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Predictability of Early Mathematical Competencies, Negative Predisposition towards Mathematics, Logical Intelligence, and Educational Environment Factors in Mathematics Performance

Predictibilidad de las competencias matemáticas tempranas, predisposición desfavorable hacia la matemática, inteligencia lógica y factores de la convivencia escolar en el rendimiento académico en matemáticas

[1, 3]Gamal Cerda and [2, 3]Carlos Pérez

[1]Facultad de Educación, Universidad de Concepción, Chile
[2]Facultad de Ciencias Físicas y Matemáticas, Universidad de Concepción, Chile
[3]CIAE, Universidad de Chile

Abstract

This research presents results about the degree of predictability of a set of psycho-affective variables related to students' performance in the subject of mathematics (N=669). It examines the role of previously assessed Early Mathematical Competencies (EMC) and other variables, such as logical intelligence, predisposition towards mathematics, and school environment factors, with respect to the grade point average that students received in the subject of mathematics during a period of four years. An inverse and significant relationship was found between a negative predisposition towards mathematics and performance in the subject. Moreover, a significant relationship was found between performance in mathematics and logical intelligence and EMC. This study also emphasizes that factors associated with the school environment, like victimization, aggression, lack of discipline, and teacher apathy, are significantly related to students' performance. The students that obtained the highest levels of EMC are also those who received the highest grade point average. Stepwise linear regression analysis allows us to infer that 47.2% of the variance of grade point averages can be explained by the variables included in the model and the important role of attitude towards mathematics and EMC.

Keywords: early mathematical competencies, logical intelligence, attitude towards mathematics, educational environment

Post to:
Gamal Cerda
Facultad de Educación, Universidad de Concepción, Chile
Email: gamal.cerda@udec.cl
Edmundo Larenas 335, Barrio universitario, Concepción. Casilla 160.C, Chile.
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Resumen

Se presentan los resultados del grado de predictibilidad de un conjunto de variables psico-afectivas en el rendimiento académico en la asignatura de matemáticas (N = 627). Se examina el rol de las Competencias Matemáticas Tempranas (CMT) evaluadas con anterioridad y otras variables como la inteligencia lógica, una predisposición desfavorable hacia la matemática y ciertos factores de la convivencia escolar con respecto al promedio de calificaciones en matemáticas que los alumnos han obtenido durante un período de seguimiento de cuatro años. Se constata que hay una relación inversa y significativa del nivel de animadversión hacia la matemática y el rendimiento en dicha asignatura, como también de esta con los niveles de inteligencia lógica y las CMT. Se destaca, además, el rol de algunos factores asociados a la convivencia escolar, como la victimización, agresión, indisciplina y desidia docente, los que se relacionan de forma inversa y significativa con el desempeño de los estudiantes. Los resultados indican que los estudiantes que alcanzaron los mejores niveles de CMT son los que presentan los más altos promedios de calificaciones. El análisis de regresión lineal por pasos (*stepwise*) permite inferir que el 47,2% de la varianza del promedio de las calificaciones en la asignatura puede ser explicada por las variables incorporadas en el modelo, destacándose el importante rol de una disposición hacia la matemática y las CMT.

Palabras clave: competencia matemática temprana, inteligencia lógica, predisposición hacia la matemática, convivencia escolar

At present there is a significant amount of research oriented towards determining the cognitive factors or variables that may play a significant role in explaining the acquisition, the development of skills or the presence of difficulties in the area of mathematics (González-Castro, Rodríguez, Cueli, Cabeza, & Álvarez, 2014; Miñano & Castejón, 2011; Navarro et al., 2011). Likewise, there has been an increase in research that examines the role of variables of an affective nature associated with learning of mathematics, either of an attitudinal or motivational nature, or related to the anxiety that such learning often causes, particularly among girls, as well as the type of support or the teaching strategies used by teachers (Ashcraft & Krause, 2007; Beilock, Gunderson, Ramirez, & Levine, 2010; Federici & Skaalvik, 2014; Furner & Berman, 2003; Gil, Blanco, & Guerrero, 2005; Schweinle, Meyer, & Turner, 2006). All of this research provides information that certainly allows educational agents to guide the possible application of teaching-learning programs aimed at obtaining higher levels of achievement in the subject, as well as implementing intervention programs aimed at the rehabilitation and enhancement of skills associated with these achievements.

