan izanda.

A. p = a/15 + b/40
B. p = 15.a + 40.b
C. p = 15.a + b/40
D. p = 40.(a+b) + 15

04 Jon-en tarifaren kasurako, zein motatakoa da deiaren kostearen (euroko zentimoetan adierazita) eta dei-iraupenaren (minutetan adierazita) arteko dependentzia?:

A. Proportzionaltasun zuzenekoa.
B. Alderantzizko proportzionala.
C. Proportzionala.
D. Proportzionaltasunik gabekoa.

F

IKASKETA-BIDAIA

Ikastolako aste kulturalean 2. DBH-ko ikasleek ikasketa-bidaiarako diru-bilketa egingo dute ogitartekoak, sandwich-ak eta pintxoak salduz. Hurrengo prezio-taula akordatu dute (eurotan adierazita):

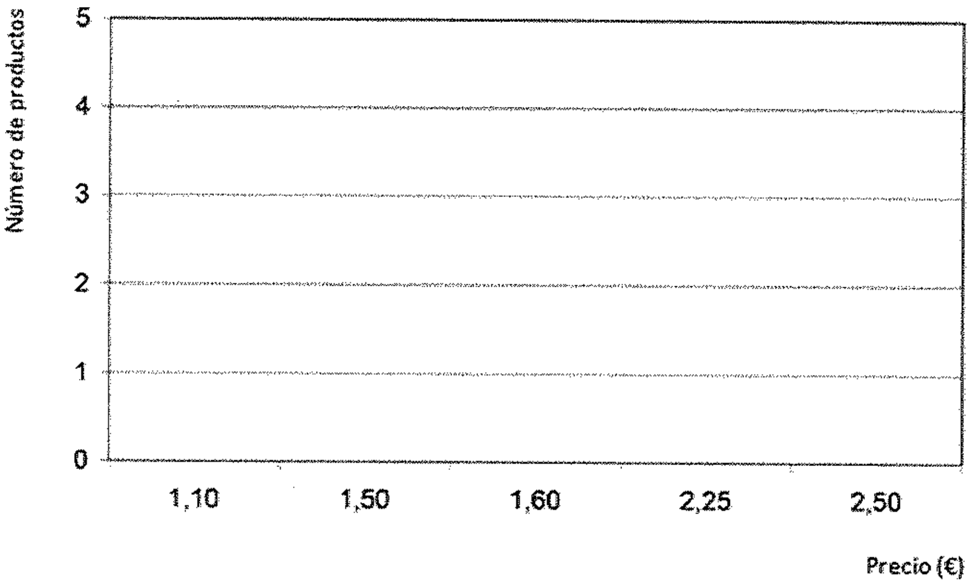
BOCATA							PINTXO		
Bocata tortilla	Bocata salchichón	Bocata jamón York	Bocata chorizo	Bocata queso	Bocata bacon	Bocata especial	Pintxo tortilla	Pintxo txaka	Pintxo especial
2,25€	1,60€	1,60€	1,60€	1,60€	1,50€	2,50€	1,50€	1,10€	2,25€

01 Taulako datuen arabera, zein da bokata baten batez besteko prezioa?:

A. 1,75 €
B. 1,86 €
C. 1,81 €
D. 1,60 €

02

Irudikatu barra-grafiko batean prezio-taularen informazioa.



03

Datuen arabera, zein da moda?:

A. 1,50 €
B. 1,60 €
C. 2,25 €
D. 2,50 €

04

Hurrengo taulan iraileko pintxoen salketaren datuak biltzen dira. Guztira 150 pintxo saldu zirela jakinda, bete taula:

	PINTXO		
	Pintxo Tortilla	**Pintxo Txaka**	**Pintxo berezia**
Kopurua	55		
Portzentaia		30%	
Zatikia			1/3

- Froga hau egitean, zelan sentitu duzu zeure burua?

Ez ahaztu koadernoaren lehenengo orrialdean eta folioan zure datu pertsonalak idazteaz.

ESKERRIK ASKO KOLABORAZIOARENGATIK !

Annex VI

The battery of instruments in Spanish for second grade

CUADERNO

Curso 2014/15

1er CICLO ESO

ESTUDIANTE

Para asegurar tu anonimato y la confidencialidad de tus datos a lo largo de esta investigación, a continuación te asignaremos un código de identificación, que deberás recordar para la siguiente prueba que realizarás en junio.

Así, en lugar de identificarte por tus nombres y apellidos, te identificaremos por un código que únicamente sabrás tú. Para ello, deberás completar las siguientes casillas:

☐ Inicial del nombre del padre (en caso de no saberlo, dejar la casilla en blanco)

☐ Inicial del nombre de la madre (en caso de no saberlo, dejar la casilla en blanco)

☐ El día de tu cumpleaños (sólo el día, no el mes) (con números)

☐ Inicial de tu primer apellido

INFORMACIÓN PERSONAL

☐ Chico ☐ Chica

- ✓ Grupo...Edad (años)...
- ✓ Fecha de nacimiento (día / mes / año)...
- ✓ Centro educativo..
- ✓ Idioma de la asignatura: ☐ castellano ☐ euskera ☐ inglés
- ✓ Nota final obtenida en el curso anterior en la asignatura de Matemáticas (seleccionar una entre las siguientes opciones):

Suspenso	Aprobado	Notable	Sobresaliente
(0 - 4.9)	(5 - 6.9)	(7 - 8.9)	(9 - 10)
☐	☐	☐	☐

- ✓ ¿Has repetido curso en Primaria? ☐ Sí ☐ No
  En caso de que la respuesta sea "Sí", ¿cuántos cursos de Primaria has repetido?...
- ✓ ¿Has repetido curso en Secundaria? ☐ Sí ☐ No
  En caso de que la respuesta sea "Sí", ¿cuántos cursos de Secundaria has repetido?...

PARTE I

INSTRUCCIONES

En las páginas siguientes de este cuadernillo deberás responder a una serie de preguntas relacionadas con tu opinión sobre las Matemáticas.

Ten en cuenta lo siguiente:

- Rellenar este cuestionario es **TOTALMENTE VOLUNTARIO Y ANÓNIMO.** Es decir, nadie va a conocer tus respuestas.
- **NO ES UN EXAMEN**, por lo que no hay respuestas buenas o malas.
- **RESPONDE CON SINCERIDAD.**

¡ ATENCIÓN !

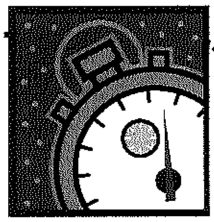
- Responde a **TODAS** las preguntas.
- Contesta a las frases con **UNA ÚNICA RESPUESTA**. Marca sólo una vez para cada afirmación.
- Para cada afirmación, **MARCA CON UNA "X" TU GRADO DE ACUERDO** con la frase. Recuerda que 0 es "totalmente en desacuerdo" (TD) y 10 es "totalmente de acuerdo" (TA), y que puedes marcar cualquier punto de la escala, incluso entre los números. En el siguiente ejemplo, el grado de acuerdo marcado sobre la escala sería de 7,5:

TD 0	1	2	3	4	5	6	7	X	8	9	TA 10

Si tienes alguna pregunta, levanta la mano y espera a que la persona que se encuentra en el aula se acerque hasta tu sitio.

Por favor, trabaja en silencio, rápido y sin perder el tiempo.

No olvides poner tus datos personales en la primera hoja del cuaderno.



It	Afirmación	Grado de acuerdo
1	En una compra entre varias personas, me pongo nervioso al calcular cuánto tiene que poner cada una	TD 0 1 2 3 4 5 6 7 8 9 10 TA
2	Me gusta estudiar Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
3	Me pongo nervioso ante una lista de ejercicios o problemas de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
4	Me pongo nervioso al calcular el precio total de lo que he comprado	TD 0 1 2 3 4 5 6 7 8 9 10 TA
5	Las Matemáticas son muy útiles	TD 0 1 2 3 4 5 6 7 8 9 10 TA
6	Me bloqueo cuando tengo que hacer sumas o restas sin calculadora	TD 0 1 2 3 4 5 6 7 8 9 10 TA
7	Me siento más torpe que mis compañeros/as resolviendo ejercicios y problemas matemáticos	TD 0 1 2 3 4 5 6 7 8 9 10 TA
8	Me pongo tenso/a cuando los ejercicios del control/examen de Matemáticas son distintos a los vistos en clase	TD 0 1 2 3 4 5 6 7 8 9 10 TA
9	Me pongo nervioso/a cuando los deberes de Matemáticas son problemas difíciles	TD 0 1 2 3 4 5 6 7 8 9 10 TA
10	Aunque me esfuerce, no entiendo las Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
11	Todas las personas necesitan saber Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
12	Tengo dificultades con las Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
13	Me pongo nervioso/a cuando estudio para un control/examen de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
14	Me gustan las Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
15	En Matemáticas sólo deberían enseñarse las cosas prácticas que utilizamos fuera del cole	TD 0 1 2 3 4 5 6 7 8 9 10 TA
16	Sólo deberían estudiar Matemáticas aquellos que las vayan a utilizar en sus trabajos	TD 0 1 2 3 4 5 6 7 8 9 10 TA
17	Me pongo nervioso/a cuando reviso el ticket de compra	TD 0 1 2 3 4 5 6 7 8 9 10 TA
18	Se me pasa el tiempo volando cuando estudio Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
19	Las Matemáticas son necesarias para la vida	TD 0 1 2 3 4 5 6 7 8 9 10 TA
20	Estudiar Matemáticas es divertido	TD 0 1 2 3 4 5 6 7 8 9 10 TA
21	Se me pasa el tiempo volando cuando resuelvo ejercicios/problemas de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
22	Las Matemáticas son importantes porque favorecen el avance de la sociedad	TD 0 1 2 3 4 5 6 7 8 9 10 TA
23	Me pongo nervioso/a cuando toca clase de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA

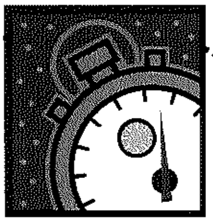
24	Me pongo nervioso/a cuando tengo que resolver un ejercicio/problema en clase de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
25	Me pongo más nervioso/a en los controles/exámenes de Matemáticas que en los controles/exámenes de otras asignaturas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
26	Me bloqueo cuando tengo que hacer un cálculo mental	TD 0 1 2 3 4 5 6 7 8 9 10 TA
27	Me pongo nervioso/a el día previo a un control/examen de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
28	No nací para aprender Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
29	Cuando hacemos un bote común, me pongo nervioso/a al calcular cómo repartir lo que ha sobrado	TD 0 1 2 3 4 5 6 7 8 9 10 TA
30	Durante un control/examen de Matemáticas, me bloqueo cuando no me sale algún ejercicio	TD 0 1 2 3 4 5 6 7 8 9 10 TA
31	Me pongo tenso/a cuando tengo que calcular el precio final de un producto rebajado	TD 0 1 2 3 4 5 6 7 8 9 10 TA
32	Soy incapaz de resolver problemas matemáticos	TD 0 1 2 3 4 5 6 7 8 9 10 TA
33	Me pongo nervioso/a al pensar que tengo que volver a estudiar Matemáticas el curso que viene	TD 0 1 2 3 4 5 6 7 8 9 10 TA
34	Me pongo nervioso/a al calcular qué me puedo comprar con la paga	TD 0 1 2 3 4 5 6 7 8 9 10 TA
35	Las Matemáticas son entretenidas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
36	Cuando compro algo, me pongo nervioso/a al comprobar las vueltas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
37	Haga lo que haga saco notas bajas en Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
38	Saber Matemáticas aumentará mis posibilidades de encontrar trabajo	TD 0 1 2 3 4 5 6 7 8 9 10 TA
39	Las Matemáticas son un "rollo"	TD 0 1 2 3 4 5 6 7 8 9 10 TA
40	Saber Matemáticas es importante para mi futuro trabajo	TD 0 1 2 3 4 5 6 7 8 9 10 TA
41	Me pongo nervioso/a cuando en clase de resuelve un ejercicio/problema de Matemáticas en la pizarra	TD 0 1 2 3 4 5 6 7 8 9 10 TA
42	Me pongo nervioso/a ante un texto (noticia, cartel publicitario, folleto informativo, etc.) con números	TD 0 1 2 3 4 5 6 7 8 9 10 TA
43	Me pongo nervioso/a cuando me pongo a hacer los deberes de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
44	Me bloqueo cuando tengo que hacer multiplicaciones o divisiones sin calculadora	TD 0 1 2 3 4 5 6 7 8 9 10 TA
45	Me pongo nervioso/a cuando veo fórmulas en el libro de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA

46	Durante un control/examen de Matemáticas, me pongo nervioso porque creo que tengo poco tiempo para terminarlo	TD 0 1 2 3 4 5 6 7 8 9 10 TA
47	Me pongo nervioso/a cuando en clase se da una explicación de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
48	Siempre será difícil para mí aprender Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
49	Las Matemáticas son útiles para entender las demás asignaturas	TD 0 1 2 3 4 5 6 7 8 9 10 TA

PARTE II

¡ ATENCIÓN !

- Escribe todas las respuestas con **BOLÍGRAFO**.
- **NO** puedes utilizar la **CALCULADORA**.
- Responde a **TODAS** las preguntas.



Ahora tienes **5 MINUTOS** para hacer esta prueba.

Si tienes alguna pregunta, levanta la mano y espera a que la persona que se encuentra en el aula se acerque hasta tu sitio.

Trabaja en silencio, rápido y sin perder el tiempo.

No olvides poner tu código de identificación en la portada de este cuaderno.

A

PARA EMPEZAR...

Realiza las siguientes operaciones aritméticas, escribiendo la respuesta en la última columna de la tabla.

01

	Operación	Respuesta
A.	3^4	
B.	$(-2)^2$	
C.	$\frac{3}{4} + \frac{1}{2}$	
D.	5,05 + 7,5	
E.	$(3+2)^2$	
F.	$(-3)^3 x(-4) + 10$	
G.	(-3) x 4 + (-5)	
H.	(-3) x [(-4) + (-5)]	
I.	$\sqrt{16}+\sqrt{4}$	
J.	$(\sqrt{16})^2$	
K.	100^3	
L.	10^2	
M.	$100^3 \times 10^2$	
N.	$100^3 + 10^2$	

- ¿Cómo te has sentido al realizar este ejercicio?

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PARTE III

INSTRUCCIONES

Por favor, responde a las preguntas de este cuadernillo. Puede que algunas partes te resulten fáciles y otras más difíciles. No se trata de un examen, es decir, no te van a poner ninguna calificación. Recuerda que es anónimo, por lo que nadie va a conocer tus respuestas.

Habrá distintos tipos de preguntas:

- Algunas tendrán cuatro posibles respuestas. Deberás elegir la correcta y rodear la letra. El ejemplo 1 muestra este tipo de pregunta.

EJEMPLO 1

¿Cuántos meses tiene un año? Rodea la opción correcta.

A.- 2 meses

B.- 17 meses

(C.-) 12 meses

D.- 11 meses

Si te has equivocado y quieres cambiar la respuesta, tacha con una X y rodea la nueva respuesta, tal y como te mostramos en el ejemplo 2, donde primero se eligió la respuesta A y después se decidió que la respuesta que se quería dar era la C.

EJEMPLO 2

¿Cuántos meses tiene un año? Rodea la opción correcta.

~~A.-~~ 2 meses

B.- 17 meses

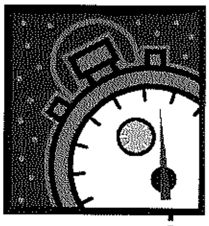
(C.-) 12 meses

D.- 11 meses

➢ Habrá Finalmente, en algunas preguntas te pediremos que dibujes una gráfica. Dibújala a mano alzada, sin utilizar instrumentos de dibujo.

¡ ATENCIÓN !

❖ Escribetodas las respuestas con **BOLÍGRAFO**.
❖ Puedes utilizar la **CALCULADORA**.
❖ Si necesitas hacer operaciones, utiliza el **FOLIO** que te damos junto con este cuadernillo. Al finalizar la prueba, deberás entregar tanto el cuadernillo como el folio.
❖ Por favor, responde a **TODAS** las preguntas.



Ahora tienes **30 MINUTOS** para hacer esta prueba.

Si tienes alguna pregunta, levanta la mano y espera a que la persona que se encuentra en el aula se acerque hasta tu sitio.

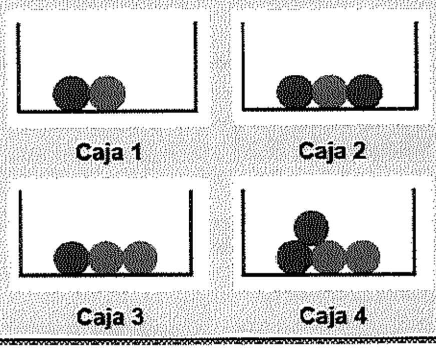
Trabaja en silencio, rápido y sin perder el tiempo.

No olvides poner tu código de identificacióntanto en la portada del cuaderno como en el folio.

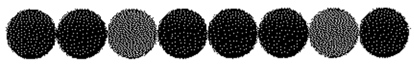
B

MÁS O MENOS PROBABLE

Tenemos las siguientes cuatro cajas, con bolas rojas y verdes:



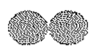
1 Andrés cogió una de estas cajas y estuvo jugando. Sacaba una bola, anotaba el color y la devolvía a la caja. El resultado fue:



¿Con qué caja crees que es más probable que estuviese jugando?

A. Con la caja 1
B. Con la caja 2
C. Con la caja 3
D. Con la caja 4

2 Andrés cogió la caja 2 y estuvo jugando. Sacaba una bola, anotaba el color y la devolvía a la caja. ¿Cuál fue la probabilidad de que obtuviera el siguiente resultado?:



A. 0
B. 1/4
C. 1/2
D. 3/4

C

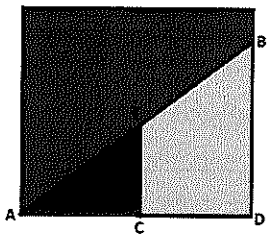
CAJAS DE LÁPICES

Un grupo de amigos fabrica cajas de lápices para vender y conseguir dinero para su viaje de estudios. Las cajas no tienen tapa y son en forma de cubo. Quieren hacer muchas cajas y gastar poco dinero en la fabricación, y han comprobado que el tamaño más adecuado es el que tiene 9cm de arista.

01 La capacidad de la caja una vez fabricada es:

A. 729 cm^3
B. 405 cm^3
C. 486 cm^3
D. 324 cm^3

02 Para que la caja resulte más bonita, los amigos deciden pintar cada cara lateral de la siguiente manera:



Si el segmento CE está trazado por la mediatriz de la arista, y el segmento AB tiene una longitud de 10 cm, ¿cuál es la longitud del segmento AE?

A. 9 cm
B. 6 cm
C. 5 cm
D. 4,5 cm

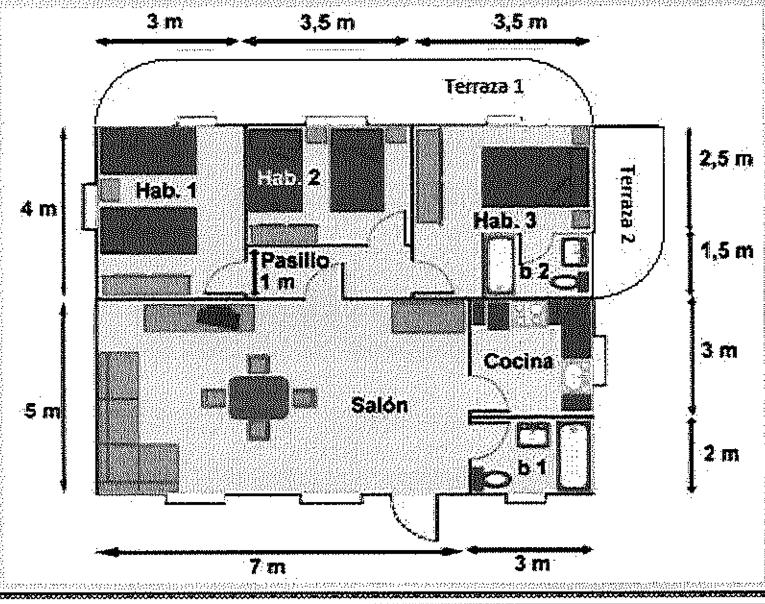
03 ¿Y la longitud del segmento EC?:

A. 4.75 cm
B. 2,2 cm
C. 4.5 cm
D. 2,5 cm

D

EL PLANO DE UNA CASA

Te presentamos el plano de una casa para que nos ayudes a hacer un estudio sobre algunas reformas que queremos realizar. En el plano puedes ver las dimensiones de las habitaciones y del pasillo.



