MOTIVATIONAL BELIEFS, SELF-REGULATED LEARNING AND MATHEMATICAL PROBLEM SOLVING

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Learning is influenced by multiple components of interrelated belief and self-directed strategies. In this study we focus on motivational beliefs (MB) and self-regulated learning (SRL) in the context of mathematical problem solving (MPS). The aim was to search for relationship between 5th and 6th Graders' MB (self-efficacy, task value beliefs and goal orientation) and SRL (use of cognitive, metacognitive and volitional strategies) and between MB and performance in MPS. Analysis of the data from 219 students, using a self-report questionnaire and a paper and pencil test, showed a significant relation between all dimensions of MB and SRL and between self-efficacy, intrinsic goal orientation and performance in MPS. The results draw attention on SRL strategies to guide instruction and scaffolding that enhances MB during MPS.

THEORETICAL BACKGROUND

Motivational beliefs

Recent educational and psychological research highlights the role of multiple affective variables and specifically of motivation towards learning in pursuing educational goals (Boekaerts, 2001). Motivation refers to the forces encouraging a person to engage on a task or to pursue a goal; in the school setting it concerns the reason for which a student works persistently to reach a desirable result (Wolters & Rosenthal, 2000). Although there are many theories of motivation that are relevant to students learning (Seiferd, 2004), the present quest pertains to three notions, namely (a) self-efficacy beliefs, (b) task value beliefs and (c) goal orientations, which are elaborated in Pintrich (1999) and Wolters and Rosenthal (2000).

Self-efficacy has been defined as one's judgment of his ability to plan and execute actions that lead to achieving a specific goal (Bandura, 1986; Tanner & Jones, 2003). In other words, self-efficacy is a self-appraised belief concerning one's competence to succeed in a task. It is supported that high self-efficacy functions as incentive for the pursuing of a goal; on the contrary, low self-efficacy functions as barrier that urges to avoiding the goal (Hamilton & Ghatala, 1994; Seiferd, 2004). For example, students who view themselves as capable to solve mathematical problems will choose to perform that task compared to low efficacious students who might attempt to avoid involvement in the task. Recent research has consistently shown that efficacy beliefs significantly influence academic achievement and they especially constitute the most powerful indicator of the prediction of the performance in mathematics tasks (Gaskill & Murphy, 2004). Moreover, it is reported that high efficacious students are more likely to use SRL strategies than low efficacious students (Tanner & Jones, 2003).

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Task value beliefs refer to the students' evaluation about the value of the task. Eccles (1983; in Pintrich, 1999) has proposed that a student may be motivated towards working on a task if the task itself is important, interesting and useful for him (e.g. help him to cope with high school demands or for his career and life in general). It has been found that task value beliefs are correlated to performance, even though not as strongly as self-efficacy correlates (Pintrich, 1999).

Goal orientation refers to the students' perception of the reasons why to engage in a learning task. Although a number of studies have discussed goal orientation using alternative terms and definitions (Pintrich, 1999), in the present study we focus on intrinsic and extrinsic goal orientation, a classical distinction proposed by Heider as early as 1958 (in Hamilton & Ghatala, 1994). Intrinsic goal orientation concerns the degree to which a student perceives himself to be participating in a task for reasons such as challenge, curiosity and mastery, using self-set standards and self-improvement. Extrinsic goal orientation denotes that a student participates in a task for reasons such as grades, rewards, performance, evaluations by others and competition (Hamilton & Ghatala, 1994). It was found that mastery goals are positively related to performance in general tasks for middle school students, while on the contrary extrinsic goals were negatively related to performance in the same tasks for the same students (Pintrich, 1999).

Besides the relation of self-efficacy, task value and goal orientation to performance, research has especially examined the relation between motivational beliefs and self-regulated learning, which is elaborated in the following section.

Self-regulated learning

In traditional schools, the teacher assumed sole responsibility in the teaching learning process from choosing short and long-term goals to specifying activities, provision of materials, the time allocation, etc. In today's classrooms there is a tendency for a redistribution of learning responsibility between the teacher and the students. This conception leaves much room for the students to become self-regulated learners, i.e., to set goals, select from a repertoire of strategies, and monitor progress toward the goal (Panaoura & Philippou, 2003; Pape, Bell & Yetkin, 2003). Research has examined this new trend in different domains (Rheinberg, Vollmeyer & Rollett, 2000) including mathematics (Schoenfeld, 1992). Mathematics educators adopted the theory of SRL as an important change that has emerged during the last two decades of the 20th century; they expect students to assume control and agency over their own learning and problem solving activities (De Corte, Verschaffel & Op't Eynde, 2000).

