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Trait- and State-Components of Mathematics Anxiety versus Perceived Mathematics Anxiety

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Abstract

Negative emotions such as mathematics anxiety (MA) may lead to the avoidance of mathematics, which can have dire consequences for future career-related decisions. This paper compared Grade 10 learners' levels of trait-MA with perceived MA according to the type of school and gender. Both quantitative and qualitative data through a survey conducted with 427 Grade 10 mathematics learners from seven schools were collected. Quantitative data were descriptively analysed, while qualitative data were inductively coded and categorised. Participants from an independent school reported higher levels of trait-MA than those from the other types of schools. Female participants experienced higher levels of trait-MA than their male counterparts. More participants reported perceived MA as opposed to those who measured high levels of trait-MA. MA was viewed as a negative emotional response to activities and situations related to mathematics with a wide range of causes and consequences. This study provides valuable insight for the development of an instrument to measure perceived MA.

Introduction

Globally, an estimated 284 million people suffer from anxiety, thus between 2.5% to 7% per country (Dattani et al., 2021). In South Africa, the corresponding number is approximately 2.15 million individuals, equating to 3.9% of the population (Dattani et al., 2021). In particular, mathematics anxiety (MA) is probably one of the most prevalent anxieties found in educational settings (Luttenberger et al., 2018) across all age groups, and gives rise to a cycle of failure (Preis & Biggs, 2001) MA, due to a negative mathematics experience, can cause mathematics avoidance, which may result in poor mathematics performance. In turn, poor performance in the subject could trigger again MA, just to have a repetitive cycle of MA. However, the Diagnostic and Statistical Manual of Mental Disorders (5th edition) (DSM-5) does not recognise MA as a disorder despite its pertinent prevalence and negative consequences.

According to the DSM-5, diagnostic criteria for all anxiety disorders require anxiety to cause "clinically significant distress or impairment in social, academic, occupational, or other important areas of functioning" to warrant a formal diagnosis (American Psychiatric Association [APA], 2013, p.191). Although terms such as persistent, excessive, inappropriate, and recurrent are used frequently in the description of the level or severity of symptoms in disorder-specific criteria, the DSM-5 does not recognise MA as a disorder. Nevertheless, several researchers (Pizzie & Kraemer, 2017; Young et al., 2012) acknowledged that, in comparison to other subjects taught in high school, MA generates sufficient distress to meet the diagnostic criteria of a specific phobia outlined in the DSM 5 despite the fluctuation in reported prevalence rates.

Mitchell and George (2022) found the prevalence of MA among Grade 4 learners to be much higher than that among Grade 6 learners. Of the 25 Grade 4 learners surveyed, 32.0% reported low MA, 48.0% moderate MA, and 20.0% high MA. Thirty-four percent of the 37 Grade 6 learners reported low MA, 56.8% moderate MA, and only 8.1% high MA. In contrast, Orbach et al. (2019a) found that only 1.3% of the 1289 Grades 4 and 5 learners included in their study were maximal trait-mathematics anxious, 4% were high trait-mathematics anxious and 12% were low trait-mathematics anxious. Hart and Ganley (2019) found MA in a sample of 1000 adults from the general population to be approximately normally distributed with a mean between some and moderate. This variability of the rates can be associated with various factors.

First, there is a variety of quantitative instruments available to measure MA in scientific research, especially when establishing ranges of scores to distinguish between low, moderate, and high mathematics-anxious individuals, such as the Fennema-Sherman Mathematics Anxiety Scale (FSMAS) (Fennema & Sherman, 1976) and the Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972), the two MA scales most commonly used in research studies (Lim & Chapman, 2013). In addition, according to Orbach et al. (2019b), there are disparate testing procedures and numerous qualitative measurement instruments to establish the prevalence of MA, the most commonly used of which are self-report questionnaires. Such questionnaires focus mainly on retrospective mathematics-related situations and cater to subjective views of a person’s own MA without considering the levels of MA experienced, which could be evaluated using a score obtained from a specific measurement instrument. Orbach et al.(2019b) claimed that current MA measures mainly measure trait-MA, as opposed to state-MA. However, learners’ perceptions of their trait-MA affect their mathematics learning and achievement and should thus be contemplated regardless of the scores they obtain on a standardised MA measure of trait-MA.

Secondly, Cipora et al. (2022) postulated that the different wording of the definitions of MA proposed by different authors reflect different understandings of MA, which may explain the wide range of rates reported when it comes to statistics on the prevalence of MA. The results from the 2021 Programme for International Student Assessment illustrate the influence of wide definition criteria on the prevalence of reported MA. When asked whether they agree or strongly agree with five statements involving mathematics, between 29.8% and 61.4% of learners responded that they agreed or strongly agreed with these statements. If MA is, for example, determined by asking questions concerning general worries about mathematics, most respondents appear to suffer from some degree of MA (Orbach et al., 2019b).

Thirdly, the various models of affect in mathematics education proposed by researchers such as McLeod (1992), DeBellis and Goldin (1997), Hannula (2011), and Grootenboer and Marshman (2016), which include MA as a component of affect, highlighted both the complexities and significance of MA in the learning and the teaching of mathematics. More recently, Buckley et al. (2016) and Orbach et al. (2019b) explicitly distinguished between trait and state components of MA. Trait-MA is viewed as an acquired and relatively enduring individual disposition or personality trait causing an individual to perceive a variety of mathematics situations as potentially dangerous (Orbach et al., 2019b). In contrast, state-MA is defined as a temporary anxiety reaction to situations related to mathematics that is experienced on-task and associated with increased arousal of the autonomic nervous system (Buckley et al., 2016; Orbach et al., 2019b).

