ATTITUDES TOWARDS MATHEMATICS, SELF-EFFICACY AND ACHIEVEMENT IN PROBLEM-SOLVING

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The aim of this study was to explore relationships between students' attitudes towards Mathematics, self-efficacy beliefs in problem-solving and achievement. The possibility of attitudes and self-efficacy to predict problem-solving performance was also examined. Attitude and efficacy scales were completed by 238 fifth-grade pupils. Problem-solving performance was measured by a specially prepared test, including simple and multi-step problems. The analysis of the data indicated significant relationship between attitudes and achievement and a stronger relationship between efficacy and achievement. Attitudes and efficacy were also correlated and both predicted achievement in problem-solving. However, efficacy was a more powerful predictor than attitudes. No gender difference was found in any of the examined variables.

Research on attitudes, as a factor related to students' difficulties in Mathematics, and particularly in solving problems, dates from the 1960s. Recently, many connected concepts have been studied, such as conceptions and beliefs of Mathematics and its learning, motivation and self-regulation, self-concept, self-esteem and self-efficacy. The general tenet is that human beings are not only cognitive individuals, but also social persons with beliefs, emotions and views that influence their development as learners. Actually, a person's behavior and choices, when confronted with a task, are determined more by her/his beliefs and personal theories, rather than by her/his knowledge of the specifics of the task.

Literature refers to *attitude* as a learned predisposition or tendency of an individual to respond positively or negatively to some object, situation, concept or another person. This positive or negative feeling is of moderate intensity and reasonable stability; sometimes it is especially resistant to change. In the variety of definitions of attitudes towards Mathematics (ATM) proposed in research studies, two main categories can be identified. Using a simple definition, ATM is just a positive or negative emotional disposition towards Mathematics (Mc Leod, 1994). Using a multidimensional definition, ATM comprises three components: an emotional respond to Mathematics, positive or negative, a conception about Mathematics, and a behavioral tendency with regard to Mathematics (Hart, 1989). Ma & Kishor (1997) propose a wider definition; they conceive ATM as *"an aggregated measure of a liking or disliking of Mathematics, a tendency to engage in or avoid mathematical activities, a belief that one is good or bad at Mathematics, and a belief that Mathematics is useful or useless"* (p. 27). The present study adopts a rather simple definition of attitudes, that includes, however, different kinds of feelings towards Mathematics and problem-solving, such as love, hate, anxiety, interest, and a perception of the usefulness of Mathematics in life, in order to facilitate young children to express their views. Thus, statements such as *"I like Mathematics"* or *"Mathematics is boring"* are defined as attitudes.

With regard to the emergence of negative attitudes, Mandler's discrepancy theory (1989) provides a ground for interpretation. He argues that a negative attitude is a result of frequent failures or interruptions of planned actions, which were intended to face mathematical tasks. Repeated emotional reactions result in the formation of an overall schema about Mathematics, which becomes relatively permanent.

A number of studies have so far indicated that many children begin schooling with positive ATM; these attitudes, however, tend to become less positive as children grow up, and frequently become negative at the high school (Ma & Kishor, 1997). It seems that the pressure exercised on students to cope with highly demanding tasks, often at a pace beyond their ambition, together with unimaginative instruction and non-positive teacher attitudes, have destructive impact on their ATM (Philippou & Christou, 1998). However, the junior school years have been identified as a crucial period in the course of development of students' ATM, meaning that teachers have both, opportunity and responsibility, to promote their students' positive attitudes and high achievement, *"the two elements widely acclaimed to be the favorable outcomes of schooling"* (Ma & Kishor, 1997, p. 41).

Current efforts in Mathematics education reform are driven by the belief that all students can learn. Motivation needs have led researchers to study the relationship between ATM and achievement. Theory assumes that even moderate fluctuations in positive feelings could systematically affect cognitive processing and so performance. Research, however, failed to provide consistent findings regarding this relationship, since a number of researchers found a positive relationship between the two variables, but others did not. To assess the magnitude of this relationship, Ma & Kishor (1997) conducted a meta-analysis on 113 primary studies. They found that the overall mean effect size was statistically significant, rather weak at the primary school and stronger at the secondary school level. Researchers attribute the low correlation at the primary school to the fact that attitudes tend to be unstable in early years and young pupils may not be able to express their attitudes precisely. They also claim that the weak effect sizes indicate that the attitude measures are perhaps less reliable and valid at the elementary school level. Ruffell et al. (1998) agree on this, and argue that the attitude measures need to be more age-specific. They also wonder whether pupils' answers reflect their real attitudes or just their temporary feelings towards the subject.