Self-regulated learning could be conceptualized in three distinct ways: First, as the learner's ability to use metacognitive strategies or differently, to control cognition. Pintrich, Smith, Garcia and McKeachie (1991) refer to the metacognitive strategies of planning, monitoring and regulating, while Rheinberg et al. (2000) identify them with control strategies such as attention, motivation, emotion and decision control. A second approach views SRL as the learner's ability to use both metacognitive and

cognitive learning strategies (Schoenfeld, 1992). Rehearsal, elaboration, and organizational strategies are identified as important cognitive strategies (Pintrich, 1999) and are related to the students' different learning styles or, differently, to information about the way in which students can learn. Finally, a third view highlights the importance of incorporating motivation, cognitive, and metacognitive components of learning (Tanner & Jones, 2003). Research based on the latter view suggests that there is a connection between motivation and SRL and, more specifically, that the former promotes and sustains the latter variable (Rheinberg et al., 2000). Specifically, empirical evidence showed that high efficacious middle school students, who believe that their course work is interesting, important and useful and adopt a mastery goal orientation, are more likely to engage in various cognitive and metacognitive activities in order to improve their learning and comprehension (Pintrich, 1999; Wolters & Rosenthal, 2000).

In this study we adopt the view that motivational beliefs and self-regulated learning should be studied as parts of an integrated whole, as neither component is alone sufficient to successfully interpret learning outcomes. For example, a student who exhibits a high degree of motivation and puts forward a considerable effort toward a goal may not be able to accomplish his academic targets if he lacks self-regulated learning strategies. On the other hand, a student who possesses a rich repertoire of self-regulatory strategies may lack enough motivation to invest the necessary effort and resources. Moreover, there is a third possibility that high motivated students who are aware of cognitive and metacognitive strategies are unable to use them due to the lack of volitional strategies (Pape et al., 2003).

Although it may seem as a paradox to talk about self-regulatory strategies if the students are unable to use them, Rheinberg et al. (2000) argue, *"…there are students who cannot force themselves to engage in aversive learning activities, even if the consequences of the learning outcome are very important*" (p. 516). The missing element may be not motivation, but volition. Volitional strategies refer to the knowledge and the skills that are necessary to create and support an intention until goal attainment (De Corte et al, 2000). Research in this area has established the importance of volition in both SRL and motivation. Pape et al. (2003) found that after one year of teaching SRL strategies, students' knowledge and awareness of strategies had been increased; yet, their volitional control was too limited to sustain their use of the strategies. Wolters and Rosenthal (2000) examined the relation between motivational beliefs and the following five distinct volitional strategies: self-consequating, environment control, interest enhancement, performance self-task and mastery self-task. They found that the students' MB are related to their use of volitional strategies.

In this paper we argue that volitional strategies should be an integral part of self-regulated learning theory, together with cognitive and metacognitive strategies. In other words we propose a model that, compared to the model offered by Pintrich (1999), includes an additional dimension, namely the volitional strategies, as described in Wolters and Rosenthal (2000). Within this conceptual framework the

aim of this study is to search for relationship between primary students' MB and SRL behaviour (including volitional strategies) with respect to solving mathematical problems and between MB and performance in the same problems.

THE PRESENT STUDY

Pintrich (1999) examined the relationship between motivational beliefs and the use of cognitive and metacognitive strategies in the middle school, the college and university contexts. Wolters and Rosenthal (2000) examined 8th grade students motivational beliefs in relation to their volitional strategies. However, it seems that no research has so far investigated the relation between elementary students' MB on the one hand, and the three components of self-regulatory strategies (cognitive, metacognitive and volitional) used by the same students, on the other hand. Furthermore, the previous researchers focused on the effect of motivational beliefs on self-regulatory strategies. In this study, following Bandura's (1997) notion of "reciprocal determinism" we examine the effect of self-regulatory strategies on motivational beliefs, i.e., we reverse the role of the two variables. The construct motivational beliefs encompasses: Self-efficacy beliefs, task-value beliefs, and goal orientations, while self-regulatory strategies integrate cognitive and metacognitive components (Pintrich, 1999), and the concept of volitional strategies, as used by Wolters & Rosenthal (2000).