Lastly, according to Lim and Chapman (2013), most research studies on MA focus on consequences and are quantitatively using a standardised instrument such as the Fennema-Sherman Mathematics Anxiety Scale (FSMAS) (Fennema & Sherman, 1976) and the Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972). Recent studies that made use of the FSMAS include studies by Acevedo et al. (2020) revealing an inverse correlation between academic performance and MA, Mkhize (2019) concluding that MA impacts how pre-service accounting teachers learn and perform accounting calculations, and Türkmenoğlu and Yurtal (2020) finding a moderately negative correlation between MA of Grade 4 learners and their mathematics self-efficacy perceptions. However, the author could not find qualitative studies addressing perceived MA, and, especially, on the type of school and gender.

Therefore, the main research question is: How do Grade 10 mathematics learners' levels of trait-MA compare with their perceived MA according to the type of school and gender?
The following sub-research questions were interrogated to answer the main research question:

(1) What are Grade 10 mathematics learners' levels of trait-MA according to the type of school and gender?
(2) How do Grade 10 mathematics learners' levels of trait mathematics anxiety compare with their perceived mathematics anxiety?
(3) What are Grade 10 mathematics learners' perceptions of mathematics anxiety?

Next, the literature review interrogates the construct of MA by differentiating between trait-MA and perceived MA and their role in learning mathematics. A discussion of both historic and current perspectives on MA illuminates the theoretical underpinning for this study and, in turn, culminates in a definition of trait-MA and perceived MA, as operationalised in this study.

Evolution of the Definition of Mathematics Anxiety

Definitions of MA, as a multidimensional construct, have evolved considerably over the past decades. Initially, Gough (1954) coined the term mathemaphobia comparing the fear of mathematics to a disease as general as a common cold but difficult to recognise until it has become chronic. Dreger and Aiken (1957) coined number anxiety, referring to emotional factors that disrupt the mastery of mathematics. Later, Richardson and Suinn (1972, p. 551) developed a well-known definition of MA, as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations". Lazarus (1974) added the emotional and intellectual block that develops, due to an irrational and impending dread of mathematics, as "mathophobia". Fennema and Sherman (1976) defined a comprehensive definition of MA, as feelings of anxiety, dread, nervousness, and associated bodily symptoms related to mathematics activities. MA is furthermore seen as the panic, helplessness, paralysis, and mental disorganisation experienced when required to solve a mathematical problem (Tobias & Weissbrod, 1980). Richardson and Woolfolk (1980) claimed that MA is the experience of negative reactions when encountering mathematical concepts or procedures during mathematical evaluation that hints at a relationship between MA and test anxiety. According to Cemen (1987), MA is a state of anxiety in response to situations involving mathematics that are seen to be a threat to self-esteem. Lately, Pletzer et al. (2016) viewed MA as feelings of tension, discomfort, high arousal, and physiological reactivity that interfere with number manipulation and mathematical problem-solving. In particular, the dynamic interaction between MA risk factors and heterogenic symptoms advocated by Rubinsten et al. (2018), and the intertwining emotional, cognitive, and attitudinal elements proposed by Yeo (2004), paint a complex picture of MA. The simple definition of MA as a fear of mathematics has thus evolved into a complex and multidimensional definition of MA (Radišić et al., 2015).

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Although the broad definition of MA, as a state of emotion underpinned by traits of fear and dread, alludes to the trait and state components of MA (Hembree, 1990), it is Buckley et al. (2016) and Orbach et al. (2019b) who explicitly defined the trait- and state- components of MA, aligned with the state-trait model of anxiety, coined by Spielberger (1972). Spielberger (1972) defined trait anxiety as an individual's predisposition to respond, and state anxiety as a transitory emotion characterised by physiological arousal and consciously perceived feelings of apprehension, dread, and tension. According to Buckley et al. (2016), trait-MA operates like an attitude leading to the avoidance of mathematics-related careers, courses, and opportunities. Trait-MA can thus be viewed as an acquired and relatively enduring individual disposition or personality trait causing an individual to perceive a variety of mathematics situations as potentially dangerous. In contrast, state-MA is a temporary anxiety reaction experienced on-task that is associated with increased arousal of the autonomic nervous system and can negatively affect performance (Buckley et al., 2016; Orbach et al., 2019b).

This study is framed by the trait-MA leg of the state-trait model of MA of Orbach et al. (2019b). While Orbach et al. (2019b) defined state-MA as a temporary anxiety reaction situation related to mathematics that is associated with increased arousal of the autonomic nervous system, trait-MA, for this study, is defined as an acquired and relatively enduring individual disposition or personality trait causing an individual to perceive a variety of mathematics related situations as potentially dangerous (Orbach et al., 2019b). Central to trait-MA is a core belief about fear of failure that leads to a primary (value) appraisal of a mathematics-related situation as a threat, if this threat perception is followed by a secondary (control) appraisal that personal resources and coping abilities are lacking, the individual may experience state-MA. The frequency and intensity of state-MA, in turn, have a reciprocal effect on the development of trait-MA.

