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The Affective Domain in Mathematics Learning

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ABSTRACT. The present work set out to analyze the beliefs, attitudes, and emotional reactions that students experience in the process of learning mathematics. The aim was to be able to demonstrate that the existence of positive attributes, beliefs, and attitudes about themselves as learners are a source of motivation and expectations of success in dealing with this subject. We used a sample of 346 students of the second cycle of Obligatory Secondary Education (ESO) of high schools in Badajoz. The participants responded to a questionnaire on beliefs and attitudes about mathematics. It was found that neither the students' gender nor their year of studies influenced their beliefs about their self-concept of mathematics.

KEYWORDS. Beliefs, Attitudes, Emotions, Mathematics Self-Concept, Secondary Education And Mathematics Learning.

INTRODUCTION

A persistent problem in understanding the role of affect in mathematics teaching and learning has been to settle on a clear definition of what is affect or the affective domain (Gómez-Chacón, 2000).

Studies of the affective dimension in mathematics were for a long time limited to investigating attitudes. In the last decades, however, the scope has broadened to include the study of beliefs and emotional reactions (McLeod, 1994). This new focus, led in great part by the work of McLeod (1988, 1992, 1994), has shown that affective questions not only play an essential role in the process of mathematics teaching and learning, but that some of them are strongly ingrained and not easy to shift by instruction.

Learning mathematics has become a necessity for an individual's full development in today's complex society. Technological advances and the growing importance of the means of communication make it necessary for people to adapt to the new situations that are arising out of social change.

It is a fact that, despite its utility and importance, mathematics is perceived by most pupils as difficult, boring, not very practical, abstract, etc., and its learning as requiring a "special ability" that is not always within everyone's reach. We are firmly convinced that these beliefs influence the fact that a considerable percentage of failures in Obligatory Secondary Education (ESO) corresponds to the area of mathematics. So many academic difficulties and failures are concentrated in this one subject that it has become a major selective filter in the educational system.

We find that many pupils generate negative attitudes towards mathematics in the course of their academic life, and on occasions present an authentic aversion to the discipline. For most pupils the subject is not a source of satisfaction, but rather one of frustration, discouragement, and anxiety. Many of them, even some of the most able, find mathematics to be just a tiresome chore.

It is thus necessary to understand and analyze how pupils, in learning mathematics and interacting with their environment, interiorize certain beliefs and negative or positive valuations of the subject and of themselves which will lead to success or failure in attaining mathematics goals. Indeed, many students, thinking that "they are not cut out for mathematics" end up by rejecting the subject, which they consider a sort of "millstone" that they have to get rid of soon as they can by choosing the options offered them in ESO and the subsequent pre-university courses of "Bachillerato" that involve little or no mathematics.

In this sense, we believe that the high indices of academic failure in the area of mathematics demand the study of the influence of affective and emotional factors on mathematics learning. Such factors could well explain the anxiety pupils feel when faced with a problem to solve, their sensations of unease, of frustration, of insecurity, the low level of self-esteem that they experience, etc., which often prevent them from efficaciously and successfully tackling mathematics tasks.

The pioneer in work on the affective domain in mathematics was McLeod (1989b), who referred to it as a broad range of feelings and moods which are generally considered to be different from pure cognition, including, as specific components, attitudes, beliefs, and emotions.

With respect to beliefs, studies of their influence on mathematics learning have occupied an outstanding place in the recent literature. McLeod (1992) differentiates four axes relating to beliefs: mathematics (the object), oneself, mathematics teaching, and the context in which mathematics education takes place (social context).

McLeod (1989b) points to two categories of beliefs that seem mainly to influence mathematics learning: beliefs about mathematics that generally involve no major affective component but do constitute an important part of the context in which affect develops, and the

pupils' (and the teacher's) beliefs themselves and how they relate to mathematics. The latter have a strong affective component, including beliefs concerning confidence, self-concept, and the attribution of causes to academic success and failure.

Beliefs concerning the pupils' self-concept as mathematics learners constitute, according to Gómez-Chacón (2000), one of the variables with most influence on mathematics teaching and learning, related to the pupils' attitudes, their perspective on the world of mathematics, and their social identity. The most important elements of this construct are their subjective knowledge and emotions relative to the following aspects: interest in mathematics, efficiency in performing mathematics tasks, motivation and pleasure with mathematics, attribution of causes to academic success or failure, and self-concept as belonging to a certain social group.

