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# Self-Regulation, Math Self-Efficacy, Math Interest and Mathematics Achievement

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**Abstract**

This study reports the relationships between self-regulation (SR), math self-efficacy, math interest, and three types of pupils' mathematics achievement. The sample included 14–16-year-old students in the 9th grade (out of 11) educated in seven standard and enhanced curricula schools in Russia (*N* = 318). Significant correlations were found between the studied constructs and various types of pupils' mathematics achievement. SR proved to be a significant predictor for higher indicators in both year math grade and for solving specific mathematical tasks. Whereas the constructs math self-efficacy and math interest are relevant to different kinds of mathematics achievements, math self-efficacy is a significant predictor for successful solving specific mathematical tasks, math interest is for the year math grade. In addition, the general level of SR acts as a mediator of the links between math interest and year math grade.

Keywords: Self-regulation, math self-efficacy, math interest, achievement;

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## 1. Introduction

Studies of psychological predictors of the educational achievement of students are now reaching a new level, connected with an integrative approach to their analysis. At this level, attention is paid to revealing mediator effects in the interrelationships of the various intrapersonal factors with academic achievement indicators. Researchers speak of the importance of a joint study of such constructs as self-regulation (SR), self-perceived ability, subject interest and self-efficacy (Hulleman, Durik, Schweigert & Harackiewicz, 2008; Lee, Lee & Bong, 2014; Tosto, Asbury, Mazzocco, Petrill & Kovas, 2016; Wigfield & Cambria, 2010). SR has recently been increasingly studied in the system of cognitive and intrapersonal predictors of academic success (Harackiewicz, Durik, Barron, Linnenbrink-Garcia & Tauer, 2008; Musso et al., 2012; Zimmerman & Martinez-Pons, 1990).

Data analysis of pupil groups with different levels of math achievement has shown that for students with a low math achievement, basic cognitive processes were of greater importance, while for the students with high math achievement the predicting factors were SR, motivation and subject interest (Musso et al., 2012). In our previous studies, we revealed that SR, acting as a significant predictor of various types of mathematical success, mediates the influence of some cognitive characteristics on mathematical achievement (Morosanova, Fomina & Bondarenko, 2015; Morosanova, Fomina, Kovas & Bogdanova, 2016). In this regard, we consider it relevant to study the specifics of the relationship between SR and constructs such as math self-efficacy and math interest.

We consider conscious SR as an integrative cognitive-personal construct. On the one hand, it is a cognitive system of information processing, including goal planning, modelling of significant conditions, programming of actions, results evaluation and, on the other hand, it is represented by the peculiarity of instrumental personality-regulatory features: flexibility, independence, reliability, responsibility, etc. This structure of the conscious SR emphasises its meta-nature as a psychological means of mobilising and integrating both cognitive and personality resources for solving educational problems (Morosanova, 2013).

An important role of self-efficacy and subject interest as predictors of academic achievement is shown in many studies. A meta-analysis of 36 studies examining the relationship between self-efficacy and academic achievement showed that, on average, self-efficacy explains about 14% of the variance in academic achievement. Moreover, it was found that self-efficacy is more important for weak students than for excellent students (Multon et al., 1991). It is also shown that students with a high level of self-efficacy better regulate their learning activity (Bandura, 1991; Schunk & Pajares, 2005).

Interest in mathematics is also an important factor in academic math success. Maths interest relates to people's intrinsic motivation to acquire new mathematical skills. Traditionally, an individual and situational interest are differentiated (Hidi, 1990). Situational interest, as a rule, has a short-term effect slightly changing the knowledge and values, whereas individual interest has a long-term effect on the knowledge and values of a person (Hidi & Baird, 1986; Hidi & Harackiewicz, 2000; Hidi & McLaren, 1990).

Interest in the study of a particular academic subject (in our case – mathematics) is more of an individual interest, prompting the student to scrutinise the subject deeper, to enrich his knowledge in the field and to achieve high results. However, these two types of interest cannot be opposed, since in real activity both types of interest will interact and influence the development of each other. So, situational interest caused by some environmental factor can cause or contribute to the development of a long-term individual interest (Hidi, 1990). Research issues in studying the influence of interest on academic achievement will be solved in the following way: on the one hand, how individual interests influence the effectiveness of teaching, and on the other hand, how the emerging situational interest activates cognitive processes for solving learning problems.

