OPEN ACCESS

INTERNATIONAL ELECTRONIC JOURNAL OF MATHEMATICS EDUCATION
e-ISSN: 1306-3030. 2018, Vol. 13, No. 3, 207-219
https://doi.org/10.12973/iejme/3879

Anxiety towards Mathematics of Workers in the Production Area of a Sugar Mill in Veracruz, Mexico

Arturo García-Santillán [1], Tomás Elio Ochoa-Domínguez [1], Jésica Josefina Ramos-Hernández [1*]

[1] *UCC Business School Universidad Cristóbal Colón, MEXICO*

* CORRESPONDENCE: jes.jrh@gmail.com

ABSTRACT

The aim of the study was to measure the level of anxiety towards mathematics among workers in the production area of a factory in the sugar industry. In order to carry out this study, the Muñoz y Mato-Vázquez scale was used (2007) and adapted to the working area. 283 workers from the three different shifts (morning, afternoon and night) were surveyed. For the data analysis and the Exploratory Factorial Analysis technique was used. The reliability of the instrument was acceptable (α = .804 and .945), according to Hair, Anderson, Tatham and Black (1991). The results suggest that the worker experiences anxiety during the evaluation process that they perform as part of the procedures in the production area where math calculations are constantly being used, meaning that the working environment causes anxiety toward math. This is related to the insecurity they feel, mainly due to the level of knowledge they have in mathematics, derived from their schooling level.

Keywords: math anxiety, sugar industry, evaluation

INTRODUCTION

The contribution of this study and where its originality lies is the analyzed context, since evidence was not found regarding existing literature about anxiety towards mathematics in sugar mills. This content focuses on a Mexican sugar mill located in the center area of the state of Veracruz. This industry is highly important in Mexican economy and tradition, where situations and facts that happened in this decade make it an interesting and current topic for analysis. Particularly, mills suffer with the shifts in prices, competition from sugar substitutes in the world market and demand from the producers for a higher guarantee price for the raw material.

Nowadays, Mexico is affected by different social conflicts, among the most common ones mentioned in the media are those related to education, which are linked to recent structural reforms, more specifically, the educational reform from the national development plan. This reform was the result of the low performance Mexican students achieved in different areas of knowledge as well as that of teachers who are responsible for educating Mexican future generations.

In this regard, there is the recent evaluation carried out in the Program for International Student Assessment, where a 28 point increase in math performance stands out between 2003 and 2012. Based on these data we can ask ourselves, how do social conflicts affect students' performance?

Aliaga, Ponce, Gutierrez, Díaz, Reyes, and Pinto (2001) studied the psychological variables related to students' performance in math and statistics in first and second year students from the Psychology School in San Marcos National University in Peru, based on the research by Hoffman (1996) and Mosquera (1999).

Article History: Received 11 April 2018 ◆ Revised 31 July 2018 ◆ Accepted 21 August 2018

Likewise, it is possible to find in the Mexican context the paper "attitude towards mathematics and mathematics with technology: gender studies in middle-school students" by Sanchez-Ruiz and Ursini (2010), whose research includes four aspects: attitudes towards mathematics, the use of technology to teach math as well as gender and performance in math; the former using as basis the paper "Motivation and ability as factors in mathematics experience and achievement" by Schiefele and Csikzentmihalyi (1995).

In this manner, the topic of attitude and anxiety towards math has been studied in the Mexican context with several students' samples. For instance, a permanent research about attitude towards statistics has been developed in college students García-Santillán, Escalera-Chávez, Rojas-Kramer and Pozos-Texon, (2014); Escalera-Chávez, García-Santillán, and Venegas-Martínez, (2014a); Escalera-Chávez, García-Santillán and Venegas-Martínez, (2014b); García-Santillán, Escalera-Chávez, Rojas-Kramer, Córdova-Rangel and Pozos-Texon, (2016) and in elementary school level García-Santillán, Edwards Wurzinger and Tejada-Peña (2015).

Interesting findings have been reported in high school students about anxiety towards math, especially in anxiety towards evaluation and temporality (Escalera-Chávez, Moreno-García, García-Santillán, & Córdova-Rangel, 2016; García-Santillán, Moreno-García, & Hernández-Utrera, 2014; Moreno-García, García-Santillán, & Cristóbal-Hernández, 2014).

Empirical studies about anxiety towards math have also been carried out at college level (García-Santillán, Escalera-Chávez, Moreno-García, & Santana-Villegas, 2016; García-Santillán, Flores-Serrano, López-Morales, & Ríos-Álvarez, 2014; Moreno-García, García-Santillán, Santana-Villegas, & Téllez-Mora, 2015).

Also, regarding anxiety towards math according to gender (Escalera-Chávez, Venegas-Martínez, & García-Santillán, 2016) and when a student starts math courses (Moreno-García, García-Santillán, Santana-Villegas, & Téllez-Mora, 2016). Additionally, about financial math (Rojas-Kramer, García-Santillán, Fuentes-Rosas, Benítez-Moreno, & Córdova-Rangel, 2015) and in the educational software design by college students as product evidence in the financial math teaching process (García-Santillán, Ríos-Álvarez, Portugal-Rincón, Zamora-Lobato, & Pozos-Texon, 2015).

About how technology has influenced the math teaching processes, García-Santillán, Escalera-Chávez, Rojas-Kramer, Moreno-García, and Pozos-Texon, (2016) measured the interaction between math and the computer, the reliability towards the computer, the commitment, the motivation and the perception of technology in the learning process in college education and how a techno-pedagogical model has been adopted. Furthermore, the level of influence from the computer or any other technological device in the math teaching and learning processes has also been measured (García-Santillán, Escalera-Chávez, Rojas-Kramer, Moreno-García, & Santana-Villegas, 2015; García-Santillán, Moreno-García, Ortega-Ridaura, 2016; Rojas-Kramer, García-Santillán, Escalera-Chávez, 2015).