For Gómez-Chacón (1997), the term mathematics self-concept refers to a person's image of themselves with respect to how he or she is perceived and valued in a mathematics learning context. The author adds that it is an aspect of learning that is linked to personal beliefs relating to the world of mathematics, i.e., to the set of ideas, judgements, beliefs, and attributions that the person has steadily built up during his or her process of learning in the school environment.

According to McLeod (1992), the pupil's self-concept as a mathematics learner should be conceived of as a substructure deriving from the structure of beliefs. At the same time, it is one of the basic descriptors of the affective domain in mathematics, closely related to emotions, attitudes, motivation, personal expectations, and attributions.

Often, students with mathematics learning difficulties due to their repeated experience of failure are those who present the most maladapted attributional patterns. Doubting their own abilities, they exaggerate the magnitude of their deficiencies, and tend to attribute their failures to their lack of ability. They also show low expectations of success, and give up easily in the face of difficulties. When they are successful, they attribute it to the easiness of the problem, to help from the teacher or their classmates, or to luck. Continued failures are seen as confirmation of their low level of ability. Their negative beliefs about themselves as learners prevent them from improving their mathematics performance, since they believe that it is beyond their possibilities to do well (Chapman, 1988).

For Weiner (1992), the type of attributions that the pupils make will have repercussions at both the cognitive (expectations) and the affective-emotional (self-concept) levels which will determine their motivation and their degree of involvement in classroom mathematics activities.

Pupils' attitudes towards mathematics learning are determined by individual personal characteristics related to their academic self-image and motivation for achievement. These condition their orientation towards certain subjects in the curriculum and not others.

In McLeod's conception, attitudes cover a multidimensional perspective of different kinds of mathematics and a range of feelings about each of them.

In the opinion of Guerrero, Blanco and Vicente (2002), denial, negation, frustration, pessimism, and avoidance are some of the attitudinal and behavioural signs that many students show when they are faced with academic activities. This may be either generic (especially in pupils with chronic academic failure) or when faced with a specific task such as mathematics.

The work of Callahan (1971) marked the beginning of the growth of concern about pupils' attitudes with respect to mathematics. Examples of the subsequent work on attitudes towards mathematics are Fennema and Sherman (1976, 1978), Whitley (1979), Wolleat, Ponte, Becker and Fennema (1980), Hannafin (1981), Schofield (1982), Haladyna, Shaughnessy and Shaughnessy (1983), Minato (1983), Smith (1985), Gairín (1990), Mohd Yusof (1994), Camacho, Hernández and Socas (1995), Carbonero Martin, Antón Martin and Arranz Espeso (1998), Hernández and Socas (1999), Hernández, Palarea and Socas (2001), and Cubillo and Ortega (2002).

There have been few studies on the affective dimension in mathematics learning, and even fewer relating to the emotions. A first sociocognitive analysis of emotions applied to the field of mathematics was that of Mandler (1989), followed by McLeod and Adams (1989), Goldin (1988), and Debellis and Goldin (1991, 1993).

For Gómez Chacón (2000), emotional reactions are the result of discrepancies between what the subject expects and what he or she experiences when the reaction is produced. In learning mathematics, pupils receive continuous mathematics-associated stimuli. They react emotionally positively or negatively, reactions that are conditioned by their beliefs about themselves and about mathematics. If, in response to similar situations, the same kind of affective reaction is produced repeatedly, the activation of the emotional reaction (satisfaction, frustration,…) could become automated and solidified into attitudes.

Hence, affects exert a decisive influence on learning and on how pupils perceive and value mathematics, as well as on their own view of themselves as learners. At the same time, they constitute a key element influencing their behaviour (Gil, 2003).

Given the breadth of the field of study represented by the affective dimension in mathematics education, in the present article we shall focus exclusively on how pupils' beliefs about themselves as mathematics learners influence their academic performance, their motivation, their attribution of causes, and their expectations.

The purpose behind the study is to recognize the importance of affective factors in determining the success and/or failure of mathematics learning, with the intention of promoting positive attitudes and beliefs in our pupils that will be reflected in improved performance and expectations of achievement in this subject.

