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Abstract

Although the impact of non-cognitive factors, such as math anxiety, math test-taking anxiety, and attitudes toward mathematics, has been extensively studied, this area remains partially unexplored in the realm of national assessments. This research focuses on the analysis of the validity and reliability of an 11-item questionnaire introduced by the Italian INVALSI Institute during the 2017-2018 school year. The study utilized a sample of 27,188 Grade 5 Italian pupils. Principal Component Analysis and Exploratory Factor Analysis were applied to refine the instrument, resulting in a final version comprising 10 items that measured two constructs: math test-taking anxiety and mathematics enjoyment. Factor analysis confirmed the excellent fit of the two-factor model. Item analyses and reliability analyses demonstrated satisfactory item-total correlations and excellent overall reliability. Consequently, the instrument proves valid and reliable for evaluating students' math test-taking anxiety and math enjoyment. Despite distinctions from larger-scale instruments like OECD-PISA, this research presents an alternative questionnaire suitable for use in both national and large-scale assessments when combined with other standardized instruments.

Introduction

The knowledge of mathematics is fundamental for the proper functioning of adults in today’s world (Ashcraft & Krause, 2007). However, research has shown that several children (cf. Justicia-Galiano et al., 2017), adolescents (cf. Ahmed, 2018; Timmerman et al., 2017), and adults (cf. Hart & Ganley, 2019) suffer from non-negligible levels of mathematics anxiety. Math anxiety is a construct defined as a negative reaction toward mathematics and math-related situations (Ashcraft & Ridley, 2005). It consists of a feeling of tension, anxiety, and avoidance when dealing with numbers or solving mathematics problems (Orbach et al., 2019; Richardson & Suinn, 1972). Mathematics anxiety has numerous impacts on students’ achievements. For instance, research has determined a small-to-moderate negative relationship between math anxiety and math achievements (Ma & Kishor, 1997; Wu et al., 2012). These detrimental effects have been proven to exist also among young (primary school) children as well (Orbach et al., 2019; Ramirez et al., 2013; Wu et al., 2012). An extensive body of research has confirmed the presence of math anxiety among Italian primary school pupils (Cargnelutti et al., 2017a, 2017b; Caviola et al., 2017a; Donolato et al., 2020; Tomasetto et al., 2021), therefore highlighting the importance of studying this phenomenon on a larger national scale.

One of the classifications of anxiety is the so-called state-trait model (Auerbach & Spielberg, 1972). In this model, a neat distinction between anxiety as a state and as a personality trait has been proposed (Orbach et al., 2019). State math anxiety (S-MA) is a temporary situation-related anxiety. Among these situations, math test-taking is considered to have an important impact (cf. Carey et al., 2017; Hopko, 2003; Hopko et al., 2003; Plake & Parker, 1982; Richardson & Suinn, 1972). Research has shown a middle-to-high correlation between math test-taking anxiety and math anxiety (Devine et al., 2012; Dew et al., 1984; Dowker & Sheridan, 2022; Kazelskis et al., 2000; Seng, 2015).

Trait math anxiety (T-MA) is a personality trait, which is enduring in time. Among T-MA, the fear of failure plays an important role (Auerbach & Spielberg, 1972; Orbach et al., 2019). Some authors (cf. Ross et al., 2015) have found some discrepancies between T-MA and S-MA in self-reports of emotions, leading to an overestimation of trait emotions in comparison with state (Buehler & McFarland, 2001). The relationship between T-MA and S-MA is moderate (Fernández-Blanco et al., 2023).

The phenomenon of math anxiety and math test-taking anxiety has been widely studied since the 1970s, i. e. since proper instruments for measuring it have been developed, tested, and validated (Ashcraft & Krause, 2007), beginning with the Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972). In the next decades, several instruments have been proposed (cf. Fernández-Blanco et al., 2023). These instruments generally measure general math anxiety (S-MA), math performance anxiety (S-MA), test-taking anxiety (S-MA/T-MA), math error anxiety (T-MA), fear of failure (T-MA), etc. (Orbach et al., 2019).