01 La superficie de la terraza 1 se puede descomponer en:

A. Un rectángulo y un círculo
B. Un rectángulo y media circunferencia
C. Un rectángulo y una circunferencia
D. Un rectángulo y medio círculo

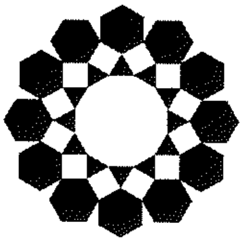
02 Queremos vallar el perímetro exterior de la terraza 2. ¿Qué longitud de valla necesitamos comprar?:

A. 17,42 m de valla
B. 7,855 m de valla
C. 6,355 m de valla
D. 9,355 m de valla

03 Queremos cambiar el suelo del baño (b1 en el plano) y para ello vamos a utilizar el mismo tipo de baldosas. El suelo de la bañera tiene 0,80 m de ancho y no se embaldosa. ¿Cuántos metros cuadrados de baldosa habrá que comprar?:

A. 1,6 m^2 de baldosa
B. 4,4m^2 de baldosa
C. 4,5m^2 de baldosa
D. 6m^2 de baldosa

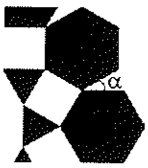
04 Tras mirar diferentes modelos de baldosas, decidimos comprar el siguiente:



¿Qué nombre recibe la figura central?

A. Dodecaedro
B. Decágono
C. Círculo
D. Dodecágono

05 La siguiente imagen muestra con más detalle una parte de la baldosa:



¿Cuál es el valor del ángulo α?:

A. 15°
B. 30°
C. 45°
D. 60°

06

Si trazamos la bisectriz al ángulo a de la anterior pregunta, ¿cuál será el valor de cada uno de los ángulos resultantes?

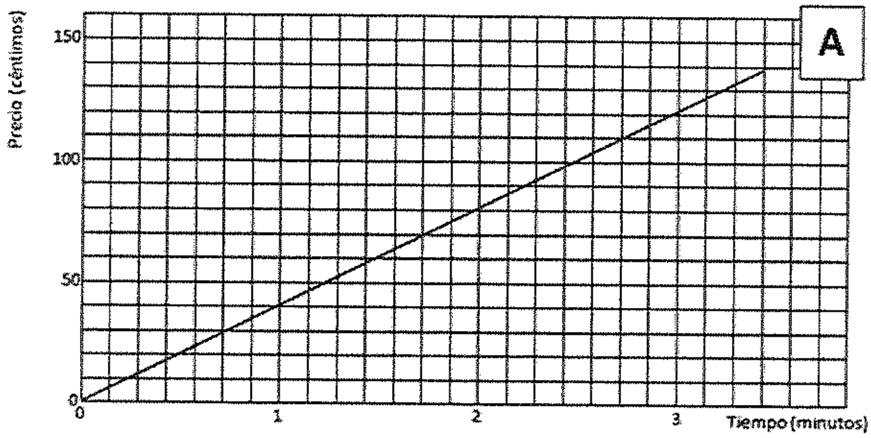
A. 15°
B. 30°
C. 7,5°
D. 22,5°

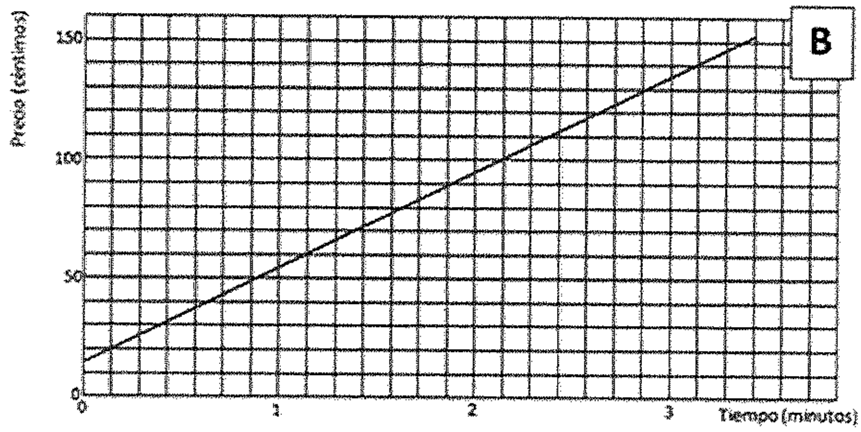
E GASTO DE TELÉFONO MÓVIL

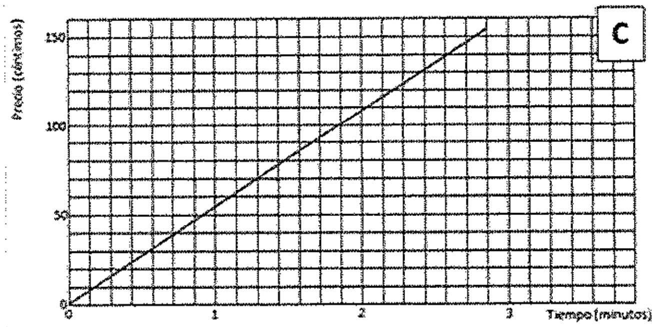
A Jon le parece que está pagando mucho dinero por la utilización de su móvil y han decidido cambiar de operador. Tras analizar diferentes opciones, Jon ha optado por la siguiente tarifa:

- 40 céntimos/minuto para llamadas a cualquier destino, y sin coste por el establecimiento de llamada.
- 15 céntimos/sms

01 Entre las siguientes gráficas, ¿cuál relaciona el coste de cada llamada en céntimos de euro con su duración en minutos para la tarifa de Jon?







A. La gráfica A
B. La gráfica B
C. La gráfica C
D. Ninguna

02 ¿Cuál es la constante de proporcionalidad entre el precio en céntimos de euro y la duración de llamada en minutos para la tarifa de Jon?:

A. r = 40
B. r = 0.40
C. r = 4
D. r = 0.040

03 Entre las siguientes fórmulas elige la función que relaciona el coste diario para la tarifa de Jon considerando que éste realiza "a" envíos de sms y "b" llamadas.

A. p = a/15 + b/40
B. p = 15.a + 40.b
C. p = 15.a + b/40
D. p = 40.(a+b) + 15

04 La relación entre el coste de cada llamada en céntimos de euro con su duración en minutos para la tarifa de Jon es una relación de:

A. Proporcionalidad directa.
B. Proporcionalidad inversa.
C. Proporcionalidad.
D. No es de proporcionalidad.

F VIAJE DE ESTUDIOS

Los alumnos de 2° ESO están preparando un viaje de estudios y para sacar dinero van a vender bocadillos, sándwiches y pinchos durante la semana cultural del centro educativo. Han acordado la siguiente tabla de precios (en euros):

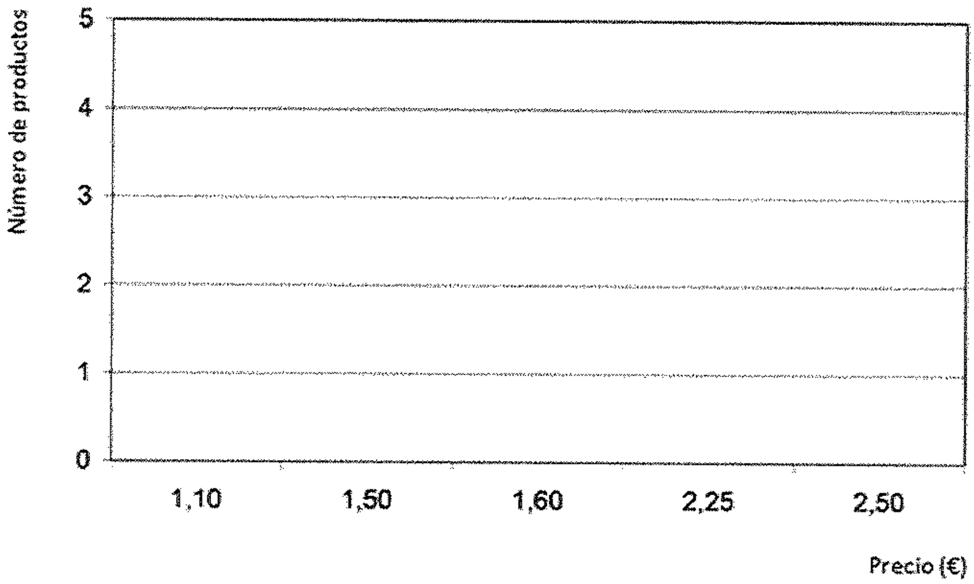
BOCATA							PINTXO		
Bocata tortilla	Bocata salchichón	Bocata jamón York	Bocata chorizo	Bocata queso	Bocata bacon	Bocata especial	Pintxo tortilla	Pintxo txaka	Pintxo especial
2,25€	1,60€	1,60€	1,60€	1,60€	1,50€	2,50€	1,50€	1,10€	2,25€

01 Según los datos de la tabla, ¿cuál es el precio medio de un bocata?:

A. 1,75 €
B. 1,86 €
C. 1,81 €
D. 1,60 €

02

Representa en un gráfico de barras la información de la tabla de precios.



03

De acuerdo a los datos, ¿cuál es la moda?:

A. 1,50 €
B. 1,60 €
C. 2,25 €
D. 2,50 €

04

En la siguiente tabla se recogen los datos relativos a la venta total de bocadillos en el mes de septiembre. Sabemos que se vendieron un total de 150 pintxos. Completa la tabla:

	PINTXO		
	Pintxo tortilla	**Pintxo txaka**	**Pintxo especial**
Cantidad	55		
Porcentaje		30%	
Fracción			1/3

- ¿cómo te has sentido al realizar esta prueba?

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No olvides poner tus datos personales en la portada del cuaderno y en el folio

¡ MUCHAS GRACIAS POR TU COLABORACIÓN !

Annex VII

The battery of instruments in Basque for fourth grade

KOADERNOA

2014/15 Ikasturtea

DBH-ko Bigarren Zikloa

IKASLEA

Ikerketan zehar zure anonimatua eta datu-konfidentzialtasuna bermatzeko, jarraian identifikazio-kode bat emango dizugu. Kode hau gogoratu behar duzu maiatzean egingo duzun hurrengo frogarako.

