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Beliefs towards Mathematics in Elementary Education Teachers: a comparative study

Raquel Fernández-César¹

Castilla La Mancha University, SPAIN

Raúl Prada-Núñez

Francisco of Paula Santander University, COLOMBIA

Natalia Solano-Pinto

Castilla La Mancha University, SPAIN

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Abstract: This work is part of a broader investigation developed in Ibero-America, whose main objective is to carry out an analysis of the affective domain towards mathematics in elementary education teachers, and how that could affect the teaching practices. In particular, this work focusses on the beliefs towards mathematics and shows the comparison between teachers of two countries: Spain and Colombia. The methodology consisted on a quantitative approach at a descriptive level, using a convenience sample composed of 235 teachers (105 from Spain and 130 from Colombia); the instrument was translated to Spanish from the scale of Beliefs of Baroody and Coslick (1998); the statistical analysis was performed with SPSS v 22. The results showed in both countries a majority of teachers who manifested Euclidean beliefs, without differences by country. On the other hand, there were significant differences in the Quasiempirist category, with more Colombian than Spanish teachers lying on; in the importance provided to the context in the teaching of Mathematics, and in the conception of the mathematical skill as inherent. The limitations of the study are exposed and several suggestions to deepen the study in the future are made.

Keywords: *Belief; Mathematics; Teachers; Elementary Education; Comparative Analysis.*

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Introduction

Many investigations regarding the processes of teaching and learning of different subjects have been carried out. Among them, Mathematics is of particular interest as a school subject. Mathematical concepts have been of special interest, since they are abstract and typically of difficult understanding,

¹ **Corresponding author:** Raquel Fernández-César
Email: raquel.fcezar@uclm.es

entailing in many cases high rates of dropout, repetition, or academic loss (Carvajal, Trejos & Caro, 2006). Advanced research has been devoted to determining the cognitive learning difficulties related to Mathematics. Such kind of work is the Miranda and Gil (2000) research. Among the causes, very often, the emotional issues acting on the metacognition and the affective dimension of the individual are identified (Gil, Blanco & Guerrero, 2005). Over the past five decades, a considerable research has been devoted to the affective dimension of the individual in the process of learning mathematics (Gomez-Chacon, 2000), highlighting the works of McLeod (1988; 1992; 1994).

The research on beliefs and emotions about Mathematics have been recently recognized as a research field in Mathematics Education (ME), although it was preceded by studies on positive or negative behavior towards a diversity of mathematical concepts. The importance that the ME community assigned to this field is reflected in a wide range of works by several authors of different geographical contexts: McLeod (1988; 1989a; 1989b; 1992; 1994); Gomez-Chacon (1997; 1998; 2003); Goldin (1998a; 1998b); Gil, Blanco and Guerrero (2005); Gil, Nieto and Barona (2006); among others. Authors like Salovey and Mayer (1990), and Goleman (1996) coined the term *emotional literacy* acknowledging the importance that affects have on the learning processes.

Today's society demand people competent in math, as well as ready to adaptation and re-adaptation to technological changes; in summary, apt to life-long learning. Aligned with that, the mathematical competence has become a necessity. Consequently, measures are needed in ME to change from the perception of the subject as difficult, unpractical, and abstract, whose study is restricted to only some special persons, to facilitate to envision its utility and importance, as reported by Gil, Guerrero and Blanco (2006). One of these measures could be to provoke teaching strategies at the compulsory stages of education that counteract people negative attitudes towards mathematics. These negative feelings are

commonly expressed as absolute rejection towards the discipline, contributing to the depletion of enrollment in the University majors where Mathematics is one of the subjects.

In the Cockcroft report (1985) it was shown that a simple mathematical task can cause feelings of anxiety, helplessness or fear in students. Due to this fact, all the research was oriented to understand and analyze how the students internalize certain beliefs, and negative or positive valuations towards mathematics. The research addressed also how the students perceived themselves as apprentices, even before they faced the mathematical tasks, concluding that the students' self-perception versus mathematics strengthened their feelings of success or frustration. According to Blanco and Guerrero (2002) the history of repeated failures led students to question his intellectual capacity in relation to the mathematical tasks, even considering useless their efforts.