In the last decade, several large-scale international assessments of mathematical knowledge have implemented a scale to measure math anxiety (and, consequently, math test-taking anxiety) within the interest population (Coronado-Hijón, 2017; Lau et al., 2022; OECD, 2013a, 2023a). For instance, the PISA Technical Report (OECD, 2023b) has explained how mathematics anxiety was measured ("ANXMAT"). The construct of mathematics anxiety is measured with a 4-point Likert scale and is comprised of 5 questions (cf. OECD, 2013b). It was developed in 2003 (OECD, 2005).

Research has also demonstrated the influence of students' attitudes toward mathematics on their academic achievements (Haciomeroglu, 2018; Wu et al., 2012). Specifically, preferences or aversions to mathematics can lead students to avoid activities related to the subject, fostering a belief that they perform poorly in mathematics and perceive it as futile. Moreover, negative attitudes toward mathematics correlate with heightened levels of mathematics anxiety (Akin & Kurbanoglu, 2011). Conversely, positive attitudes serve as a motivational factor, encouraging students to engage in learning (Mazana et al., 2019). Studies conducted with international large-scale assessments indicate that affective variables play a significant role in students' performance on mathematics tests (Areepattamannil et al., 2015; Guzel & Berberoglu, 2010).

Despite the interest in exploring the phenomenon of math test anxiety and attitudes toward mathematics, this construct has been rarely assessed by national standardized assessments of mathematics. In Italy, an attempt to measure pupils' math test anxiety and attitudes toward it (e.g., enjoyment) has been made in the school year 2017-2018. After completing the test of mathematical knowledge, Grade 5 students were asked to answer a questionnaire. Among its questions, eleven items measured the levels of math test-taking anxiety and their enjoyment of mathematics. To the best of our knowledge, the instrument has not been used in other research, nor the results have been employed by researchers and policymakers to suggest changes. Also, except for some works (cf. Falzetti, 2018), the results of the questionnaire have not been analyzed nor published in many publications. Therefore, the present study aims to analyze the validity and reliability of the instrument used by the Italian institute INVALSI to measure students' math test anxiety and enjoyment of mathematics.

Theoretical Framework

Math Anxiety and Math Test-Taking Anxiety

A factor known to impact math achievement is math anxiety (MA), which is characterized by feelings of tension and fear in math-related activities and situations (Ashcraft, 2002; Richardson & Suinn, 1972). MA is not an isolated phenomenon; rather, it is widespread, with high levels present in approximately 17% of the population (Ashcraft & Moore, 2009). High levels of MA are linked to lower math achievements and avoidance of math-related situations (Ashcraft & Ridley, 2005; Barroso et al., 2021; Cargnelutti et al., 2017a, 2017b; Hill et al., 2016). Higher MA leads to an affective drop, resulting in decreased performance due to its presence rather than a lack of competencies (Ashcraft & Moore, 2009), subsequently resulting in lower academic performances, such as lower school grades (Ma & Xu, 2004; Núñez-Peña et al., 2013).

Moreover, negative emotions like fear and worry can impact students' self-efficacy and motivation in math, causing a reduced enjoyment of mathematics, the development of negative attitudes, decreased effort in math-related activities (Choe et al., 2019), or even avoidance of such activities.

The occurrence of MA can be influenced by various factors, including environmental elements like teachers' and parents' attitudes toward math and their perception of their students' or children's abilities, teaching methods, instructional approaches, educational system characteristics, stereotypes (e.g., regarding females' math abilities), and personal factors such as trait anxiety or gender (Beilock et al., 2010; Luttenberger et al., 2019).

MA can be broadly categorized into two main dimensions: trait MA (T-MA) and state MA (S-MA; Orbach et al., 2019). T-MA refers to a stable and enduring predisposition or disposition that individuals possess, reflecting a consistent level of apprehension and discomfort towards mathematical tasks across various situations and contexts (Auerbach & Spielberg, 1972; Orbach et al., 2019). This dimension suggests a long-term tendency for individuals to experience heightened anxiety in mathematical settings. On the other hand, S-MA is a more transient and situation-specific form of anxiety, representing the fluctuating emotional responses individuals may have during specific math-related activities or assessments (Auerbach & Spielberg, 1972; Orbach et al., 2019). S-MA can be influenced by immediate factors such as the difficulty of a particular math task (Daches Cohen et al., 2021;

Demedts et al., 2022; Dew et al., 1984), time constraints (Caviola et al., 2017b; Luttenberger et al., 2019), or the overall stress level experienced in a given moment (Caviola et al., 2017b). Recognizing and understanding both trait and state mathematics anxiety is crucial for developing targeted interventions and strategies to alleviate the negative impact of anxiety on mathematical performance and overall well-being.