It is hard to refer to cause effect relationship between ATM and achievement. Results from the IEA's Third Study of Mathematics revealed that although Japanese students outperform students from other countries, they have negative Mathematics attitudes (Mullis et al., 2000). This could be attributed to culture differences. However, the particular relationship is a multi-dimensional construct and it is not easy to be analyzed (Ruffell et al., 1998).

Regardless of the relationship between attitudes and achievement, teachers and Mathematics educators tend to believe that children learn more effectively when they are interested in what they learn and they achieve better if they like what they learn

(Ma & Kishor, 1997). Thus, students who come to enjoy Mathematics, increase their intrinsic motivation to learn, and vice-versa. It is obvious, therefore, that continual attention should be directed towards creating, developing and reinforcing positive attitudes towards any subject of the curriculum (Pintrich, 1999; Middleton & Spanias, 1999). Nevertheless, attitudes are relatively stable and one should not expect noteworthy changes to occur over a short period of time.

Self-efficacy (SE) beliefs constitute a key component in Bandura's social cognitive theory. The construct signifies a person's beliefs, concerning her or his ability to successfully perform a given task or behavior. It was found that SE is a major determinant of the choices that individuals make, the effort they expend, the perseverance they exert in the face of difficulties, and the thought patterns and emotional reactions they experience (Bandura, 1986). Furthermore, SE beliefs play an essential role in achievement motivation, interact with self-regulated learning processes, and mediate academic achievement (Pintrich, 1999).

Bandura (1997) postulates four sources of SE information; mastery experiences, vicarious experiences, verbal-social persuasion and physiological and emotional arousal which has to do with the level of emotional and physiological readiness of the individual to undertake a specific task. Although all four sources of SE information play roles in the creation of efficacy beliefs, it is the interpretation of this information that is critical. Cognitive processing determines how the sources of information will be weighed and how they will influence the analysis of the task and the assessment of personal competence.

SE differs from related motivational constructs, such as outcome expectancy, self-concept, self-esteem or locus of control, which are more general self-descriptive constructs that incorporate many forms of self-knowledge and self-evaluating feelings (Pajares, 1996). Bandura (1986) argues that SE refers to personal judgments of one's capabilities to organize and execute courses of action to attain *specific* goals, and measuring SE should focus on the level, generality and strength across *specific* activities and contexts. Therefore, whereas a subject-specific self-concept test item might require the respondent to react to the statement *"I am a good student in Mathematics",* the SE item would require reaction to the statement *"I can solve percent problems".* Ignoring of this tenet, leads to insufficient research findings, and that is why Pajares (1996) argues that if the purpose of a study is to find relationships between SE and performance, SE judgments should be consistent with and tailored to the domain of the task under investigation.

Bandura (1986) claims that young students are generally overconfident about their abilities. He argues that some overestimation of capability is useful, since it increases effort and persistence. However, attention is needed for the protection of children from the danger of disappointment, in the case of continual failures. Children's SE beliefs become more accurate and stable over time, and it is very difficult to change (Bandura, 1997).

The relationship among efficacy, academic motivation and achievement in Mathematics has been widely studied. It was found that SE beliefs appear to be a more important factor influencing attitudes, achievement, and educational and career choices, than other variables such as anxiety, Mathematics experiences, perceptions of Mathematics and self-regulation beliefs (Zimmermann, 2000). It was also found that the influence of SE on Math performance is as strong as is the influence of general mental ability (Hacket & Betz, 1989), and that a negative relationship between SE in problem-solving and anxiety occurs (Pajares, 1996). Other studies have reported that SE in problem-solving is a stronger predictor of that performance than anxiety, self-concept or perceived usefulness of Mathematics (Pajares & Graham, 1999). It is further argued that the relation of SE to motivation and self-regulated learning can indirectly influence performance in Mathematics (Pintrich, 1999), since students with high level of SE are motivated and confident in their skills, use self-regulatory strategies and achieve better than others. Another finding concerns the reciprocal nature of the relationship between SE and performance; past accomplishments inform currently held SE expectations, which in turn influence task initiation and persistence (Bandura, 1997).