All the aforementioned invited to focus the present paper on the affective domain in mathematics, pioneered by McLeod (1989b), who defined it as an extended range of feelings and moods (state of mind) that were usually considered as something different from the pure cognition and includes as specific components the attitudes, beliefs and emotions. Therefore, when the students must learn Mathematics, they receive a steady stream of stimuli associated with this process that generates tension and emotional overreaction, positive or negative. This reaction is conditioned by their beliefs about themselves and about mathematics, and, when it is repeated and always accompanied by the same emotional reaction, becomes systematic and computerized, and materializes in attitudes and emotions.

Several studies have been focused on the beliefs. For instance, Bermejo (1996) distinguished two broad categories of students' beliefs towards Mathematics: the beliefs about Mathematics, which are mainly influenced by the school context; and, the beliefs of students in relation to Mathematics, which would depend more on affection, since they were related to the self-concept and confidence. Whereas McLeod (1992) differentiated four axes with respect to beliefs: beliefs about mathematics and its teaching

and learning; beliefs about oneself as a learner of mathematics; beliefs about the teaching of mathematics; and, beliefs arising from the social context. On the other hand, Gomez-Chacon (2000) highlighted four areas of interest: to identify and describe the beliefs inside the belief system of the individual; to determine the influences of the belief system; to know how they originate and develop the belief systems; and, to search the conditions to bring about a change of beliefs. Provided that these studies had been carried out with different instruments, they are not perfectly comparable. The present study was focused on the beliefs about Mathematics.

As far as we know, several studies on the student attitudes toward mathematics have been developed from the 70's up to current dates in different geographical contexts. A sample of that are the works of Aiken (1970); Callahan (1971); Haladyna, Shaughnessy and Shaughnessy (1983); Thompson (1984); Hembree (1990); Tocci and Engelhard (1991); Goodykoontz (2008); Opolot-Okurut (2005); Gil, Blanco and Guerrero (2005); Padrón (2008); Mato and de la Torre (2009); Domino (2009); Alemany-Arrebola and Lara (2010); Perry (2011); Roca and Díez-Palomar (2011); Asante (2012); González-Pienda et al. (2012); Mata, Monteiro and Peixoto (2012); Hodges and Kim (2013); Ngurah and Lynch (2013), among the most prominent. But just a few took into consideration students social diversity (Butty, 2001; Cain-Caston, 1993).

Gil, Blanco and Guerrero (2005) defined the attitude as an evaluative predisposition (positive or negative) that determined personal intentions and influenced behavior. These authors considered attitudes consisting on three components: cognitive, which was expressed in the underlying beliefs; affective, which was manifested in feelings of acceptance or rejection of the task or the subject; and intentional, expressed as a trend towards a certain type of behavior. Other authors, as Callejo (1994) and the National Council of Teachers of Mathematics (NCTM, 1991), identified two categories of attitudes when the object of study is Mathematics. On the one hand, the *attitudes towards mathematics*, referred to the assessment and

appreciation of the discipline and the interest on the subject and his apprenticeship. On the other hand, the *mathematical attitudes*, referred to the mode of using general abilities as the flexibility of thinking, open-mindedness, critical thinking, objectivity, among others, which are important aspects of the mathematical work. The first one was considered more related to the affective domain, while the second one was directly related with the cognitive one. Nonetheless, the aforementioned literature asserted that both domains are interrelated in such a way that affects govern the learning process.

The study of emotions, as well as the attitudes towards Mathematics, has ignited the interest of many researchers across the world from the last years of the 20th century. This is the case of Goldin (1988a); Mandler (1989); Debellis and Goldin (1991; 1993); Hidalgo, Maroto and Palacios (2005); Ignacio, Nieto and Barona (2006); Alemany-Arrebola and Lara (2010); Costillo Borrego et al. (2013), among others.