The basis for the hypotheses of this study was the assumption that conscious SR of learning activity is a significant predictor of different types of mathematical success, while at the same time it is a mediator for the relationship between math interest and math achievement.

## 2. Methods

### *2.1.Participants*

The sample included 318 (158 males) 14–16-year-old students (mean age = 15.1), from the 9th grade (out of 11), educated in seven standard and enhanced curricula schools in Russia.

### *2.2.Procedure*

Participants completed the questionnaire and computerised test battery in groups at their school computer classes, supervised by a researcher. The tests were completed in the same order, in a single session during the first half of a school day. The testing process lasted approximately 1 hour and students could take a break after each test. Parental and school consent was obtained for all the participants. Analyses were carried out on depersonalised data.

### *2.3.Measures*

- *Self-regulation.* A version of the Self-Regulation Profile Questionnaire – Self-Regulation Profile of Learning Activity Questionnaire (SRPLAQ) (Morosanova, Vanin & Tsyganov, 2011) was used to assess the regulatory features. SRPLAQ is organised into eight sub-scales, each including nine items that describe typical situations reflecting cognitive and personality contexts of SR, assessed on a four-point scale. Four sub-scales evaluate cognitive processes, implementing basic systems of SR: planning, modelling, programming and results evaluation. The other four sub-scales evaluate regulatory and personality features, which on the one hand, characterise the quality of regulatory processes and, on the other hand, act as instrumental personality traits: flexibility, independence, reliability and responsibility. The questionnaire also includes a nine-item social desirability scale. An integrative scale – General level of conscious SR – is estimated by summing up the scores from the eight sub-scales. The reliability of scales in our sample is $\alpha = 0.61 - 0.89$.
- *Math self-efficacy* was measured with eight items drawn from the Program for International Student Assessment (PISA) student questionnaires (2000, 2003, 2006: www.pisa.oecd.org). Participants were asked how confident they would feel about undertaking a series of mathematically based tasks, including calculating how much cheaper a TV would be after a 30% discount and understanding graphs presented in newspapers. Students were not asked to solve the problems, just to rate their confidence in being able to do so on a four-point scale ranging from 'Not At All Confident' (0) to 'Very Confident' (3). The total score was computed as the mean of items. Reliability of this measure in our sample was $\alpha = 0.93$, $n = 321$.
- *Math interest* used three items, also drawn from PISA questionnaires. The scale included items such as 'I look forward to my mathematics lessons'. Ratings ranged from one (strongly disagree) to four (strongly agree). This short measure also showed good reliability ($\alpha = 0.93$, $n = 321$).

*Mathematics achievement.* Data on three aspects of the students' mathematical performance were collected. *Understanding number* assesses mathematical skills according to levels required at age 16 by the UK national curriculum. This test is made up of 18 items selected from National Foundation for Educational Research (NFER) booklets (levels 1–8; NFER-Nelson, 1994, 1999, 2001). This untimed test, adapted for administration in Russia, assesses the understanding of the relationship between numerical expressions and patterns of numbers, understanding of mathematical operations and relationships between operations. *Problem verification task,* adapted from Murphy and Mazzocco (2008), assessed mathematical fluency. Arithmetic problems (24 fraction problems and six problems each for addition, multiplication, subtraction and division) appear on the screen one at a time with an answer provided. The task is to judge as quickly as possible whether the answer is correct. *Year math grade* was a grade for algebra for the whole year, obtained for all students using school registers. Russian schools assess students' performance using a five-point system, with grade 5 indicating excellent performance, 4 – good performance, 3 – satisfactory performance, 2 – bad performance (fail) and 1 – very bad fail.

We used SPSS 17.0 for the data analysis (ANOVA correlations, regression analyses). Mediation analyses were conducted to explore whether significant associations between math self-efficacy, math interest and math achievement were mediated by SR. For this purpose, we successively analysed the results of several series of regressions between the dependent variable, the independent variables and the mediator. In addition, the obtained mediator models were assessed using the Sobel test.

## 3. Results

### *3.1.Descriptive statistics*

The descriptive statistics for all the variables are presented in Table 1. The variance analysis of the variables studied by the 'sex' factor has not revealed significant differences. In our previous studies, we also hadn't seen any significant differences in the variables of SR between boys and girls.

