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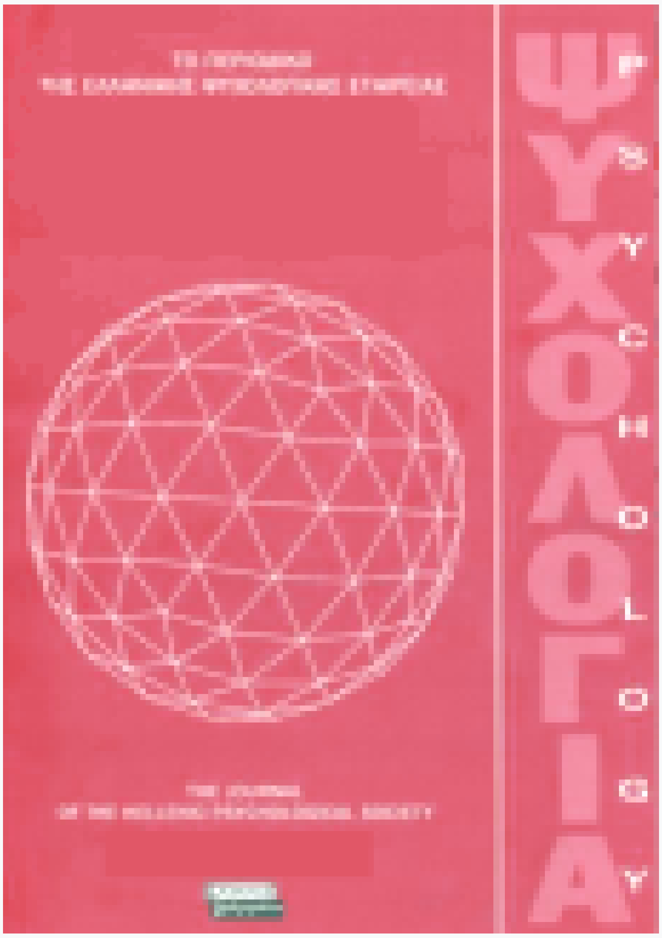

The integration of cognitive, metacognitive and affetive factors in self-regulated learning: The effect of task difficulty

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The integration of cognitive, metacognitive, and affective factors in self-regulated learning: The effect of task difficulty

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ABSTRACT The present study aimed to determine the effects of cognitive and affective factors on the process of self-regulated learning. Specifically, the study aimed to investigate the effects of cognitive ability, motivational orientations and use of cognitive and metacognitive strategies on performance on two text comprehension tasks which differed in their complexity. The sample included 290 students of both genders, who came from the 7th, 9th and 11th grade. Students were given a test of their verbal abilities, two text-processing tasks as well as self-regulation measures tapping motivational beliefs and general learning strategies (that is, their metacognitive knowledge of learning strategies), and self-reported measures on the specific, on line learning strategies used to complete the given tasks. Path analysis showed that cognitive ability had a significant although small effect on motivational orientation and on on-line metacognitive strategies examined apart from performance outcome. One's motivational beliefs influenced one's use of general learning strategies but neither of these two factors significantly effected performance outcome. The level of difficulty of the given text was a significant factor as it effected on-ine strategy use as well as performance outcome. Results suggest that self-regulated learning is a complex system involving several factors, but it does not suffice by itself to determine performance. Cognitive ability is still the best predictor of performance.

Key words: Cognitive ability, Learning strategies, Self-regulation.

Recent research conducted in the field of learning and motivation has shifted its focus away from the study of students' overall learning abilities and their learning outcomes and towards the student's capacity to regulate their own learning (Boekaerts, 1996). This new perspective on research in educational psychology reflects the belief that learning is essentially a subjective process directed towards the achievement of learning goals. It is no longer equated simply with the transfer of information into the learner's memory or acquiring high assessment results. Rather, many researchers now believe that a major goal of formal education should be to instil in students self-regulatory skills. That is, students should be able to guide their own learning towards their own learning goals. These skills are considered essential not only to guide one's own learning during formal schooling, but also to educate oneself and enrich one's knowledge once the individual has graduated (Boekaerts, 1996). To this respect, therefore, the students' primary motive should be to be active participants in the teaching-learning process,

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developing their own knowledge while gradually becoming independent of their teachers. In this respect they should be able to «learn to steer and direct their learning, control their effort expenditure and manage their emotions» (Boekaerts, 1996, p. 101). These aspects of learning, according to researchers, such as Pintrich (1995) and Boekaerts (1996), have been referred to as self-regulated learning (SRL).

Lompscher, Artelt, Schellhas, and Blib (1995) (see also Ridley, Schutz, Glanz, & Weinstein, 1991) have specifically described SRL as a process which involves the interaction of the following factors: (a) the establishment of learning goals; that is, whether the individual wishes to achieve a «deep» understanding of the learning material or simply a «surface» understanding of it so as to meet the expectations and demands of others, i.e., parents, teachers; (b) domain-specific prior knowledge and cognitive abilities of the individual; (c) strategy knowledge and attitudes towards strategy acquisition and use; (d) the individual's emotional state and his/her motivational orientation. In their model of SRL, Lompscher et al. (1995) emphasise learning strategies as the determining factor of an effective learning process; however, the choice and use of a specific strategy is a product of the interaction between the above cognitive and affective factors.

The aim of the present study was exactly to test the possible interaction between cognitive ability, strategy knowledge, motivational/affective factors, and their effect on strategy use on a specific task and performance outcome. In other words, our goal was to identify whether the various components of SRL interact and determine on-line strategy use and performance, or if single factors, such as cognitive ability, suffice to effect strategy use and performance. We were also interested to know if SRL changes according to task difficulty.