Mathematical problem solving was chosen for two main reasons: First, it is considered to be one of the most difficult tasks elementary children have to deal with, since it requires the application of multiple skills (De Corte et al., 2000). Second, as a complex task, problem solving is a potentially rich domain to study SRL, due to demands of cognitive and metacognitive skills (Panaoura & Philippou, 2003).

Specifically, this study sought answers to the following four questions: (1) Is there a significant relation between motivational beliefs (self-efficacy beliefs, task value beliefs, intrinsic and extrinsic goal orientation) and the level of students use of cognitive, metacognitive and volitional strategies, while engaging in problem-solving tasks? (2) Is there a significant relation between motivational beliefs and performance in problem solving? (3) Which components of self-regulated learning can effectively predict students' motivational beliefs? (4) Which components of motivational beliefs can effectively predict the problem solving performance?

METHOD

Data were collected from 219 5th and 6th grade students (108 boys and 111 girls), 110 students were five graders whereas 109 six graders. Students were coming from five different elementary schools, and ten different classrooms.

The students' problem-solving performance was measured through a specially developed test, comprised of six mathematical tasks. Four of them were "routine", whereas the other two were "non-routine" tasks. Two of the routine tasks were one-step problems and the other two were two-step problems in the sense that two

successive operations were required for their solution. These tasks were chosen to cover four types "change", "proportion" "grouping" and "compare" problems, whereas the "non-routine" problems required the "retrogradation" strategy and the "do a table" strategy, respectively.

We used a modified version of the Motivated Strategies for Learning Questionnaire (MSLQ, see Pintrich et al., 1991), a self-report instrument designed to measure students' motivational beliefs and self-regulated learning in classrooms contexts. The motivation subscale consists of 20 items, assessing students' self-efficacy in problem solving (e.g. "I am certain I can understand the most difficult mathematical problems presented in my mathematics classroom"), value beliefs (e.g. "I think I will be able to apply in other courses what I learn in problem solving") and their goals while solving mathematical problems (e.g. "I prefer to solve mathematical problems that really challenge me, so I can learn new things" or "Getting a good grade in problem solving test is the most satisfying thing for me right now"). The self-regulated strategy subscale comprises of 20 items regarding students' use of cognitive strategies (e.g. "I memorize key words to remind me of important concepts of mathematical problems"), metacognitive strategies (e.g. "When trying to solve mathematical problems, I make up questions to help focus my reading") and volitional strategies (e.g. "I tell myself I should keep working to learn as much as I can"). All statements were Likert type with four points (from 1-"I absolutely disagree" through 4-"I absolutely agree"). Students were first given the mathematical problem performance test and as soon as they had finished it they were given the questionnaire for MB and SRL. Pearson correlation and multiple regression analysis of the Statistical Package for the Social Scientists (SPSS) were used for the analysis of the data.

FINDINGS

Table 1 shows the correlation coefficients between each dimension of the motivational beliefs and self-regulated learning strategies. Clearly, all components of self-regulated strategies relate to all components of motivational beliefs. It is noteworthy that the relation between extrinsic goal orientation and cognitive and metacognitive strategies appears slightly lower, while all correlations between volitional strategies and motivational beliefs appear to be at in the range 0.346-0.407, which is quite higher than the level of cognitive and metacognitive strategies. It was further found that students' problem solving performance significantly related with self-efficacy beliefs, and intrinsic goal orientation. No significant correlation was found between problem solving performance and task-value beliefs, or extrinsic goal orientation. It is important to highlight the finding that the strongest correlation appears between problem solving performance and self-efficacy beliefs.

Applying multiple regression analysis with motivational beliefs as the dependent variable and cognitive strategy use (X1), metacognitive strategy use (X2) and volitional strategy use (X3) as the independent variables, the following regression equation was obtained: Motivational Beliefs = 0.412 X3 + 0.281 X1, [R=0.621**,

(F=52.09, p= 0.00), R^2 =0.386**, **p< 0.01]. It is noteworthy that the use of volitional strategies in MPS, constitutes the most powerful indicator of the students' motivational beliefs (Beta=0.412, t=5.433, p=0.00).