As objectives we therefore set ourselves to describe the beliefs that pupils have about themselves as mathematics learners, and to analyze the attitudes and emotional reactions that

they show to mathematics and mathematics learning. Our working hypotheses were the following: (1) the assessment obtained in the area of mathematics and the preferences for the different subjects in the curriculum are significantly related to gender; and (2) there exists a close relationship between gender, the level of secondary education being studied by the pupils, and their beliefs about themselves as mathematics learners.

METHOD

The study sample was obtained by means of a two-stage probabilistic sampling procedure. In the first stage, a series of secondary schools was selected at random for each stratum (state school or state-subsidized private school; central or non-central municipal district), and the study unit was taken to be the groups of pupils of each school so as to ensure the representativity of the strata. In the second stage, for each school in the sample, groups of pupils of the 3rd and 4th years of ESO were chosen at random.

The sample was selected by proportional assignment, with the size being determined using standard sampling formulas based on the total population size to give a 95% confidence level expressed as a rounded confidence coefficient with a 0.5% margin of error. The resulting sample size was calculated to be approximately 300 pupils, representing some 7% of the population.

The final sample consisted of 346 pupils —166 males and 180 females— from 13 to 18 years old. They were drawn from six secondary education schools in the city of Badajoz — three state schools (46% of the pupils) and three state-subsidized schools (54%). By educational level, 192 pupils were in the 3rd year of ESO, and 154 in the 4th year. By municipal zone, 240 pupils were from schools in the central district of Badajoz (69.4%), and 106 pupils (30.6%) from schools in non-central districts. They were of a low-middle sociocultural background, with normal intellectual levels, and no physical, psychological, or sensorial handicaps.

The data collection instrument was a questionnaire on beliefs and attitudes about mathematics. It comprised 52 items each with four response alternatives ("strongly agree", "agree", "disagree", and "strongly disagree"). The questionnaire was elaborated taking into account the previous studies of Callejo (1994), Camacho, Hernández and Socas (1995), and Gómez-Chacón (2000). Items relating to beliefs about the role of the mathematics teacher and about aspects of the sociocultural context were added, based on a review of the literature and on the instruments of the aforementioned workers.

The selected items were arranged into the following thematic blocks:

• *Data identifying the pupil*, including variables relating to gender, age, secondary education year, type of school and the municipal zone, assessment obtained in mathematics, preference for the subjects in the

curriculum, parents' educational or instructional level and work situation, and number of siblings in the family.

• *Beliefs about the nature of mathematics and its teaching and learning* (items 1 to 11), referring to the view of its utility, applicability, and importance; the perception of mathematics as an abstract, mechanical, and rote-learning subject, and the view of its learning.

• *Beliefs about oneself as a learner of mathematics* (items 12 to 22), referring to confidence and security in oneself, expectations of achievement, the desire for mastery of the subject, the social value provided by the subject, and the attributions of the causes of success or failure to effort, to the teacher's attitude, to dedication, or to luck.

• *Beliefs about the role of the mathematics teacher* (items 23 to 30), including aspects of methodology, the teaching resources used in the classroom, and teacher-pupil interaction.

• *Beliefs corresponding to the social and family context* (items 31 to 41), relating to the interest and expectations of parents and classmates, the social image projected by mathematics with respect to socioeconomic status and social stereotypes.

• *Attitudes and emotional reactions to mathematics and its learning* (items 42 to 52), including such variables as degree of perseverance, satisfaction, curiosity, security, rejection of the discipline because of lack of interest and appeal, and the level of anxiety, sense of failure, frustration, and blocks in problem solving.

Given the large number of variables involved in the study, in the present article we shall focus only on the block of items referring to Beliefs about oneself as a learner of mathematics (items 12 to 22). These refer to the mathematics self-concept as one of the components of the affective domain in mathematics learning. Table 1 lists the items corresponding to this block, and the mean scores obtained for each.

Table 1: Scores obtained on the items in the “Beliefs about oneself as a learner of mathematics” block.