According to Orbach et al. (2019b), self-report instruments assessing MA by asking participants to respond to descriptions of hypothetical mathematics-related situations are grounded in more competence or identity-related beliefs and can be considered measures of trait-MA. In the context of this study, trait-MA is considered measurable with a standardised instrument such as the FSMAS.

In the past, the construct of perceived MA has not been pertinently coined. In contrast to trait-MA, perceived MA could be viewed as a more subjective construct. For this study, perceived MA is defined as a self-identified emotional response to seeing, doing, and thinking about activities and situations related to mathematics. This emotional response impairs the individual's ability to function optimally in these mathematics-related situations. Perceived MA is independent of the score obtained on a standardised measure of MA. Therefore, the purpose of this paper is to compare Grade 10 learners' levels of trait-MA with perceived MA, according to the type of school and gender.

Method

This study followed a survey strategy where a combination of qualitative and quantitative research methods provided a more complete understanding of a research problem (Creswell & Creswell, 2019). The data collection instrument used for the survey was a questionnaire comprising three sections: (1) Section A collected demographical information; (2) Section B consisted of the Fennema-Sherman Mathematics Anxiety Sub-Scale (FSMAS); and (3) Section C utilised two open-ended questions, namely: What are your perceptions of mathematics anxiety? to explore participants' views on MA; and If you believe you suffer from mathematics anxiety what could the possible reasons be? to interrogate participants' perceived MA.

The Fennema-Sherman Mathematics Anxiety Scale (FSMAS) (Fennema & Sherman, 1976), designed specifically to measure MA in the classroom and validated in various studies with high school learners (Fennema & Sherman, 1976; Yeo, 2004), was considered a suitable fit for this study. The FSMAS measures the MA of participants by asking them to rate their general agreement or disagreement with twelve statements in respect of mathematics related situations in the learning environment on a five-point Likert scale (1 = Strongly disagree, 2 = Mildly disagree, 3 = Neutral, 4 = Mildly agree, 5 = Strongly agree). The 12 statements are divided into four categories: (1) thinking about mathematics; (2) solving mathematics problems; (3) taking mathematics tests; and (4) learning mathematics lessons. These categories are identified by Yeo (2004), as displayed in Table 1.

Table 1. Items of FSMAS

Category	Statement
Thinking about mathematics	Item 1: Mathematics does not scare me at all. Item 7: Mathematics makes me feel uncomfortable and nervous. Item 8: Mathematics makes me feel restless, irritable, and impatient. Item 12: Mathematics makes me feel uneasy and confused.
Solving mathematics problems	Item 3: I usually do not worry about my ability to solve mathematics problems. Item 9: I get a sinking feeling when I think of trying hard mathematics problems. Item 10: My mind goes blank, and I am unable to think clearly when doing mathematics.

Category	Statement
Taking mathematics tests	Item 4: I almost never get stressed out while taking mathematics tests. Item 5: I have usually been at ease during mathematics tests. Item 11: A mathematics test would scare me
Learning mathematics lessons	Item 2: It would not bother me at all to take extra mathematics classes. Item 6: I have usually been at ease in mathematics classes.

For this study, the seven schools, representing all types of secondary schools in the Gauteng province of South Africa, were purposively selected. In the South African context, a public school is a state-controlled school, while an independent school is a privately governed school. All South African public ordinary schools are state-controlled and are categorised into no-fee and fee-paying schools based on their socio-economic status. Under the apartheid era, township schools, located on the outskirts of cities, were attended by black learners, while ex-Model C schools were reserved for white pupils. These terms are not officially acknowledged anymore by the Department of Basic Education but are widely used to refer to schools' resource allocation. Rural schools in South Africa are situated in rural areas with diverse communities.

The seven schools were conveniently selected to ensure they were readily accessible to the researcher and included: (1) public (ex-model C and township), independent, and rural schools; (2) English, Afrikaans, and dual-medium schools; and (3) high schools offering Grade 10 mathematics. The seven high schools comprised one Afrikaans ex-Model C school, two English ex-Model C schools, one dual-medium technical ex-Model C school, an Indian independent school, a township public school, and one rural public school.

The sample consisted of 427 participants from a population of 744 Grade 10 mathematics learners across the seven selected schools, who chose mathematics as a school subject and who agreed to participate voluntarily. The sample included learners from one independent school (n = 29; 6.8%) and six public schools: one rural public school (n = 41; 9.6%), one township public school (n = 49; 11.5%), and four ex model-C public schools (n= 308; 72.1%). The ages of the participants varied from 14 to 18 years (*M* = 15.68, *SD* = 0.921). Table 2 summarises demographic data relating to the participants included in the study.