Strategy use

Researchers of SRL support the view that the strategies used during the learning process consist of cognitive as well as metacognitive strategies (Pintrich & DeGroot, 1990; Pressley, Borkowski, & Schneider, 1989; Zimmerman, 1994).

Cognitive strategies include the use of different types of rehearsal, elaboration and organizational strategies, all of which help the student to encode, recall and comprehend information. The choice of use of the last two strategies mentioned, namely elaboration and organizational, reflect a deeper level of cognitive functioning, which usually results in higher academic performance (Weinstein & Mayer, 1986; Pintrich & Garcia, 1991). Therefore, these strategies are considered to be more positive and effective in attaining learning goals than surface strategies.

Metacognition is a term which refers to one's awareness about one's own knowledge, mental abilities and tendencies while also to one's ability to monitor and control one's own cognitive processes (Flavell, 1979). Thus, metacognition is a process which uses reflective thinking to develop awareness about one's own person, goals and appropriate strategy use in a given learning context. Research findings (Brown, 1987) have shown that metacognition is related to the student's developmental maturation; the conscious control of learning; the ability to plan, monitor and correct errors, and the ability to change one's own learning behaviours.

Metacognitive strategies for learning include: (a) planning (i.e., establishing goals) which helps to activate relevant prior knowledge, thus making the organization and comprehension of the learning material more effective; (b) monitoring (i.e., assessing comprehension while reading) which helps the student to relate material to prior knowledge, and lastly, (c) regulating (i.e., adjusting reading rate to text difficulty) which generally refers to the student's continuous adjustment of his/her cognitive activity (Pintrich & DeGroot, 1990; Zimmerman & Martinez-Pons, 1986, 1988).

The aforementioned cognitive and metacognitive strategies represent two important components of SRL which will be examined in the present study.

Motivational orientations

Research findings regarding one's motivational beliefs have shown that these reflect one's learning goals, and can be summarized as: (a) extrinsic motives, which characterize individuals who have «surface» learning goals, and (b) intrinsic motives, which correspond to those who have «deep» learning goals.

Specifically, individuals with extrinsic motives (also known as having an "extrinsic goal orientation", Pintrich, Smith, Garcia, & McKeachie, 1991) are concerned with responding to the external demands imposed on them. That is, they rely on identifying the main elements of a given task, memorizing them and reproducing the shallow aspects of the task (Entwistle, 1992; Marton & Saljo, 1976). In addition, these individuals consider engaging in learning tasks to be a means to some end, usually that of finding work. Individuals with extrinsic motives in learning usually elaborate learning material on a superficial level, using less effective strategies and thus reach a low level of academic achievement.

Conversely, the main concern of individuals with intrinsic motives (also known as "intrinsic goal orientation", Pintrich et al., 1991) is to comprehend the learning material for their own personal intentions. Furthermore, a given text is read from a critical perspective, new information is connected to that pre-existing and the accuracy of the conclusions which are drawn, are assessed based on one's logic (Marton & Saljo, 1976). Besides this, the individual is also interested in enriching his/her knowledge and developing or improving existing cognitive abilities. Thus, the learning material is processed to a deep level, using effective strategies and consequently, achieving a high level of academic performance (Ames, 1992).

From the above, it seems that intrinsic goal orientation is an adaptive motivational belief; however, according to researchers such as Bandura (1993) and Pintrich et al. (1991), self-efficacy and task value are two equally adaptive motivational beliefs.

In particular, *self-efficacy* refers to the assessment of one's own learning abilities and one's judgement about one's capability to master a task as well as one's confidence about the skills one has to perform the given task (Pintrich et al., 1991). This attribute also correlates positively with the use of effective learning strategies and in turn, results in higher academic performance by the student (Schunk, 1991; Bandura, 1993).

Task value refers to the student's perception of how interesting, important and useful a given task is (Pintrich et al., 1991). Task value is an attribute also found to correlate positively with the use of effective learning strategies (Pintrich & DeGroot, 1990; Schiefele, 1991), thus leading to higher academic performance (Wigfield & Eccles, 1992).

Emotional state

The emotional state of the individual and, more specifically, one's anxiety level, is another factor which influences the choice and use of learning strategies and, consequently, the performance outcome of the student. For instance, Artelt, Schellhas and Lompscher (1995) have shown that having a high anxiety level correlates positively with the choice and use of surface or non-effective strategies whereas a low anxiety level correlates negatively with the choice and use of strategies which require deep processing of learning material and are, therefore, more effective. According to Lugt-Tapesser and Schneider (1987), anxiety levels hamper effective cognitive processing of information by driving one's focus of attention more on redundant information, which in turn, is processed at a superficial level.

Cognitive ability

Besides strategy use, motivational beliefs and emotional state, one's cognitive abilities (general or domain-specific) may also be associated with the type of learning strategies actually used and with one's level of performance outcome (Efklides, Papadaki, Papantoniou, & Kiosseoglou, 1998). Specifically, O'Donnell, Dansereau, and Rochlin (1991) claim that individual differences in vocabulary significantly effect the level of recall and application of one's related prior knowledge in a given learning context. These findings are consistent with previous research findings (Borkowski & Peck, 1986; Scruggs & Mastropieri, 1988) which have demonstrated a positive relationship between verbal ability and academic achievement. However, in terms of strategy regulation, other findings (i.e., Alexander & Schwanenflugel, 1994) have shown that intelligence (as assessed by verbal and non-verbal intelligence tests used) does not appear to have an influential role in comparison to other factors such as one's metacognitive level and prior knowledge. Therefore, the role of cognitive abilities in self-regulatory behaviour is presently unclear.