Horrela, zure izen-abizenez bidez identifikatu beharrean, zuk bakarrik jakingo duzun kode baten bidez identifikatu zaitugu. Horretarako, hurrengo laukiak bete beharko dituzu:

- ☐ Aitaren izeneko iniziala (jakinezean, utzi hutsean)
- ☐ Amaren izeneko iniziala (jakinezean, utzi hutsean)
- ☐ Zure urtebetetzeko eguna (eguna soilik, ez hila) (idatzi zenbakia(k))
- ☐ Zure lehen abizeneko iniziala

INFORMAZIO PERTSONALA

☐ Mutila ☐ Neska

- ✓ Taldea……………………………Adina (urteak)……………………………
- ✓ Jaiotze-data (urtea / hila / eguna)……………………………………
- ✓ Ikastetxea……………………………………………………………
- ✓ Irakasgaiko hizkuntza: ☐ gaztelania ☐ euskara ☐ ingelesa
- ✓ Pasaden ikasturtean Matematikan aterariko azken emaitza (hurrengo aukeren artean, hautatu bat):

Suspentsua	Nahikoa	Oso ongi	Bikaina
(0 - 4.9)	(5 - 6.9)	(7 - 8.9)	(9 - 10)
☐	☐	☐	☐

- ✓ Errepikatu duzu Lehen Hezkuntzako ikasturterik? ☐ Bai ☐ Ez
  Erantzuna "Bai" bada, zein Lehen Hezkuntzako ikasturte errepikatu duzu?……………………………………
- ✓ Errepikatu duzu Derrigorrezko Bigarren Hezkuntzako ikasturterik? ☐ Bai ☐ Ez
  Erantzuna "Bai" bada, zein Lehen Hezkuntzako ikasturte errepikatu duzu?……………………………………

I. ATALA

ARGIBIDEAK

Koaderno honetako hurrengo orridaldeetan Matematikari buruzko iritziarekin erlazionatutako galderak erantzun beharko dituzu.

Kontuan izan:

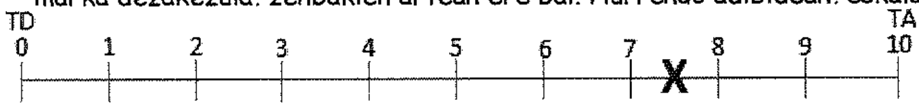
- Galdera-sorta hau erantzutea **GUZTIZ BORONDAZTEKOA ETA ANONIMOA** da. Hau da, inork ez ditu zure erantzunak jakingo.

- **EZ DA AZTERKETA BAT**, eta honen ondorioz, ez dago erantzun onik ezta txarrik ere.

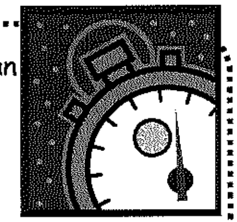
- **ERANTZUN ZINTZOTASUNEZ.**

ADI !

- Erantzun **GALDERA GUZTIAK.**
- Erantzun esaldiak **ERANTZUN BAKAR BATEKIN** .Esaldi bakoitzarako, markatu behin.
- Esaldi bakoitzarako, **MARKATU "X" BATEKIN ZURE ADOSTASUN-MAILA.** Gogoratu 0-ak "Guztiz desadostasunean" (GD) eta 10-ak "Guztiz adostasunean" (GA) adieratzen dutela, eta eskalan zehar edozein puntu marka dezakezula. zenbakien artean ere bai. Hurrengo adibidean. eskalan



Galderaren bat sortuz gero, altxatu eskua eta itxaron ikasgelan arduraduna zure eserlekura hurbildu arte.



Isilik lan egin, arin eta denborarik galdu gabe, mesedez.

Ez ahaztu koadernoko lehenengo orridaldean zure datu-pertsonalak idazteaz.

It	Esaldia	Adostasun-maila
1	Pertsona batzuen arteko erosketa batean, gutako bakoitzak zenbat eman behar duen kalkulatzean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
2	Matematika ikastea gustuko dut	TD 0 1 2 3 4 5 6 7 8 9 10 TA
3	Matematikako ariketa- edo buruketa-zerrendaren aurrean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
4	Erositakoaren prezioa kalkulatzean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
5	Matematika oso erabilgarria da	TD 0 1 2 3 4 5 6 7 8 9 10 TA
6	Batuketak edo kenketak kalkulagailurik gabe egin behar ditudanean trabatzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
7	Ikaskideekin alderatuta, problema eta ariketa matematikoak ebazterakoan motelagoa naizela ustea dut	TD 0 1 2 3 4 5 6 7 8 9 10 TA
8	Matematikako krontola/azterketako ariketak klasean ikusitakoekin alderatuta desberdinak direnean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
9	Matematikako etxerako lanak buruketa zailak direnean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
10	Nahiz eta ahalegindu, ez dut Matematika ulertzen	TD 0 1 2 3 4 5 6 7 8 9 10 TA
11	Pertsona guztiek Matematika jakin behar dute	TD 0 1 2 3 4 5 6 7 8 9 10 TA
12	Matematikarekin arazoak dauzkat	TD 0 1 2 3 4 5 6 7 8 9 10 TA
13	Matematika krontola/azterketarako ikasten dudanean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
14	Matematika gustuko dut	TD 0 1 2 3 4 5 6 7 8 9 10 TA
15	Matematikan eskolaz kanpo erabalgarriak diren gauza praktikoak soilik irakatsi beharko lirateke	TD 0 1 2 3 4 5 6 7 8 9 10 TA
16	Matematika beren lanbideetan erabiliko dutenek soilik ikasi beharko lukete	TD 0 1 2 3 4 5 6 7 8 9 10 TA
17	Erosketa-tiketa berrikusten dudanean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
18	Matematika ikasten dudanean denbora di-da batean igarotzen zait	TD 0 1 2 3 4 5 6 7 8 9 10 TA
19	Matematika beharrezkoa da bizitzarako	TD 0 1 2 3 4 5 6 7 8 9 10 TA
20	Matematika ikastea dibertigarria da	TD 0 1 2 3 4 5 6 7 8 9 10 TA
21	Ariketa edo problema matematikoak egiten ditudanean denbora di-da batean igarotzen zait	TD 0 1 2 3 4 5 6 7 8 9 10 TA
22	Matematika garrantzitsua da gizartearen garapena errazten baitu	TD 0 1 2 3 4 5 6 7 8 9 10 TA

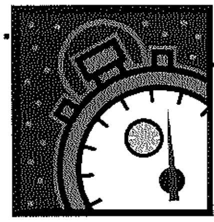
23	Matematika klasea dudan bakoitzean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
24	Matematika klasean ariketa edo buruketa bat egin behar dudanean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
25	Matematikako krontola/azterketetan urduriago jartzen naiz gainontzeko irakasgaietako krontola/azterketeetan baino	TD 0 1 2 3 4 5 6 7 8 9 10 TA
26	Buruzko kalkulu bat egin behar dudanean trabatzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
27	Matematikako krontola/azterketaren aurreko egunean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
28	Ez nintzen Matematika ulertzeko jaio	TD 0 1 2 3 4 5 6 7 8 9 10 TA
29	Potoa jartzen dugunean, gainontzekoa nola banatu kalkulatzean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
30	Matematikako krontola/azterketan ariketaren bat ez dakidanean trabatzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
31	Beheratutako produktu baten salneurri finala kalkulatu behar dudanean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
32	Ez naiz buruketak ebazteko gai	TD 0 1 2 3 4 5 6 7 8 9 10 TA
33	Datorren ikasturtean Matematika berriro ere ikasi beharko dudala pentsatsean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
34	Aste-sariarekin zer eros dezakedan kalkulatzean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
35	Matematika entretenigarria da	TD 0 1 2 3 4 5 6 7 8 9 10 TA
36	Zerbait erosi eta gero, gainerakoak egiaztatzean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
37	Egiten dudana egiten dudala, Matematikan emaitza baxuak ateratzen ditut	TD 0 1 2 3 4 5 6 7 8 9 10 TA
38	Matematika jakiteak lana aurkitzeko aukera gehiago emango dizkit	TD 0 1 2 3 4 5 6 7 8 9 10 TA
39	Matematika oso aspergarria da	TD 0 1 2 3 4 5 6 7 8 9 10 TA
40	Matematika jakitea garrantzitsua izango da nire etorkizuneko lanarako	TD 0 1 2 3 4 5 6 7 8 9 10 TA
41	Klasean matematikako ariketa edo buruketa bat arbelean egiten dutenean, urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
42	Zenbakiak dituen testu baten (berri baten, kartel baten, iragarki batean,...) aurrean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
43	Matematikako etxerako lanak egiten hastean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
44	Biderketak edo zatiketak kalkulagailurik gabe egin behar ditudanean trabatzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
45	Matematikako liburuan formulak ikusten ditudanean	TD 0 1 2 3 4 5 6 7 8 9 10 TA

	urduri jartzen naiz	
46	Matematikako krontola/azterketan urduri jartzen naiz bukatzeko denbora laburra daukadalako ustean	TD 0 1 2 3 4 5 6 7 8 9 10 TA
47	Klasean matematikari buruzko azalpen bat ematen dutenean urduri jartzen naiz	TD 0 1 2 3 4 5 6 7 8 9 10 TA
48	Matematika ulertzea zaila egingo zait beti	TD 0 1 2 3 4 5 6 7 8 9 10 TA
49	Matematika erabilgarria da gainontzeko irakasgaiak ulertzeko	TD 0 1 2 3 4 5 6 7 8 9 10 TA

II. ATALA

ADI !

- **BOLIGRAFOZ** idatzi erantzun guztiak.
- **EZ** erabili **KALKULAGAILUA**.
- Erantzun **GALDERA GUZTIAK**.



Orain **5 MINUTU** edukiko dituzu froga egiteko.

Galderaren bat sortuz gero, altxatu eskua era itxaron ikasgelan dagoen arduraduna zure eserlekura hurbildu arte.

Isilik lan egin, arin eta denborarik galdu gabe.

Ez ahaztu koadernoaren lehenengo orrialdean eta folioan zure datu pertsonalak idazteaz.

A

HASTEKO...

Egin hurrengo eragiketak, erantzunak taulako azken zutabean idatziz..

01

	Eragiketa	Erantzuna
A.	$4 \times [-2 + 3 \times (4 + 2) - 2] : 7$	
B.	$(-24)^4 / (-6)^4$	
C.	$(3 - 2/3) + (3 - \frac{1}{4})$	
D.	$(5/2 - 1) \times 3$	
E.	$(\sqrt{5} + 2) x (\sqrt{5} - 2)$	
F.	$\frac{1}{2} : (1/4 + 1/3)$	
G.	$100^5 \times 10^4$	

- Ariketa hau egitean, zelan sentitu duzu zeure burua?

III. ATALA

ARGIBIDEAK

Erantzun koaderno honetako galderak, mesedez. Litekeena da atal batzuk errazak gertatzen zaizkizula, eta beste batzuk, ordea, zailagoak. Ez da azterketa bat, hots, ez dizute kalifikaziorik ipiniko. Gogoratu anonimoa dela, eta honen ondorioz, inork ez ditu zure erantzunak jakingo.

Galdera-mota desberdinak egongo dira:

- Batzuek 4 erantzun posible edukiko dituzte. Zuzena aukeratu beharko duzu, eta dagokion letra inguratu. Hurrengo adibideak galdera-mota hau erakusten du.