Table 2. Demographic Details of Participants

School	Type of school	Number of Grade 10 mathematics learners	Number of learners who participated in the study		
			Total n (%)	Male n (%)	Female n (%)
1	Indian independent school	30 (4.0%)	29 (6.8%)	16 (3.8%)	13 (3.0%)
2	Rural public school	44 (5.9%)	41 (9.6%)	22 (5.2%)	19 (4.4%)

School	Type of school	Number of Grade 10 mathematics learners	Number of learners who participated in the study		
			Total n (%)	Male n (%)	Female n (%)
3	English ex-Model C school	110 (14.8%)	75 (17.6%)	14 (3.3%)	61 (14.3%)
4	Afrikaans ex-Model C school	101 (13.6%)	79 (18.5%)	39 (9.1%)	40 (9.4%)
5	Dual-medium technical ex-Model C school	159 (21.4%)	119 (27.9%)	68 (16.0%)	51 (11.9%)
6	Township public school	52 (7.0%)	49 (11.5%)	14 (3.3%)	35 (8.2%)
7	English ex-Model C school	248 (33.3%)	35 (8.2%)	7 (1.6%)	28 (6.6%)
Total		744 (100.0%)	427 (100.0%)	247 (42.2%)	180 (57.8%)

The researcher collected data in person from three schools during school time. Teachers of two other schools also collected data during school time, while data could not be collected during school time at the last two schools, as the data collection process would detract from limited teaching time. The teachers at these two schools handed the questionnaires to the learners to complete in their own time after the purpose had been explained. Data were collected over approximately six weeks in the middle of the South African school year.

Both the demographical data and the data gathered with the FSMAS were analysed descriptively with the assistance of the statistics software programme SPSS (version 27.0). The data were distributed according to the various types of schools and cross-tabulated against participants' gender. Scores for Items 1 to 6 were reversed to align the directionality of all the items to avoid misrepresentation of responses.

The data were read several times to get a sense of what they contained and words or phrases that appeared frequently were noted. Words and phrases with similar meanings were grouped and a code was assigned. Coding was checked with a knowledgeable person to ensure agreement. The qualitative data gathered from the responses to the open-ended questions were captured in a matrix with the rows consisting of the cases (participants) and the columns allowing each answer to be split according to the codes identified. Codes were subsequently grouped into themes. During analysis, the qualitative data were quantified according to frequency to establish trends.

Quality Measures

The reliability of the FSMAS was ensured by calculating the Cronbach Alpha values for the overall score as well for each of the individual items. Principal Component Analysis was used to establish internal validity. The

Cronbach Alpha values as well as the mean inter-item correlations for the subscales were reviewed to test the reliability of the Principal Component Analysis.

The trustworthiness of qualitative results was established through credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1982). Strategies to ensure credibility included peer debriefing and member checks. Providing a thick description of concepts and categories, and structures and processes together with purposive and theoretical sampling, ensured transferability. To safeguard dependability, an audit trail was created, and all findings were controlled against the literature. Meticulous data management and recording and the explicit separation of 1st-order and 2nd-order findings guaranteed confirmability.

Ethical Considerations

Ethical clearance was obtained from the University of Johannesburg (UJ) ethics committee as well as permission from the Gauteng Department of Education to conduct the study. Schools, teachers, parents or guardians, and learners gave consent. The purpose of the study was explained to the participants. They were assured beforehand that completing the questionnaire would not impact their marks. Pseudonyms consisting of an alpha code to indicate the school followed by a code indicating the class and a number to identify the learner, for example, M/10B/12, were assigned to each learner. All ethical measures were adhered to, for example, participants' right to refuse participation or to withdraw their participation at any time, without consequence, the prevention of harm or discrimination against any participant, the anonymity of participants, and confidentiality.

Results

The participants' levels of trait-MA according to the type of school and gender are first displayed. Thereafter, the participants' levels of trait-MA and their perceived MA are compared. Lastly, perceptions about MA are presented.

Participants' Levels of Trait-Mathematics Anxiety according To Type of School and Gender

Descriptive statistics were used to calculate the means and standard deviations for the total FSMAS scores. The demographic information collected in Section A of the questionnaire was cross-tabulated with the means and standard deviations for the FSMAS scores. Summary statistics for the total FSMAS scores across types of schools and gender were calculated, as displayed in Table 3.

Table 3. Summary Statistics for Total FSMAS Scores

Demographic detail		**FSMAS score (Maximum score of 60)**		
		n	**Mean (*M*)**	**Standard deviation (*SD*)**
Type of school	Independent	29	39.3	10.44
	Public – Rural	41	33.1	7.76
	Public – Township	49	37.8	7.73

Demographic detail		**FSMAS score (Maximum score of 60)**		
		n	**Mean (*M*)**	**Standard deviation (*SD*)**
	Public – Ex-Model C	308	36.0	10.07
Gender	Female	247	37.1	9.62
	Male	180	35.0	9.81
Total		427	36.2	9.75

Summary statistics (mean and standard deviation) for the scores obtained on each of the twelve FSMAS items were calculated. Results are reported in Table 4, together with the Cronbach Alpha values for each of the individual items.

Table 4. Summary Statistics and Cronbach Alpha of FSMAS Items

FSMAS item	**Mean (N = 425)**	**Standard deviation**	**Cronbach Alpha value**
Question 1 Reversed: Mathematics does not scare me at all	2.74	1.17	0.85
Question 2 Reversed: It wouldn’t bother me at all to take extra mathematics classes	4.15	1.20	0.88
Question 3 Reversed: I usually don’t worry about my ability to solve mathematics problems	2.67	1.21	0.85
Question 4 Reversed: I rarely get stressed out while taking mathematics tests	2.43	1.33	0.85
Question 5 Reversed: I have usually been at ease during mathematics tests	2.60	1.25	0.85
Question 6 Reversed: I have usually been at ease in mathematics classes	3.36	1.14	0.85
Question 7: Mathematics makes me feel uncomfortable and nervous	2.96	1.36	0.84
Question 8: Mathematics makes me feel restless, irritable, and impatient	2.88	1.38	0.85
Question 9: I get a sinking feeling when I think of trying hard mathematics problems	3.29	1.37	0.84
Question 10: My mind goes blank, and I am unable to think clearly when doing mathematics	2.89	1.41	0.843
Question 11: A mathematics test would scare me	3.09	1.38	0.84
Question 12: Mathematics makes me feel uneasy and confused	3.01	1.34	0.84
Overall	36.2	9.76	0.86