However, there has not been a study about the level of math anxiety or the attitude towards math in workers from a production area in a factory. The existent studies have only been focused in students at different academic levels, so it has become relevant to explore other samples where math is also used as part of people's daily life activities.

The interest that currently encases the sugar industry – which has been a creator of culture for a long time and gave birth to the first agroindustry in America – is considered an inheritance from colonization by Hernan Cortes who brought in plants from Cuba in 1522 (Hernandez, Valencia, & Hernandez, 2013). Nowadays, sugar factories are the main center where populations grow surrounded by chacuacos and the steam whistling so typical in this kind of industry in Mexico.

The activities assigned for production personnel are related to the ability of using basic math applied to the operational level such as dosage, mixtures and extractions of the process, as well as in maintenance activities where the need of math is way more recurrent due to the different specialties such as measurements and accuracy typical of each activity. Therefore, the openness to math must be such that allows the right comprehension and correct use of it for every routine. Based on the arguments described previously, we have to pose the following question: which is the variables structure that best describes the level of anxiety towards math among the production area workers in a sugar factory production?

We intend to specifically answer the following questions:

Which are the dimensions or factors that better explain the level of anxiety among the workers in the sugar factory?

Considering that the Muñoz and Mato-Vazquez scale (2007) was designed to study the anxiety towards math phenomenon in students, the following concern arises:

Could it be possible to apply the Muñoz and Mato-Vazquez scale to sugar factory workers?

Can the level of anxiety towards math be explained with at least one factor?

From here, the following hypotheses are set:

H o1: There is no group of latent variables to explain anxiety towards math.

H i1: There is a group of latent variables to explain anxiety towards math.

H o2: Anxiety towards math cannot be explained at least by just one factor.

H i2: Anxiety towards math can be explained at least by just one factor.

In order to understand the variables involved from theory, an analysis and discussion about the theoretical and empirical fundaments that have explained anxiety towards math is carried out in the following pages.

LITERATURE REVIEW

In order to understand in detail how this theoretical structure about anxiety towards math has been designed for students who are at different academic levels and afterwards to be able to contextualize it to different populations, specifically workers in the production area in a sugar factory, seminal referents are analyzed and discussed next.

Among the seminal referents who have analyzed the topic of anxiety we have Dreger and Aiken (1957) who introduced the term "anxiety towards math" as a variable that allows to describe the difficulties and students' attitude towards math. It is known that it has been difficult to explain this variable ever since, but at least the phenomenon began to be explained based on the opinions of those who wrote about the topic without even using statistical techniques back then to measure this anxiety to math variable (Wood, 1988)

Later on, studies focused on measuring attitude towards math began to be carried out. For these, surveys that included different factors of the variable were used and this made necessary the use of statistical procedures (Dutton & Blum, 1968). Then, the study of math is next and psychometric scales were designed that integrated dimensions related to beliefs, anxiety and student's perception towards math.

About the scales developed to measure the phenomenon of anxiety towards math, there is evidence in literature ever since 1957 with Dreger and Aiken works, to whom one of the first instruments of numerical anxiety is attributed; after them in 1972 Richardson and Suinn designed the Mathematics Anxiety Rating Scale (MARS); then the Fennema-Sherman Mathematics Attitude Scale (1976) is developed. Following this same idea other scales were designed: the Mathematics Anxiety Scale by Sandman (1980) and the Math Anxiety Questionnaire by Wigfield and Mecce (1988).

There is evidence in the consulted bibliography about the abbreviated version of the MARS scale, which was developed in other studies by Levitt and Hutton (1984); Rounds and Hendel (1980); Plake and Parker (1982); Alexander and Martray (1989). It was later used in Suinn and Winston works (2003) who created 30 items from Rounds and Hendel works (1980), Alexander and Cobb (1984), Alexander and Martray (1989). The 30 items gathered were measured through the analysis of principal components with crosswise rotation, from which two factors were obtained that represented 70.3% of variability of the total number of items of the MARS scale. The math anxiety test represented 59.2% of variance; meanwhile numerical anxiety represented 11.1% of variance.

In this specific case of the MARS scale and its psychometric properties, a wide research has been developed (Camp, 1992; Capraro, Capraro, & Henson, 2001; Drew, Galassi, & Galassi, 1984; Resnick, Viehe, & Segal, 1982; Richardson & Suinn, 1972; Rondas & Hendel, 1980; Strawderman, 1985; Suinn & Edwards, 1982). But further studies, which turned out to be really important, are about the deficiencies of the instrument and the underlying construct which turns out to be unidimensional (Richardson & Suinn, 1972; Suinn, Edie, Nicoletti, & Spinelli, 1972). Other studies revealed that there could have been more than one underlying construct of math anxiety (for instance, Alexander & Cobb, 1984; Alexander & Martray, 1989; Brush, 1981; Ferguson, 1986; Plake & Parker, 1982; Resnick et al., 1982; Rondas & Hendel, 1980; Satake & Amato, 1995)

Ling (1982) studied the validity of anxiety towards math as a multidimensional construct and his findings took him to obtain six factors (personal effectiveness; assertiveness; fear towards math; extroversion; success and dogmatism) which represent the 76% of the total variance. Besides, Bessant (1995) showed in his study that 43% of the variance in the MARS scores is explained by six factors: anxiety towards the general evaluation, daily numerical anxiety, anxiety towards passive observation, anxiety towards performance, anxiety towards math tests and anxiety to problem solving.