The present study

Based on the aforementioned findings of previous research, it is evident that there has been a strong interest in SRL and, in particular, in the interaction of its individual components with performance outcome. However, there have been few studies which focused on other possible factors which may effect the self-regulatory system or may be implemented into the system. These factors include both cognitive ability and task factors such as task difficulty. Task factors may be responsible for the adaptation of the strategies used during actual task processing. Accordingly, the general purpose of the present study was to examine possible interrelations between cognitive ability and the other components of the self-regulatory system -learning strategies and motivational/affective factors- and other factors, such as task difficulty, and to see if these relations contribute or not to self-regulatory behaviour during on-line processing of a cognitive task.

Specifically, the domain of text processing was chosen in order to examine the learning strategies of students in relation to the other factors under study.

Hypotheses

Hypothesis 1. With regard to the factor of cognitive ability, an attempt was made to determine the exact relationship between this and the cognitive and metacognitive strategies under study, and with the students' subsequent performance on text-processing tasks.

It was hypothesised (Hypothesis 1a) that a positive relation would exist between one's level of cognitive ability and the use of self-regulatory cognitive and metacognitive strategies as well as the type of strategy chosen during the performance of a cognitive task. That is, high levels of cognitive ability would correlate positively with the use of more effective strategies while low levels of cognitive ability would correlate with the use of strategies which demand surface processing of the material and are, thus, less effective. This hypothesis was based on research findings mentioned above.

Moreover, based on previous research findings, the use of effective strategies is expected to lead to higher performance outcomes. Thus, cognitive ability was expected to have both a direct and an indirect effect of performance, via the learning strategies used (Hypothesis 1b).

Hypothesis 2. Cognitive ability was expected to correlate accordingly with motivational orientations and task anxiety (the other two components of SRL). That is, it was hypothesised that positive motivational orientations would correlate positively with cognitive ability while negative ones would correlate negatively, as would task anxiety.

Hypothesis 3. The effect of task difficulty was examined in the present study, with the use of two texts of different levels of complexity. An attempt was made to look into the following relations: how the different levels of objective text difficulty relate to (a) performance outcome and (b) the strategies the students used, that is, whether they changed or not or 'regulated', their strategy use during task completion in order to meet the processing demands of the text. It was hypothesised (Hypothesis 3a) that task performance would be better for the more 'simple' task, that is, the one which objectively, had an easy text to be processed. Regarding the strategies which would be used, (Hypothesis 3b), it was expected that 'deep' and effective strategies would be reported in relation to the second, more difficult task rather than the first, easy one. And this because the difficult text would require more elaboration in order to grasp its meaning. On the contrary the easier text was expected to involve surface strategies, because comprehension of the text can be achieved with less elaboration.

Method

Design

In order to achieve the aims which were set out, the following study was designed. It was directed towards students of both junior and senior high school and it concerned the domain of text-processing. This specific domain was selected for the assessment of strategy use and self-regulatory behaviour since past research (i.e., Lompscher, 1995) has shown that text-processing and problem solving are especially appropriate domains for the formation and use of cognitive and metacognitive strategies.

Specifically, the present study was separated into three parts:

1. The first part included: (a) four cognitive tests to be taken by participants, assessing their level of vocabulary as well as their reasoning abilities; (b) the Motivated Strategies for Learning Questionnaire (MSLQ), by Pintrich, Smith, Garcia, & McKeachie (1991), which was to be completed by participants. The questionnaire concerned their motivational beliefs and the learning strategies which they use in general, when engaged in reading comprehension tasks at school.

2. The second part was referred to as «Text A» and consisted of the first text (the easy one) to be read, followed by three questions on the text, to be answered by participants. The answers provided by participants were an indication of the level of processing they had performed on the given text, that is, deep or surface processing. Participants then had to complete a second questionnaire, which regarded the specific learning strategies they had used during the processing of Text A. Thus, this questionnaire represented the on-line strategies of the participants, whereas the first questionnaire given (MSLQ) represented the general strategies which the participants use in similar cognitive contexts.

3. The third part was referred to as «Text B» and consisted of the second text (the difficult one) to be read, followed by the same elements as Text A apart from that the given text to be processed was objectively more difficult. That is, it was comprised of a more complex level of syntax and vocabulary. A post hoc comparison of

participants' performance on the two tasks showed that the more simple, Text A, had a higher performance (M=8.545) than that of the more complex, Text B, (M=7.952) [t(289)=4.87, p<.000], as was expected.

Participants

The participants to the present study (N=290) were of three age groups (12, 14 and 16 years old) and came from three different high schools. Furthermore, the sample consisted of both genders, 134 boys and 156 girls.

Tasks

The tasks and questionnaires used were the following:

1. Cognitive ability tasks. A series of tests deriving from the Kit of Factor-Referenced Cognitive Tests (Ekstrom, French, Harman, & Derman, 1976), were used in order to assess cognitive abilities. Three of these tests assessed the verbal abilities of the partcipants. More specifically, the *Vocabulary test* measured participants' knowledge of word meanings and it included 18 items, where a word was given and the participant had to choose among four other alternative words, the one with the most similar meaning to that of the initial given word. Maximum scoring on this test was 18 points in the case where the participant chose all the correct answers.

The *Synonyms test* consisted of 10 words, and for each given word, the participant had to provide as many synonyms of the word as possible. The scoring was based on the number of synonyms provided.

The *Antonyms test* had the same format as the above mentioned Synonyms test, however, participants had to provide as many antonyms as they could, for each given word. Once again, the scoring was based on the number of antonyms provided. Participants were given 5 minutes to complete each of the above tests.

The fourth and final cognitive test given was the *Inferences test* which assessed the participant's ability to reason and draw logical conclusions. The test consisted of five questions where for each one, a statement was given followed by five different conclusions. The participant had to choose the most suitable conclusion to each statement. Maximum scoring here was 5 points and 5 minutes were granted for its completion.