Gil, Blanco and Guerrero (2005) claimed that emotions were psychological responses, including the physiological, cognitive, motivational, and the experiential system. They arose as a response to an event (internal or external) that had a meaning (positive or negative) to the individual. These authors identified the *emotional act* as an expression of the students' beliefs about the nature of the mathematical activity, about themselves as students or part of a class. Gomez-Chacón (1997) asserted that the beliefs of students seemed to be a crucial aspect in structuring the classroom social reality. Inside that classroom is where the process of teaching and learning is carried out, and where the meaning of the emotional acts is created. Therefore, emotions are not only automatic or physiological strong affective responses, but also the complex result of classroom learning, social influence and interpretation (Gomez-Chacón, 2000).

With the aforementioned information, it becomes evident that there are at least two categories of people: those who think that math is difficult to learn, tends to be boring, obscure, and generates feelings of frustration, anguish and almost collective aversion, and those who feel attracted to and satisfaction

respecting mathematics. This situation makes a challenge the teaching of the subject, emphasizing the influence on that process of the teacher characteristics regarding knowledge and affects towards Mathematics. According to Godino (2002), there are teachers of mathematics who have knowledge deficiencies, which impede them to manage their students learning difficulties. Contreras (2002) asserted that this was evidenced when teachers make mistakes similar to their students. No less important is the case of mathematics teachers with aversion or fear towards Mathematics, interpreted as affective deficiencies towards this subject.

As Padrón (2008) affirmed, the mathematics teacher deficiencies, affective or cognitive, resulted in a fragile and deficient professional performance that threatened the establishment and consolidation of appropriate pedagogical practices. This situation could hamper the learning process, making difficult to recognize and properly handle the previous knowledge of the students, as well as impeding to fit and organize the appropriate experiences aiming to develop a meaningful and contextual learning. In summary, the teacher mathematical knowledge, the classroom direction, as well as the beliefs towards math, could compromise the elementary education teachers performance and so, their teaching of mathematics.

The present work was focused on the exploration of the beliefs towards mathematics of elementary education teachers, and the comparison of them in two Ibero-American countries: Spain and Colombia.

Methodology

The methodology followed was a quantitative approach on a descriptive basis, comparing the variables between the two countries.

Participants

There was a convenience sample reached through a non-probability sampling method. In both contexts, the teacher participation was volunteer. The sample group consisted of 235 teachers, out of which 130 were Colombians (55.4%) and 105 Spanish (44.6%).

Instrument

The instrument was composed of nine items extracted from the Baroody and Coslick (1998) questionnaire translated to Spanish. The answer to each item was rated on a five score Likert scale, ranging from totally disagree (1), to totally agree (5), including the neutrality (3).

A pilot study of the instrument in the Colombian context was performed by using the Classical Theory of the Test (TCT), to assure that the beliefs' instrument measured with greater precision and minimum error. To validate the instrument, a two steps process was followed: firstly, the experts' opinion, including several rounds with specialists in the area whose observations were incorporated to reach a consensus on the wording of the items; and secondly, the discrimination index for reliability analysis. Provided that the items in the instrument correspond to non-cognitive variables, the main indicator for evaluating the individual behavior of each item and its contribution to the global scale was its discriminating ability. On the other hand, the concept of internal consistency of the items was considered as a reliability criterion, and the Cronbach's Alpha coefficient as the most appropriate method.

After the pilot study, the text of each item was formulated as shown in table 1.

The Cronbach Alpha coefficient was calculated for the whole questionnaire in each country: Colombian teachers, .763; Spanish teachers, .559.

For the Colombian context, according to the scale suggested by George and Mallery (2003, p. 231), the instrument was assumed acceptable, while, for the Spanish context was slightly below the acceptance threshold.

Table 1.