Moreover, math anxiety and math test-taking anxiety are closely related phenomena that can significantly impact an individual's performance and attitude towards mathematics (Devine et al., 2012; Dew et al., 1984; Dowker & Sheridan, 2022; Kazelskis et al., 2000; Seng, 2015). Math test-taking anxiety is a more specific subset of math anxiety, focusing on the emotional distress experienced during examinations or assessments in mathematics (Kazelskis et al., 2000). Individuals with math test-taking anxiety may experience heightened stress and fear specifically when faced with mathematical assessments (Dew et al., 1984), potentially affecting their ability to demonstrate their true mathematical abilities during exams (Devine et al., 2012).

Measuring Math Test-Taking Anxiety and Attitudes toward Mathematics

Scales of Math Anxiety and Math Test-taking Anxiety

Since the early 1970s, the study of math anxiety (and, within it, math test-taking anxiety) gained widespread attention, driven in part by the development of several standardized, validated, and reliable scales (Ashcraft & Krause, 2007). Among these scales, the 98-item Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972) emerged as a fundamental instrument for assessing the presence of math anxiety. Due to its extensive length, a revised 24-item version, known as MARS-R, was introduced (Plake & Parker, 1982). This instrument is capable of measuring both state math anxiety (S-MA) and trait math anxiety (T-MA) (Hopko, 2003). Subsequent years saw various modifications and abbreviations, including the Abbreviated Math Anxiety Scale (AMAS; Hopko et al., 2003) and its modified version (mAMAS; Carey et al., 2017), specifically designed for children aged 8-13. These instruments have been translated into multiple languages and validated across various cultural contexts, such as the Italian setting, for use in both high schools and colleges (Primi et al., 2014), as well as in primary schools (Caviola et al., 2017b).

Math Anxiety and Large-scale Assessments

Due to the observed negative correlation between MA and students' achievements in mathematics (Ma & Kishor, 1997; Wu et al., 2012), international large-scale assessments of mathematical knowledge have started incorporating questions related to the MA construct in their tests. This approach aims to gain a clearer understanding of the adverse effects of MA on students' performance. For example, the OECD-PISA test has included such questions since 2003 (OECD, 2005). The instrument incorporates the ANXMAT scale, a 5-item 4-point Likert scale designed to measure students' math anxiety. This tool has been consistently utilized in both OECD-PISA assessments and research aimed at comprehending the role of MA in students' achievements (Coronado-Hijón, 2017; Lau et al., 2022; Lee, 2009; OECD, 2013a, 2023a). Factor analysis has confirmed that this instrument measures the same construct, i.e. math anxiety (Lee, 2009). Far less is known about whether national standardized assessments of mathematical knowledge also include scales measuring math anxiety.

Attitudes toward Mathematics and Large-scale Assessments

Several questions within the self-report background questionnaires of the PISA assessment are intended to gauge students' attitudes toward mathematics (Gjicali & Lipnevich, 2021). These encompass students' attitudes toward the subject itself, subjective norms, intentions, and behavioral engagement (Areepattamannil et al., 2015; Gjicali & Lipnevich, 2021; Lee, 2009; Lee & Stankov, 2013; Wang et al., 2023). Specifically, the PISA questionnaire measures students' attitudes toward mathematics with ten sub-questionnaires (among which the ANXMAT), which encompass students' interest in mathematics (INTMAT; e.g., "I enjoy reading about mathematics", "I look forward to my mathematics lessons", "I am interested in the things I learn in mathematics"), instrumental motivation for mathematics (INSTMOT; e.g., "I will learn many things in mathematics that will help me get a job"), math self-concept (SCMAT; e.g., "I am just not good at mathematics"), and others (OECD, 2013b). The exploration of whether similar questionnaires are incorporated into national assessments remains relatively unexplored, and the validity of such instruments has not been thoroughly investigated.