**Table 1. Descriptive statistics for all measures: means and standard deviations**

| Measures | N | Mean | SD |
|---|---|---|---|
| Math interest | 321 | 2.38 | 1.14 |
| Math self-efficacy | 321 | 2.96 | 1.10 |
| Problem verification task | 309 | 40.00 | 5.28 |
| Understanding number | 293 | 12.09 | 3.46 |
| Year math grade | 301 | 4.05 | 0.68 |
| Goal planning | 303 | 4.61 | 2.07 |
| Modelling of sign conditions | 303 | 5.39 | 2.12 |
| Programming of actions | 303 | 5.29 | 1.84 |
| Results evaluation | 303 | 4.51 | 2.06 |
| Flexibility | 303 | 5.34 | 1.91 |
| Independence | 303 | 4.54 | 1.71 |
| Reliability | 303 | 4.17 | 1.91 |
| Responsibility | 303 | 3.79 | 2.15 |
| General level | 303 | 32.34 | 9.91 |

### *3.2.Correlations*

The correlation analysis of the mathematics achievements with SR, math self-efficacy and math interest is presented in Table 2. It is worth to note that math self-efficacy is associated with all kinds of mathematical success, while math interest is linked to understanding number and year math grade. Regulatory characteristics have the largest number of meaningful links to the year math grade and understanding number.

**Table 2. Correlations between regulatory characteristics, math self-efficacy, math interest and mathematical achievements measures**

| Measures | Problem verification task | Understanding number | Year math grade |
|---|---|---|---|
| Goal planning | –0.040 | –0.026 | 0.092 |
| Modelling of sign conditions | **0.147*** | **0.212**** | **0.253**** |
| Programming of actions | –0.012 | 0.013 | 0.091 |
| Results evaluation | 0.070 | 0.094 | **0.218**** |
| Flexibility | 0.032 | 0.013 | 0.053 |
| Independence | 0.025 | 0.109 | **0.142*** |
| Reliability | 0.075 | **0.139*** | 0.107 |
| Responsibility | 0.001 | 0.026 | **0.120*** |
| General level | 0.097 | **0.137*** | **0.242**** |
| Math interest | 0.109 | **0.170**** | **0.213**** |
| Math self-efficacy | **0.123*** | **0.217**** | **0.171**** |

Note. Bolded values are significant at *$p < 0.05$; **$p < 0.01$.

### *3.3.Regression analyses*

As independent variables in the regression analysis, three types of mathematical success were included: regulatory characteristics, math self-efficacy and math interest. Table 3 presents the statistical parameters of the obtained significant models. It should be noted that for the mathematics achievement variable 'Problem Verification Task' no significant model was obtained.

**Table 3. Regression models**

| Criterion | $R^2$ | Adjusted $R^2$ | F | Significant predictor | Beta | Sig. |
|---|---|---|---|---|---|---|
| Understanding number | 0.24 | 0.06 | 8.31 | General level of SR | 0.12 | 0.049 |
| | | | | Math self-efficacy | 0.19 | 0.001 |
| Year math grade | 0.32 | 0.10 | 16.30 | General level of SR | 0.21 | 0.000 |
| | | | | math interest | 0.20 | 0.000 |

The results of regression analysis proved the general level of SR to be a significant predictor for both academic success (year math grade) and success in solving mathematical tasks of different complexities (understanding number). Math self-efficacy and math interest turned out to be significant predictors for different types of mathematical success: math self-efficacy for understanding number and math interest for year math grade.

### *3.4.Mediation analyses*

As predictors in mediator analysis, we included math self-efficacy and math interest, as dependent variables – mathematics achievement indicators, while regulatory characteristics were included as mediators. An incomplete mediator effect was found for a model in which the predictor was math interest, the dependent variable – year math grade, and the mediator was SR general level (see Figure 1).

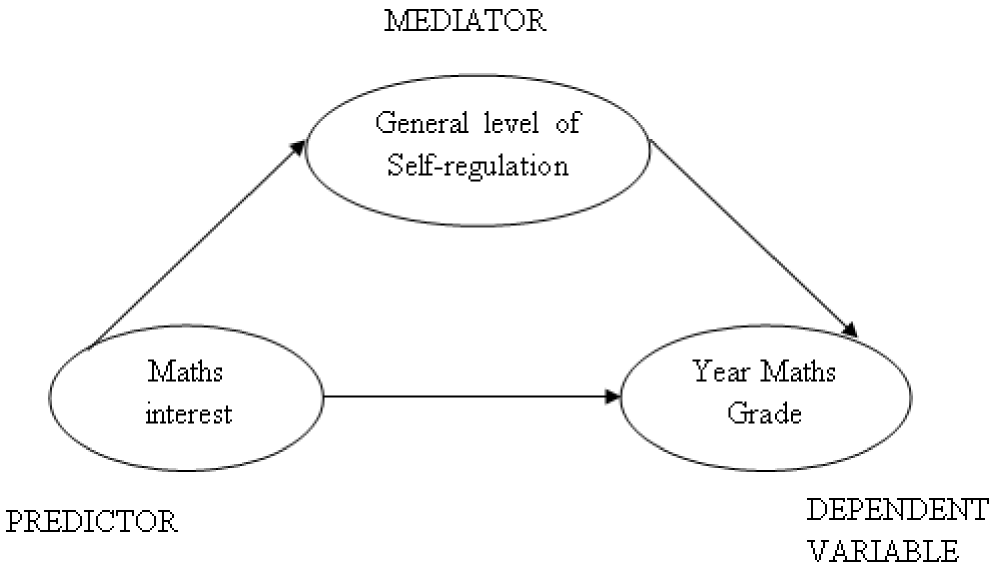


**Figure 1. Mediator model.**

Specifically, the relationship between math interest and year math grade was significantly reduced from 0.21 to 0.15 when SR general level was included (Sobel's test = 2.47, $p$ = 0.01).

## 4. Discussion

In our study, we obtained data on the specific relationship between SR, math self-efficacy, math interest and various types of pupils' mathematics achievement. It was shown that SR, being a significant predictor of the mathematical success, also mediates the relationship between math interest and year math grade.

SR and math self-efficacy turned out to be significant predictors for the variable 'understanding number', which characterises the mathematical abilities of students. That is, the successful solving of specific problems and equations under testing conditions depends on the student's self-perceived ability to solve the tasks of different levels and types. This result is correlated with those of other researchers who showed that self-efficacy beliefs about mathematics have been found to be strongly associated with mathematics achievement (e.g., Hackett & Betz, 1989; Hoffman & Schraw, 2009; Pietsch, Walker & Chapman, 2003).

Math interest turned out to be a significant predictor (along with General level of SR) for the year math grade variable, which characterises the student's overall academic performance in mathematics for the year. In addition, mediator analysis revealed that SR mediates the relationship between math interest and the final academic achievements. These results lead to assume that when subject interest is supported by a high level of academic SR, higher learning outcomes can be observed.

In general, researchers note that the relationship between students' achievement goals and their subject interests is logical in both direct and opposite contexts: interest in the content of the subject can predict the setting and adoption of the goals and, vice versa, learning goals can contribute to the emerging interest of students in certain subject areas. Some studies have shown that SR includes subject interest as a goal and therefore cannot be viewed as a factor in academic SR (Hidi & Ainley, 2008; Sansone & Thoman, 2005). On the other hand, subject interest is linked to the academic SR and achievements, and even turned to be an independent predictor of SR (Lee et al., 2014).

The results of our studies suggest that SR acts as a meta-process that facilitates mobilisation and actualisation of both cognitive and intrapersonal resources in achieving the optimal activity result. As we suppose, there exist an individual, age related and situational specifics of the SR role in determining the educational achievements of school children. Further research may be focused on the study of SR in the system of cognitive and intrapersonal predictors in these specific contexts.

## 5. Conclusion

This study shows the specifics of relationship between SR, math self-efficacy, math interest and mathematics achievement. SR turns out to be an important predictor for higher results in two types of mathematical achievements: Year math grade and understanding number. Math self-efficacy significantly predicts only understanding number, while math interest – only year math grade. In addition, the general level of SR acts as a mediator of the math interest and mathematics achievement. The obtained results show that the general level of SR can be used as a reliable predictor of students' academic achievements.

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