Kazelskis (1998) studied the factorial structure of the three scales on math anxiety that have been used the most: the RMARS (Alexander & Martray, 1989) the Mathematics Anxiety Questionnaire (MAQ; Wigfield & Mecce, 1988) and the Mathematics Anxiety Scale (MAS; Fennema & Sherman, 1976). Applying the exploratory factorial analysis with principal components extraction and crosswise rotation, he got six dimensions of math anxiety that represented 61% of the total variance.

Bowd and Brady (2002) apply the principal components analysis with Varimax rotation to 357 high level education college students and found three factors that explained the 73% of variability in the RMARS scores, the three factors were named: anxiety towards the math test (11 items), anxiety towards the math course (8 items) and anxiety towards numerical homework (4 items).

Studies about math anxiety became particularly relevant to those researchers on the topic. For instance, to prove the recurrent validity of the RMARS instrument, the MAS Attitude Fennema-Sherma scale was used (1976) and its results showed there are no negative relations which means that students who had more favorable attitudes towards math experienced less math anxiety (Alexander & Martray, 1989). Besides, Moore, Alexander, Redfield and Martray (1988) found a moderate to high correlation between the RMARS and the MAS scale (Fennema & Sherman, 1976), the Anxiety State-Feature Inventory (Spielberg, Gorsuch, Lushene, Vagg, & Jacobs, 1983) and the Anxiety Test Inventory (Spielberg, 1980).

Moore et al. (1988) also found that the RMARS scores correlated significantly with the Mathematics American College Testing scores and the math course grades. On this same idea, Alexander and Martray (1989) also found that the factors of the RMARS scale discriminate between students from secondary school who took geometry and algebra courses and those who did not, and the results were: the students who took a geometry and algebra course at school experienced way less anxiety towards math compared to those who did not take those courses.

In another study, Sanchez-Ruiz and Ursini (2010) carried out a research with secondary students establishing as its main objective to know the attitudes towards math among Mexican students in middle-school and in different contexts. They assumed that the sociocultural and contextual factors are decisive in attitudes, which lead them to the conclusion that Mexican secondary school students' attitude is modified gradually during their secondary education.

No relation between attitude and performance was found, however, self-confidence is linked to performance. Gender does not influence attitude and performance, but it does influence the referents used to justify them. They highlight the influence that attitude and performance in math encases the teacher and student's attitude.

In other recent studies, such as the one of Fernandez and Lahiguera (2015) in which they carry out a research among elementary school students in rural areas. They applied a learning method based on what they identify as "Matemagia" which changes the environment in the classroom and allows to improve the learning outcomes using magic tricks as resources, besides promoting curiosity, creativity and critical thinking. In their study, they stick to the hypothesis that math classes are scarcely motivating due to the traditional work routines. They are basically based on a text book and in mechanical execution of math operations, as well as the teacher's explanation. In another hypothesis they show that the desire the student has for learning is promoting curiosity as well as motivating the students to get their attention. They conclude that the surroundings, being rural in this case, are not a learning factor as it would be the one related with teaching and the effects on the attitude of students and teachers towards math.

Later on, Garcia-Santillan, Escalera-Chavez, Moreno-Garcia and Santana-Villegas (2015) carried out a study to determine the factors that explain anxiety towards math. In order to do so, they use the scale designed by Muñoz and Mato-Vazquez (2007), which was applied to college students from different bachelor degrees. The questionnaire is made up of 24 items divided in five factors or dimensions: "anxiety towards evaluation" (11 items), "anxiety towards temporality" (4 items), "anxiety towards understanding of mathematical problems" (3 items), "anxiety towards numbers and operations" (3 items), and "anxiety towards mathematics in real life" (3 items). The component extracted picks a self-value that explains 74% of the variance from the scale scores.

Based on the arguments previously described it is possible to state that the environment in classrooms during the first years of education is a detonator for the comprehension of math fundamentals. As academic advance in middle education level happens, self-confidence, anxiety and the referents used by students are the reason of academic progress. The student who reaches college level has conscience and auto regulation characteristics and authors coincide overall, that the teacher plays the most important role in the perception of math. With these fundamentals we describe the methodological design, analysis and results from this present research.

METHODOLOGY

It is a non-experimental, transactional and exploratory study originated from the need to know the level of anxiety towards math that thrives among the workers of the sugar factory and represents an empirical approximation to the phenomenon of anxiety towards math.

The sample selected was non-probabilistic sampling, we consider as population the total number of workers that make up the personnel being 600 workers who are the base of operation and maintenance in the production during the Zafra 2015-2016, out of which 82 belong to restricted areas departments. Therefore, we could identify a population of 518 elements available to be surveyed, as long as they comply with the inclusion criteria indicated below (see **Table 1**).

Table 1. Department distribution of personnel and minimum number for sampling

Department	Zafra workers						
	Shifts					%	Sample
	1	2	3	4	Total		
Batey	8	8	8	8	32	6.18%	14.0
Mills	19	19	19	-	57	11.00%	25.0
Clarification	12	12	12	-	36	6.95%	16.0
Evaporation	8	8	8	-	24	4.63%	11.0
Crystallization	18	18	18	4	58	11.20%	26.0
Centrifugation	11	11	11	4	37	7.14%	16.0
Drying and packaging	Restricted access						
Sugar handled							
Laboratories							
Boilers	29	29	29	2	89	17.18%	40.0
Power plant	7	7	9	11	34	6.56%	15.0
Environmental sanitation	1	1	1	2	5	0.97%	2.0
General services	1	1	1	10	13	2.51%	6.0
Internal workshop	1	1	1	8	11	2.12%	5.0
Buildings maintenance	6	6	6	2	20	3.86%	9.0
Stock materials	2	2	2	5	11	2.12%	5.0
Mechanical maintenance	4	4	4	58	70	13.51%	31.0
Industrial security	-	-	3	4	7	1.35%	3.0
Instrumentation	4	4	4	2	14	2.70%	6.0
Total	131	131	136	120	518	100%	230

Source: elaborated based on daily working attendance data

The sample calculation for finite populations gave us 230 workers to survey (**Table 1**). To secure the sample against a possible bias due to the rejection of some instruments badly edited or answered, we applied the instrument to 302 people from the different shifts in the sugar factory La Gloria, S.A. Of all the cases, only 283 were valid since 19 questionnaires (3.71%) were invalided for not having completed all the answers. Of all the cases we could learn that 264 were male (93.29%) and 19 female (6.71) all with an academic average of 10.3 years equivalent to the first year of high school and only 2 people (0.66%) with illiteracy. The research was carried out on the first 13 days of January, 2016.