The Italian Context

In Italy, the Italian institute INVALSI annually assesses students' mathematical knowledge as part of the education system evaluation, employing the INVALSI test for students in Grades 2, 5, 8, 10, and 13 (INVALSI, 2018a). Aligned with the national curriculum, the INVALSI mathematics assessment gauges students' knowledge and skills (INVALSI, 2018a, 2018b). The INVALSI test for primary school pupils is pencil-and-paper, with each student receiving a test comprising several questions. The number of questions may vary annually, and they can be open or closed, requiring diverse forms of interaction. All tests are graded by the INVALSI Institute, following a grading scheme similar to those used in the PISA and TIMSS assessments, i.e. with the Item Response Theory. A score of 0 corresponds to the latent abilities of students in the pilot study, with the score distribution linearly transformed to achieve a student average of 200 and a standard deviation of 40. For primary school pupils, test scores are expressed also in the form of percentages of correct answers.

In the 2017-2018 school year, the INVALSI Institute introduced additional questions in the students' mathematics test to evaluate their levels of test-taking anxiety, attitudes toward mathematics, and the influence of economic, social, and cultural factors (cf. Falzetti, 2018). For instance, the official INVALSI report (INVALSI, 2018c) highlights a gender disparity in opinions and motivations towards mathematics favoring boys; however, the report does not delve into a detailed analysis of the questionnaire results. For the purposes of the current research, our focus is on the questionnaire included at the end of the mathematics test. Although it has not been explicitly labeled as a "math test anxiety questionnaire" nor "math enjoyment questionnaire", we contend that, for the intended purposes of this research, it could have served to measure this construct. To gain a clearer understanding of the constructs measured by the instrument, factor analysis and reliability analysis were conducted.

Methodology

The present research applied the non-experimental quantitative research methodology.

Statistical Sample

In the present research, the secondary data analysis research method was used. The statistical sample from the *Servizio Statistico* webpage (https://serviziostatistico.invalsi.it/) comprised a group of Grade 5 Italian primary school pupils who participated in the 2017-2018 INVALSI mathematics assessment. The sample comprised 27,188 pupils. From the available data, it was impossible to determine the average age of the students in the sample; usually, pupils in Grade 5 are approximately 10 to 11 years old. Also, from the sample, it was impossible to determine the gender of the students or their geographic region.

Instrument

The used instrument is the one presented in the INVALSI questionnaire for grade 5 pupils and reported in the Appendix. The instrument consists of 11 items, 5 of which require the student to think about the INVALSI test that has been taken (e.g., "I was already worried about having to take the test"), and 6 items concern general opinions about mathematics (e.g., "In general, I enjoy learning mathematical topics"). This questionnaire was included at the end of the mathematics test. Students answered the questions on a 4-point Likert scale (i.e., "Not at all", "A little", "Somewhat", "A lot").

Data Analysis

In the present research, both the Principal Component Analysis (PCA) and the Exploratory Factor Analysis (EPA) were used. The PCA was performed to identify the number of dimensions in the scale. Orthogonal rotations were used (Sass & Schmitt, 2010) which are easier to interpret (Williams et al., 2010). Several iterations of the PCA were applied to retrieve a clear factor structure. The following criteria were applied to decide which items should be retained (Zwick & Velicer, 1986):

1. item loadings have to exceed .40 on at least one factor;
2. in items with factor loadings >.30 on more than one factor, a minimum gap of .10 is needed;
3. a factor needs to be identified with at least three significant loadings.

A reliability analysis was performed, as well as an item analysis to identify and eliminate possible problematic items from the final version of the instrument. The item analysis was conducted based on the calculation of the item-total correlations. Values greater than .40 are considered acceptable (cf. Berk, 1978). Finally, the reliability of the overall instrument and its factors were examined by computing both Cronbach's alpha coefficient and McDonald's omega (Ravinder & Saraswathi, 2020). All the data were analyzed using the *Jamovi* statistical software.

Results

Principal Component Analysis

Initially, the factorability of the 11 items was examined. The Kaiser-Meyer-Olkin measure of sampling adequacy was .901, above the commonly recommended value of .600 (Dziuban & Shirkey, 1974). Moreover, all factors had a KMO measure of sampling adequacy greater than .815. Bartlett's test of sphericity was significant ($\chi^2(55)$ = 124214; $p < .001$). Given these indicators, the factor analysis was deemed to be suitable for all 11 items.