According to Orbach et al. (2019a), when determining the prevalence of MA, a test score that varies one standard deviation from the sample mean value could be considered statistically conspicuous. The mean FSMAS score obtained by participants (N=427) was 36.2 with a standard deviation of 9.76. A score of 46 (one standard deviation or 10 points above the mean of 36) or more may thus be indicative of a considerable level of MA. Six levels of trait-MA were defined by clustering the FSMAS scores obtained by participants, based on the relationship between the mean score and standard deviation, as follows: (1) Non-trait-mathematics anxious - less than two standard deviations below the mean; (2) Low trait-mathematics anxious – above two standard deviations below the mean but below one standard deviation below the mean; (3) Low medium trait-mathematics anxious – below the mean but above one standard deviation below the mean; (4) High medium trait-mathematics anxious – above the mean but below the mean plus one standard deviation; (5) High trait-mathematics anxious – more than one standard deviation above the mean but below two standard deviations above the mean; (6) Maximal trait-mathematics anxious – more than two standard deviations above the mean. A breakdown of the calculations is shown in Table 5.

Table 5. Level of Trait-Mathematics Anxiety Based on Mean and Standard Deviation

Level of trait-MA	Calculation of interval	Actual interval
Non-trait-MA	$FSMAS \leq M - 2\,SD$	$FSMAS \leq 15$
Low trait-MA	$M - 2\,SD < FSMAS \leq M - 1\,SD$	$15 < FSMAS \leq 25$
Low medium trait-MA	$M - 1\,SD < FSMAS \leq M$	$25 < FSMAS \leq 35$
High medium trait-MA	$M < FSMAS \leq M + 1\,SD$	$35 < FSMAS \leq 45$
High trait-MA	$M + 1\,SD < FSMAS \leq M + 2SD$	$45 < FSMAS \leq 55$
Maximal trait-MA	$FSMAS \geq M + 2SD$	$FSMAS \geq 56$

The frequencies for each level of trait-MA were also determined. The number of participants who obtained scores for each level of trait-MA was cross-tabulated against quintiles, gender, and ethnicity. Results are displayed in Table 6.

Table 6. Frequency of Participants' Level of Trait-Mathematics Anxiety

Demographic detail		Non n %	Low n %	Low medium n %	High medium n %	High n %	Maximal n %	Total n %
Type of school	Independent	0 (0.00%)	4 (0.94%)	7 (1.64%)	7 (1.64%)	10 (2.34%)	1 (0.23%)	29 (6.79%)
	Public-Rural	1 (0.23%)	7 (1.64%)	17 (3.98%)	12 (2.81%)	4 (0.94%)	0 (0.00%)	41 (9.60%)
	Public-Township	1 (0.23%)	2 (0.47%)	14 (3.28%)	24 (5.62%)	8 (1.87%)	0 (0.00%)	49 (11.47%)
	Public-Ex Model C	6 (1.41%)	42 (9.84%)	92 (21.55%)	112 26.23%)	51 (11.94%)	5 1.17%)	308 (72.14%)

Demographic detail		Non n %	Low n %	Low medium n %	High medium n %	High n %	Maximal n %	Total n %
Gender	Female	3 (0.70%)	28 (6.56%)	73 (17.10%)	93 (21.78%)	47 (11.01%)	3 (0.70%)	247 (57.85%)
	Male	5 (1.17%)	27 (6.32%)	57 (13.35%)	62 (14.52%)	26 (6.09%)	3 (0.70%)	180 (42.15%)
TOTAL		8 (1.87%)	55 (12.88%)	130 (30.44%)	155 (36.30%)	73 (17.10%)	6 (1.41%)	427 (100.00%)

Participants' Levels of Trait-Mathematics Anxiety versus Their Perceived Mathematics Anxiety

Thereafter, the frequencies of participants with self-reported perceived MA, according to Question 2 in Section C of the questionnaire, and those who measured high- or maximal MA, were compared. Table 7 compares the number of participants with perceived MA, namely, those who self-reported that they suffered from MA by responding with a yes to Question 2 in Section C of the survey questionnaire, with the number of participants who measured high- or maximal trait-MA based on their FSMAS scores. These numbers were cross-tabulated across the type of school and gender. Only two male participants, who responded negatively to the self-report question on perceived MA, had FSMAS scores above 45, indicative of high/maximal trait-MA.