Inclusion criteria

- Must be working personnel from the sugar factory mentioned.
- Must answer the questionnaires entirely on the different scales.
- Must be working in the manufacturing departments on the dates the surveys are applied.
- Written acceptance by the survey respondent, to answer all the questionnaires.
- Must work in an area of non-restricted access.

The instrument used was the anxiety towards math scale proposed by Muñoz and Mato-Vazquez (2007), which previously explained in the literature review, and it is made up of 24 items integrated in five dimensions. The dimensions are represented the following way: Anxiety towards evaluation (X1ANSIEVAL), anxiety towards temporality (X2ANSIETEM), anxiety towards the understanding of mathematical problems (X3ANSPROBM), anxiety towards numbers and operations (X4ANSINUOP), and anxiety towards mathematics in real life (X5ANSIMATV). The scale is a Likert kind, with values ranging from: SN= never (1), PV= rarely (2), N= neutral (3), MV= usually (4), SM= always (5). Each dimension incorporates the items shown on **Table 2**:

Table 2. Anxiety towards math scale

Codes	Dimensions	Ítems
X1ANSIEVAL	Anxiety towards evaluation	1,2,8,10,11,14,15,18,20,22,23
X2ANSIETEM	Anxiety towards temporality	4,6,7,12
X3ANSPROBM	Anxiety towards the understanding of math problems	5,17,19
X4ANSINUOP	Anxiety towards numbers and math operations	3,13,16
X5AMSIMATV	Anxiety towards math in real life	9,21,24

Source: from Muñoz and Mato-Vazquez (2007)

The rejection and/or acceptance of null hypothesis criterion (Ho) establishes: rejecting the null hypothesis (Ho) if the calculated x2 is larger than the theoretical x2. Besides, the propriety of the factorial technique is justified based on the values of the Bartlett sphericity test KMO>0.7; x2 with n (gl), values MSA>0.5; σ <0.01.

Results Analysis

The data obtained in the field were processed in the SPSS v. 19 software, where the results obtained are as follows:

Instrument validation

The value obtained from the Alfa Cronbach was 0.945 (individual items) and 0.804 (items grouped by dimension), which detonates an acceptable internal consistency. This coefficient measures the correlations among the items from the instrument, the minimum acceptable value is 0.70 (Oviedo and Campo-Arias, 2005).

Properties of the factorial technique

To validate the statistical technique used, the first criterion was the Bartlett and Kaiser sphericity test, the value of x2 with n df and sig. <0.05 (Hair et al., 1998). The values obtained are shown on **Table 3**.

Table 3. Bartlett test of sphericity with KMO

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.872
Bartlett's Test of Sphericity	Approx. Chi-Square	1066.284
	df	10
	Sig.	0.000

Source: own with sample data

The KMO value obtained of 0.872, the x2 value 1066.284 with 10 degrees of freedom and the statistical significance 0.000 exceed the theoretical values threshold, so it can be concluded to this point that the statistical technique for the data analysis is right and besides there is evidence of the Ho rejection. Besides **Table 4** shows the correlations matrix where you can see the determining value (0.022) that is close to zero, which indicates the correlations presence is high, characteristic of the use of this technique.

Table 4. Correlations matrix

Variables	X1 ANSIEVAL	X2 ANSIETEM	X3 ANSPROBM	X4 ANSINUOP	X5 AMSIMATV
X1ANSIEVAL	1.000				
X2ANSIETEM	.838	1.000			
X3ANSPROBM	.759	.716	1.000		
X4ANSINUOP	.794	.806	.667	1.000	
X5AMSIMATV	.578	.532	.578	.443	1.000
a. Determinant = 0.022					

Source: own with sample data

The values of Measure Sampling Adequacy per variable (MSA) observed in the anti-image matrix of table 5 tend to be 1 with its lowest value at 0.841 and the highest at 0.909, being these values pretty acceptable in theoretical terms, confirming that factorial analysis is adequate for the explanation of the studied phenomenon.

Table 5. Anti-image matrix

Anti-image Covariance	**X1 ANSIEVAL**	**X2 ANSIETEM**	**X3 ANSPROBM**	**X4 ANSINUOP**	**X5 AMSIMATV**
X1ANSIEVAL	.213				
X2ANSIETEM	-.092	.235			
X3ANSPROBM	-.086	-.043	.374		
X4ANSINUOP	-.082	-.108	-.033	.298	
X5AMSIMATV	-.071	-.034	-.121	.046	.611
Anti-image Correlation					
X1ANSIEVAL	**.847**[a]				
X2ANSIETEM	-.410	**.855**[a]			
X3ANSPROBM	-.304	-.145	**.909**[a]		
X4ANSINUOP	-.326	-.408	-.099	**.867**[a]	
X5AMSIMATV	-.196	-.091	-.254	.109	**.903**[a]
Measures of Sampling Adequacy (MSA)[a]					

Source: own with sample data

With the values obtained previously (**Tables 3**, **4** and **5**) and once validated the factorial technique there is evidence that a group of variables exists that acknowledge and explain the level of anxiety in the studied participants, from here, these are rotated with Varimax and the obtained components are extracted, which will tell the total of the variance that explains the studied phenomenon.