EJEMPLO 1

¿Cuántos meses tiene un año? Rodea la opción correcta.

A.- 2 meses

B.- 17 meses

C.- 12 meses

D.- 11 meses

Gaizki erantzun eta erantzuna aldatu nahi baduzu, "X" batekin ezabatu eta erantzun berria inguratu, hurrengo adibidean agertzen den moduan. Adibidean lehenengoz erantzun A aukeratu zen, eta gero eman nahi zen erantzuna 'C' zela aukeratu zen.

EJEMPLO 2

¿Cuántos meses tiene un año? Rodea la opción correcta.

A.- 2 meses

B.- 17 meses

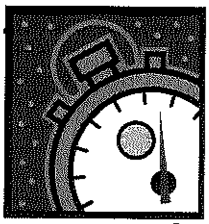
C.- 12 meses

D.- 11 meses

Azkenik, galdera batzuetan grafika bat marraztu beharko duzu. Eskuz irudikatu, marrazki-tresnarik erabili gabe.

ADI !

- **BOLIGRAFOZ** idatzi erantzun guztiak.
- **KALKULAGAILUA** erabil dezakezu.
- Eragiketak egitekotan, erabili koadernoarekin batera emandako **FOLIOA**. Froga bukatu ondoren, bai koadernoa bai folioa entregatu beharko dituzu.
- Erantzun **GALDERA GUZTIAK**, mesedez.



Orain **30 MINUTU** edukiko dituzu froga egiteko.

Galderaren bat sortuz gero, altxatu eskua eta itxaron ikasgelan dagoen arduraduna zure eserlekura hurbildu arte.

Isilik lan egin, arin eta denborarik galdu gabe.

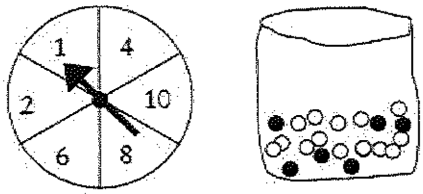
Ez ahaztu koadernoaren lehenengo orrialdean eta folioan zure datu pertsonalak idazteaz.

B FERIA

01 Daniela erruletan jolasean dabil feriako kaseta batean. Jolasa-arauak hurrengoak dira:

- Erruleta zenbaki bikoitian gelditzen bada, poltsatik kanika bat hartu ahal du. Eta kanika beltza bada, sari bat irabaziko du.
- Erruleta zenbaki bakoiti batean gelditzen bada, jolasa bukatutzat emango da.

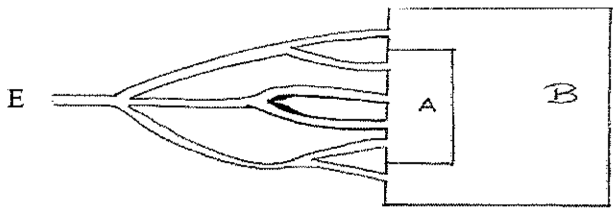
Erruleta eta poltsako kanikak hurrengo irudietan irudikatzen dira:



Zein da saria iabazteko probabilitatea?:

A. 1/4
B. 1/3
C. 1/2
D. 3/4

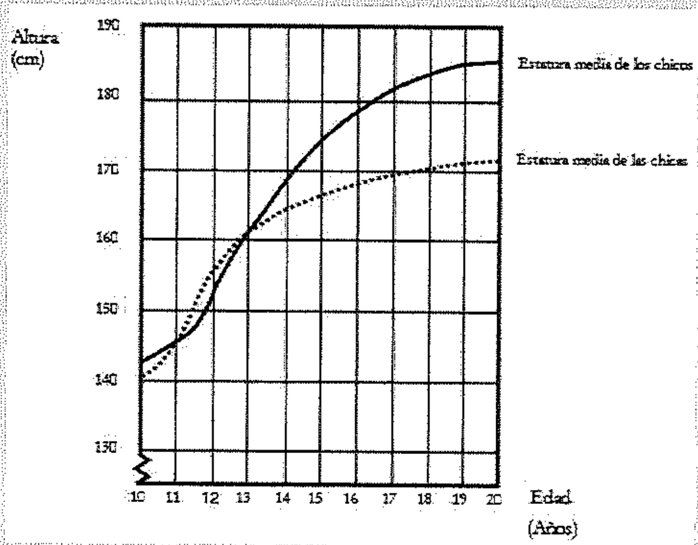
02 Segidan Daniela labirintora abiatuko da. "E" puntutik sartzen bada, eta bidean aukera desberdinekin topatzen dituen bakoitzean aurrerantz abiatzeko aukera hauetako bat itsusmutuan hartzen badu, zein da "A" puntura heltzeko probabilitatea?



A. 2/3
B. 4/3
C. 5/6
D. 1/3

C GAZTERIA GERO ETA ALTUAGOA DA

Hurrengo grakikoak Euskadiko 2013ko gazteriaren batez besteko altuera erakusten du:



01 Aurreko grafikoaren arabera, zein bizitzarotan dira neskak altuagoak beren adineko mutilak baino?:

A. 10 eta 11 urteen artean.
B. 11 eta 12 urteen artean.
C. 11 eta 13 urteen artean.
D. 12 eta 13 urteen artean.

02 Nesken kasurako, zenbatekoa da 10 eta 12 urteen arteko batez-besteko hazte-tasa?:

A. 7,5 cm-koa
B. 10 cm-koa
C. 15 cm-koa
D. 20 cm-koa

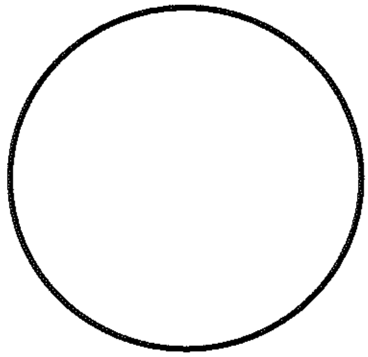
03 Grafikoko datuak frogatzeko, 3.DBH-ko ikasleriaren altuera neurtu dugu, zeinen batez-besteko adina 15ekoa baita. Hurrengo emaitzak jaso ditugu:

Estatura (cm)	[140,150)	[150,160)	[160,170)	[170,180)
Chicos	6	30	12	0
Chicas	0	16	26	10

Aurreko emaitzak kontuan izanda, bete hurrengo maiztasun-taula:

Altuera (cm)	Guztizko maiztasuna	Maiztasun erlatiboa	Portzentaia (%)
[140, 150)			
[150, 160)			
[160, 170)			
[170, 180)			

04 Aurreko galderan aipatutako 3.DBH-ko ikasleriaren kasurako, irudikatu sektore-diagrama.



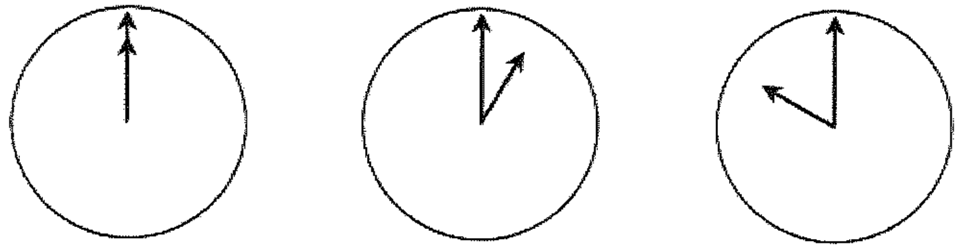
05 "Altuera" aldagaiaren kasurako, hurrengo esaldien artean, zeinek deskribratzen du aurreko balore-banaketaren desbideratze tipikoa?:

A. Zentralizazio-neurri bat da, balore-multzoaren batezbestekoa adierazten duena.
B. Zentralizazio-neurri bat da, datu-banaketako gehieneko maiztasunarena adierazten duena.
C. Zentralizazio-neurri bat da, datu-multzo ordenatutako erdiko aldagaiaren balorea adierazten duena.
D. Sakabanatze-neurri bat da, balore-multzoaren eta batez-besteko balorearen aldea zenbatekoa den adierazten duena.

D

TXATEATU

Mark-ek (Sydnetkoa, Australia) eta Hans-ek (Berlinekoa, Alemania) askotan Interneteko txat-en bidez berba egiten dute. Horretarako, aldi berean konektatu behar dute. Txateatzeko ordu aproposa aurkitzeko, Mark-ek munduko ordu-mapa bilatu eta hurrengoa aurkitu zuen:



Greenwich 12 de la noche — Berlín 1:00 de la noche — Sydney 10:00 de la mañana

01

Sydney-n arratsaldeko 7:00ak direnean, zein da Berlineko ordua? :

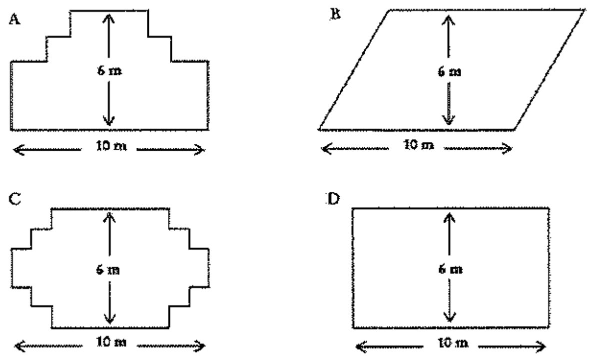
A. Gaueko 4:00ak.
B. Goizeko 10:00ak.
C. Arratsaldeko 4:00ak.
D. Gaueko 10:00ak.

E

LORAZAINTZA

Ikastolako zuzendariak Lehen Hezkuntzarako eskola-baratzea eraikitzea erabaki du.

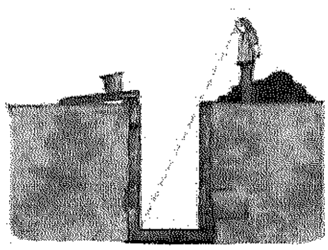
01 Hasiera batean, zuzendariak eskola-baratzerako hurrengo diseinuak hartu ditu kontuan:



Esparruko perimetroa zerratzeko burdineko 32 metro baino ez baditugu, zein diseinu baztertu behar dugu?:

A. A diseinua
B. B diseinua
C. C diseinua
D. D diseinua

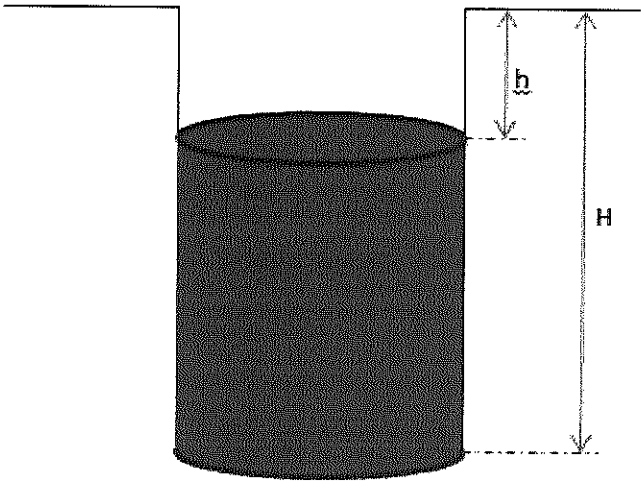
02 Baratza ureztatzeko lurzoruko pozu natural bat aprobetxatzea erabaki da. Zenbatekoa da bere sakonera, zabalera 1,2 m-koa bada eta ertzetik 0,8 m urrundu eta gero, altuerako 1,7 m-tako persona batek pozo-hondarra ikusten badu?