Table 7. Perceived Mathematics Anxiety versus High or Maximal Mathematics Anxiety

Demographic detail		Perceived MA n (%)	High / Maximal trait-MA FSMAS score > 45 n (%)	TOTAL N (%)
Type of school	Independent	24 (8.42%)	11 (13.92%)	29 (6.79%)
	Public – Rural	38 (13.33%)	4 (5.06%)	41 (9.60%)
	Public – Township	198 (69.48%)	8 (10.13%)	49 (11.47%)
	Public – Ex Model C	25 (8.77%)	56 (70.89%)	308 (72.14%)
Gender	Female	180 (63.16%)	50 (63.29%)	247 (57.85%)
	Male	105 (36.84%)	29 (36.71%)	180 (42.15%)
TOTAL		285 (66.74%)	79 (18.50%)	427 (100.00%)

Perceptions about MA

Participants' perceptions about MA were analysed according to the Control-Value Theory of Achievement Emotions (CVTAE), coined by Pekrun et al. (2007). Two specific themes emerged, namely achievement emotions and appraisal. Pekrun et al. (2007) defined achievement emotions as emotions tied directly to achievement activities, thus encompassing most of the emotions experienced during academic learning and achievement. Achievement emotions include not only emotions associated with outcome, namely, success or failure but also activity-related emotions associated with activities such as task demands and classroom instruction. Findings of the qualitative data analyses exploring participants' thinking about MA were coded and deductively categorised according to the theme of *Achievement Emotion*. Results are displayed in Table 8.

Table 8. Codes and Categories on Perceptions of Mathematics Anxiety

Theme	**Categories**	**Codes**	**Frequency of responses (*f*)**	**% out of 423**
Achievement Emotion	Negative emotional reaction or feeling	Afraid/scared	145	34.3%
		Stressed	106	25.1%
		Nervous/anxious / worried / panic	102	24.1%
		Uneasy/uncomfortable/uncertain/flustered/ confused/lack of confidence	25	5.9%
		Unmotivated/despondent/do not care/ overwhelmed	19	4.5%
		Angry/Irritated/frustrated	6	1.4%
	The object of emotional reaction or feeling	Seeing/doing/thinking about anything mathematics related/class	291	68.8%
		Mathematics assessment (tests/exams)	100	23.6%
		Mathematics performance/failure	38	9.0%

The CVTAE postulates that appraisals such as value and control, act as proximal antecedents of the achievement emotions experienced. Central to trait-MA is a core belief about fear of failure that leads to a primary (value) appraisal of a mathematics-related situation as a threat. If this threat perception is followed by a secondary (control) appraisal that personal resources and coping abilities are lacking, the individual may then experience state-MA. The frequency and intensity of state-MA, in turn, have a reciprocal effect on the development of trait-MA. Findings of the qualitative data analyses investigating reasons why (1) participants' primary or value appraisal of mathematics considers it a threat; and (2) participants' secondary or control appraisal is that they lack personal resources and situational-coping abilities in respect of mathematics, were coded and deductively categorised according to the theme appraisal. These codes and categories are displayed in Table 9.

Table 9. Codes, Sub-Categories, and Categories Aligned With Appraisal

Theme	Categories	Sub-categories	Codes	Frequency of responses (*f*)	% out of 423
Appraisal	Primary/Value appraisal: Threat	Importance for future	Access to tertiary educational institutions Career choices Job opportunities	267	63.1%
		External pressure	Perceptions about mathematics Expectations from parents/teachers/peers/significant others	158	37.4%
	Secondary/Control appraisal: Lack of personal resources and situational coping abilities	Concerns about ability	Doubt ability when struggling to understand/do not know Feel not good at mathematics	132	31.2%
		Pressure from self	Personal goals and standards Desire to excel	82	19.4%

Discussion

As previously highlighted, the study distinguished between trait-MA and perceived MA in the following manner: (1) Trait-MA was seen as an individual disposition or personality trait resulting in the individual appraising situations related to mathematics as a threat, ultimately leading to avoidance behaviour (Buckley et al., 2016; Orbach et al., 2019b); (2) The more subjective construct of perceived MA as coined by the authors was viewed as a self-identified emotional response to situations related to mathematics that impairs the individual's ability to function optimally in these situations. Conspicuous levels of trait-MA can often be identified using a standardised measure of MA, such as the Fennema-Sherman Mathematics Anxiety Scale (FSMAS) (Fennema & Sherman, 1976) and the Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972), the two MA scales most commonly used in research studies (Lim & Chapman, 2013). In contrast, perceived MA is mostly independent of the score obtained on a standardised measure of MA. To compare Grade 10 mathematics learners' measured levels of trait-MA to their perceived MA, findings on demographic details in terms of gender and types of schools were considered.

Grade 10 Mathematics Learners' Levels of Trait-MA According To Type of School and Gender

The mean scores of the FSMAS for the independent Indian school (M = 39.3; SD = 10.44) were higher than that of the public schools (M = 35.9; SD = 9.66). This finding confirms the analysis by Lee (2009) of 41 countries that participated in the 2003 Programme for International Student Assessment which showed a high prevalence of MA in Asian countries. The heightened levels of MA found in the Indian independent school may be due to the cultural importance of high mathematics achievement to gain access to tertiary education.

A comparison of the mean scores of the FSMAS scores between gender, as reported in Table 3, shows a difference in the mean score (FSMAS diff = 2.1) with female participants scoring consistently higher (M = 37.1; SD = 9.62) than male participants (M = 35.0; SD = 9.81). These results confirm those of the meta-analysis by Hembree (1990), who found that female participants reported higher levels of MA than male participants across all grade levels investigated. This finding, however, contradicts that of Spangenberg and Van Putten (2020), who found females to have significantly less MA than their male counterparts. Female participants in this study appeared more willing to discuss their struggles with mathematics learning and MA than male participants, which could indicate that they may have been more open to reporting on their MA.