On **Table 6** the obtained factorial weights are shown for each one of the dimensions in the scale used, as well as the variance proportion for each factor represented for their communalities and whose sum represents the self-value and the total percentage of the variance explained. Besides we can see that the only component extracted has factorial weights of > a 0.5 of each one of the five factors.

Table 6. Component matrix, communalities and variance

Factors	**Component 1**		**Communalities**
X1ANSIEVAL	0.931		0.867
X2ANSIETEM	0.914		0.836
X3ANSPROBM	0.867		0.751
X4ANSINUOP	0.872		0.761
X5AMSIMATV	0.705		0.497
Eigenvalue		3.711255	
Total variance		74.240 %	

Source: own with sample data

As you can see on **Table 6** and **7**, the eigenvalue of 3.711255 corresponds to the sum of the communalities of each of the factors X1ANSIEVAL, X2ANSIETEM, X3ANSPROBM, X4ANSINUOP and X5AMSIMATV, same self-value that shows 74% of variability of the anxiety phenomenon present in the production area workers of the sugar factory who are being studied.

Table 7. Explained variance matrix

Component	**Initial self-value**			**Extraction Sums of Squared Loadings**		
	Total	**Variance %**	**Cumulative %**	**Total**	**% de variance**	**% acumulado**
1	3.712	74.240	74.240	3.712	74.240	74.240
2	0.622	12.445	86.685			
3	0.317	6.333	93.018			
4	0.193	3.856	96.875			
5	0.156	3.125	100.000			

Extraction method: Main Component Analysis

Source: own with sample data

As it can be observed, the extracted component composition detonates in its values the presence of factorial weights over 0.5 in each of the dimensions, being X1ANSIEVAL (anxiety towards evaluation) the one with the highest weight (0.931), X2ANSIETEM (anxiety towards temporality) with a factorial weight slightly below (0.914), in a second group with lower values but important as well, we can find X4ANSINUOP (anxiety towards numbers and operations) with (0.872), and X3ANSPROBM (anxiety towards the understanding of mathematical problems) with (0.867), finally the component with the less factorial weight is represented by X5AMSIMATV (anxiety towards mathematics in real life) with (0.705).

Importance of the Study

It is possible to derive some collateral research paths from this study, which could respond to the following questions:

Empirical works that deal with the topic of anxiety towards math in different kinds of populations other than academic were not identified in the literature, this is, workers in a given company or factory, neither public nor private.

The importance of developing empirical studies in this kind of populations different from academic ones contributed to the study of this phenomenon and provides evidence that enriches the empirical and theoretical body that explains this symptom of anxiety towards math. One of the dimensions even refers specifically to anxiety towards real life situations where the use of math is present.

Mexican blue-collar workers usually have an elementary or secondary education level, they occasionally have a high school diploma and very few have a bachelor degree diploma. The blue-collar employee who needs to work a daily basis for his survival, will likely have no time to keep on studying a technical career, given the fact that work shifts are really exhausting. Hence, the result of this work will be of great interest for discussion as well as in comparison with other documented findings from other empirical studies carried out in different populations.

This work could be easily related with the research that was the basis for this study, since the population surveyed have had the chance to finish their middle basic education (secondary), therefore they were exposed to environments that could have influenced their academic progress in math as Garcia-Santillán et al. mentions (2015) when showing that anxiety is a factor that prevents students from having a good performance during the learning process.

CONCLUSIONS

Based on the results obtained after the information analysis in the study carried out with operational personnel from the production area of the sugar factory, we got enough evidence to conclude that there is a group of variables that allows us to explain math anxiety among the operational personnel of the sugar factory.

On the contrary, with the values obtained from calculated X2 with n degrees of freedom, higher than theoretic X2, as well as the value of Bartlett´s test of sphericity (> 0.8) and statistical significance < 0.000 provide support for this rejection, which leads us to thing that there is in fact a set of variables that can explain anxiety towards math in the operation personnel of the sugar factory.

As a summary, we can answer all the questions with the following information:

To the question, which are the dimensions or factors that better explain the level of anxiety among the workers in the sugar factory? The result indicates that the five dimensions in the Muñoz and Mato-Vazquez scale (X1ANSIEVAL, X2ANSIETEM, X3ANSPROBM, X4ANSINUOP and X5AMSIMATV) gives us an eigenvalue of 3.711, equivalent to 74% of the variance of the phenomenon studied. Regarding the question, would it be possible to apply the Muñoz and Mato-Vazquez scale to a population of workers in a sugar factory? We can also point out that the afore-mentioned scale gives us a high reliability index in the data collected with such instrument. (Cronbach´s alpha is 0.945 in the individual items and 0.804 in the grouped factors per dimension).

In the Varimax rotation and components extraction, we got a factor that collects the factorial weights of the five dimensions (X1ANSIEVAL 0.931; X2ANSIETEM 0.914; X4ANSINUOP 0.872; X3ANSPROBM 0.867; X5AMSIMATV 0.705) which answers the question about how the level of anxiety towards math can be explained with at least one factor. We can point out convincingly that it can be explained by just one component factor as it is described in **Tables 6** and **7**.

Consequently, we could reject the null hypothesis Ho1 that points out the non-existence of a group of variables that allows to explain the anxiety towards math among the workers in the production area and in the same manner, the Ho2, which denies that anxiety can be explained with at least one factor, is rejected as well. In both cases, the alternative hypothesis could be proved since the dimensions of the anxiety variable in the Muñoz and Mato-Vazquez scale structure do constitute a group of variables that explain the variability of the factorial scores of anxiety towards math among the workers in the sugar factory; also, one component with factorial weights over > 0.5 was made.