With regard to the East Asian students' paradox, several explanations have been provided. It is argued that social environment interferes in this particular case (Rao et al., 2000), however, Pajares & Miller (1995) claim that, in those studies, SE was assessed with global items of the sort that plagued SE research -e.g., *"I am not so good at Mathematics"*. Despite of the low self-expectations that Asian students had, in comparison to western students, it was found that SE was positively related to performance within the Asian sample (Rao et al., 2000).

The above results have important implications for education, indicating that a careful instructional design could play a significant role in promoting both, students' ATM and their SE beliefs. Hence, teachers need to pay as much of attention to their students' affect world as to actual performance. Very important, of course, is the level of teachers' own sense of efficacy on the one hand, and their ATM on the other. It has been argued that teachers' beliefs about Mathematics play a major role in shaping their instructional practice, and consequently influence their pupils' attitudes, SE, interests and achievement (Philippou & Christou, 1998; Tschannen-Moran & Hoy, 2000).

Research findings seem to pay limited attention to gender differences, with respect to ATM and gender (Ma & Kishor, 1997). In addition, boys and girls report equal confidence in their Math ability during elementary school, but, by high school, boys are more confident than girls (Pajares & Graham, 1999).

In the light of above, the following research questions were formulated: *What is the level of fifth grade students' ATM? What is the level of their SE beliefs in problem-solving? Is there a gender effect on ATM, SE and performance in problem-solving? Can SE and ATM predict problem-solving performance?*

METHODOLOGY

The sample consisted of 238 fifth-grade students (99 boys and 139 girls) from eleven classes, from six primary schools in Cyprus, rural and urban. Three questionnaires were administered to the subjects during the academic year 2001-2002, measuring ATM, SE and achievement in problem-solving. The process was in line with Bandura's aspect, that efficacy and performance should be assessed within as close a time period as possible, and that efficacy and attitudes assessment should precede performance assessment.

Three scales were used to measure ATM[1]: The first one was an eleven point linear scale on which students were asked to locate their attitudes *(1=absolute detest, 11= real love, 6= neutral).* The second scale consisted of five comic-type pictures, each presenting persons with various expressions about Mathematics[2]. Specifically, their feelings towards the subject appeared in callouts *(e.g. "I hate Math! Every time I do Mathematics, I want to scream!").* Students, of course, were expected to choose the picture reflecting their own feelings. Finally, the third scale consisted of 30 five-point Likert-type statements, reflecting feelings towards Mathematics, ranging from extreme negative to extreme positive *(e.g. "Mathematics thrills me! It is my favorite lesson!", "I detest Mathematics and avoid them all times!").*

Three instruments measured SE and related constructs: The first one comprised two questions, reflecting students' Mathematics self-concept; the first question asked students to assess their abilities in Mathematics on an eleven point linear scale, and the second one asked them to compare their Mathematics ability with their classmates', again on an eleven point linear scale *(1 represented the lowest and 11 the highest extreme)*. The second scale presented, in five pictures, people expressing their confidence to solve mathematical problems, and students should choose the picture corresponding better to their own SE beliefs in problem-solving. Once more, SE beliefs were presented in callouts *(e.g. "Problem-solving? Well, not too good, not too bad!", "I'm the best student in my class. I usually don't make mistakes in problem-solving!").* Lastly, the third measure comprised 34 five-point Likert-type efficacy and self-concept statements, ranging from strongly agree to strongly disagree *(e.g. "I can easily solve two-step word problems", " I am not good at problem-solving in general!").*

The subjects' problem-solving performance was measured by a test consisting of ten word-problems, nine routine problems and one procedure problem. Students were requested to explain their solutions with schemas, equations or even with word explanations. A typical routine problem and the procedure problem follow:

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[1] Three complementary scales were used in order to make up for the young children's difficulty to respond in similar scales and/or their tendency to be careless. The statements were amended from widely used scales (e.g. Dutton's Attitude Scale and Smith's Justification Scale (Reference in Philippou & Christou, 1998); Byrne's Self-Concept Scales, 1996; Pajares' Self-Efficacy Scales, 1996, etc.), to suit the needs of the specific age group and cultural setting.

[2] The comic-type picture scale was used on the grounds that kids make fun of similar situations and they react more spontaneously.

Routine problem: George's father has £3500 cash. How much money does he need, in order to buy a car which costs £12.350? *Procedure problem:* In a subsidized school shop, footballs were sold at the price of £4 each, while basketballs were sold at £5 each. 12 balls were sold in total and the profit was £52. How many footballs and basketballs were sold?