Nş	**Item**	**Mean score**
12	Liking or disliking mathematics influences the choice of modality of Bachillerato [the two pre-university years of secondary education], according to whether or not mathematics is included.	3.15
13	Being good at mathematics (getting good marks, having a good attitude) makes you feel more appreciated and admired by your classmates.	2.23
14	If I do not understand mathematics, it will be hard for me to assimilate and master other related subjects (like physics, chemistry, etc.).	3.04
15	My performance in mathematics depends in a large part on the teacher's attitude towards me.	2.77
16	When I spend more study time on mathematics I get better results in problem solving.	3.13
17	When I solve a problem, I usually have some doubt about whether the result is correct.	2.98
18	I have confidence in myself when I have to do mathematics problems.	2.45
19	I consider myself very capable and good at mathematics.	2.31
20	I am calm and relaxed when I am solving mathematics problems.	2.49
21	When I make an effort to solve a problem, I usually come up with the correct result.	2.73
22	Luck plays a part in whether you can successfully solve a mathematics problem.	1.91

For the statistical treatment of the data, after the necessary pre-processing, coding, and transferring to electronic storage, the results were analyzed using the statistical package SPSS

The following descriptive statistics were used, all at a 95% confidence level with a 5% margin of error: frequencies, percentages, arithmetic means, and standard deviations. Possible correlations between pairs of variables were analyzed using the Pearson correlation coefficient.

RESULTS

The data that were obtained (Tables 2 and 3) showed that the performance of the girls in mathematics was slightly below that of the boys. Table 2 lists the pass/fail percentages by gender. One observes that the percentage of failures (these pupils would have to recuperate that examination before they can complete ESO) was 23.9% for the girls and 20.5% for the boys.

Table 2: Mathematics performance, by gender.

Gender			Frequency	%	Cumulative %
Boys	Valid	Fail	34	20.5	20.5
		Pass	132	79.5	100
		Total	166	100	
Girls	Valid	Fail	43	23.9	23.9
		Pass	137	76.1	100
		Total	180	100.0	

Also, with respect to the assessment grades obtained by the pupils in mathematics, one observes in Table 3 that 17.5% of the boys attained the Highly Commended level (17.5%) as against 14.4% of the girls. The sum of the percentages of Pass Plus, Commended, and Highly Commended was 60.3% for the boys, and 54.4% for the girls.

Table 3: Pupils' assessment grades in mathematics, by gender.

Gender			Frequency	%	Cumulative %
Boys	Valid	Fail	34	20.5	20.5
		Pass	32	19.3	39.8
		Pass plus	28	16.9	56.6
		Commended	43	25.9	82.5
		Highly commended	29	17.5	100
		Total	166	100	
Girls	Valid	Fail	43	23.9	23.9
		Pass	39	21.7	45.6
		Pass plus	24	13.3	58.9
		Commended	48	26.7	85.6
		Highly commended	26	14.4	100
		Total	180	100.0	

The following results refer to the block of items concerning beliefs about oneself as a learner of mathematics (items 12-22). Figure 1, corresponding to item 18, shows that 37.3 % of the boys state that they lack confidence in themselves when they are faced with problem solving, as against 51.1% of the girls. The boys also feel calmer when they solve mathematics problems. In this sense, Figure 2, corresponding to item 20, shows 42.2% of the boys in agreement.

Figure 1: Opinion about confidence in mathematics, by gender.

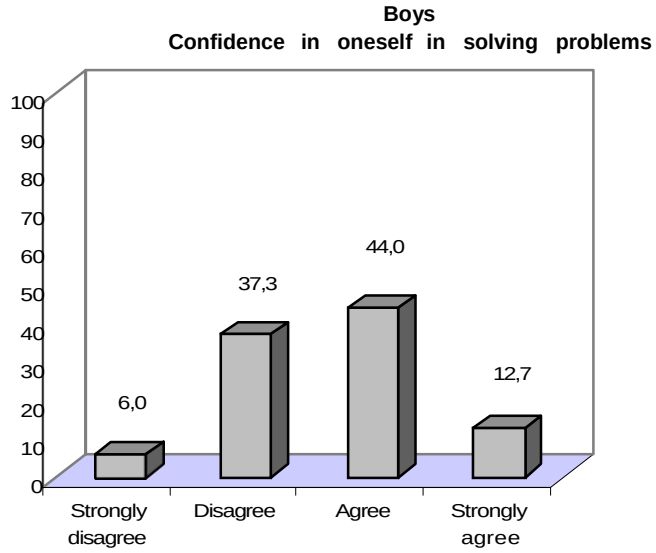
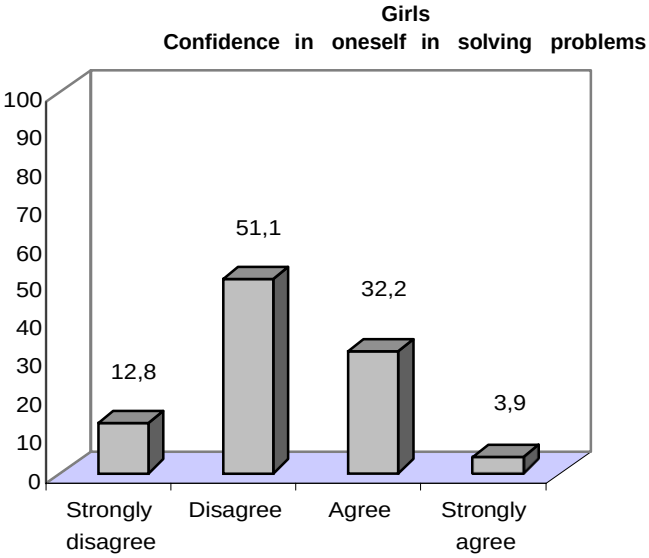


Figure 2: Opinion about lack of anxiety in mathematics, by gender.



Nevertheless, as can be observed in Table 4 regarding item 12, "Liking or disliking mathematics influences the choice of modality of 'Bachillerato' (the two pre-university years of secondary education), according to whether or not mathematics is included", the girls are more

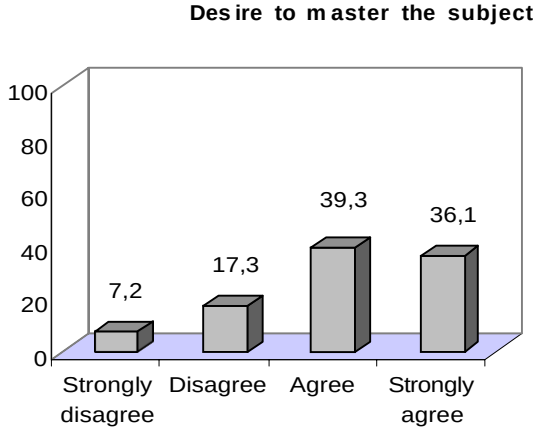
conditioned than the boys by the pleasure and attraction they do or do not feel for mathematics when they come to make a choice of which mode of pre-university education to follow. The correlation analysis, however, showed that the differences between sexes was not significant (r_{xy} = 0.017; p = 0.750). Unexpectedly, the influence of a like or dislike for mathematics was less in the 4th year of ESO than in the 3rd.

Table 4: Evaluation of the like or dislike of mathematics and vocational choice, by gender.

Gender			Frequency	%	Cumulative %
Boys	Valid	Strongly disagree	12	7.2	7.2
		Disagree	19	11.4	18.7
		Agree	70	42.2	60.8
		Strongly agree	65	39.2	100
		Total	166	100	
Girls	Valid	Strongly disagree	8	4.4	4.4
		Disagree	19	10.6	15
		Agree	89	49.4	64.4
		Strongly agree	64	35.6	100
		Total	180	100.0	

As is shown in Figure 3, corresponding to item 14, "If I do not understand mathematics, it will be hard for me to assimilate and master other related subjects (like physics, chemistry, etc.)", the desire to master the subject, and the expectations of success in it are patent. Thus, while 39.3% of the pupils agree that if they neither understand nor master mathematics they will not assimilate and understand other subjects that are related to it, only 7.2% disagree. There were no significant differences by gender (r_{xy} = 0.001; p = 0.981).

Figure 3: Opinion about the desire to master the subject.



Lastly, with respect to attributing the causes of success and/or failure in mathematics, 39.2% of the boys considered that the teacher's attitude does not condition their success or failure in mathematics, while 41.7% of the girls did attribute it to the behaviour of the teacher (Figure 4, corresponding to item 15, "My performance in mathematics depends in a large part on the teacher's attitude towards me"). Also, as one observes from Table 5, corresponding to item 22, "Luck plays a part in whether you can successfully solve a mathematics problem", for the boys neither does this factor influence their performance in the subject (12% agree, as against 20% of the girls).