2. Reading comprehension tasks. Each given reading comprehension task included a text followed by three text-based questions. As mentioned above, the two given tasks differed in their text complexity, in terms of vocabulary, syntax and structure. The first text-based question asked for the main idea of the text, while the following two questions were of multiple choice format and assessed the level of text comprehension which the participants had attained; each alternative answer provided in the multiple choice question, reflected a different level of cognitive processing. Each of the above questions was rated on a 4-point scale, in terms of the extent of text processing performed, for a total of 12 points.

Scoring was as follows: The score (1) was given for a wrong or completely irrelevant answer. The score (2) was given for a surface answer, that is an exact reproduction of the wording of the text. The score (3) was given for a somewhat processed answer where knowledge was formulated in participant's own words. The score (4) was given for an abstract answer which demonstrated a deep level of text processing. There was no time limit on the processing of the two tasks.

3. Questionnaires. The questionnaires used in the present study regarded participants' motivational orientations as well as their use of learning strategies, both on an action and on a reflection level.

On-line strategies: The assessment of on-line strategies used during the cognitive processing of the given tasks was done via the text processing scale of the questionnaire "How do you learn?" (Lompscher, 1995). This questionnaire consists of four subscales, each representing four different dimensions of learning strategies: *surface structure* (Surf) (6 items, Cronbach's alpha for Text A for this sample=.1614, Text B alpha=.2074); *deep structure* (Deep) (7 items, Cronbach's alpha=.6703 and .7233 for Text A and B, respectively); *learning techniques* (Tech) (7 items, Cronbach's alpha=.6416 and .6624 for the two texts respectively); and *metacognitive strategies* (MC) (7 items, Cronbach's alpha=.6235 and .7662 for the two texts). Each strategy item was rated separately on a 4-point scale.

Motivated Strategies for Learning Questionnaire: This questionnaire (Pintrich et al., 1991) was used for the assessment of learning strategies (used generally in similar learning contexts) and motivational beliefs. The learning strategies scale used consisted of the following subscales: *rehearsal* (Reh) (4 items, Cronbach's alpha for this sample=.6870); *elaboration* (Elab) (6 items, alpha=.7370); *organisation* (Org) (4 items, alpha=.6119); *critical thinking* (CT) (5 items, alpha=.6465); and *metacognitive self-regulation* (MSR) (12 items, alpha=.7440). The motivation scale consisted of the following subscales: *intrinsic goal orientation* (IGO) (4 items, alpha=.5011); *extrinsic goal orientation* (EGO) (4 items, alpha=.6782); *task value* (TV) (6 items, alpha=.8174); *control of learning beliefs* (LB) (4 items, alpha=.5340); *self-efficacy* (S-eff) (8 items, alpha=.8250); and *task anxiety* (TA) (5 items, alpha=.7105). Each dimension of learning strategies and motivation was rated separately on a 7-point scale.

Procedure

Participants were tested in groups in their classrooms in two sessions. During the first session, which lasted approximately 45 minutes, they were given the cognitive ability tasks and the MSLQ. In the second session they were given the two texts and the on-line questionnaires.

Results and Discussion

In order to test the above stated hypotheses, Path analysis using the EQS statistical program (Bentler, 1993) was applied as well as a series of ANOVAs for the testing of the differences on self-regulatory behaviour in the two texts.

Path Analysis

The path analysis model attempted to determine the causal paths connecting cognitive ability, motivational orientations, learning strategies (both on-line and general), and performance outcome. The following strategy was adopted for the better understanding of text difficulty effects. The path model was firstly tested in the data of the easy text (Text A); then it was applied to the data of the difficult text (Text B). In this way it was possible to identify task effects on the pattern of interrelations between the variables of the study. This strategy is consistent with the concept of "self-regulation" which implies monitoring and control of behaviour as it evolves on each particular occasion. Furthermore, the identification of text-independent patterns of relations, would indicate systemic relations of a more general nature.

In the model tested cognitive ability (CA) was represented by the sum of the scores on the cognitive ability tasks. The motivational orientation and strategies were also represented by a sum score of the items of the respective factor of the questionnaires.

The path model best fitting the data of the easy text is presented in Table 1. The fit indices for the model were: $x^2(91)=75.882$, $p=.873$, CFI=1.000, NFI=.950, NNFI=1.016.

The fit indices for the model of the difficult

Table 1

The path model showing the interrelations between cognitive ability, motivational orientations, learning strategies (general and on line) and performance for the easy text

	Independent variables																	
Dependent	CA	IGO	EGO	TV	LB	S-eff	TA	Reh.	Elab.	Org.	CT	MSR	Perf A	Surf A	Deep A	Tech A	MCA	E
IGO	-.065*																	.998
EGO	-.208						.285											.930
TV		.535	.176															.824
LB				.360														.933
S-eff	.103	.191		.434														.827
TA	-.096*																	.995
Reh.	-.105			.352						.465								.696
Elab.		.304	-.137	.248							.289	.178						.625
Org.									.325			.467						.714
CT		.391	-.118		-.220	.257	.163											.822
MSR	-.132	.257	.105	.294	.174		.156				.167							.696
Perf A	.157																	.987
Surf A								.269										.963
Deep A	.167								.166			.193		.281				.886
Tech A	-.129														.405		.290	776
MC A	-.093*				.109									.161	.546			.770

Note: The symbol* indicates non significant relation

Abbreviations:

CA = Cognitive ability
IGO = Intrinsic goal motivation
EGO = Extrinsic goal motivation
TV = Task value
LB = Learning belief
S-eff = Self-eficacy
TA = Task anxiety
Reh = Rehearsal
Elab = Elaboration
Org = Organization
CT = Critical thinking
MSR = Metacognitive self-regulation
Perf A = Performance - Text A
Perf B = Performance - Text B
Surf A = Surface - Text A
Surf B = Surface - Text B
Deep A = Deep - Text A
Deep B = Deep - Text B
Tech A = Technical - Text A
Tech B = Technical - Text B
MC A = Metacognitive - Text A
MC B = Metacognitive - Text B

text were not so good: $x^2(92)=124.786$, $p=.013$, CFI=.978, NFI=.925, NNFI=.968. This model is given in Table 2.