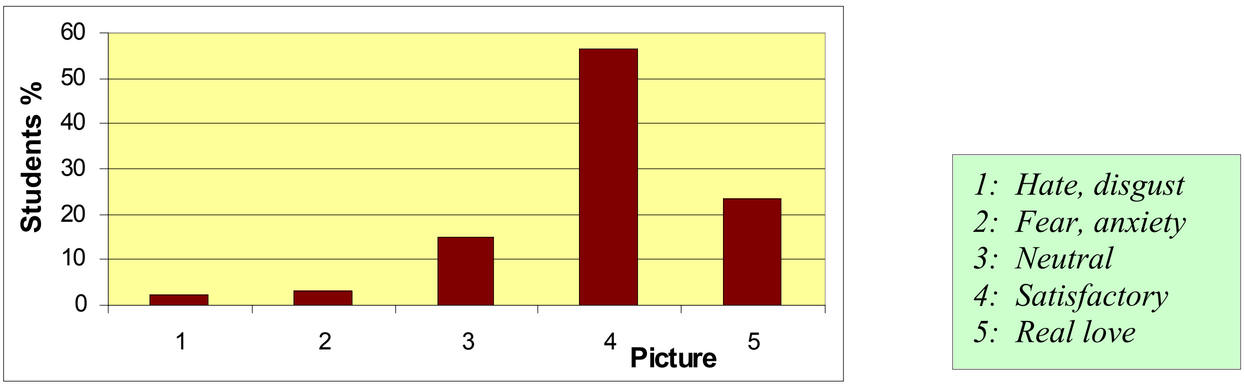
The responses to ATM and SE instruments were transferred into a five-point equidistant scale. Thus, to each of the five pictures, used in these instruments, a number was assigned, from 1-extremely negative ATM or extremely low SE- to 5 - real love for Mathematics or extremely high SE beliefs. Also, the eleven points of the linear scales used in the same instruments, were grouped together into five levels[3], where 1 and 2 indicated extremely negative ATM or extremely low SE, 3, 4 and 5 negative ATM or just low SE, 6 neutral ATM and SE beliefs, 7, 8 and 9 positive ATM or high SE, while 10 and 11 indicated real love for Mathematics or extremely high SE beliefs. Total scores were thus calculated for ATM, SE (questions reflecting students' self-concept were excluded) and problem-solving performance instruments, reflecting ATM, SE and performance indexes, respectively. The Cronbach's alpha reliability coefficient was high in all the three instruments ($a_1 = 0.90$, $a_2 = 0.93$, $a_3 = 0.81$, respectively).

RESULTS

The results are presented and discussed with respect to students' responses on the ATM and SE scales. Then, the relationship between gender, ATM, SE and problem-solving performance is explored.

The analysis of the data revealed that a high proportion of students hold positive ATM. Their answers on the linear scale indicated that 50% adore Mathematics, while 21,8% consider the subject as one of their favorite lessons. 18,1% declare neutral, choosing the middle of the scale, and only 10,1% express negative attitudes, hate and disgust. The same pattern of responses also emerges from students' feelings analysis, based on the five pictures of the ATM instrument. These results are presented graphically in Figure 1:

Figure 1: Students' ATM, based on the pictures



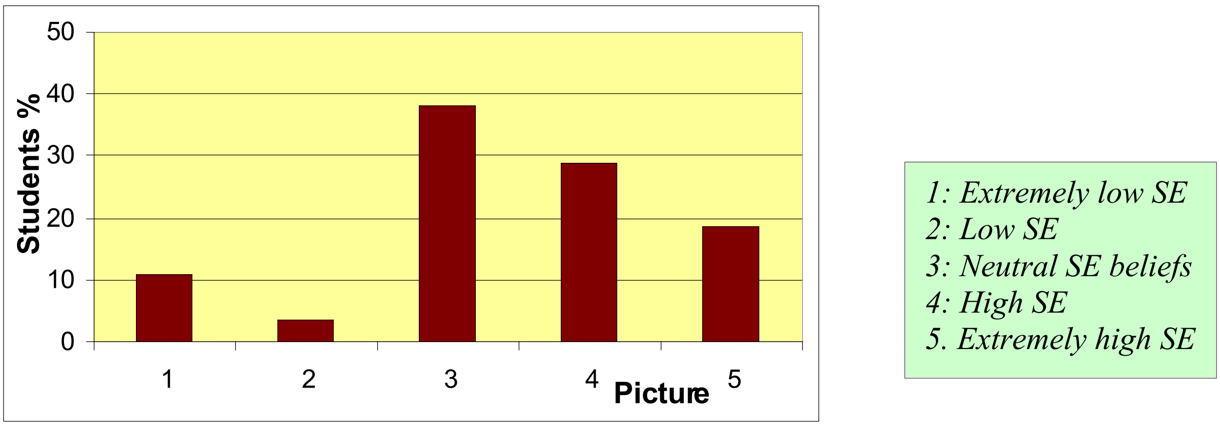
[3] Two reasons for this grouping: First, we wanted to reduce the scale length to five, to make it comparable to the five statements of the "picture scale", and to the Likert type statements as well. Second, the five point characterization, seems logical; one point for neutrality, two for mild positive and mild negative views, respectively, and two points for the extreme positive or extreme negative feelings and beliefs, respectively.