The goal set in the research is achieved by identifying the structures of the variables; moreover, the factors that better explain the level of anxiety among workers in the sugar factory correspond to the anxiety towards the evaluation with a factorial weight of 0.931 and anxiety towards temporality with a factorial weight slightly below 0.914.

We can say that the scale indicators are related with the results obtained in the tasks the worker performs in the production area with a permanent supervision from an observer, which is part of the evaluation process of the procedures carried out; added to this lack of confidence from the worker in relation to the knowledge he has about the necessary math calculations for the evaluation, and complemented with the temporality that involves the moment of making the necessary calculations to perform a task and possible future responsibilities, this allows us to deduct that the working environment influenced by the applied leadership style could be held accountable for the current anxiety that the production are worker in the sugar factory presents.

Other Possible Research Paths

It is possible to derive some collateral research paths from this study, which could respond to the following questions:

How is working productivity affected by the remnants that math has left in the worker based on their highest academic level reached?

Do trust and the kind of leadership applied have a direct relationship with the anxiety towards evaluation and temporality levels?

How has school environment influenced workers in determining the kind of activity done inside the factory?

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Arturo García-Santillán – Researcher and Coordinator of doctoral program in Management Science at UCC Business School. Universidad Cristóbal Colón, Veracruz, México.

Tomás Elio Ochoa-Domínguez – Student of PhD in Management Science at UCC Business School. Universidad Cristóbal Colón, Veracruz, México.

Jésica Josefina Ramos-Hernández – Student of PhD in Management Science at UCC Business School. Universidad Cristóbal Colón, Veracruz, México.

REFERENCES

Alexander, L., & Cobb, R. (1984). Identification of the dimensions and predictions of mathematics anxiety among college students. Paper presented at the meeting of the Mid-South Educational Research Association, New Orleans, LA.

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. https://doi.org/10.1080/07481756.1989.12022923

Auzmendi, E. (1992). Las Actitudes hacia la Matemática Estadística en las Enseñanzas Medias y Universitarias. Bilbao, Mensajero.

Bessant, K. C. (1995). Factors associated with types of mathematics anxiety in college students. *Journal for Research in Mathematics Education, 26*(4), 327-345. https://doi.org/10.2307/749478

Bowd, A, D., & Brady, P. H. (2002). Factorial structure of the Revised Mathematics Anxiety Rating Scale for undergraduate education majors. *Psychological Reports, 91*(1), 199–200. https://doi.org/10.2466/pr0.2002.91.1.199

Brush, L. R. (1981). Some thoughts for teachers on mathematics anxiety. *Arithmetic Teacher, 29*(4), 37–39.

Camp, C. C. (1992). *A comparison of the math anxiety and math self-efficacy constructs* (Unpublished doctoral dissertation), Virginia Commonwealth University.

Capraro, M. M., Capraro, R. M., & Henson, R. K. (2001). Measurement error of scores on the Mathematics Anxiety Rating Scale across studies. *Educational and Psychological Measurement, 61*(3), 373–386. https://doi.org/10.1177/00131640121971266

Cardoso Espinosa, Edgar Oliver; Cerecedo Mercado, María Trinidad; Ramos Mendoza, José Roberto; (2012). Actitudes hacia las matemáticas de los estudiantes de posgrado en administración: Un Estudio Diagnóstico. *REXE. Revista de Estudios y Experiencias en Educación, 11*(22), 81-98.

Dew, K. M. 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. https://doi.org/10.1037/0022-0167.31.4.580

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

Dutton, W. H., & Blum, M. P. (1968). The measurement of attitudes towards arithmetic with a Likert-type test. *Elementary School Journal*, *68*(5), 259–264. https://doi.org/10.1086/460443

Escalera-Chávez, M. E., García-Santillán, A., & Córdova-Rangel, A. (2013). Structural Equation Model to measure Attitude toward E-commerce. *Australian Journal of Basic and Applied Sciences*, *7*(12), 256-261.

Escalera-Chávez, M. E., García-Santillán, A., & Venegas-Martínez, F. (2014a). Modeling attitude toward Statistical with structural equation (2014). *Eurasia Journal of Mathematics, Science & Technology Education, 10*(1), 23-31.

Escalera-Chávez, M. E., García-Santillán, A., & Venegas-Martínez, F. (2014b). Confirmatory Factorial Analysis to Validity a Theoretical Model to Measure Attitude toward Statistics. *Mediterranean Journal of Social Science, 5*(1), 569-577. https://doi.org/10.5901/mjss.2014.v5n1p569

Escalera-Chávez, M. E., Moreno-García, E., García-Santillán, A., & Córdova-Rangel, A. (2016). Factores que propician el nivel de ansiedad hacia la matemática en estudiantes de nivel medio superior en la región de Rioverde San Luis Potosí. *European Journal of Education Studies 2*(1), 9-22.

Escalera-Chávez, M. E., Venegas-Martínez, F., & García-Santillán, A. (2016). A Model of Differential Equations to Measure Mean Differences by Gender with Respect to Attitude towards Mathematics. *Mediterraneam Journal of Social Science (MJSS)*, *7*(4), 158-164. https://doi.org/10.5901/mjss.2016.v7n4p158

Fennema, E., & Sherman, J. A. (1976). Fennema-Sherman Mathematics Attitude Scale: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *JAS Catalog of Selected Documents in Psychology*, *6,* 31. https://doi.org/10.2307/748467

Ferguson, R. D. (1986). Abstraction anxiety: A factor of mathematics anxiety. *Journal of Research in Mathematics Education, 17*(2), 145–150. https://doi.org/10.2307/749260

Fernández César, R., & Lahiguera Serrano, F. J. (2015). Matemagia y su influencia en la actitud hacia las matemáticas en la escuela rural. *Números*, *89*.