	Self-Regulated Learning strategies			Performance in MPS tasks
Motivational beliefs	Cognitive strategies	Metacognitive strategies	Volitional strategies	
Self-efficacy	0.378**	0.366**	0.407**	0.321**
Task-value beliefs	0.432**	0.230**	0.346**	0.132
Intrinsic goal orientation	0.424**	0.282**	0.352**	0.178**
Extrinsic goal orientation	0.170*	0.186**	0.376**	-0.02

p*<0.05, p**<0.01

Table 1: Correlation coefficients between Motivational Beliefs and Self-regulated Learning strategies and between Motivational Beliefs and performance in Mathematical Problem Solving

Multiple regression analysis applied to the data with performance in MPS tasks as the dependent variable, and each of the components of MB, self-efficacy beliefs (X1), task-value beliefs (X2), intrinsic goal orientation (X3) and extrinsic goal orientation (X4), as the independent variables, resulted in the following regression equation: Performance = 0.476 X1, [R=0.320**, (F=21.44, p= 0.00), R^2 =0.102**, **p< 0.01]. Self-efficacy beliefs concerning MPS, constitutes the one and only indicator of the performance in MPS (Beta=0.32, t=4.631, p=0.00).

DISCUSSION

The research reviewed here suggests that the use of self-regulated learning strategies promotes students' motivational beliefs. Concerning the first research question, the findings showed that all three components of SRL are significantly and positively related to all dimensions of MB (Rheinberg et al., 2000). This leads to the conclusion that students who tend to use SRL strategies while solving a mathematical task, are more probable to have increased MB, and vice versa. Analytically, elementary school students who use cognitive, metacognitive and volitional strategies are more likely to feel more efficacious about their ability to do well during MPS procedure. In addition, they are more likely to report higher appreciation of the MPS task, personal interest in the task and utility value of the task for future goals. Students also seem to adopt intrinsic goal orientation, which means that the use of SRL strategies helps them to a concern with learning and mastering the task using self-set standards and self-improvement. Similar results appeared for middle school and college students in

various courses (Pintrich, 1999; Wolters & Rosenthal, 2000). However, a concern for getting grades and pleasing others is not strongly associated with an adaptive pattern of SRL. Similarly, Pintrich (1999) found negative relations for all SRL variables with extrinsic goals, for middle school students. It seems interesting to investigate further the reasons for the appearance of these developmental differences between elementary and middle school students, in the pattern of relations between extrinsic goal orientation and SRL.

As a response to the second research question, it was found that elementary school students, who believe that hold high efficacy beliefs with respect to problem solving and are confident in their skills, are more likely to achieve higher performance in MPS (Gaskill & Murphy, 2004). Intrinsic goal orientation was also positively related to performance in MPS, even though this relation was not as strong as the one of self-efficacy beliefs. The goal or criterion of learning and mastery seems to be a much better motive for higher performance in mathematics than an extrinsic goal. Extrinsic goals were the only motivational variable that showed negative relation to performance. It seems that students who are operating under an extrinsic goal of just getting good grades, pleasing others, or avoiding a punishment do not achieve higher performance, compared to students who adopt intrinsic goal orientations.

Multiple regression analysis, applied for the third research question, showed that volitional strategies were the best predictor of MB. This outcome has been expected since volitional strategies seem to be "conceptually closer" to the idea of motivation. Motivational beliefs refer to the reasons that move a person to work on a task, while volitional strategies concern one's willingness and ability to regulate his motivation and actions. This finding suggests that, the students who have the knowledge and skills to create and support an intention until goal attainment can be predicted as having strong MB (Rheinberg et al., 2000). In other words, elementary school students' use of volitional strategies can lead to greater effort and persistence in MPS tasks. This is in line with Wolters and Rosenthal (2000), about general academic tasks for 8^{th} graders. Furthermore, multiple regression analysis showed that self-efficacy was the sole dimension of motivation that predicted performance in problem-solving. Therefore, self-efficacy is a personal resource that students can draw upon when they are faced with the difficult and time-consuming tasks associated with solving mathematical problems, as Pintrich (1999) stated for academic tasks.

In conclusion, the adoption of motivational beliefs during solving mathematical problems in elementary school is neither easy nor automatic and should not be taken for granted. Many students have little if any motivation to work on a mathematics task or to pursue a goal, while others depend solely on extrinsic motivation. In that, mathematics classroom practices should and can be changed to facilitate adaptive efficacy beliefs about MPS, encourage interest and appreciation of the tasks' value and foster the adoption of mastery goals toward MPS. The results, of the research presented here, draw attention on the possibility to enhance motivational beliefs by

promoting self-regulated learning through instruction of cognitive, metacognitive and especially volitional strategies.

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