Figure 1 indicates that 23,5% of the children really love Mathematics, while 56,3% express positive attitudes towards the subject. 15,1% stated that *"Doing Mathematics or not, means the same for me",* and only 5% of the students reported that Mathematics makes them feel anxiety or disgust.

The overall mean of the ATM index, based on the answers to all the questions in ATM instrument, was found to be 4,01 (SD=0,7), out of a maximum value of 5.

Analyzing the data about Mathematics self-concept and SE in problem-solving, it was found that most of the subjects feel quite efficacious in Mathematics (38,5% of the subjects have high and 32,8% extremely high SE beliefs), 22,4% expressed neutral beliefs, and only 6,3% rated themselves on the negative side of the scale. Some differences are obvious in the answers to the second question of SE instrument, that asked students to rate themselves in comparison with their classmates, since now they become more strict judges of their abilities. Thus, 16,8% of them believe that they are not as good as the majority of their classmates, and "only" 24,4% claim that they are excellent students. 37,4% stated that they are very good students at Mathematics, in comparison with others, and 21,4% rated themselves in the middle of the scale. As the questions become more task specific, students' sense of efficacy is diminishing. Therefore, in the case of the question that asked them to define their SE beliefs in problem-solving, based on the given five pictures, 38,2% of the children were found to be neutral, and 14,3% expressed very low SE beliefs. However, 47,5% -almost half of the subjects- still have high SE beliefs, and 18,5% of them extremely high. Figure 2 presents these results graphically:

Figure 2: Students' SE beliefs based on the pictures



Combining together all these responses, as well as those of the Likert type scale, an overall SE index had a mean of 3,75 (SD=0,6), out of 5.

The achievement distribution in the problem test was found to be quite close to the normal, with mean and median coinciding, at the value of 27 out of 60 (SD=13,88). Clearly, the test was rather difficult for the subjects of the study, even though most of the problems were similar to tasks included in their Mathematics books. It seems that, despite much leap service, the objective of problem-solving is not very well accomplished. No doubt, students' poor problem-solving results need further investigation.

Table 1 presents the correlations among all the variables of the study:

Table 1: Correlations between gender, SE, ATM and performance variables

r	Gender	SE	Attitudes	Performance
Gender	----	-0,07	-0,01	-0,03
SE		----	0,44**	0,55**
Attitudes			----	0,37**

**: P < 0,001

It is obvious that gender is not significantly correlated with any of the other variables -ATM, SE or performance. However, strong significant differences, at the level of P<0,001, are observed between the other variables. The highest correlations arise between SE and performance (r=0,55), indicating that students with high SE beliefs achieved high performance at the problem-solving test. Correlation between ATM and performance is slightly weaker (r=0,37), while ATM and SE are also correlated (r=0,44), reflecting that students with high SE beliefs have more positive ATM than the others.

The results of a multiple regression analysis (forward selection), shown in Table 2, indicate a linear correlation between SE and ATM, and performance in problem-solving (F=55,41, P<0,001). The coefficient of adjusted R^2 suggests that 32% of the variance is due to the linear and combined influence of the two independent variables –ATM and SE. Thus, it can be said that ATM and SE contribute significantly to the prediction of problem-solving achievement. However, SE is a stronger predictor than ATM, since its Beta coefficient has a greater value (0,48 and 0,15 respectively, both significant), while the significance level of its t value is very small ($P_{SE} < 0,001$ and $0,01<P_{attitudes}<0,05$).