A principal component analysis was used to identify and compute composite scores for the factors underlying the 11-item mathematics anxiety attitude questionnaire. With the parallel analysis (Hayton et al, 2004; Çokluk & Koçak, 2016), two components were identified, i.e. math test taking anxiety (Component 1) and math enjoyment (Component 2). The two components explained 38.1% and 23.5% of the variance respectively, for a total of 61.6% of the variance. Solutions for two factors were each examined using the varimax and oblimin rotations of the component loading matrix. Little difference was found in the two rotations for the component loadings, thus the varimax rotation was considered (see Table 1).

Table 1. First PCA Component Loadings

Variable	Component		Uniqueness
	1	2	
Q1A_MAT		.759	.421
Q1B_MAT		.756	.428
Q1C_MAT		.768	.404
Q1D_MAT		-.799	.348
Q1E_MAT			.845
Q2A_MAT	.854		.249
Q2B_MAT	.769		.402
Q2C_MAT	.868		.230
Q2D_MAT	.804		.343
Q2E_MAT	.847		.267
Q2F_MAT	.837		.283

Note. Only loadings greater than .400 are shown.

Before deciding on the final number of factors, we checked the Rotated Component Matrix. We retained the items that had a loading exceeding .40 on at least one factor (1). For the items with factor loadings that exceed .30 (2) more than one factor, a minimum gap of .10 between the loadings is required and at least 3 significant loadings are required for factor identification (3). Considering Table 1 and criterion (1), the item Q1E_MAT had no loading greater than .400 and this item was thus deemed unsuitable. After deleting the aforementioned item, the second PCA with varimax rotation was performed. The number of extracted components was still two (Table 2). The components explained 41.8% and 24.9% of the variance respectively; overall, 66.7% of the variance was explained. All the items respected the criteria (1), (2), and (3) and were thus maintained for future analyses.

The items loaded on the first component were related to math test-taking anxiety, while the items loaded on the second component were related to mathematics enjoyment. Items covered by each component are presented in Table 3, therefore the final version of the questionnaire consists of 10 items.

Table 2. Second PCA Component Loadings

Variable	Component		Uniqueness
	1	2	
Q1A_MAT		.765	.412
Q1B_MAT		.765	.413
Q1C_MAT		.776	.390
Q1D_MAT		-.798	.348
Q2A_MAT	.855		.248
Q2B_MAT	.770		.402
Q2C_MAT	.870		.228
Q2D_MAT	.805		.341
Q2E_MAT	.849		.267
Q2F_MAT	.839		.282

Note. Only loadings greater than .400 are shown.

Table 3. Components from the PCA and the Questions related to them

Components	Items
Math test anxiety	[Q1A_MAT] I was already worried about having to take the test.
	[Q1B_MAT] I was so nervous that I couldn't find the answers.
	[Q1C_MAT] While answering, I felt like I was doing poorly.
	[Q1D_MAT] While answering, I felt calm.
Math enjoyment	[Q2A_MAT] In general, I enjoy learning mathematical topics.
	[Q2B_MAT] I like reading math books.
	[Q2C_MAT] I am happy to study mathematics.
	[Q2D_MAT] I am interested in learning math well.
	[Q2E_MAT] I like learning new mathematical topics.
	[Q2F_MAT] I can't wait for the math lesson.

Exploratory Factor Analysis

An Exploratory Factor Analysis (EFA) was used to identify and compute composite scores for the factors underlying the test anxiety and mathematics attitude questionnaire. We used a parallel analysis (Hayton et al, 2004; Çokluk & Koçak, 2016) and the minimum residual extraction method. Two factors were identified, i.e. math test-taking anxiety (Factor 1) and math enjoyment (Factor 2). The varimax rotation was used to explore the factor loadings (see Table 4).

The first factor explained 38.9% of the variance, while the second factor explained 19.4% of the variance, for a total of 58.3% of the variance.

The EFA model fit was evaluated by the standards proposed by Hu & Bentler (1999) and Brown (2015). An excellent fit was found for the two-factor model for the data:

- the RMSEA was .0361 (90% CI [.337; .0387]), lower than the recommended <.06 (Hu & Bentler, 1999);
- the TLI was 0.988, higher that than the recommended ≥.95 (Bentler, 1990; Hu & Bentler, 1999).

Table 4. The EFA Factor Loadings

Variable	Factor		Uniqueness
	1	2	
Q1A_MAT		.659	.556
Q1B_MAT		.659	.557
Q1C_MAT		.684	.519
Q1D_MAT		-.732	.443
Q2A_MAT	.830		.295
Q2B_MAT	.719		.453
Q2C_MAT	.849		.267
Q2D_MAT	.767		.316
Q2E_MAT	.816		.314
Q2F_MAT	.816		.303

Note. Only loadings greater than .400 are shown.

Reliability Analysis

After the EFA, an item analysis was performed to identify and eliminate possible problematic items from the final 10-item instrument. The item discrimination was checked through the corrected item-total correlation values. All the identified item-total correlations were >.30, thus the correlations are considered acceptable (cf. Zijmans et al., 2018). The corrected item-total correlations (*r*) are presented in Table 5. In this table, the means and standard deviations of each item are presented as well.

Table 5. Item-total Correlation Coefficients

Item	*M*	*SD*	*r*
Q1A_MAT*	2.63	1.02	.334
Q1B_MAT*	3.24	.883	.321
Q1C_MAT*	2.63	.980	.365
Q1D_MAT	2.59	1.00	.407
Q2A_MAT	3.40	1.21	.730
Q2B_MAT	2.74	1.22	.604
Q2C_MAT	3.39	1.22	.735
Q2D_MAT	3.81	1.10	.655
Q2E_MAT	3.61	1.15	.707
Q2F_MAT	3.08	1.30	.699

Note. * Item reversed in analysis.

As seen in Table 5, each item's corrected item-total correlation values ranged from a minimum of .321 to a maximum of .735. This suggests that all items work well and there is no need to eliminate any of them from the scale.The reliability of the final version of the questionnaire was assessed by employing internal consistency measures. The reliability of the overall instrument was measured with Cronbach's alpha (α) and McDonald's omega (ω) coefficients. The overall reliability is very good (α = .856; ω = .860). Moreover, the internal consistency of the math test anxiety (α = .783; ω = .784) was very good, and the consistency of the math enjoyment (α = .915; ω = .916) was excellent.

Furthermore, as depicted in Table 5, it is evident that students predominantly expressed strong agreement with questions Q2D_MAT ("I am interested in learning math well"; *M* = 3.81; *SD* = 1.10) and Q2E_MAT ("I like learning new mathematical topics"; *M* = 3.61; *SD* = 1.15). Conversely, the questions Q1B_MAT ("I was so nervous that I couldn't find the answers"; *M* = 1.76; *SD* = .883) and Q1A_MAT ("I was already worried about having to take the test"; *M* = 2.37; *SD* = 1.02) received the lowest agreement. In general, students exhibited a tendency toward lower agreement with questions related to math test-taking anxiety, suggesting a diminished level of such anxiety among the participants. Notably, students expressed a positive disposition towards the statements in the math enjoyment section of the instrument, indicating an overall enjoyment of learning mathematics.

Discussion and Conclusion

Various non-cognitive factors are believed to have a significant impact on students' performance in mathematics, including their attitudes toward mathematics (Akin & Kurbanoglu, 2011; Areepattamannil et al., 2015; Guzel & Berberoglu, 2010; Haciomeroglu, 2018; (Mazana et al., 2019; Wu et al., 2012), their mathematics anxiety (Ashcraft & Ridley, 2005; Ma & Kishor, 1997; Orbach et al., 2019; Richardson & Suinn, 1972; Wu et al., 2012), and to it correlated (Devine et al., 2012; Dew et al., 1984; Dowker & Sheridan, 2022; Kazelskis et al., 2000; Seng, 2015) mathematics test-taking anxiety (Carey et al., 2017; Hopko, 2003; Hopko et al., 2003; Plake & Parker, 1982; Richardson & Suinn, 1972).

In recent decades, there have been several attempts to integrate large-scale assessments with questionnaires addressing non-cognitive, metacognitive, affective, and motivational factors (cf. Coronado-Hijón, 2017; Lau et al., 2022; OECD, 2005, 2013a, 2023a). The objective has been to gain a more comprehensive understanding of students' achievements on these standardized tests. However, despite the significance of considering various factors that may impact students' performance on mathematics tests, the incorporation of specific questionnaires to measure students' attitudes toward mathematics (e.g., their enjoyment of the subject) or their test anxiety remains relatively scarce, especially in the context of national assessments of mathematical knowledge.

In the 2017-2018 school year, the Italian INVALSI institute, responsible for the periodic assessment of students' knowledge, implemented an additional questionnaire within the mathematics test for Grade 5 pupils. This questionnaire addressed various factors, including pupils' math test-taking anxiety and enjoyment of mathematics (i.e., attitudes toward it). Although the instrument has been mentioned in only a few works (cf. Falzetti, 2018), it has not been formally studied yet. Therefore, the aim of the present research was to examine the constructs measured by the instrument (see Appendix) and assess its reliability.

Through PCA, the initial 11-item instrument underwent refinement by removing one item that did not meet the established criteria. The final version of the instrument consisted of 10 items, measuring two constructs: math test-taking anxiety and mathematics enjoyment. Subsequently, the instrument underwent Exploratory Factor Analysis (EFA), which confirmed the excellent fit of the two-factor model. Following the EFA, item analyses and reliability analyses were conducted to assess the appropriateness of the items. The item-total correlations were all satisfactory (> .300). The overall reliability of the instrument was deemed very good, and the reliabilities of the two subscales were good to very good.

Hence, the instrument utilized in the 2017-2018 INVALSI test for Grade 5 pupils is deemed valid and reliable for measuring pupils’ mathematics test-taking anxiety and math enjoyment. Moreover, educators and researchers can employ the 10-item questionnaire to gain a deeper understanding of pupils’ attitudes toward mathematics and identify the potential existence of high levels of math test-taking anxiety, which represents one component of math anxiety (Devine et al., 2012; Dew et al., 1984; Dowker & Sheridan, 2022; Kazelskis et al., 2000; Seng, 2015). While the instrument cannot directly assess the overall presence of math anxiety, it may be utilized in conjunction with more standardized math anxiety tests (e.g., Carey et al., 2017; Hopko, 2003; Hopko et al., 2003).

The instrument analyzed in this research comprises 10 items and is not directly comparable to certain other instruments used in large-scale research, such as the OECD (2013b). For instance, the OECD-PISA test instrument consists of more than 60 items, measuring 10 different constructs. Nevertheless, some items in the INVALSI instrument are comparable to those employed in the OECD-PISA research (cf. OECD, 2013b). Table 6 presents a comparison of these items. Extracted from the official technical report of the OECD-PISA assessment (OECD, 2013b), the reliabilities for attitudes toward mathematics can be interpreted. For instance, the ANXMAT subscale, intended to measure students' math anxiety, has a reliability of .78, which is comparable to the reliability of the INVALSI instrument (.78). Similarly, the OECD-PISA subscale measuring students’ interest in mathematics (.87) has comparable reliability to the INVALSI subscale measuring students’ enjoyment of mathematics (.92). However, it is important to note that the INVALSI and OECD-PISA research involved students of different ages; INVALSI included Grade 5 pupils (approximately 10-11 years old), while OECD-PISA research involved Grade 10 students (approximately 15-16 years old). Additionally, the two instruments do not share the same items, making their comparison (see Table 6) merely illustrative.

The descriptive statistics derived from pupils’ responses indicate relatively low levels of test-taking anxiety and rather high levels of enjoyment. These results are promising, given the existing literature that establishes a close relationship between math anxiety and math test-taking anxiety (Devine et al., 2012; Dew et al., 1984; Dowker & Sheridan, 2022; Kazelskis et al., 2000; Seng, 2015). Both of these phenomena are known to have a detrimental impact on pupils’ performance in mathematics (Ashcraft & Moore, 2009; Ma & Xu, 2004; Núñez-Peña et al., 2013). Therefore, cultivating positive attitudes toward mathematics and minimizing math test-taking anxiety could potentially enhance pupils’ performance in national assessments (cf. Ashcraft & Moore, 2009), consequently strengthening the reliability of the test results.

Table 6. A Comparison of the INVALSI Instrument and the OECD-PISA Instrument

Anxiety	INVALSI instrument	Equivalent (OECD, 2013b).
Math test anxiety	I was already worried about having to take the test.	I get very tense when I have to do mathematics homework (ANXMAT).
	I was so nervous that I couldn't find the answers.	I get very nervous doing mathematics problems (ANXMAT).
	While answering, I felt like I was doing poorly.	I worry that I will get poor <grades> in mathematics (ANXMAT).
	While answering, I felt calm.	I get very nervous doing mathematics problems (ANXMAT).
Math enjoyment	In general, I enjoy learning mathematical topics.	I do mathematics because I enjoy it (INTMAT).
	I like reading math books.	I enjoy reading about mathematics (INTMAT).
	I am happy to study mathematics.	No equivalent.
	I am interested in learning math well.	I am interested in the things I learn in mathematics (INTMAT).
	I like learning new mathematical topics.	No equivalent.
	I can't wait for the math lesson.	I look forward to my mathematics lessons (INTMAT).

Hence, we recommend that policymakers consider incorporating questions assessing students' math anxiety levels, math test anxiety, and motivation/enjoyment of mathematics into standardized mathematics tests. This inclusion aims to offer a more comprehensive understanding of students' actual knowledge and competencies. Additionally, educators could benefit from this information as an additional resource in their teaching practices. Equipped with insights into students' anxiety levels and their enjoyment of mathematics, educators can tailor their instructional strategies to alleviate anxiety and enhance students' appreciation for the subject. The nuanced information derived from national or other large-scale assessments would aid teachers and policymakers in making informed decisions to enhance the quality of learning. Furthermore, it allows for better management of non-cognitive factors that might otherwise impede students' performance on these assessments.

The instrument used in the 2017-2018 Grade 5 mathematics INVALSI test shares certain similarities with the one utilized in the PISA assessment (OECD, 2013b), and it demonstrates comparable reliability. Consequently, the INVALSI questionnaire could be incorporated into other national assessments and large-scale evaluations. Its concise format may aid respondents in maintaining focus while answering, potentially enhancing data reliability (cf. Bowling et al., 2022; Gogol et al., 2014). However, the instrument has inherent limitations. It lacks the capacity to gauge the complete spectrum and nuances of pupils' intrinsic motivation toward mathematics, as well as their levels of math anxiety. Therefore, further research is imperative to appropriately modify the instrument, ensuring its continued validity and reliability while expanding its scope to measure additional factors that may influence students' performance on standardized mathematics tests.

Limitations

Some limitations should be acknowledged. Firstly, the study employs a substantial sample of Grade 5 Italian pupils; however, information regarding the average age, gender distribution, and regional representation of the students is absent. These demographic factors can significantly influence attitudes and anxiety levels, and their exclusion may restrict the generalizability of our findings. Secondly, the research relies solely on data from the 2017-2018 school year, potentially missing variations in attitudes and test anxiety levels over time. We recommend future research to address this limitation by adopting a longitudinal approach. Thirdly, while the INVALSI instrument is considered valid and reliable within the Grade 5 context, its suitability for other grade levels or diverse educational and cultural settings remains unexplored. Different age groups or educational environments may manifest distinct attitudes and anxiety patterns. Additionally, we propose future research to triangulate our quantitative findings with qualitative data. For example, incorporating student interviews or focus groups could offer a more comprehensive understanding of students' anxiety and attitudes.

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Appendix. The INVALSI Questionnaire

Q1. Thinking about the recent INVALSI Mathematics test you just took, how much do you agree with these statements? Place a cross in only one box for each row.

A. I was already worried about having to take the test.

B. I was so nervous that I couldn't find the answers.

C. While answering, I felt like I was doing poorly.

D. While answering, I felt calm.

E. The math questions were easier than the exercises we usually do.

Q2. Let's talk about the subject of Mathematics. How much do you agree with the following statements? Place a cross in only one box for each row.

A. In general, I enjoy learning mathematical topics.

B. I like reading math books.

C. I am happy to study mathematics.

D. I am interested in learning math well.

E. I like learning new mathematical topics.

F. I can't wait for the math lesson.