From the results on the frequency of participants' level of trait-MA, a few participants (63 out of 427, 14.75%) reported low levels of trait-MA (FSMAS score of 25 or below). Almost a third of the participants (130 out of 427, 30.44%) measured within one standard deviation below the mean (M = 36.2; SD = 9.75) and were deemed low-medium mathematics anxious (FSMAS score between 25 and 35). More than half of the participants (236 out of 427; 54.81%) scored above the mean (M = 36.2; SD = 9.75), a few of which (73 out of 427; 17.10%) showed high trait-MA (FSMAS score between 45 and 55) and a small number of them (8 out of 427; 1.41%) displayed maximal trait-MA (FSMAS score of above 56). Although a few participants experienced high trait-MA (17.10%) and maximal trait-MA (1.42%), the prevalence of MA is still higher than that recorded by Orbach et al. (2019a) who found that only a small number of learners in their study showed high trait-MA (4%) and maximal trait-MA (1.3%) during the transition from primary to secondary school. The current study used the Fennema-Sherman Mathematics Anxiety Scale (FSMAS) (Fennema & Sherman, 1976) to measure trait-MA, whereas Orbach measured MA with the Mathematics Attitudes and Anxiety Questionnaire (Thomas & Dowker, 2000), which could be a reason for the difference in results. The difference could, however, also be ascribed to how trait-MA levels were defined, and the differences in sample sizes and the age of the participants.

Comparing Levels of Trait Mathematics Anxiety with Perceived Mathematics Anxiety

In the comparison of the number of participants with high or maximal levels of trait-MA, as measured with the FSMAS with the number of participants who self-reported that they suffer from MA, only a few participants (79 out of 427; 18.50%) measured high or maximal levels of trait-MA on the FSMAS, as opposed to many participants (285 out of 427; 66.74%) with perceived MA. This finding concurs with Orbach et al. (2019a) postulating that when definition criteria for MA are narrowed, a much smaller number of individuals will be viewed as mathematics anxious, as opposed to when wider criteria such as asking questions concerning general worries about MA are used. Many participants could thus consider MA to be a fear of mathematics or an emotional reaction to mathematics, as opposed to a narrower, more clinical, definition where the crippling effects of anxiety are considered.

Perceptions about Mathematics Anxiety

From the analysis of how participants perceived MA, a third of the participants equated MA to being scared or afraid (145 out of 423; 34.3%), a quarter described MA as being stressed (106 out of 423; 25.1%), and portrayed MA as being nervous, anxious, worried, or panicking (102 out of 423; 24.1%), while only a few depicted MA as feelings of uneasiness, discomfort, uncertainty, confusion, and lack of confidence (25 out of 423; 5.9%) or feeling unmotivated, despondent, and overwhelmed (19 out of 423; 4.5%). According to a small number of participants (6 out of 423; 1.4%), MA made them feel angry, frustrated, and irritated. Participants' responses could indicate that mathematics is an emotionally laden subject that evokes strong emotions in learners.

Most participants (291 out of 423; 68.8%) described the object of their negative emotional reaction as them seeing, doing, and thinking about activities and situations related to mathematics, for example, mathematics classes. Participant F/K6/17 aptly described MA as "Wanneer jy die woord wiskunde hoor en 'n angsaanval kry" [When you hear the word mathematics and have a panic attack] and Participant TL/10/29 stated: "I think it's when you get nervous or panic when you have to write or attend mathematics, or when you don't understand mathematics". Many participants (100 out of 423; 23.6%) specifically highlighted mathematics assessments, namely tests and examinations, as the object of their MA, for example, Participant M/10A/13 claimed MA is "the fear you have during mathematics classes or tests" and participant ND/10D/18 revealed that MA is "like getting scared when you have to write mathematics tests and exams." Very few of the participants (38 out of 423; 9.0%) referred to worries about their performance in mathematics and the possibility of failing as the object of their MA. Participant M/10B/10 expressed that "mathematics anxiety is being scared that you may fail it, and not believing that you can make it in mathematics". Participant ND/10F/21 also acknowledged that MA is "when mathematics stresses a person out, enough to even have them fail". These findings concur with the emotional manifestations of MA described by other researchers, for example, feelings of tension and anxiety (Richardson & Suinn, 1972); irrational and impeding dread (Lazarus, 1974); feelings of anxiety, dread, and nervousness (Fennema & Sherman, 1976); feelings of tension and discomfort (Pletzer et al., 2016); a state of emotion underpinned by traits of fear (Hembree, 1990); and feelings of pressure, inadequacy, and unease (Radišić et al., 2015). Participants' views thus support a broad definition of MA encompassing a variety of negative emotional reactions where mathematics is involved, as opposed to a more clinical definition of anxiety. These views are confirmed by the results comparing the frequency of participants who self-reported that they suffer from MA versus those who measured high or maximal levels of MA based on their FSMAS scores, which showed a much higher number of participants with perceived MA. Although participants' level of MA may not be considered clinically aligned according to the diagnostic criteria of anxiety disorders in the Diagnostic and Statistical Manual of Mental Disorders (5th ed) (DSM-5), their MA may still cause considerable distress and Grade 10 mathematics learners may notwithstanding benefit from an intervention to combat MA.

Participants' primary or value appraisal was evident in that they perceived mathematics as a threat due to two main reasons. First, the importance of mathematics for the future was emphasised by many participants (267 out of 423; 63.1%), noting that access to tertiary educational institutions, career choices, and job opportunities are dependent on satisfactory mathematics performance. Participant APAX/10A/2 summarised her reason for taking core mathematics as follows: “a wider job variety as well as acceptance into good universities. With mathematics, there are more job opportunities available than there are with mathematics literacy.” Participant JDK/MK2/28 explained: “Because I saw with mathematics literacy it would not take me anywhere and with core mathematics, it can take me as far as I can get”.

Secondly, external pressure due to perceptions about mathematics and expectations from significant others such as parents, teachers, and peers, was reported by more than a third of the participants (158 out of 423; 37.4%). The fear of disappointing significant others may cause MA, as participant N/1-4/22 explained: “people don’t want to disappoint their parents”. Participant F/K6/6 also stated: “jy is bang om mense teleur te stel en slegte punte te kry [you are scared to disappoint people and get bad marks]”. The role of peer pressure was also highlighted as participant JDK/MK2/16 clarified: “When you want to be seen and when you want to be better than someone else”. Participant APAX/10A/5 illustrated: “By surrounding yourself with people who are clever or good at mathematics and it makes you feel very stressed about your own marks or how to do a mathematics question, also by always wanting to be correct”. Participant ND/10C/7 referred to perceptions about mathematics: “Listening to what people say about mathematics makes us think it’s hard and we end up doubting ourselves”. Participant APAX/10B/16 concurred: “There is a common stereotype that mathematics is a hard subject to get good marks in”. This finding confirms Ramirez et al. (2018) arguing that MA can be attributed to social influences from significant others like parents and teachers.

Participants’ secondary or control appraisal was apparent in their acknowledgement that they lacked personal resources and situational coping abilities to deal with the primary threat identified. Several participants raised concerns about their ability to do mathematics (132 out of 423; 31.2%). Participant TL/10/31 stated: “Some learners are not quick to learn”. Participant ND/10C/20 confirmed: “Some learners are slow learners. They take time before they can understand it.” Participant ND/10D/12 declared: “Mathematics requires a lot of problem solving so not everyone is able to solve. I think it puts people under pressure when they can’t solve mathematics problems”. A few participants (82 out of 423; 19.4%) alluded to the pressure they put themselves under due to their personal goals and standards and their desire to excel. Participant F/K3/9 explained: “Die druk wat jy op jouself sit om goed te doen [the pressure you put yourself under to do well]” leads to MA, Participant APAX/10A/9 agreed that MA can be contributed to “the want to do well and get good grades”. This finding corresponds to the view of Cemen (1987) that MA is a state of anxiety in response to situations involving mathematics that are seen to be a threat to self-esteem. Participants’ doubts about their mathematical abilities may explain their belief that they cannot cope with the demands of the subject.

Conclusion

MA is not only one of the most prevalent anxieties in educational contexts, but its negative impact is also far-reaching. The complexity and importance of this construct are also highlighted by the multiplicity of quantitative measures and definitions of MA as well as the array of models of affect in mathematics education. Therefore, the purpose of the study was to compare Grade 10 learners’ levels of trait-MA with perceived MA according to the type of school and gender.

The research study found that many Grade 10 mathematics learners have high levels of trait-MA but also revealed a frequent occurrence of perceived MA. Many participants viewed MA as a negative emotional reaction elicited by mathematics-related settings. In particular, the mean score for participants from the independent school was higher than the participants of the other types of schools, which may point to a cultural difference in the various schools. A comparison of mean scores also revealed that female participants experienced higher levels of MA than their male counterparts. As more participants reported perceived MA than those who measured high or maximal levels of MA, there are still concerns about how learners' perceived MA affect their performance in mathematics.

This finding suggests that the FSMAS as well as other standardised measures of MA may fall short in measuring all aspects of MA, especially on the type of school and gender. Developing and implementing interventions to reduce MA should thus not be limited to individuals who obtained high scores on MA measures such as the FSMAS, but should be context- and gender-sensitive, and consider individuals with perceived MA.

A limitation of the study is that it only investigated the MA of Grade 10 mathematics learners within a specific context. This sample should be broadened to a more representative sample of mathematics learners for other contexts before the results can be generalised. The study also relied only on one single self-report measure of trait-MA, namely the FSMAS, which could have been subjected to various flaws and response bias. A different standardised measure of MA might have given different results. Only descriptive statistics were used to determine the levels of MA. Correlational statistics might have indicated whether the differences in demographics were significant. Larger sample sizes and the inclusion of learners from other phases and subjects such as mathematical literacy may add valuable information to the knowledge base. Repeating the study with an alternative MA measuring instrument may further inform the findings.

Nevertheless, how participants in this study viewed MA provides valuable insight for developing an instrument to measure perceived MA. An understanding of the kinds of MA many learners are suffering from might inform teaching strategies in the mathematics classroom as well as the development of interventions aimed at combating MA.

Recommendations

The large discrepancy between the number of participants that reported perceived MA and the frequency of participants with high- or maximal MA begs the question of whether perceived MA can also impact learning and achievement and may warrant further research.

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