Figure 4: Opinion about attributing the cause of success to the teacher, by gender.

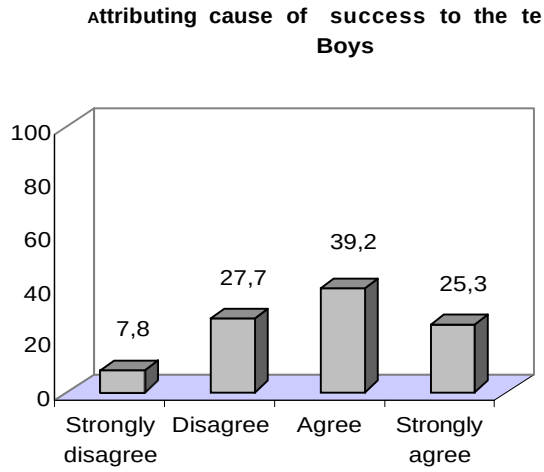


Table 5: Evaluation of attributing the cause of success to luck, by gender.

Gender			Frequency	%	Cumulative %
Boys	Valid	Strongly disagree	51	30.7	30.7
		Disagree	86	51.8	82.5
		Agree	20	12	94.6
		Strongly agree	9	5.4	100
		Total	166	100	
Girls	Valid	Strongly disagree	57	31.7	31.7
		Disagree	85	47.2	78.9
		Agree	36	20	98.9
		Strongly agree	2	1.1	100
		Total	180	100.0	

There were, however, statistically significant differences observed between the sexes in their attribution of the cause of success to dedication (r_{xy} = 0.119; p = 0.026) (item 16, "When I spend more study time on mathematics I get better results in problem solving") and to effort (r_{xy} = -0.143; p = 0.008) (item 21, "When I make an effort to solve a problem, I usually come up with the correct result").

DISCUSSION

In general terms, this descriptive analysis of the beliefs that pupils have about themselves as mathematics learners showed that the boys in the sample had a better adjusted mathematics self-concept than the girls. Indeed, the data were coherent with the theoretical basis that self-concept and performance mutually influence and determine each other, since the boys' performance in mathematics was also found to be better than that of the girls. In this sense, to attain a good level of performance, it is necessary, although not sufficient, for pupils to have a positive concept of their worth and of their competence to do the work at school. At the same time, success in their academic activities tells them that they are competent and capable, thereby contributing to the consolidation of a positive self-concept.

More boys obtained the "Highly Commended" mark than girls, even though the percentage of girls in the overall sample was higher. It therefore seems that getting good marks in the subject motivates the pupils and improves their self-concept as learners of mathematics, since they feel more competent and capable, and at the same time this feeling of security, self-worth, and liking for the subject reinforces their self-concept as learners, and stimulates their academic performance.

In this sense, Sampascual, Navas and Castejón (1994) found that pupils with a high or satisfactory level of performance, unlike those with a low or unsatisfactory level, enjoy a more positive self-concept, have higher expectations, get better marks, and are more likely to attribute the cause of success to effort.

On the one hand, the boys showed themselves to have more confidence, to feel more secure, calmer, and with more ability and skills in this subject than the girls. These attitudes and emotional reactions towards mathematics influence positively their perception of the discipline, their mathematics self-concept, and their expectations of achievement. In this sense, authors such as Lester, Garofalo and Kroll (1989) have noted that pupils' beliefs about problem solving tend to affect positively or negatively their self-confidence in that activity.

On the other hand, the girls were influenced by their like or dislike of mathematics more than the boys when it came to choosing which modality of Bachillerato they were going to study in the following pre-university years of secondary education. There could be several reasons: they feel more rejection towards this subject, they experience greater anxiety, they get lower marks than the boys, they have lower expectations of success, etc.

A study by Marshall (1989) on the problem-solving strategies that pupils use found that the pupils' commentaries before actually beginning on solving the problems they had been set were negative in tone regarding mathematics. This was interpreted as a symptom of anxiety, and a revealing indicator of a negative attitude to mathematics. That finding coincides to a great degree with those of the present work. The present findings also confirm the contributions of

McLeod (1988) and Baroody (1988) that the pupils' beliefs and their interactions in problem-solving situations lead to affective-emotional responses that have repercussions on how they perceive the discipline, on their self-concept and causal attributions, and consequently on their performance and expectations of attainment.