García-Santillán, A., Edwards-Wurzinger, A., & Tejada-Peña, E. (2015). What factors explain the anxiety level towards studying mathematics among students in elementary school? *Mediterranean Journal of Social Science (MJSS)*, *6*(4), 564-572. https://doi.org/10.5901/mjss.2015.v6n4p564

García-Santillán, A., Escalera-Chávez, M. E., Moreno-García, E., & Santana-Villegas, J. (2016). Confirmatory analysis to validate a theoretical model that explains student anxiety toward mathematics. *Eurasia Journal of Mathematics, Science and Technology Education, 12*(2), 361-372.

García-Santillán, A., Escalera-Chávez, M. E., Rojas-Kramer, C., Moreno-García, E., & Santana-Villegas, J. (2015). Student perception toward computer in teaching-learning math in tertiary education. A theoretical construct validation. *Journal of Business Economics and Information Technology, 2*(3), 4-13.

García-Santillán, A., Escalera-Chávez, M., Córdova Rangel, A., & López-Morales, S. (2014). The Golden Trilogy in the Teaching-Learning Process. *Turkish Online Journal of Educational Technology, 13*(3), 138-147.

García-Santillán, A., Escalera-Chávez, M., Rojas-Kramer, C. E., Pozos-Texon, F. (2014). Empirical study on undergraduate student and their attitude towards statistic course and statistical field. *American Journal of Education Research, 2*(12), 1151-1159. https://doi.org/10.12691/education-2-12-4

García-Santillán, A., Escalera-Chávez, M., Rojas-Kramer, C., Córdova-Rangel, A., Pozos-Texon, F. (2016) Attitude toward statistic on universities sceneries. *The Online Journal of New Horizons in Education, 6*(1), 136-150.

García-Santillán, A., Flóres-Serrano, M., López-Morales, J., & Ríos-Álvarez, L. (2014). Factors associated that explain anxiety toward mathematics on undergraduate students (An empirical study in Tierra Blanca Veracruz-México). *Mediterraneam Journal of Social Sciences*, *5*(15), 483-493. https://doi.org/10.5901/mjss.2014.v5n15p483

García-Santillán, A., Moreno-García, E., & Hernández-Utrera, I. (2014). Anxiety toward mathematics on high school students: An empirical study in CETIS 15, Veracruz-Mexico. *Australian Journal of Basic and Applied Sciences*, *8*(6), 307-317.

García-Santillán, A., Moreno-García, E., & Ortega-Ridaura, I. (2016). Actitud hacia la matemática y el rol de las TIC en los procesos de enseñanza aprendizaje. Una aproximación para la definición de un modelo teórico. *European Journal of Education Studies*, *1*(2), 102-118.

García-Santillán, A., Ríos-Álvarez, L., Escalera-Chávez, M., Zamora-Lobato, T., & Pozos-Texon, F. (2015). From traditional classroom to programming and design financial tool to debt restructuring with equivalent equations model. *Mediterraneam Journal of Social Sciences, 6*(2), 35-43. https://doi.org/10.5901/mjss.2015.v6n2p35

García-Santillán, A., Ríos-Álvarez, L., Portugal-Rincón, A., Zamora-Lobato, T., & Pozos-Texon, F. (2015). Financial software design, as evidence of product in the teaching learning of financial mathematics. *Aust. J. Basic & Appl. Sci., 9*(1), 323-331.

García-Santillán, A.; Escalera-Chávez, M., Rojas-Kramer, C., Moreno-García, E.; and Pozos-Texon, F. (2016). Structural equation model to validate: Mathematics-Computer Interaction, Computer Confidence, Mathematics Commitment, Mathematics Motivation and Mathematics Confidence. *International Journal of Research in Educaction and Science (IJRES), 2*(2), 518-526. https://doi.org/10.21890/ijres.81576

Gómez-Chacón, I. Ma. (2009). Actitudes matemáticas: propuestas para la transición del bachillerato a la universidad. *Educación Matemática*, *21*(3), 5-32.

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1999). *Multivariate data analysis* (5th ed.). Spain Prentice Hall.

Hernández, F. J., Valencia, A. del C., Hernández, H., & González, J. A. T. (2013). El sector cañero en Nayarit desde una perspectiva organizacional y ambiental. Retrieved from http://www.eumed.net/libros-gratis/2013a/1333

Hoffman, W. C. (1996). The Lie algebra of visual perception. *Journal of Mathematical Psychology, 3*(1), 65-98. https://doi.org/10.1016/0022-2496(66)90005-8

Kazelskis, R. (1998). Some dimensions of mathematics anxiety: A factor analysis across instruments. *Educational and Psychological Measurement, 58*(4), 623–633. https://doi.org/10.1177/0013164498058004006

Levitt, E., & Hutton, L. (1984). A psychometric assessment of the Mathematics Anxiety Rating Scale. *International Review of Applied Psychology, 33*(2), 233–242. https://doi.org/10.1111/j.1464-0597.1984.tb01431.x

Ling, J. L. (1982). A factor analytic study of mathematics anxiety. Unpublished doctoral dissertation, Virginia Polytechnic Institute and State University.

Moore, B., Alexander, L., Redfield, D., & Martray, C. (1988). The Mathematics Anxiety Rating Scale Abbreviated: A validity study. Paper presented at the meeting of the American Educational Research Association, New Orleans.