For the optimal presentation and comprehension of results, the data will be presented in terms of each hypothesis made and with the aid of figures depicting the corresponding parts of the models.

Cognitive ability, on-line learning strategies, performance. According to Hypothesis 1a, cognitive ability should affect the choice and use of specific learning strategies. In terms of the on-line strategies used to complete the easy text, as shown in Figure 1a, some of them were affected directly, although slightly, by the students' cognitive ability. The only exception to this finding was that of the surface strategy variable used in Text A, which was not directly affected by cognitive ability. In the case of the difficult text, as shown in Figure 1b, the surface strategy was also not related to cognitive ability and so did the metacognitive strategies. The MCA loading was very low in the case of Text A also. So what is consistent in the two models is the positive relation of cognitive ability with deep strategy use, which increases as the task becomes more difficult and an automatic processing is not so easy to lead to text comprehension.

At this point, it must be mentioned that with regard to the surface strategy variable (the subscale of the questionnaires used for both Texts, A and B), the Cronbach alpha value was very low; thus, the reliability of this subscale is weak, as it was applied to the sample of the present study, and certain conclusions cannot be drawn. What needs to be commented is the negative relation between cognitive ability and the use of technical strategies in both texts. This may indicate that the higher the cognitive ability, the easier it was to process the text, which yielded the use of technical strategies less necessary. Finally, as regards the relation between cognitive ability and metacognitive strategies, it seems that they were not used systematically by the students and there was no clear relation with cognitive ability. These findings are not in accordance with Hypothesis 1a. Therefore Hypothesis 1a was only partially confirmed.

With regard to Hypothesis 1b, which predicted effects of cognitive ability via the learning strategies on performance, Figures 1a and 1b and Tables 1 and 2 show that this was not the case. In fact, performance in both Text A and Text B was effected only by cognitive ability and not the learning strategies. Therefore Hypothesis 1b was not confirmed.

Based on the above findings, it can be inferred that students' cognitive abilities constitute a determining factor of their performance outcomes and not the actual learning strategies which they use. This finding needs further investigation. Besides this, cognitive abilities are not closely tied to the on-line strategies of the student so as to enhance students' performance indirectly by facilitating the use of more effective strategies. Lastly, the effect of the cognitive ability factor on performance increases accordingly to the level of objective difficulty of the given text.

Cognitive ability, general strategies, and performance. The results concerning the effects of cognitive ability on the general learning strategies used by students in similar learning contexts were similar to those revealed for the on-line strategies. That is, the effects of cognitive ability on general learning strategies were minimal. They were significant only in the case of rehearsal and metacognitive self-regulation. What is even more interesting is that these relations were negative. This suggests, firstly, that students are becoming aware of certain strategies only and not of all available strategies. Secondly, the students become aware of strategy use when they experience difficulty in processing a text. That is, when cognitive ability does not suffice for the desired outcome and they need to use other means (strategies) to achieve it. This may explain the negative relation. Another possible explanation is that high in

Table 2
The path model showing the interrelations between cognitive ability, motivational orientations, learning strategies (general and on-line) and performance for the difficult text

	Independent variables																	
Dependent	CA	IGO	EGO	TV	LB	S-eff	TA	Reh.	Elab.	Org.	CT	MSR	Perf B	Surf B	Deep B	Tech B	MCB	E
IGO	-.065*																	.998
EGO	-.208						.285											.930
TV		.535	.176															.824
LB				.360														.933
S-eff		.193		.420														.836
TA	-.096*																	.995
Reh.	-.105			.352						.465								.695
Elab.		.304	-.137	.248							.288	.178						.625
Org.									.324			.467						.713
CT		.391	-.118		-.220	.257	.163											.822
MSR	-.132	.257	.105	.294	.174		.156				.167							.696
Perf B	.321																	.947
Surf B								.275										.961
Deep B	.264								.347					.333				.829
Tech B	-.163													.113	.586			782
MC B					.094									.281	.255	.383		.671

Note: The Symbol* indicates non significant relation
Abbreviations:
CA = Cognitive ability
IGO = Intrinsic goal motivation
EGO = Extrinsic goal motivation
TV = Task value
LB = Learning belief
S-eff = Self-eficacy
TA = Task anxiety
Reh = Rehearsal
Elab = Elaboration
Org = Organization
CT = Critical thinking
MSR = Metacognitive self-regulation
Perf A = Performance - Text A
Perf B = Performance - Text B
Surf A = Surface - Text A
Surf B = Surface - Text B
Deep A = Deep - Text A
Deep B = Deep - Text B
Tech A = Technical - Text A
Tech B = Technical - Text B
MC A = Metacognitive - Text A
MC B = Metacognitive - Text B

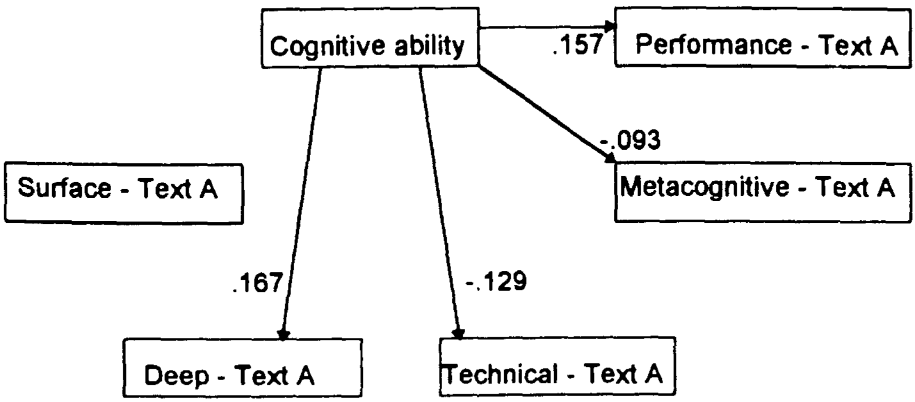

Figure 1a
The relations between cognitive ability and specific learning strategies in the easy text

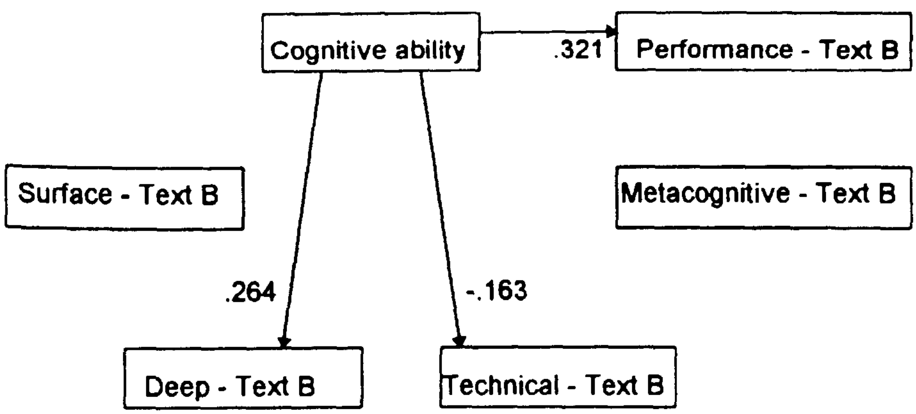

Figure 1b
The relations between cognitive ability and specific learning strategies in the difficult text

cognitive ability students do not use the less productive strategy of rehearsal. Therefore Hypothesis 1a (as it applies to general learning strategies) was again partly confirmed.

Cognitive ability and motivational orientations. Hypothesis 2 predicted that cognitive ability would correlate with the other component of SRL, namely motivational orientations. As shown in Figure 2 cognitive ability correlated negatively with extrinsic goal orientation and positively with self-efficacy. The relations with intrinsic goal orientation and task anxiety were not significant and negative. The two significant relations of cognitive ability are in line with

Hypothesis 2. However, generally speaking the effects of cognitive ability on motivational orientations were low or non-existent. What is also interesting is that motivational orientations had no effects on performance of either Text A or Text B, contrary to the assumptions made by the proponents of SRL.

Text difficulty, learning strategies, performance. The hypothesis concerning the relationship between text difficulty and text performance (Hypothesis 3a) was confirmed, since, the mean performance outcomes for Texts A and B were 8.54 and 7.95 respectively (see Method for test of significance). This finding indicates that, at a cognitive level, participants applied deep, elaborative strategies more to Text A than to Text B, because the higher the scoring the deeper the processing according to the scoring criteria. However the students did not realize they were doing so when asked to report their strategy use as was indicated by the lack of relation of on-line learning strategies with performance.

In order to better understand the factors that influenced the reported strategy use and the possible effect of task difficulty (Hypothesis 3b), we shall firstly refer to the evidence provided by the path analyses and then to the differences shown by ANOVAs.

As shown in Figure 3a, 3b, and 3c, one group of factors which was found to influence the reported use of general strategies is motivational orientations. Tables 1 and 2 show that rehearsal was related only to task value. This finding suggests that greek students use this strategy because they consider it productive in tasks of value. Elaboration (Figure 3a) was found to be positively related to intrinsic goal orientation and task value and negatively to extrinsic goal orientation as predicted by previous research. Organizational strategies were not found to correlate with motivational orientations. Critical thinking, however, was positively related to intrinsic goal orientation, self efficacy and task anxiety. It was negatively related to extrinsic goal orientation and control of learning behaviour (Figure 3b).

The above findings suggest that negative affect and not only intrinsic motivation and perceived competence are necessary for the application of critical thinking. Extrinsic goal orientation is not conducive to critical thinking

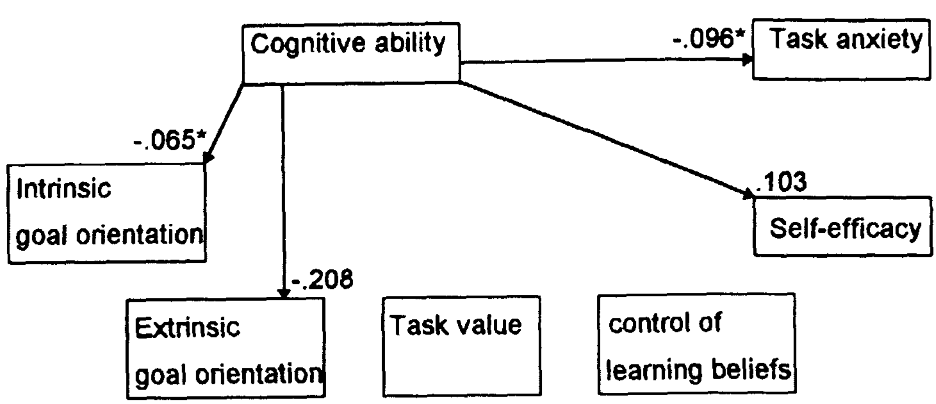

Figure 2
The relations between cognitive ability and motivational orientations
Note: The symbol* denotes non significant relation.

whereas learning beliefs seem to lead one to external means of control that do not promote critical thinking. Finally, the use of metacognitive self-regulation (Figure 3c) was influenced by all motivational orientations except self-efficacy. However, the stronger effects were by intrinsic goal orientation and task value. Taking into consideration the small but negative effect of cognitive ability and the lack of relations with self-efficacy it can be concluded that metacognitive self-regulation is reported when ability is not enough by itsel to control behaviour and the person is motivated (intrinsically or extrinsically) to perform well because the task is valued. Therefore, general learning strategies are mainly effected by motivational orientations and each strategy by a different cluster of motivational factors. It should be made clear, however, that the above findings essentially reflect students' motivations and beliefs about learning strategies in general and this does not imply that the same factors influence the use of on-line strategies.

Indeed our findings revealed that none of the task-specific strategies was related to any motivational orientation, in both texts, except for metacognitive strategies which were effected by learning beliefs. Therefore motivational orientations were not sufficient by themselves to influence on-line strategy use. Cognitive ability partly did so. The factor that did influence the on-line use of strategies was the general learning strategies and the specific strategies themselves. These effects are presented in Figures 4 and 5. In essence, the pattern of interrelations is similar in the two texts. What is worth noting is the relation of the elaboration with deep strategies, which is understandable (Figures 4a and 5a). What is less obvious is the positive relation between surface and deep strategies. This implies that greek students do not consider them incompatible and use them jointly. This is consistent with the finding that rehearsal was related to task value. It is probable that the school system is such that requires both deep processing of text and retention of surface features.

The application of technical means for the processing of the texts was influenced by deep strategies and either metacognitive strategies (in Text A) or surface strategies (in Text B) (Figures 4b and 5b). The use of metacognitive strategies was influenced by both deep and surface approaches, and by learning beliefs. In the difficult text it was also influenced by the use of technical means (Figures 4c and 5c). These findings suggest that task difficulty did have an effect on on-line strategy use, particularly the use of technical means and metacognitive strategies. This finding is partly in line with Hypothesis 3b.

In order to further test the effects of task difficulty, a repeated measures ANOVA was applied with on-line strategies and text as within subjects factors. The main effects of strategy [$F(3,705)=118.69$, $p=.000$] and text [$F(1,235)=42.71$, $p=.000$] were significant and so was the strategy by text effect [$F(3,705)=32.52$, $p=.000$]. This interaction was due to the fact that surface strategies were used more in Text A ($M=2.341$) than in Text B ($M=2.006$), whereas there was no significant difference in the other strategies. Therefore, both path analyses and the ANOVAs revealed a modification of on-line strategies from one text to the other, although this effect was more obvious in surface strategies. For these reasons Hypothesis 3b was partially confirmed, since there was no increase of deep strategies in Text B.

General discussion

The aim of the present study was to investigate possible interrelations between cognitive ability, components of the self-regulatory system and context factors such as task difficulty, and to see if these relations contribute or not to strategy use and performance during on-line processing of a cognitive task.

The findings of the study are significant as

Figure 3a

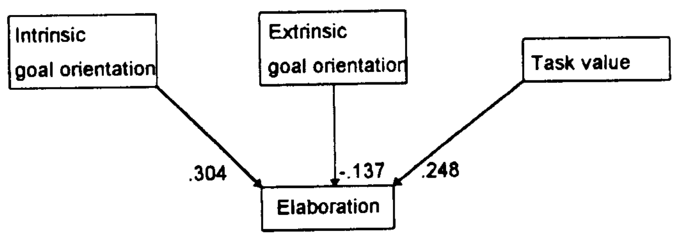

Figure 3b

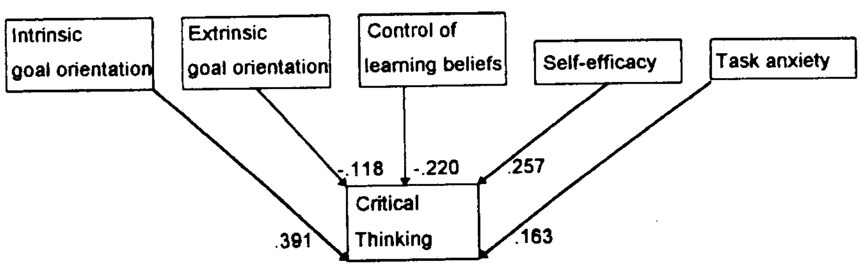

Figure 3c

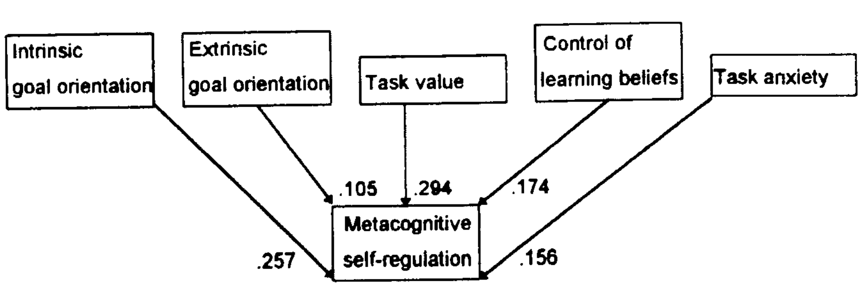

Figure 3
The relations between motivational orientations and general learning strategies

Figure 4a

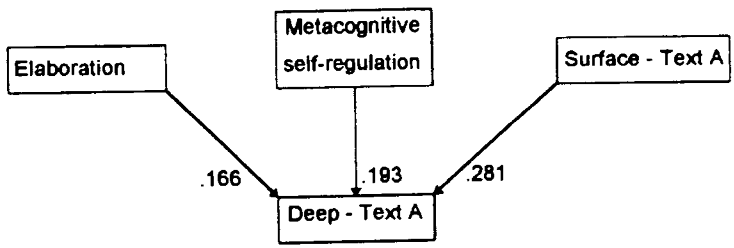

Figure 4b

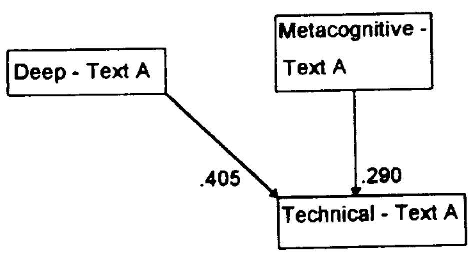

Figure 4c

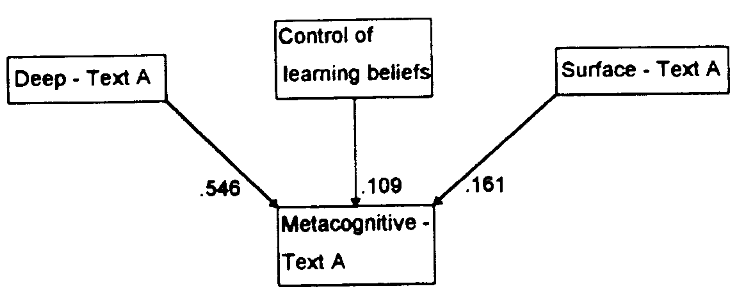

Figure 4
The relations between learning strategies in the easy text

Figure 5a

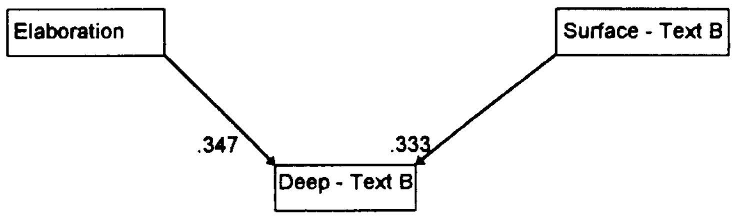

Figure 5b

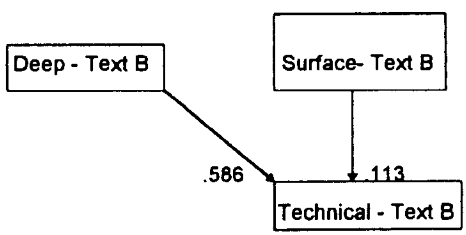

Figure 5c

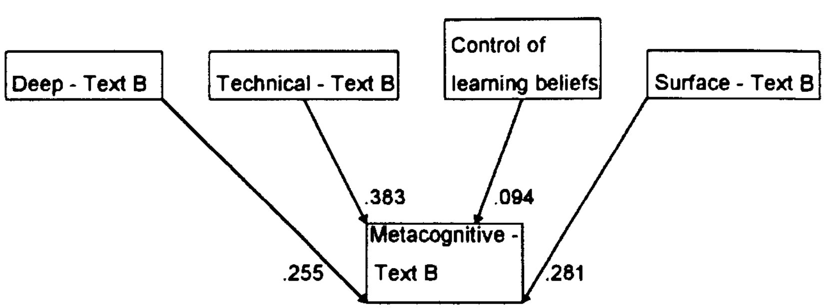

Figure 5
The relations between learning strategies in the difficult text

they demonstrate that self-regulated learning involves a complex interaction between many factors, and that each of these factors bears a different degree of significance to the system as a whole. Firstly, cognitive ability acts as a major factor in self-regulatory behaviour since it effected almost all of the variables under study. Furthermore it was the only factor that influenced performance outcome. Secondly, cognitive ability did not effect general learning strategies. This result supports the past findings of Alexander and Schwanenflugel (1994), according to which, cognitive ability is minimally involved in the choice and use of strategies. Hoewever our findings suggest that cognitive ability may be involved in the use of strategy during on-line processing. Therefore more research is needed in this direction. Thirdly, motivational orientations and strategy knowledge bear less influence on performance and on on-line strategies than cognitive ability. This finding is in contrast to the past findings of Zimmerman and Martinez-Pons (1986, 1988), which suggested that the use of effective strategies and positive motivational beliefs lead to higher performance outcomes.

In our study motivational orientations were found to influence the preferences of learning strategies at a general level, independently of actual task requirements. At the on-line level, the task and its characteristics interacted with the learning strategies available and with one's ability to handle the task. Previous experience with specific learning strategies which are reinforced by the testing system may play a more significant role in the choice of strategy than general knowledge of learning strategies or motivational orientations. This is a particularly interesting finding, because it shows that SRL should be seen not only in relation to the person but also in relation to the school system.

The present study also revealed that when the level of task difficulty increases, performance outcome is directly negatively effected, as was expected. However, the use of strategies is also affected, so that although one specific strategy prevails, others collaborate alongside. Therefore, through the use of metacognition, students regulate their strategy use, thus allowing them to effectively meet the processing demands of the given text. This finding indicates that context factors such as task difficulty may actually be responsible for the adaptation of the strategies used during on-line task processing.

In general, the present study suggests the importance of the continuation in research on self-regulated learning. However, further research should be conducted within a broader framework where the interactive influence of other factors is also considered. For instance, contextual variables that support, encourage or discourage self-regulated learning, the students' learning environments and the demands imposed on them, are factors which should all be considered.

It is now apparent that learning and instructional environments are becoming more self-directed and autonomous (for example, internet courses and multimedia environments). Therefore, now more than ever, we need to develop models, guidelines or curriculum materials to help students improve their self-regulatory behaviour. More generally, conceptual models of self-regulated learning are crucial for the understanding of human thoughts, behaviours and emotions, in both research and applied educational domains.

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