A. 0,56 m-koa
B. 1,5 m-koa
C. 2,55 m-koa
D. 3 m-koa

03

Pozua euri-uraz beteko da. Oinarria zirkularra bada, "d" diametrokoa, eta osoko altuera "H" bada, zenbatekoa izango da ura biltzeko pozuaren kapazitatea, ertzetik uraren azaleraino "d" distantzia uzten dela suposatuz?:

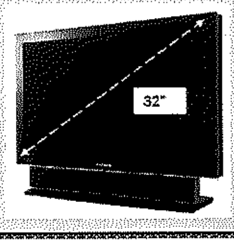


A. $V = \pi.\frac{D^2}{2}.(H-h)$
B. $V = \pi.\frac{D^2}{4}.(H-h)$
C. $V = \pi.\frac{D^2}{2}.H-h$
D. $V = \pi.D.(H-h)$

F

LCD TELEBISTA

Entzute handiko telebista-fabrika batek hurrengo LCD telebista-modeloa merkaturatu du:



01 Hona hemen "x" telebista fabrikatzeko enpresako urteroko gastuak:

$G(x) = 20.000 + 250x$ (euroetan adierazita)

Eta hona hemen salmentetatik jasotako diru-sarreretarakoa:

$S(x) = 600x - 0{,}1x^2$ (euroetan adierazita)

Zenbat telebista saldu behar ditu enpresak gutxienez, diru-sarrerak gastuak baino altuagoak izaten has daitezen?:

A. 57
B. 507
C. 1020
D. 2041

02 G(x) funtzioari dagokionez, hurrengo esaldien artean, zein da zuzena?:

A. Porportzionaltasun zuzenezko funtzioa da, zeinen grafika zuzen bat baita, 20.000 balorezko maldarekin eta 250 balorezko termino independienteraekin.
B. Alderantzizko proportzionaltasunezko funtzioa da, zeinen grafika zuzen bat baita, 20.000 balorezko maldarekin eta 250 balorezko termino independienteraekin.
C. Porportzionaltasun zuzenezko funtzioa da, zeinen grafika zuzen bat baita, 250 balorezko maldarekin eta 20.000 balorezko termino independienteraeki.
D. Alderantzizko proportzionaltasunezko funtzioa da, zeinen grafika zuzen bat baita, 250 balorezko maldarekin eta 20.000 balorezko termino independienteraekin.

03 S(x) funtzioari dagokionez, hurrengo esaldien artean, zein da zuzena?:

A. Alderantzizko proportzionaltasunezko funtzioa da, zeinen grafika zuzen bat baita.
B. Alderantzizko proportzionaltasunezko funtzioa da, zeinen grafika kurba bat baita.
C. Funtzio kuadratikoa da, zeinen grafika parabola bat baita.
D. Funtzio exponentziala da, zeinen grafika kurba bat baita.

04 Telebistak pantailako diagonalako luzeeraren arabera sailkatzen dira. Zenbatekoa izango da telebistako altuera, oinarria 70 cm-koa bada?

Oharra: pulgada eta 25,4mm balio berekoak dira.

A. 32 cm-koa
B. 40,3 cm-koa
C. 41,3 cm-koa
D. 65,23 cm-koa

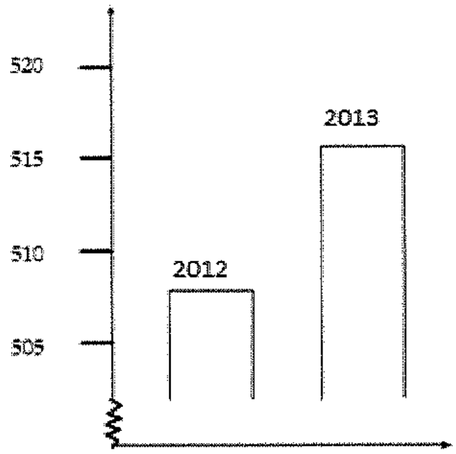
05 Behin erosita, telebista debaluatu egiten da. Izan ere, urte batetik bestera, salneurria balioko %20tan balioaztatzen da. Hasiera batean, 775 eurotan erosiko bagenu, zenbat balioko luke 10 urte barru?

A. 83,21 €
B. 104,02 €
C. 773 €
D. 773,2 €

06

Duela gutxi, aldizkari batean telebista-modelo honetako 2012 eta 2013 urteen arteko salmentak argitaratu ziren. Grafikarekin batera, hurrengo informazioa agertu zen artikuluan:

"Grafikoak erakusten duenez, 2012 urtean, 2013 urtearekin alderatuta, telebista-modelo honetako salmentek izugarrizko gorakada izan zuten".



Zure ustez, aldizkariko baieztapena zentzuzkoa da?:

A. Ez, ez dauka zentzurik. Kazetariek errealitatea exageratzea gustuko dute, eta ez zuten "izugarrizko" hitza erabili beharko.
B. Bai, zentzuzkoa da, urte batetik bestera salmenta-kopurua ia bikoiztu egin baita.
C. Ez, ez dauka zentzurik. Ezin da baieztatu ea gorakada izugarria izan zen. Izan ere, 2011ko salmenta-kopurua eta 2012koa berberak izan balira, ezin ezingo litzateke baieztatu 2013an izugarrizko gorakada egon denik.
D. Ez, ez dauka zentzurik, portzentaiez arituz gero, salmenten gorakada oso txikia izan baita.

- Froga hau egitean, zelan sentitu duzu zeure burua?

Ez ahaztu koadernoaren lehenengo orrialdean
eta folioan zure datu pertsonalak idazteaz.

ESKERRIK ASKO
KOLABORAZIOARENGATIK !

Annex VIII

The battery of instruments in Spanish for fourth grade

CUADERNO

Curso 2014/15

2º CICLO ESO

ESTUDIANTE

Para asegurar tu anonimato y la confidencialidad de tus datos a lo largo de esta investigación, a continuación te asignaremos un código de identificación, que deberás recordar para la siguiente prueba que realizarás en junio.

Así, en lugar de identificarte por tus nombres y apellidos, te identificaremos por un código que únicamente sabrás tú. Para ello, deberás completar las siguientes casillas:

☐ Inicial del nombre del padre (en caso de no saberlo, dejar la casilla en blanco)

☐ Inicial del nombre de la madre (en caso de no saberlo, dejar la casilla en blanco)

☐ El día de tu cumpleaños (sólo el día, no el mes) (con números)

☐ Inicial de tu primer apellido

INFORMACIÓN PERSONAL

Chico ☐ Chica ☐

- Grupo...Edad (años)...
- Fecha de nacimiento (día / mes / año)...
- Centro educativo...
- Idioma de la asignatura: ☐ castellano ☐ euskera ☐ inglés
- Nota final obtenida en el curso anterior en la asignatura de Matemáticas (seleccionar una entre las siguientes opciones):

Suspenso	Aprobado	Notable	Sobresaliente
(0 - 4.9)	(5 - 6.9)	(7 - 8.9)	(9 - 10)
☐	☐	☐	☐

- ¿Has repetido curso en Primaria? ☐ Sí ☐ No
  En caso de que la respuesta sea "Sí", ¿cuántos cursos de Primaria has repetido?...
- ¿Has repetido curso en Secundaria? ☐ Sí ☐ No
  En caso de que la respuesta sea "Sí", ¿cuántos cursos de Secundaria has repetido?...

PARTE I

INSTRUCCIONES

En las páginas siguientes de este cuadernillo deberás responder a una serie de preguntas relacionadas con tu opiniónsobre las Matemáticas.

Ten en cuenta lo siguiente:

- Rellenar este cuestionario es **TOTALMENTE VOLUNTARIO Y ANÓNIMO**. Es decir, nadie va a conocer tus respuestas.

- **NO ES UN EXAMEN**, por lo que no hay respuestas buenas o malas.

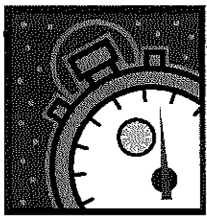
- **RESPONDE CON SINCERIDAD.**

¡ ATENCIÓN !

- Responde a **TODAS** las preguntas.
- Contesta a las frases con **UNA ÚNICA RESPUESTA**. Marca sólo una vez para cada afirmación.
- Para cada afirmación, **MARCA CON UNA "X" TU GRADO DE ACUERDO** con la frase. Recuerda que 0 es "totalmente en desacuerdo" (TD) y 10 es "totalmente de acuerdo" (TA), y que puedes marcar cualquier punto de la escala, incluso entre los números. En el siguiente ejemplo, el grado de acuerdo marcado sobre la escala sería de 7,5:

TD 0	1	2	3	4	5	6	7		8	9	TA 10
								X			

Si tienes alguna pregunta, levanta la mano y espera a que la persona que se encuentra en el aula se acerque hasta tu sitio.



Por favor, trabaja en silencio, rápido y sin perder el tiempo.

No olvides poner tus datos personales en la primera hoja del cuaderno.

It	Afirmación	Grado de acuerdo
1	En una compra entre varias personas, me pongo nervioso al calcular cuánto tiene que poner cada una	TD 0 1 2 3 4 5 6 7 8 9 10 TA
2	Me gusta estudiar Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
3	Me pongo nervioso ante una lista de ejercicios o problemas de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
4	Me pongo nervioso al calcular el precio total de lo que he comprado	TD 0 1 2 3 4 5 6 7 8 9 10 TA
5	Las Matemáticas son muy útiles	TD 0 1 2 3 4 5 6 7 8 9 10 TA
6	Me bloqueo cuando tengo que hacer sumas o restas sin calculadora	TD 0 1 2 3 4 5 6 7 8 9 10 TA
7	Me siento más torpe que mis compañeros/as resolviendo ejercicios y problemas matemáticos	TD 0 1 2 3 4 5 6 7 8 9 10 TA
8	Me pongo tenso/a cuando los ejercicios del control/examen de Matemáticas son distintos a los vistos en clase	TD 0 1 2 3 4 5 6 7 8 9 10 TA
9	Me pongo nervioso/a cuando los deberes de Matemáticas son problemas difíciles	TD 0 1 2 3 4 5 6 7 8 9 10 TA
10	Aunque me esfuerce, no entiendo las Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
11	Todas las personas necesitan saber Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
12	Tengo dificultades con las Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
13	Me pongo nervioso/a cuando estudio para un control/examen de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
14	Me gustan las Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
15	En Matemáticas sólo deberían enseñarse las cosas prácticas que utilizamos fuera del cole	TD 0 1 2 3 4 5 6 7 8 9 10 TA
16	Sólo deberían estudiar Matemáticas aquellos que las vayan a utilizar en sus trabajos	TD 0 1 2 3 4 5 6 7 8 9 10 TA
17	Me pongo nervioso/a cuando reviso el ticket de compra	TD 0 1 2 3 4 5 6 7 8 9 10 TA
18	Se me pasa el tiempo volando cuando estudio Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
19	Las Matemáticas son necesarias para la vida	TD 0 1 2 3 4 5 6 7 8 9 10 TA
20	Estudiar Matemáticas es divertido	TD 0 1 2 3 4 5 6 7 8 9 10 TA
21	Se me pasa el tiempo volando cuando resuelvo ejercicios/problemas de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
22	Las Matemáticas son importantes porque favorecen el avance de la sociedad	TD 0 1 2 3 4 5 6 7 8 9 10 TA
23	Me pongo nervioso/a cuando toca clase de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA

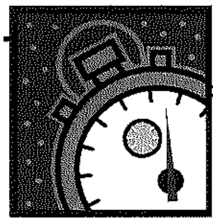
24	Me pongo nervioso/a cuando tengo que resolver un ejercicio/problema en clase de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
25	Me pongo más nervioso/a en los controles/exámenes de Matemáticas que en los controles/exámenes de otras asignaturas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
26	Me bloqueo cuando tengo que hacer un cálculo mental	TD 0 1 2 3 4 5 6 7 8 9 10 TA
27	Me pongo nervioso/a el día previo a un control/examen de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
28	No nací para aprender Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
29	Cuando hacemos un bote común, me pongo nervioso/a al calcular cómo repartir lo que ha sobrado	TD 0 1 2 3 4 5 6 7 8 9 10 TA
30	Durante un control/examen de Matemáticas, me bloqueo cuando no me sale algún ejercicio	TD 0 1 2 3 4 5 6 7 8 9 10 TA
31	Me pongo tenso/a cuando tengo que calcular el precio final de un producto rebajado	TD 0 1 2 3 4 5 6 7 8 9 10 TA
32	Soy incapaz de resolver problemas matemáticos	TD 0 1 2 3 4 5 6 7 8 9 10 TA
33	Me pongo nervioso/a al pensar que tengo que volver a estudiar Matemáticas el curso que viene	TD 0 1 2 3 4 5 6 7 8 9 10 TA
34	Me pongo nervioso/a al calcular qué me puedo comprar con la paga	TD 0 1 2 3 4 5 6 7 8 9 10 TA
35	Las Matemáticas son entretenidas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
36	Cuando compro algo, me pongo nervioso/a al comprobar las vueltas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
37	Haga lo que haga saco notas bajas en Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
38	Saber Matemáticas aumentará mis posibilidades de encontrar trabajo	TD 0 1 2 3 4 5 6 7 8 9 10 TA
39	Las Matemáticas son un "rollo"	TD 0 1 2 3 4 5 6 7 8 9 10 TA
40	Saber Matemáticas es importante para mi futuro trabajo	TD 0 1 2 3 4 5 6 7 8 9 10 TA
41	Me pongo nervioso/a cuando en clase de resuelve un ejercicio/problema de Matemáticas en la pizarra	TD 0 1 2 3 4 5 6 7 8 9 10 TA
42	Me pongo nervioso/a ante un texto (noticia, cartel publicitario, folleto informativo, etc.) con números	TD 0 1 2 3 4 5 6 7 8 9 10 TA
43	Me pongo nervioso/a cuando me pongo a hacer los deberes de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
44	Me bloqueo cuando tengo que hacer multiplicaciones o divisiones sin calculadora	TD 0 1 2 3 4 5 6 7 8 9 10 TA
45	Me pongo nervioso/a cuando veo fórmulas en el libro de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA

46	Durante un control/examen de Matemáticas, me pongo nervioso porque creo que tengo poco tiempo para terminarlo	TD 0 1 2 3 4 5 6 7 8 9 10 TA
47	Me pongo nervioso/a cuando en clase se da una explicación de Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
48	Siempre será difícil para mí aprender Matemáticas	TD 0 1 2 3 4 5 6 7 8 9 10 TA
49	Las Matemáticas son útiles para entender las demás asignaturas	TD 0 1 2 3 4 5 6 7 8 9 10 TA

PARTE II

¡ ATENCIÓN !

- Escribetodas las respuestas con **BOLÍGRAFO**.
- **NO** puedes utilizar la **CALCULADORA**.
- Responde a **TODAS** las preguntas.



Ahora tienes **5 MINUTOS** para hacer esta prueba.

Si tienes alguna pregunta, levanta la mano y espera a que la persona que se encuentra en el aula se acerque hasta tu sitio.

Trabaja en silencio, rápido y sin perder el tiempo.

No olvides poner tu código de identificación en la portada de este cuaderno.

A PARA EMPEZAR...

Realiza las siguientes operaciones aritméticas, escribiendo la respuesta en la última columna de la tabla.

01

	Operación	Respuesta
A.	$4 \times [-2 + 3 \times (4 + 2) - 2] : 7$	
B.	$(-24)^4 / (-6)^4$	
C.	$(3 - 2/3) + (3 - \frac{1}{4})$	
D.	$(5/2 - 1) \times 3$	
E.	$(\sqrt{5} + 2)x(\sqrt{5} - 2)$	
F.	$\frac{1}{2} : (1/4 + 1/3)$	
G.	$100^5 \times 10^4$	

➢ ¿Cómo te has sentido al realizar este ejercicio?

____

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PARTE III

INSTRUCCIONES

Por favor, responde a las preguntas de este cuadernillo. Puede que algunas partes te resulten fáciles y otras más difíciles. No se trata de un examen, es decir, no te van a poner ninguna calificación. Recuerda que es anónimo, por lo que nadie va a conocer tus respuestas.

Habrá distintos tipos de preguntas:

- Algunas tendrán cuatro posibles respuestas. Deberás elegir la correcta y rodear la letra. El ejemplo 1 muestra este tipo de pregunta.

EJEMPLO 1

¿Cuántos meses tiene un año? Rodea la opción correcta.

A.- 2 meses

B.- 17 meses

C.- 12 meses

D.- 11 meses

Si te has equivocado y quieres cambiar la respuesta, tacha con una X y rodea la nueva respuesta, tal y como te mostramos en el ejemplo 2, donde primero se eligió la respuesta A y después se decidió que la respuesta que se quería dar era la C.

EJEMPLO 2

¿Cuántos meses tiene un año? Rodea la opción correcta.

A.- 2 meses

B.- 17 meses

C.- 12 meses

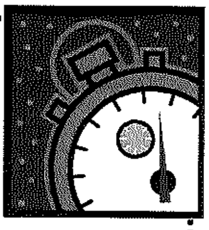
D.- 11 meses

➢ Habrá Finalmente, en algunas preguntas te pediremos que dibujes una gráfica. Dibújala a mano alzada, sin utilizar instrumentos de dibujo.

¡ ATENCIÓN !

- Escribetodas las respuestas con **BOLÍGRAFO**.
- Puedes utilizar la **CALCULADORA**.
- Si necesitas hacer operaciones, utiliza el **FOLIO** que te damos junto con este cuadernillo. Al finalizar la prueba, deberás entregar tanto el cuadernillo como el folio.
- Por favor, responde a **TODAS** las preguntas.

Ahora tienes **30 MINUTOS** para hacer esta prueba.



Si tienes alguna pregunta, levanta la mano y espera a que la persona que se encuentra en el aula se acerque hasta tu sitio.

Trabaja en silencio, rápido y sin perder el tiempo.

No olvides poner tu código de identificacióntanto en la portada del cuaderno como en el folio.

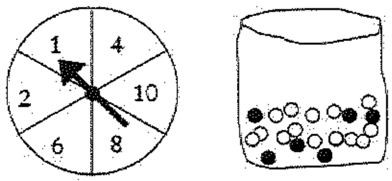
B FERIA

01

Daniela juega a la ruleta en una casa de feria. Las reglas son las siguientes:

- Si la ruleta se para en un número par, puede sacar una canica de la bolsa. Y si la canica es negra, gana un premio.
- Si la ruleta se para en un número impar, se termina el juego.

La ruleta y las canicas de la bolsa se representan en los dibujos siguientes:

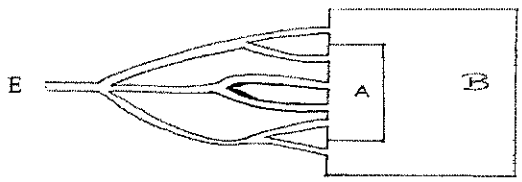


¿Cuál es la probabilidad de que Daniela gane un premio?:

A. 1/4
B. 1/3
C. 1/2
D. 3/4

02

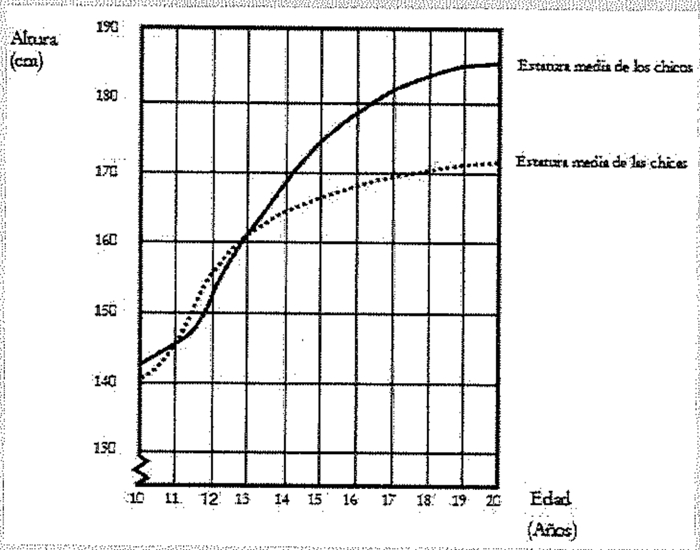
A continuación, Daniela se dirige al laberinto. Si entra por E y avanza tomando siempre al azar un camino entre los posibles que se le presentan, ¿qué probabilidad tiene de acabar en A?:



A. 2/3
B. 4/3
C. 5/6
D. 1/3

C LA JUVENTUD SE HACE MÁS ALTA

La estatura media de los chicos y las chicas de Euskadi en 2013 está representada en el siguiente gráfico:



01

De acuerdo con el gráfico anterior, como promedio, durante qué periodo de su vida son las chicas más altas que los chicos de su misma edad?:

A. Entre los 10 y los 11 años.
B. Entre los 11 y los 12 años.
C. Entre los 11 y los 13 años.
D. Entre los 12 y los 13 años.

02

¿Cuál es la tasa media de crecimiento desde los 10 a los 12 años para el caso de las chicas?:

A. 7,5 cm
B. 10 cm
C. 15 cm
D. 20 cm

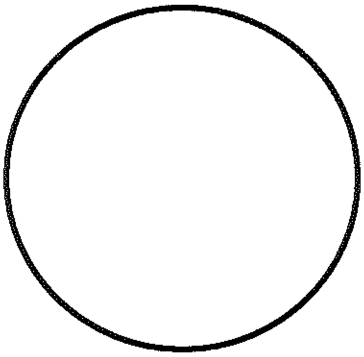
03 Para contrastar los datos de la gráfica, hemos medido las estaturas de los alumnos de 3º ESO, que tienen una edad media de 15 años. Se han obtenido los siguientes valores:

Estatura (cm)	[140,150)	[150,160)	[160,170)	[170,180)
Chicos	6	30	12	0
Chicas	0	16	26	10

A partir de estos datos, rellena la siguiente tabla de frecuencias:

Estatura (cm)	Frecuencia absoluta	Frecuencia relativa	Porcentaje (%)
[140, 150)			
[150, 160)			
[160, 170)			
[170, 180)			

04 Elabora el diagrama de sectores para el caso de los estudiantes de 3º ESO mencionado en el apartado anterior.



05 ¿Cuál de las siguientes afirmaciones nos permite definir la desviación típica de la anterior distribución de valores para la variable estatura?:

A. Es una medida de centralización que representa el promedio del conjunto de valores.
B. Es una medida de centralización que representa el valor con mayor frecuencia de la distribución de datos.
C. Es una medida de centralización que representa el valor de la variable en la posición central del conjunto ordenado de datos.
D. Es una medida de dispersión que representa cuánto se aleja la distribución del valor promedio.

D

CHATEAR

Mark (de Sydney, Australia) y Hans (de Berlín, Alemania) se comunican a menudo a través de Internet mediante el chat. Tienen que conectarse a la vez para poder chatear. Para encontrar una hora apropiada para chatear, Mark buscó un mapa horario mundial y halló lo siguiente:

01

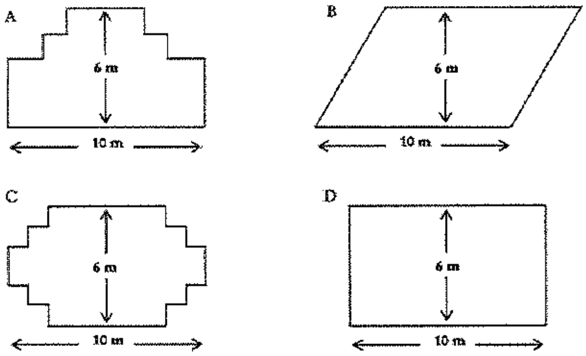
Cuando son las 7:00 de la tarde en Sydney, ¿qué hora es en Berlín?:

A. 4:00 de la noche
B. 10:00 de la mañana
C. 4:00 de la tarde
D. 10:00 de la noche

E JARDINERÍA

En el colegio, el director ha decidido construir una zona de huerta para que los alumnos de Primaria planten diferentes tipos de verduras y hortalizas.

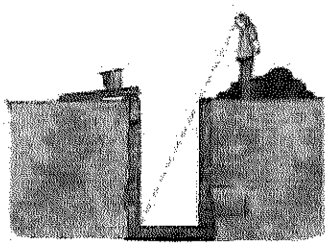
01 Inicialmente, el director está considerando los siguientes diseños para la zona de huerta:



Si tan sólo contamos con 32 metros de longitud de alambre para vallar el perímetro de la zona, ¿qué diseño tenemos que descartar?:

A. Diseño A
B. Diseño B
C. Diseño C
D. Diseño D

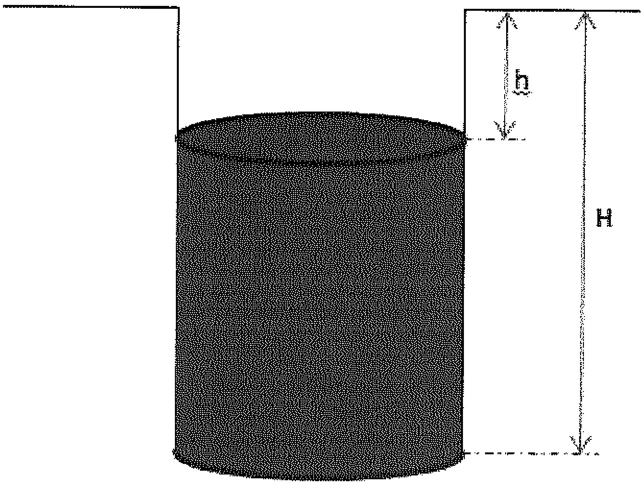
02 Para regar una huerta, se decide aprovechar un pozo ya existente en el terreno. ¿Cuál es su profundidad si su anchura es de 1,2 m y alejándote 0,8 m del borde, una persona de 1,7 m de altura ve que la línea de fondo del pozo?:



A. 0,56 m
B. 1,5 m
C. 2,55 m
D. 3 m

03

El pozo se llenará con agua de lluvia. Si su base es circular, de diámetro "d" y su altura total "H", ¿qué capacidad de almacenamiento de agua tendrá el pozo suponiendo que se deja una distancia "h" desde el borde hasta la superficie del agua?:



A. $V = \pi.\frac{D^2}{2}.(H-h)$

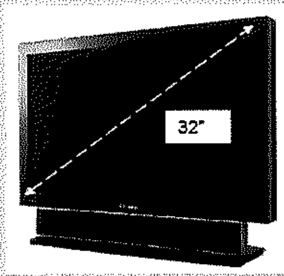
B. $V = \pi.\frac{D^2}{4}.(H-h)$

C. $V = \pi.\frac{D^2}{2}.H-h$

D. $V = \pi.D.(H-h)$

F TELEVISIÓN LCD

Una conocida marca de fabricantes ha sacado al mercado el siguiente modelo de televisión LCD:



01 Los gastos anuales de la empresa por la fabricación de x televisiones son:

$G(x) = 20.000 + 250x$ (en euros)

Y los ingresos que se obtienen por las ventas son:

$I(x) = 600x - 0{,}1x^2$ (en euros)

¿Cuántas televisiones necesita vender la empresa como mínimo para que el nivel de ingresos empiece a superar al de gastos?:

A. 57
B. 507
C. 1020
D. 2041

02 Respecto a la función gastos ($G(x)$), ¿cuál de las siguientes afirmaciones es verdadera?:

A. Es una función de proporcionalidad directa, cuya representación gráfica es unarecta con pendiente m = 20.000 y término independiente de valor 250
B. Es una función de proporcionalidad inversa, cuya representación gráfica es una recta con pendiente m = 20.000 y término independiente de valor 250
C. Es una función de proporcionalidad directa, cuya representación gráfica es una recta con pendiente m = 250 y término independiente de valor 20.000
D. Es una función de proporcionalidad inversa, cuya representación gráfica es una recta con pendiente m = 250 y término independiente de valor 20.000

03 Respecto a la función ingresos (I(x)), ¿cuál de las siguientes afirmaciones es verdadera?:

A. Es una función de proporcionalidad inversa, cuya representación gráfica es una línea recta.
B. Es una función de proporcionalidad inversa, cuya representación gráfica es una línea curva.
C. Es una función cuadrática, cuya representación gráfica es una parábola.
D. Es una función exponencial, cuya representación gráfica es una curva.

04 Los televisores se clasifican por la longitud de la diagonal de la pantalla medida en pulgadas ("). ¿Cuánto medirá la altura de esta televisión, si la base mide 70 cm?

Nota: Una pulgada equivale a 25,4 mm

A. 32 cm
B. 40,3 cm
C. 41,3 cm
D. 65,23 cm

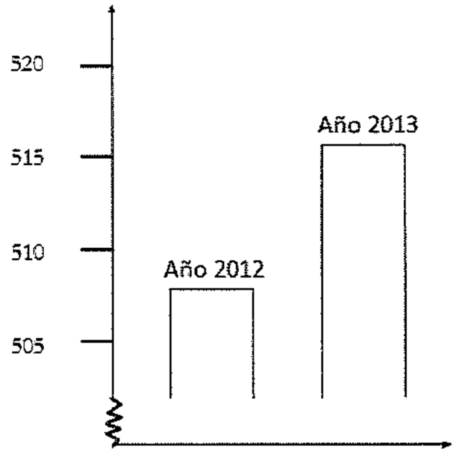
05 Una vez comprada, la televisión se devalúa. Se estima que su valor pierde cada año un 20% de su valor. Si se hubiese comprado por 775 euros, como marcaba inicialmente su precio, ¿cuánto valdría dentro de 10 años?

A. 83,21 €
B. 104,02 €
C. 773 €
D. 773,2 €

06

Recientemente, en una revista se publicó un artículo en el que se exponía las ventas de este modelo de televisor durante los años 2012 y 2013. El gráfico se acompañaba de la siguiente información:

"El gráfico muestra que hay un enorme aumento del número de ventas de este modelo de televisor comparando 2012 con 2013".



¿Crees que la afirmación de la revista es una interpretación razonable del gráfico?:

A. No, no es razonable. A los periodistas les gusta siempre exagerar, y no debería haber utilizado la palabra "enorme".
B. Sí, sí es razonable ya que el número de ventas casi se ha duplicado.
C. No, no es razonable. No se puede confirmar si el incremento es enorme ya que si en 2011 el número de ventas hubiera sido el mismo que en 2012, entonces no se puede afirmar que hay un incremento enorme en 2013.
D. No, no es razonable, ya que en términos de porcentaje, el incremento en las ventas es muy pequeño.

- ¿cómo te has sentido al realizar esta prueba?

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No olvides poner tus datos personales en la portada del cuaderno y en el folio

¡ MUCHAS GRACIAS POR TU COLABORACIÓN !