Moreno-García, E., García-Santillán, A., Santana-Villegas, J. C., & Téllez-Mora, M.E. (2016). Latent variables to understand anxiety perceived by the undergraduate student when faced with mathematics courses. *Mediterraneam Journal of Social Science (MJSS)*, *7*(2), 243-250. https://doi.org/10.5901/mjss.2016.v7n2p243

Moreno-García, E., García-Santillán, A., & Cristóbal-Hernández, C. (2014). Evaluation, temporality, numerical skill and daily mathematics operations, as factors that explain Anxiety toward mathematics on high school students (An empirical study in Tuxtepec-Oaxaca, México). *Asian Social Sciences*, *10*(12) 79-89. https://doi.org/10.5539/ass.v10n12p79

Mosquera, R. (1999). Geometría diferencial y neurociencia. Proyecto de investigación. Facultad de Ciencias Matemáticas, UNMSM.

Muñoz, J. M., & Mato, M. D. (2006). Diseño y validación en un cuestionario para medir las actitudes hacia las matemáticas en alumnos de ESO. *Revista Galego-portuguesa de psicología e educación: revista de estudios e investigación en psicología y educación, 13*, 413-424.

Oviedo, H., & Campo-Arias, A. (2005). Aproximación al uso del coeficiente alfa de Cronbach. *Revista de psiquiatría, 34*(4), 572-580.

Plake, B. S., & Parker, C. S. (1982). The development and validation of a revised version of the Mathematics Anxiety Rating Scale. *Educational and Psychological Measurement, 42*(2), 551–557. https://doi.org/10.1177/001316448204200218

Programa para la evaluación internacional de los alumnos (PISA) (2012). Resultados. Retrieved from: http://www.oecd.org/pisa/keyfindings/PISA-2012-results-mexico-ESP.pdf

Resnick, J. H., Viehe, J., & Segal, S. (1982). Is math anxiety a local phenomenon? A study of prevalence and dimensionality. *Journal of Counseling Psychology, 29*(1), 39–47. https://doi.org/10.1037/0022-0167.29.1.39

Richardson, F. C., & Suinn, R. M. (1972). The Mathematics Anxiety Rating Scale: Psychometric data. *Journal of Counseling Psychology, 19*(6), 551–554. https://doi.org/10.1037/h0033456

Rojas-Kramer, C. A., García-Santillan, A., Fuentes-Rosas, L., Benitez-Moreno, G. E., & Córdova-Rangel, A. (2015). Engineering Students' Perception of Financial Mathematics-An empirical study based on the EAPH-MF scale. *Journal of Mathematics Research*, *7*(3), 178-190. https://doi.org/10.5539/jmr.v7n3p178

Rojas-Kramer, C., García-Santillán, A., & Escalera-Chávez, M. (Feb 2015). Improved Undergraduate Perceptions of Financial Mathematics by Using ICT in Teaching. *International Journal of Humanities Social Sciences and Education (IJHSSE), 2*(2), 135-142.

Rojas-Kramer, C., García-Santillán, A., Cordova-Rangel, A., Fuentes-Rosas, L., & Benítez-Moreno, G. (2015) Understanding Students' Perceptions to Improve Teaching of Mathematics. *International Journal of Humanities and Social Science* *5*(3), 166-172.

Rounds, J. B., & Hendel, D. D. (1980). Measurement and dimensionality of mathematics anxiety. *Journal of Counseling Psychology*, *27*(2), 138–149. https://doi.org/10.1037/0022-0167.27.2.138

Sánchez-Ruiz, J. G., & Ursini, S. (2010). Actitudes hacia las matemáticas y matemáticas con tecnología: estudios de género con estudiantes de secundaria. *RELIME. Revista latinoamericana de investigación en matemática educativa*, *13*(4), 303-318.

Sandman, R. S. (1980). The mathematics attitude inventory: Instrument and user's manual. *Journal for Research in Mathematics Education*, *11*(2), 148–149. https://doi.org/10.2307/748906

Satake, E., & Amato, P. P. (1995). Mathematics anxiety and achievement among Japanese elementary school students. *Educational and Psychological Measurement, 55*(6), 1000–1007. https://doi.org/10.1177/0013164495055006009

Schiefele, U., & Csikszentmihalyi, M. (1995). Motivation and ability as factors in mathematics experience and achievement. *Journal for research in mathematics education*, *26*(3), 163-181. https://doi.org/10.2307/749208

Spielberger, C. D. (1980). Preliminary professional manual for the Test Anxiety Inventory. Palo Alto, CA: Consulting Psychologists Press.

Spielberger, C. D., Gorsuch, R. L., Lushene, R. E., Vagg, P. R., & Jacobs, G. A. (1983). State-Trait Anxiety Inventory for adults sampler set: Manual, test, scoring key. California: Mind Garden. SPSS, Inc. (1998). SPSS Base 10.0 Applications Guide. Chicago: SPSS Inc.

Strawderman, V. W. (1985). *A description of mathematics anxiety using an integrative model* (Unpublished doctoral dissertation), Georgia State University.

Suinn, R. M., & Edwards, R. (1982). The measurement of mathematics anxiety. The Mathematics Anxiety Rating Scale for Adolescents–MARS-A. *Journal of Clinical Psychology, 38*, 576–577. https://doi.org/10.1002/1097-4679(198207)38:3<576::AID-JCLP2270380317>3.0.CO;2-V

Suinn, R. M., Edie, C. A., Nicoletti, E., & Spinelli, P. R. (1972). The MARS, a measure of mathematics anxiety: Psychometric data. *Journal of Clinical Psychology, 28*, 373–375. https://doi.org/10.1002/1097-4679(197207)28:3+<373::AID-JCLP2270280320>3.0.CO;2-C

Wigfield, A., & Meece, J. L. (1988). Math anxiety in elementary and secondary school students. *Journal of Educational Psychology*, *80*, 210–216. https://doi.org/10.1037/0022-0663.80.2.210

Wood, E. F. (1988). Math anxiety and elementary teachers: What does research tell us? *For the Learning of Mathematics*, *8*, 8–13.

http://www.iejme.com