Table 2: Multiple Regression Analysis for the Prediction of Performance

	B	Beta	t	F	R	R^2 Adj.
				55,41**	0,57	0,32
Constant	-15,47		-3,65			
SE	8,73	0,48	8,02**			
Attitudes	2,43	0,15	2,55*			

*: 0,01<P<0,05 **: P<0,001

According to all these, the regression equation becomes:
Performance = 0,48 SE + 0,15 ATM.

These results confirm that ATM and SE contribute significantly to the prediction of problem-solving achievement. However, SE is a stronger performance predictor than ATM.

DISCUSSION

The basic aim of this study was the exploration of the relationship between gender, students' ATM, their SE beliefs and their performance in problem-solving. The possibility of ATM and SE to predict problem-solving performance was also examined. The analysis of the data confirms earlier findings that young students have positive ATM (Ma & Kishor, 1997; Philippou & Christou, 1998) and high SE beliefs (Bandura, 1986). Students' sense of efficacy diminishes, somehow, when students compare their abilities with classmates, and even more, when they focus attention to specific tasks, e.g. problem-solving. Pajares (1996) points out that SE beliefs should be assessed at the optimum level of specificity, especially when the purpose of a study concerns prediction of performance. The use of general constructs, such as self-concept or self-esteem, minimizes the predictive influence of SE and fails to clarify the relationship between SE and achievement.

Results also revealed significant correlations among ATM, SE and performance. It is remarkable, however, that correlation between SE and performance is stronger than correlation between ATM and performance. This is in agreement to earlier research findings (Hacket & Betz, 1989· Pajares, 1996· Ma & Kishor, 1997· Middleton & Spanias, 1999). Consequently, it seems that students with positive ATM have high SE beliefs at a specific domain and achieve better. Similarly, ATM and SE are predictors of performance, and, consistently with previous findings, the predictive power of SE was found to be stronger than the corresponding power of ATM (Hacket & Betz, 1989; Pajares & Graham, 1999· Pintrich, 1999; Zimmermann, 2000).

With regard to gender differences, the results of this study affirm similar findings in recent research (Ma & Kishor, 1997· Pajares & Graham, 1999); it was found that although boys report higher SE, have more positive ATM, and get somewhat better results than girls, there is no significant difference among gender, ATM, SE and performance at this age group.

Drawing inference of causality between SE, ATM and performance is difficult, but earlier evidence indicates that the relationship is rather reciprocal. That is why many SE researchers have suggested that teachers should pay, as much of attention to students' perceptions of capability as to actual capability, for it is these perceptions that may more accurately predict students' behavior (Pajares, 1996). On the other hand, if teachers provide situations of success for all students, this will improve students' sense of efficacy and their attitudes towards learning, with all the benefits that could arise from such a case.

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APPENDIX

Sample Statements of the SE scale

1.	I am one of the best students in Mathematics.	1	2	3	4	5
2.	I believe that I have a lot of weaknesses in Mathematics.	1	2	3	4	5
3.	Compared to other students, I am a weak student in Mathematics.	1	2	3	4	5
4.	Mathematics is not one of my strengths.	1	2	3	4	5
5.	I usually can help my classmates, when they ask me for help in problem-solving.	1	2	3	4	5
6.	I can usually solve any mathematical problem.	1	2	3	4	5
7.	I do not feel sure about my self in problem-solving.	1	2	3	4	5
8.	When I start solving a mathematical problem, I usually feel that I would not manage to give a solution.	1	2	3	4	5
9.	I can easily solve two-step problems.	1	2	3	4	5
10	I have difficulties in solving one-step problems.	1	2	3	4	5

Sample statements of the ATM scale

1.	I am interested in Mathematics!	1	2	3	4	5
2.	Mathematics is boring!	1	2	3	4	5
3.	I would study Mathematics if it were optional.	1	2	3	4	5
4.	Mathematics thrills me! It's my favorite subject!	1	2	3	4	5
5.	I get anxious when doing Mathematics.	1	2	3	4	5
6.	I do not like school Mathematics.	1	2	3	4	5
7.	I detest Mathematics and avoid it all the times!	1	2	3	4	5
8.	Mathematics is useful for anyone's life.	1	2	3	4	5
9.	I enjoy the struggle to solve a mathematical problem.	1	2	3	4	5
10.	I like problem-solving.	1	2	3	4	5

1=strongly disagree, 2 disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree