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Inter-Relations among Motivation, Self-Perceived Use of Strategies and Academic Achievement in Science: A Study with Spanish Secondary School Students

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Abstract: The relationship between motivation and the use of learning strategies is a focus of research in order to improve students' learning. Meaningful learning requires a learner's personal commitment to put forth the required effort needed to acquire new knowledge. This commitment involves emotional as well as cognitive and metacognitive factors, and requires the ability to manage different resources at hand, in order to achieve the proposed learning goals. The main objectives in the present study were to analyse: (a) Spanish secondary school students' motivation and self-perception of using strategies when learning science; (b) the nature of the relationship between motivation and perceived use of learning strategies; (c) the influence of different motivational, cognitive, metacognitive and management strategies on students' science achievement. The Motivated Strategies for Learning Questionnaire (MSLQ) was administered to 364 middle and high-school students in grades 7–11. For each participant, the academic achievement was provided by the respective science teacher. The results obtained from the Pearson product-moment correlations between the study variables and a stepwise regression analysis suggested that: (1) motivation, cognitive and metacognitive, and resource management strategies, have a significant influence on students' science achievement; (2) students' motivation acts as a kind of enabling factor for the intellectual effort, which is assessed by the self-perceived use of learning strategies in science; and, (3) motivational components have a greater impact on students' performance in science than cognitive and metacognitive strategies, with self-efficacy being the variable with the strongest influence. These results suggest a reflexion about the limited impact on science achievement of the self-perceived use of cognitive and metacognitive strategies, and highlight the importance of students' self-efficacy in science, in line with previous studies.

Keywords: motivation; learning strategies; science learning achievement; secondary school students; MSLQ questionnaire

1. Introduction

People's strategic efforts in learning and decision making are better understood when motivational and cognitive factors are considered together [1,2]. Recently, the neural bases of the interaction between motivation and cognitive control have been studied [3] (Yee and Braver, 2018), and physiological mechanisms by which motivation influences cognitive control have been described [4].

In their psychological approach, Ausubel proposed a particular relationship between motivational and cognitive factors as a pre-requisite for meaningful learning: the learner's personal commitment to put forth the required effort needed to properly process the learning materials, integrating the new information with prior knowledge and managing the resources at hand to foster comprehension. Involved in the commitment with learning, students' motivation seems to enable the activation of metacognitive and self-regulatory mental activity [5].

When students' motivational, cognitive and metacognitive factors are integrated, a significant effect on their academic achievement is observed [6]. Zimmerman [7–9] accounted for this fruitful motivation-cognition integration in their self-regulated learning model aimed at helping teachers to develop a more effective teaching.

In science learning, variated motivational components have proven to have considerable influence on science achievement [10–13]. Moreover, the relevance of the merging of motivation and learning strategy use was pointed out by Anderman and Young [14], Obrentz [15], and Bryan, Glynn and Kittleson [16]. Models integrating motivation and science learning in specific ways have also been proposed and tested. Miñano, Castejón, and Gilar [17] proposed a structural model aimed at examining to what extent the motivational variables interact with cognitive variables, such as intelligence or learning strategies, in predicting academic performance. The proposed model had a satisfactory fit, explaining 66% of the variance of academic achievement. Alpaslan, Yalvac, Loving and Willson [18] used structural equation modelling to explore the relations among personal epistemologies, self-regulated learning and achievement in physics. The model explained about 12% of the variance of students' achievement in physics. Sungur and Güngören [11] built a structural equation model, showing that students' perception of classroom environment concerning motivating tasks, autonomy support, and mastery evaluation were positively associated with motivational and cognitive components of self-regulation and science achievement. The model proposed by Lee, Lim and Grabowski [19] revealed that the combination of generative learning strategy prompts with metacognitive feedback enhanced learners' self-regulation, and this improved their recall and comprehension of the human heart system.

Summing up, emotional factors have to be considered as integrated with cognitive, metacognitive and management factors to understand and improve students' academic achievement. Among these factors, strategies play an essential role. Learning strategies can be defined as a sequence of specific activities that will enable the learner to gain new knowledge [20].

2. Aims and Predictions

In the present study, we aimed at obtaining data about Spanish secondary school students' motivation and the use of strategies when learning science in an integrated manner. We also aimed at relating students' integrated motivational and cognitive perceptions with their academic achievement in science. Up to our present knowledge, there are not similar studies in the Iberoamerican context. Our predictions were formulated in agreement with previous outcomes in different cultural contexts:

(P1) Motivation, cognitive and metacognitive, and resource management strategies will significantly influence students' achievement in science.

(P2) Motivation will act as an ability factor for the learning strategies: low motivation should be associated with the low use of learning strategies, (and then with a limited intellectual effort).

(P3) Due to the rational grounds of science knowledge, the cognitive and metacognitive strategies will have a greater impact on students' performance in science than motivation and management strategies.

Due to their subjective nature, emotions are difficult to assess in a direct way and thus, have to be assessed in an indirect way. One possibility is students' self-reports. The Motivated Strategies for Learning Questionnaire (MSLQ onwards), elaborated by Pintrich, Smith, Garcia and McKeachie [21], was proposed, with the goal of providing data about students' self-perception of motivation, cognitive, metacognitive and resource management strategies in an integrated way. This instrument has been used in about 150 research papers [22]. Its validity has been stated in diverse contexts using Turkish high school students [23], Uruguayan students of psychology [24], Mexican university students [25], and Hong Kong high school students [26].

Several studies relating some MSLQ dimensions to students' achievement in science and mathematics have been conducted in many countries with university students [27,28], high school students [12,29], and even with primary students [30,31].

3. Methods

3.1. Research Design

An ex post facto design was used in this study, since no manipulation of the variables occurred. The relationship between variables was retrospectively determined. Quantitative analyses were conducted using statistics when needed.

3.2. Participants

A sample of 364 male and female Spanish middle and high-school students enrolled in courses from 7th to 11th grade (12–18 years old) participated in the present study. In order to increase the students' diversity in the sample, the participants belonged to 7 high schools of different ownership (public, privately managed-cooperative, and privately managed-religious) located in the surroundings of Valencia. The socio-economic level associated to these areas is intermediate, the families having no important economic or social troubles. Although no participants showed unusual differential characteristics, the selection was random and thus, this sample does not represent the secondary students' population in Spain.

In each school, the classroom groups and the participants were not selected. Students were all invited to participate in educational research as anonymous volunteers, and informed that their collaboration would have no consequences on their marks. Informed consent was required from the families and school management. No previous selection of students was carried out, but all those included in the course groups participated in the present research.

3.3. Instruments and Measures

3.3.1. MSLQ: The Self-Perceived Use of Metacognitive Strategies and Motivation Was Evaluated with the Motivated Strategies for Learning Questionnaire (MSLQ)

The MSLQ contains three different sections:

A. The Motivation section consists of 31 items that mainly assess the students' learning objectives, their beliefs about learning and self-efficacy, and the value given to the learning tasks. The scales (or components) included in this section are: (Intrinsic) Goal Orientation, Extrinsic Goal Orientation, Task Value, Control of Learning Beliefs, Self-Efficacy, and Test Anxiety.
B. The Cognitive and Metacognitive strategies section includes 31 items that evaluate information processing (elaborating and organizing the information provided, for instance), and the metacognitive regulation of the learning processes. Rehearsal, Elaboration, Organization, Critical Thinking and Metacognitive Self-Regulation are the scales included here.
C. The Resource Management to facilitate learning section is made of 19 items. They were designed to assess the students' perception of how much classmates and teachers can help doing the tasks, and the way spaces and times are arranged to keep in task as long as necessary. The components in this section are: Time and Study Environment, Effort Regulation, Peer Learning, Support of Others (or Help Seeking).

Each item proposes an assertion, and the student has to assess it using a Likert scale of 7 points, where 1 means "Not at all true of me" and 7 means "Very true of me". The score of each scale is obtained by averaging the items involved.

3.3.2. Academic Achievement

For each participant, the academic achievement was obtained directly from the science teachers in each secondary school. The traditional scale for academic marks in Spain ranks 0–10. These marks were the final ones that every school must provide to the government educational department, and are based on the same scale and the same published assessment criteria. Some non-controlled criterial differences among teachers/centers could appear, but of a limited extent, due to governmental control. In fact, globally the students' marks did not show significant differences in the different educational centers (Kruskal–Wallis: $X^2(6) = 6.849$; $p = 0.335$).

The global mean value and standard deviation of students' marks were: M = 6.9; SD = 1.8. Participants' marks were not normally distributed (Kolmogorv–Smirnov test; $p < 0.001$); the skewness was non-significant (skew = −0.23; SEs = 0.13; skew/SEs = −1.77; $p > 0.05$), but the kurtosis was clearly significant (kurtosis = −0.073, SEk = 0.26; kurt/SEk = −2.9; $p < 0.01$). Differences with the Gaussian expected frequencies mainly appeared in extreme marks (more students than expected in 3.0–4.0 and 9.0–10), suggesting that teachers overestimated or underestimated students' achievement in some extreme cases.

3.4. Procedure

The MSLQ was translated into Spanish, and adapted to an electronic format, to facilitate the process of collecting responses from different educational centers. In each center, permissions were requested, and the science teachers were instructed on the administration of the questionnaire to their students.

The questionnaire was administered in a normal science class. Completion lasted less than 90 min, and typically took 65–80 min. One of the researchers was present in the sessions to clarify participants' doubts. Excel and SPSS 24.0 were used to collect and to analyze data, using descriptive and inferential statistics.

4. Results

4.1. Self-Perceived Use of Learning Strategies in Science Learning

The scores for the global questionnaire and for every section were obtained by averaging the corresponding items. According to the Kolmogorov–Smirnov test, the distribution of the global mean value (all the sections included) was not significantly different from a normal distribution ($p > 0.20$), with an average of M = 4.81 and Standard Deviation of SD = 0.64. Quartile values were placed at values 4.41; 4.85; 5.26. The scores for the components in the three sections of the MSLQ are shown in Table 1.

Participants reported using more motivational components than cognitive and metacognitive strategies or resource management strategies. The most used components in science learning (according to students' self-perceptions) were GO and EO (both motivational), and the less used were R (cognitive) and PE (resource management).

Table 2 shows the product-moment correlations between pairs of components obtained in the sample. The r values ranged from −0.07 to 0.74, and most were significant. The components with higher multiple correlation with the other components were MR (RMR = 0.85); E (RE = 0.81); and SE (RSE = 0.81); and the components with lower multiple correlation were TA (RTA = 0.46); SO (RSO = 0.50); and LB (RLB = 0.57).

Table 1. Mean values obtained for the The Motivated Strategies for Learning Questionnaire (MSLQ) components (scale 1–7).

	Sections and Components	Mean	SD
	Motivation		
GO	Goal Orientation	5.22	1.00
EO	Extrinsic Goal Orientation	5.36	1.11
TV	Task Value	5.06	1.24
LB	Control of Learning Beliefs	5.15	1.01
SE	Self-Efficacy	5.14	1.14
TA	Test Anxiety	4.64	1.17
	Motivational average	5.09	0.78
	Cognitive and Metacognitive Strategies		
R	Rehearsal	3.86	0.88
E	Elaboration	4.89	1.01
O	Organization	5.01	1.34
CT	Critical Thinking	4.67	1.04
MR	Metacognitive Self-Regulation	4.83	0.86
	Cog and Metacog-average	4.66	0.81
	Resource Management Strategies		
TE	Time and Study Environment	4.92	0.83
ER	Effort Regulation	4.72	1.12
PE	Peer Learning	4.02	1.38
SO	Support of Others (Help Seeking)	4.58	0.99
	Management-average	4.56	0.69

Table 2. Pearson correlation between the MSLQ components in the sample.

	GO	EO	TV	LB	SE	TA	R	E	O	CT	MR	TE	ER	PE
EO	0.52 **													
TV	0.61 **	0.60 **												
LB	0.36 **	0.44 **	0.48 **											
SE	0.61 **	0.61 **	0.69 **	0.48 **										
TA	0.18 **	0.20 **	0.09	0.13 *	−0.07									
R	0.31 **	0.31 **	0.41 **	0.27 **	0.36 **	0.18 **								
E	0.38 **	0.30 **	0.37 **	0.28 **	0.41 **	0.10	0.57 **							
O	0.23 **	0.17 **	0.24 **	0.18 **	0.23 **	0.12 *	0.45 **	0.55 **						
CT	0.38 **	0.30 **	0.38 **	0.24 **	0.40 **	0.15 **	0.47 **	0.65 **	0.32 **					
MR	0.43 **	0.36 **	0.48 **	0.26 **	0.47 **	0.15 **	0.60 **	0.74 **	0.50 **	0.64 **				
TE	0.27 **	0.26 **	0.37 **	0.20 **	0.38 **	−0.02	0.45 **	0.45 **	0.43 **	0.31 **	0.55 **			
ER	0.29 **	0.24 **	0.34 **	0.13 *	0.39 **	0.01	0.37 **	0.40 **	0.31 **	0.31 **	0.54 **	0.54 **		
PE	0.21 **	0.13 *	0.14 **	0.07	0.10 *	0.19 **	0.31 **	0.37 **	0.27 **	0.40 **	0.37 **	0.05	0.03	
SO	0.20 **	0.16 **	0.16 **	0.06	0.10 *	0.15 **	0.28 **	0.32 **	0.17 **	0.17 **	0.33 **	0.10 *	0.15 **	0.40 **

**: $p < 0.01$; *: $p < 0.05$.

The reliability (internal consistency) of the whole MSLQ questionnaire was high (Cronbach's $\alpha = 0.86$), and so was the reliability of the motivational section ($\alpha = 0.82$) and of the cognitive and metacognitive section ($\alpha = 0.84$). However, the reliability of the resource management section was low ($\alpha = 0.50$), probably because this section is only made up of four components.

4.2. Relationship between Motivation and Perceived Use of Learning Strategies

We analyzed the nature of the relationship between Motivation and the perceived use of learning strategies. First, the motivation components taken together (averaged) significantly correlated with the mean score of the cognitive and metacognitive section ($r = 0.51$; $p < 0.001$), and with the mean score of the resources management section ($r = 0.41$; $p < 0.001$). Thus, 26% of the variance of the perceived use of Cognitive and Metacognitive strategies and 17% of the variance of Management strategies can be explained by students' Motivation.

Second, the cognitive and metacognitive section and the management section were considered together (9 strategies) as a Strategy-use variable in an averaged score, as they share an important part of their variances (46%; Pearson-r = 0.68; $p < 0.001$). Third, different levels for Motivation and for Strategy-use were defined: Low level (score ≤ 3), Intermediate (3 < score ≤ 5), High (score > 5). The low levels were infrequent in both variables (7 cases in low Motivation, i.e., 2% of the sample, and 7 different participants in low Strategy-use). Therefore, in both variables, the low and intermediate levels were collapsed and considered together. Table 3 shows the distribution of participants when these variables are crossed.

Table 3. Relationship between the motivation level and the use-of-Strategies level, as perceived by the students themselves.

	Motiv-Low	Motiv-High
Strat-use Low	130 (87.8%)	122 (56.5%)
Strat-use High	18 (12.2%)	94 (43.5%)
Total	148 (100%)	216 (100%)

Careful observation of the data in Table 3 suggests that low Motivation is strongly associated to a low Strategy-use with a high probability, but high Motivation cannot be associated to any level of Strategy use. In the complementary analysis, a low level of Strategy-use cannot be associated to any level of Motivation, but a high level of Strategy-use is strongly associated to high Motivation.

4.3. Influence of Motivation and Learning Strategies on Academic Achievement in Science

Table 4 shows the components significantly correlated with the achievement scores of students in science. Only Task Anxiety (Motivation-type: r = −0.01), Critical Thinking (Cognitive and Metacognitive-type: r = 0.09), and Peer Learning (Managing-type: r = 0.08) had no significant correlations with students' academic achievement scores.

Table 4. Significant correlations between MSLQ component and academic achievement in science.

Sections and Components	Pearson's r
Motivation	
GO: Goal Orientation	0.14 **
EO: Extrinsic Goal Orientation	0.24 ***
TV: Task Value	0.28 ***
LB: Control of Learning Beliefs	0.15 **
SE: Self-Efficacy	0.41 ***
TA: Task anxiety	−0.03
Motivation-average:	0.29 ***
Cog. and Metacognitive Strategies	
R: Rehearsal	0.26 ***
E: Elaboration	0.20 ***
O: Organization	0.18 ***
CT: Critical Thinking	0.09
MR: Metacognitive Regulation	0.26 ***
Cognitive and Metacognitive-average	0.25 ***
Resource Management Strategies	
TE: Time and study environment	0.29 ***
ER: Effort regulation	0.29 ***
PE: Peer learning	0.08
SO: Support of others (or Help seeking)	0.18 ***
Management-average	0.31 ***

***: $p < 0.001$; **: $p < 0.01$.

When all the MSLQ components were considered together as predictors in linear regression, they explained 27 percent of the variance of participants' scores in science ($F(15,348) = 8.509$; $p < 0.001$; $R = 0.52$). When a step-wise method with forward selection was used to enter only the significant predictors ($p < 0.05$), the resulting equation (for normalized variables) was:

$$\text{Science achievement} = 0.497\ \text{SE} + 0.176\ \text{SO} + 0.171\ \text{TE} - 0.198\ \text{GO} - 0.112\ \text{CT}$$

These significant predictors explained 25 percent of the variance of the students' scores ($F(5358) = 23.711$; $p < 0.001$; $R = 0.50$). Using a forward procedure, the predictor coming first was Self-Efficacy, with the greatest single contribution, 17 percent (see Table 3); next, the components Time and Study Environment (2.1%), and Support of Others (1.9%) added significant single contributions. Goal Orientation and Critical Thinking obtained negative coefficients in the regression, although these strategies had positive correlations with the achievement scores in science. Thus, the above equation did not reveal an inverse relationship between students' GO or CT and their academic achievement in science. Instead, the negative coefficients were due to corrections to avoid over-estimation and to improve the prediction. These corrections added 4.0 percent to the explained variance. The contributions of the remaining strategies not included in the equation were non-significant ($p > 0.05$), due to co-linearity.

Considering the type of components, motivational components explained 19.7% of variance of students' achievement in science; the strategies together explained 14.5% of that variance. Considered apart, the cognitive and metacognitive strategies explained 10.0%; and the resource management strategies explained 12.8% of the variance of students' achievement in science.

5. Discussion

In the present work, we used the MSLQ questionnaire to obtain information about students' self-perception of their use of different self-regulated learning components in science. The global average indicated that participants consider that they use variated self-regulated learning components with a moderate-high frequency. In our sample, 75 percent of students obtained an average above the central, neutral value (4 in a Likert-type 7-point scale). In fact, the 1st quartile was placed at a score of 4.4 over the central, "neutral" value 4.0.

Motivational components reached higher mean scores compared to cognitive and metacognitive ones, suggesting that participants were more aware of their emotional approaches to learn science topics than of their abilities to organize, structure, elaborate, relate, summarize information, or monitor learning obstacles. Resource management components were the least used, according to participants' self-perception, with Peer Learning (PE) being one of the components having a low mean value: only 40 percent of students declared using this strategy with some frequency.

The mean values for the fifteen components in MSLQ (see Table 1) obtained in the present study are similar to the ones obtained by Pintrich, Smith, García and Mckeachie [32]. In that initial study, motivational components obtained the higher average and resource management components obtained the lower average, as in the present study. In absence of the complete individual data of Pintrich et al.'s [32] study, we made a "clumsy approach" to compare our values to the ones obtained by Pintrich et al. [32] (p. 808, Table 1). First, we computed a t-test for the two sets of fifteen mean values. The t-value was low ($t(14) = 1.00$; $p > 0.10$), suggesting no differences between the mean values of components in both studies. In addition, both sets of mean values had a high correlation ($r(15) = 0.67$).

Therefore, although MSLQ was validated for college students, it seems usable with secondary students as well. However, differences in the evolutionary state in students between 12 and 18 years old have to be considered in future replications. Karadeniz, Buyukozturk, Akgun, Cakmak, and Demirel [33] conducted a validation study in a Turkish context, to adapt the MSLQ to male and female primary and high school students from 6th to 11th grades. Students in the sample were tested focusing on different academic subjects: mathematics, sciences, social sciences and language. In order to compare results from this Turkish study to the present Spanish study, we computed again a t-test and a Pearson's correlation for the two sets (Turkish/Spanish) of fifteen mean values. The mean values were not significantly different, and varied in parallel across the different components ($t(14) = 1.19$; $p > 0.10$); both sets of mean values were highly correlated ($r(15) = 0.79$). However, additional replications are needed to increase the reliability of the present results for secondary students using the MSLQ questionnaire.

Influence on Academic Achievement

In their study with undergraduates, Komarraju and Nadler [34] obtained that Self-Efficacy, Effort Regulation and Help-Seeking together explained 18 percent of variance of the academic achievement. This value is comparable to the one obtained in the present study from these same three predictors together: 21 percent. In a similar analysis with Malaysian engineering undergraduates, Kosnin [35] reported that the MSLQ scales together predicted 35 percent of the variance of their academic achievement, not far from the 27 percent obtained in the present study. However, Test Anxiety was a significant predictor in Kosnin's study, but not in the present one, suggesting possible uncontrolled effects due to cultural factors.

As correlations between academic scores and the different components are concerned, the Pearson r-values obtained in the present study are comparable to the ones from other empirical studies. In their analysis on the reliability and predictive validity of the MSLQ questionnaire, Pintrich et al. [32] obtained r-values very similar to the values obtained in the present study for the components sharing the higher variance with the academic scores (data are offered in the order: their study/present study): Self-Efficacy (0.41/0.41), Effort Regulation (0.32/0.29), Metacognitive Regulation (0.30/0.26), Time and Study Environment (0.28/0.29), Elaboration (0.22/0.20). Yet, some differences appeared in some strategies: Rehearsal (0.05/0.26), Extrinsic Goal orientation (0.02/0.24), Task Anxiety (−0.27/−0.03), Support of Others (or Help Seeking) (0.02/0.18). The differences in Extrinsic Goal Orientation and Support of Others could be explained by the different academic level, university in Pintrich et al.'s [32] study, or secondary education in the present study. University students are expected to have more intrinsic and less extrinsic motivation towards the own goals and to be more autonomous in their learning work than teenagers. As Rehearsal concerns, the differences are difficult to evaluate as in the present study participants were focused on science learning only, whereas in Pintrich et al.'s [32] findings, participants proceeded from several branches including Foreign Language, Humanities, etc. However, some differences in the r-values for some strategies (as Rehearsal, for instance) could be due to differences in the teaching approaches.

In the same vein, Kitsantas, Winsler, and Huie [36] conducted a study with undergraduates in the first year at the university. They correlated some of the MSLQ scales (Task Value, Self-Efficacy, Test Anxiety, Metacognitive Self-Regulation and Time Management), with the GPA marks for two distant moments, 2nd and 5th semesters. Again, most correlations they obtained were very similar to the ones obtained in the present study (correlation GPA-2nd semester/GPA-5th semester/correlation Marks-present study): Self-Efficacy (0.37/0.44/0.41); Task-Value (0.30/0.32/0.28); Time and Study Environment (0.35/0.32/0.29) and Metacognitive Regulation (0.21/0.22/0.26). Differences appeared in Test-Anxiety (−0.20/−0.19/−0.03).

Self-Efficacy was the most strongly related component to academic achievement (see Table 3), thus having the greatest single contribution in explaining the variance of students' marks (17 percent). This is a well-known result from previous studies. For instance, Robbins, Lauver, Le, Davis, Langley, and Carlstrom [37] conducted a meta-analysis of factors influencing students' academic achievement. Factors considered in more than 100 studies included institutional commitment, perceived social support, social involvement, achievement motivation, academic goals, self-efficacy, self-concept, self-regulatory study skills, and contextual factors. The academic self-efficacy was the strongest predictor of students' academic achievement in this meta-analysis. Bryan, Glynn and Kittleson [16] conducted a study with 14–16-year-old students, focused on the influence of motivation on learning science. Using a structural equations adjustment, they found that intrinsic goals, self-determination, self-efficacy and academic achievement were significantly associated, but self-efficacy showed the strongest association (r = 0.62). The highest correlation between students' performance and any strategy was observed for self-efficacy (r = 0.40), in a recent study conducted by Jackson (2018), with 258 undergraduates enrolled in STEM gatekeeping courses. A positive and significant correlation between the self-efficacy items of MSLQ and academic achievement (r = 0.45) was also found by Al-Harthy, Was, and Isaacson [38], in a sample of 265 undergraduate students enrolled on an educational psychology course. Lynch and Trujillo [29] also found that self-efficacy was the strongest and more consistent MSLQ factor associated with academic performance in a sample of 66 college students, in the second semester of organic chemistry.

However, it is expected that self-efficacy and academic achievement influenced each other, in both directions. Cheung [39] showed that students' science self-efficacy could be increased by using efficacy-enhancing teaching based on Bandura's theory of self-efficacy. Bernacki, Nokes-Malach, and Aleven [40] found this mutual and continuous feedback effective, while students performed a problem-solving activity. A similar mutual effect was also observed in a study conducted with Italian junior students, where self-efficacy beliefs interacted with personality traits to explain academic achievement [41].

Rehearsal was the strategy of the lowest perceived use in science in the present study: only 25 percent of students declared using this strategy with certain frequency. This is not a surprising result, as comprehension of science concepts, laws, principles and applications are hardly achieved by mere repetition and training. However, individual differences in this strategy had significant and positive impact on the academic achievement: the higher perceived use of this strategy, the higher the mark in science. This is not an expected result, as learning activities based on rehearsal are expected to have low importance in learning science and low influence in academic marks. The positive and significant influence of this strategy turns the attention to the level of cognitive demand of the tasks proposed by secondary science teachers in assessment. Among other important skills, Stiggins [42] proposes science teachers to assess students' mastery of content knowledge, where mastery includes both knowing and understanding, and their use of knowledge to reason and solve problems (see [43]). Rehearsal does not seem relevant to acquire such skills, but other cognitive and metacognitive strategies.

The Peer Learning and Support of Others (or Help Seeking) strategies are related to the ability of a student to obtain help from other students when they need it, asking them for information, collaborating in learning activities, or obtaining some help to overcome learning obstacles. However, in the present study, both strategies obtained low averages compared to the rest of MSLQ. This result suggests that science learning activities in secondary classrooms do not properly encourage collaborative learning, even though the socio-constructivist approach to science education claims that knowledge has to be elaborated and shared by the members of a learning community by means of collaborative work [44–46].

6. Conclusions

It should first be emphasized that the MSLQ questionnaire seems usable with secondary students. This approach is justified, because the main values for the fifteen MSLQ components obtained in this study were similar to other related studies with university students. Furthermore, the Pearson's r-values between components sharing the higher variance with the academic scores in the present study were very similar to the ones obtained in other surveys.

It has been reported that most components of the SRL dimensions have significant correlations with students' performance scores in science. In the present study, all the components of the MSLQ questionnaire were used to predict the students' scores in a multiple regression analysis. This analysis was significant, and explained 27 percent of the variance of participants' scores in science. In addition, separate regression analyses were carried out for each MSQL section—motivational, or cognitive and metacognitive and management strategies—and all of them were also significant. Motivational components together explained almost 20 percent of the variance of students' scores in science;

the cognitive and metacognitive components jointly explained 10 percent; and resource management components explained 13 percent of that variance. In view of this, it appears that the first prediction (P1) "Cognitive and metacognitive strategies, motivation, and resource management will influence the science achievement significantly" has been supported by the data in this study.

As the second prediction (P2) concerns, the data in Table 3 suggested that a high level of Motivation is (almost) a necessary, but not a sufficient condition for using many strategies frequently when learning science. In this way, data seem to support P2 about the role of Motivation as an enabling factor for using strategies frequently when learning science.

Within the limits of the present study, cognitive and metacognitive strategies included in the MSLQ instrument explained less variance of the academic marks (10 percent) than motivation (20 percent), or than resource management strategies (13 percent). Thus, the third prediction (P3) was not supported by the data. It is surprising that the cognitive and metacognitive strategies have lower impact on performance in science than the motivational components, and a coherent explanation is still needed. It opens the question on what science is being taught and how it is assessed in Spanish secondary schools.

One of the consequences that could arise from the current study is the need to investigate the effects of different instructional methods focusing on self-regulatory strategies. To date, it has been proven that Inquiry Based Learning [47] and Problem Based Learning [48] methodologies were superior to traditional instructional approaches on various facets of students' self-regulated learning.

Moreover, Self-efficacy (a motivational component in the MSLQ questionnaire) was the largest contributor to students' science achievement. However, concluding from this outcome that self-efficacy has to be directly promoted in the school curriculum could be inappropriate. Due to the circular nature and mutual influence of self-efficacy and academic success, the one-way causal effect of self-efficacy on academic achievement is difficult to isolate; perhaps the data obtained here and in other similar studies are due to the opposite relationship: the success in school science causes an increase of the student's perception of self-efficacy. This is also a matter for further research.

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