Wording of the Items After the Pilot Study

1. Mathematics is essentially a complex system of interconnected concepts, approaches and representations	1	2	3	4	5
2. Mathematics is a body of knowledge logically structured	1	2	3	4	5
3. For me, Mathematics is a body of knowledge, absolute, universal, abstract and free of values	1	2	3	4	5
4. Mathematics mainly imply memorization of procedures and rules	1	2	3	4	5
5. Managing Mathematics is characterized by the application of rules and algorithms	1	2	3	4	5
6. The mathematical knowledge is fixed and immutable	1	2	3	4	5
7. Mathematics are open to questioning, arguments or personal interpretations related to the context	1	2	3	4	5
8. Mathematical skill is an inherent quality	1	2	3	4	5
9. Managing Mathematics embodies a way of thinking and solve problems	1	2	3	4	5

The authors suggested items 1-3 related to an epistemic posture corresponding to Euclideanism (E), items 4-6 to Quasiempirism (QE) and items 7-9 to Constructivism, the internal consistency of each category was analyzed and showed in table 2.

Assuming the Cronbach Alpha coefficient as a measure of the item-total correlation, it was calculated for each category and country. Comparing these coefficients, according to George and Mallory (2003), QE resulted acceptable regardless the country, and E resulted poorly acceptable, with slight differences per country. The exception was the C category, which was very low in the Colombian sample, but particularly low in the Spanish one. Therefore, the items related to this category (7-9) were dealt separately.

Table 2.

Cronbach Alpha Coefficient in Each Category per Context (# items=3)*

	Spain	Colombia
E*	.540	.558
QE*	.756	.783
C*	.028	.432

The instrument was delivered online and emailed to several public educational institutions in Spain, while handed out in a printed version in Cúcuta, a mainly rural region in the North of Colombia.

Data analysis

The Statistical Package for Social Sciences version 24 (SPSSv24) was used for the analysis of the data. A significance level of .05 was used, unless otherwise mentioned.

Results and Discussion

As it was indicated in the previous paragraphs, the values of E and QE through total value in each category, while the items of C were analyzed separately.

Table 3.

Mean Values and Standard Deviation, M(SD,) for E and QE in Each Country

	Spain	Colombia
E	10.93(2.28)	10.96(2.63)
QE	7.35(2.56)	9.24(3.06)

Since the nominal neutral value for each category was 9, the mean values in E were above that in the two cases, while in QE lied below in Spanish teachers but not in the Colombian ones. It would mean that none of the elementary education teachers manifested pure beliefs, but most of them scored higher in the E category, which is the Euclidean one, regardless the country.

The variability coefficient of descriptive statistics in table 4 scored between 20 and 24% for the E category, while between 33 and 36% in the QE. Provided that, the normality of the distribution was

checked (K-S test, $p < .001$) and the mean values in each country were compared through the U-Mann Whitney test. The results proved that the almost null difference in E was not statistically significant ($U=744.00$; $p > .05$), while the observed difference in QE was significant ($p < .00$). Therefore, in the teachers who manifested mostly Euclidian conceptions, the country was not an influencing factor, while those who showed Quasiempirist beliefs belonged in a higher extent to the Colombian sample.

Deepening in this study, the frequency distribution for the QE category was shown in figure 1

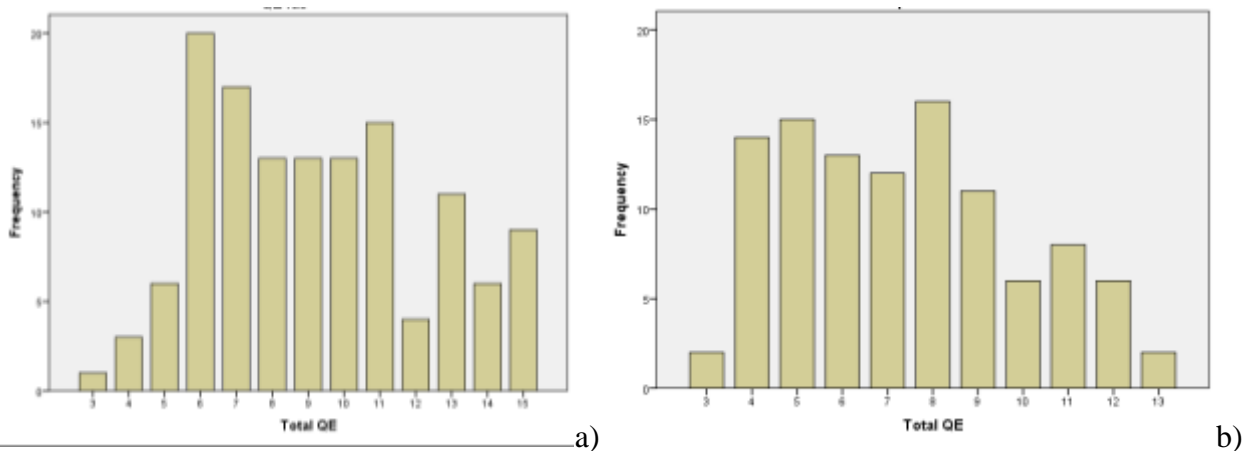


Figure 1. Frequency distribution of the total values in the QE category: a) Colombian teachers (Median=9); b) Spanish teachers (Median=7)

It is worth noting that the nominal neutral value is 9, exactly the median value in the Colombian sample, but 2 units above the median in the Spanish. It meant that more than 50% of the Spanish teachers were below the nominal neutral value in QE making this category less representative of Spanish teachers' beliefs than E.

Regarding the rest of the items in the questionnaire, 7, 8, and 9, provided that the category they were assumed to be part of showed such a low Cronbach Alpha coefficient, were considered individually.

Table 4.

Mean Value, Standard Deviation, M(SD), and Median, in Spanish and Colombian Sample for Items 7, 8 and 9

Item	Spain		Colombia	
7	3.52(1.08)	4	3.82(1.16)	4
8	2.23(.98)	2	2.80(1.33)	3
9	3.79(.96)	4	3.97(.88)	4

The items with the highest score in both countries were 7 and 9, above the neutral value, while item 8 was well below this neutral value in the Spanish sample and close to that in the Colombian one. Due to the high variability of the scores, the analysis of normality was considered pertinent (K-S test, $p < .00$), and the possible differences due to the country checked with a non-parametric test (U-Mann Whitney). Statistically significant differences due to country were detected in item 7 ($U=17.00$; $p < .05$) and 8 ($U=1.00$; $p < .05$), while they were not significant in item 9 ($U=172.00$; $p > .05$). It means that the Colombian sample is more leaned to consider a fact the influence of the context in Mathematics perception (item 7), and more neutral respecting the fact that Mathematical skill is an inherent quality (item 8). The Spanish sample showed a similar tendency but less strong regarding the influence of the context, while seemed more reluctant to assume item 8 statement. Nonetheless, regarding the fact that Managing Mathematics embodies a way of thinking and solve problems, teacher in both countries show a very similar and positive belief.

Conclusion

The purpose of this study was to explore and compare the beliefs in elementary education teachers of Spain and Colombia. The used instrument was a translation into Spanish of several items of the questionnaire proposed by Baroody y Coslick (1998) after an experts' revision. The authors identified

three belief categories or epistemic postures towards Mathematics, with three items each. Due to the fact that the internal consistency was not reasonably high for the total construct, the analysis was done by category in the first two, Euclidian and Quasiempirist, and by item in the third one, Constructivist.

In the Colombian sample it was verified that none of the teachers showed pure beliefs, as reported by Fernandez-César and Rodrigues (2017) about Spanish teachers. The majority of elementary education teachers manifested Euclidian beliefs, regardless the country, followed by Quasiempirist beliefs, that were affected by country. The teachers of Colombia resulted to be QE in a higher extent than Spanish teachers. This fact can be due to the general orientation of the Colombian preservice elementary teacher University programmes, not particularly focused on Mathematics as a tool to interpret the world.

The Constructivist domain of this questionnaire cannot be considered as a category with this sample, and the items are treated separately, providing country differences in two of them but not in the last one. However, the differences were between mean positive values located above 3 in both countries respecting the context influence in Mathematics, and below 3 when dealing with the acquisition or inherent mathematical skill.

The limitations of the present paper are focused on the sampling process and the instrument used. The convenience sample make the results non-representative of the elementary education teachers in the analyzed countries. The instrument showed limited validity for this sample, so a deeper and wider study including revision of the experts' panel composition considering a native English speaker as one of the members, teacher interviews and open questions is recommended for the future.

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