The pupils in general state that being good at mathematics (getting good marks, having a good attitude,…) does not bring any greater social prestige from the rest of their classmates. Nonetheless, the desire to master the subject and the expectations of success in it were patent, since they considered that unless they understand and can do mathematics they will not assimilate and understand other subjects that are related to it.

The studies carried out by Fennema and Sherman (1976, 1978) found significant differences in mathematics learning between boys and girls, with the boys learning more effectively due in part to greater confidence in themselves in their mathematics work. In the case of equal effectiveness in learning, the girls showed less confidence in themselves than the boys. The results of the present work showed that the boys achieved a higher performance in this subject and had more confidence in themselves than the girls when they are faced with mathematics tasks.

In an analysis of the relationships between attitudes and mathematics learning, Gairín (1990) concluded that the variable genderhad no significant effect on attitudes towards mathematics. This result is different from what was found in the present study, in which gender did show a relationship with the pupils' attitudes and emotional reactions to mathematics.

With respect to the attribution of the causes of success and/or failure in mathematics, unlike the girls, the boys believed that neither the teacher's attitude nor luck condition performance in this subject. They did, however, believe that dedication and effort are essential factors in achieving success in the discipline. Seeing success as dependent on effort and dedication means that pupils tackle mathematics tasks with a positive self-concept, since if they think they succeeded because they made an effort or that they failed because they did not devote much time to the subject, in no way will this lessen their concept of themselves.

This result has a certain connection with the findings of Pintrich, Anderman and Klobucar (1994) and Navas, Sampascual and Castejón (1995) with respect to the relationship between the attribution of success to internal and controllable causes (effort, skill, dedication) and motivational and cognitive aspects. The results of those studies confirmed that pupils who attributed success to internal causes and to control were less anxious, had greater expectations of success, were more oriented towards mastering the subject, were self-reliant and metacognitive, and also performed better. The pupils who believed that their failure was due to unstable and uncontrollable factors were less oriented to mastering the subject, were less effective learners, had lower expectations of achievement, and showed poorer academic performance.

On the contrary, our data differ from those obtained by Wolleat et al. (1980). They found that girls explained their success as due to their effort, while boys explained it on the basis of their ability. In explaining failure, the girls more than the boys attributed this question to the difficulty of the task. Our results indicated that the boys attributed their successes and/or failures in mathematics to their effort and feeling of competence, while the girls saw the cause as luck and the attitude of the teacher.

CONCLUSIONS

In view of the results, we can draw the following conclusions:

1. The pupils' beliefs about themselves as mathematics learners (self-confidence, attributions of causes, expectations of achievement, etc.) are related neither to gender nor to the year of secondary education that they are studying. For this reason, we reject the first hypothesis of the existence of significant differences in pupils' mathematics self-concept with respect to gender and the year of secondary education.

2. The pupils' attitudes and emotional reactions towards mathematics and mathematics learning varied according to gender, but not according to the secondary education year. Therefore, the second hypothesis that was proposed is partially rejected, since we accept the existence of gender differences in the attitudes and emotions of the pupils towards mathematics learning, but reject the influence of the year of secondary education that they are studying.

To conclude, we present a series of proposals which we believe necessary to keep in mind in future studies related to the topic. Firstly, it would be of great interest to introduce "programs of emotional literacy in mathematics education", with the aim of promoting a change in attitudes, beliefs, and emotions in ESO towards mathematics and mathematics learning. Also, before there can be an improvement in attitudes towards mathematics, there has to be both a change in its image —in which process we believe that the methodology of teaching has a definite role to play— and an improvement in the relationships between teachers and pupils.

Secondly, we believe that there is a need to foment collaboration between educational psychologists and mathematics teachers in the affective domain field, given its influence on the quality of school-level learning. This will require the establishment of projects and programs of prevention and intervention in difficulties of mathematics learning, and of emotional education in this area of knowledge. The aim will be to stimulate the attraction and taste for mathematics, and to improve attitudes, beliefs, and the emotional reactions that pupils experience when they are learning it.

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