This study seeks to provide a joint view of both dimensions, considering both cognitive and affective factors simultaneously, to structure more complex predictive models with greater explanatory power, thereby approaching paradigms that are more relevant and appropriate to school reality (Akin & Kurbanoglu, 2011; Barbero, Holgado, Vila, & Chacón, 2007; Guven & Cabakcor, 2013; Lim & Chapman, 2013; Martín, Martínez-Arias, Marchesi, & Pérez, 2008).

The complex and presumably interdependent relationship between cognitive, affective, or motivational factors has been acquiring greater relevance in studies on the processes of activation, acquisition, and construction of school knowledge and its influence on achieving positive academic performance (Bandalos, Finney, & Geske, 2003; Martín et al., 2008; Mckenzie, Gow, & Schweitzer, 2004; Miñano & Castejón, 2011). The conclusions of these studies are replicated in the area of mathematics learning, where factors such as attitude to the school subject, levels of intelligence, and academic motivation seem to be strongly interconnected (Barbero et al., 2007; Barkatsas, Kasimatis, & Gialamas, 2009; Moenikiaa & Zahed-Babelan, 2010; Rosário et al., 2012; Suárez-Álvarez, Fernández, & Muñiz, 2013). Similarly, the beliefs, stereotypes, and expectations of achievement appear to have a direct relationship with achievements in mathematics (Hailikari, Nevgi, & Komulainen, 2008; Nosek & Smyth, 2011; Selkirk, Bouchey, & Eccles, 2011).

A first group of variables associated with academic achievement or failure in mathematics can be established in function of the general or specific mastery of the subject, such as general intelligence or memory. Another set of variables may be associated with skills or abilities in the field, such as early mathematics skills, schemes of logical-formal reasoning, or so-called *number sense* (Passolunghi & Lanfranchi, 2012). Thus, different authors state that the work and strengthening of Early Mathematical Competencies (EMC) can be established as a relevant variable of great benefit to students, since it has been proven that these are predictors of later mathematics performance (Aubrey, Shen, & Byrnes, 2013; Jordan, Kaplan, Locuniak, & Raminemi, 2007; National Research Council, 2009; Navarro et al., 2012).

In the same regard, logical inductive reasoning or logical intelligence has a psycho-evolutionary nature, and early promotion of this can also become an aid to learning and comprehension of mathematics and, therefore, be a tool to tackle school failure. In the specific case of the Chilean school population, successful experiences have been reported in this field (Cerda, Pérez, & Melipillán, 2010a, 2010b; Cerda, Ortega, Pérez, Flores, & Melipillán, 2011).

Along with these cognitive factors, there are other factors of an affective nature that could also be relevant in explaining the difficulties of students in learning mathematics or their poor results. Among these factors is predisposition towards mathematics and school environment.

The disposition or motivation with which the students face the subjects in their school environment, especially mathematics, can be considered a relevant variable for learning. It is to be expected that an unfavorable predisposition towards mathematics negatively influences school performance, just as a student with intrinsic motivation tends to become more involved in the task and thus display greater effort, which is associated with inquisitive behavior and improved performance and, in turn, is negatively related to the state of anxiety, especially among male students (Marchand & Skinner, 2007; Skaalvik & Skaalvik, 2005; Yaratan & Kasapoğlu, 2012). School environment has a direct impact on learning and, in this area, situations such as intimidation negatively interfere with learning (Toledo, Magendzo, & Gutiérrez, 2009).

One tool to measure EMC is the Utrecht Early Mathematical Competence Test (TEMT-U by the Spanish acronym), devised by researchers from the Universiteit Utrech in the Netherlands (Van Luit, Van de Rijt, & Pennings, 1998). This test was later adapted in Finland and Germany, and subsequently in Spain in 2009 by Navarro et al. (2009), from the Department of Psychology of the Universidad de Cádiz. In Chile it was adapted by a group of researchers from the Universidad de Concepción (Cerda et al., 2012). During the adaptation process in Chile, the test was applied to a sample of 1,437 students who belong to 16 educational centers during 2009 and 2010. The application of the TEMT-U provided relevant information on the EMC that these students had, allowing various comparisons to be established regarding attributive variables and determining the levels of mathematical competence by age groups. Once the tool was adapted to the school population, as a natural continuation of the study appeared the need to monitor these students after a prudent amount of time in order to relate the levels of the EMC observed with academic achievement in mathematics and, jointly, to examine whether these early competencies were related to variables of logical inductive reasoning or logical intelligence, factors related to school environment, and to predisposition towards mathematical tasks.

In relation to all of the above, the following research questions can be formulated: Are early mathematics skills a predictive factor for academic performance in mathematics among students currently enrolled in the third, fourth, fifth, and sixth years of basic education in Chile? How do these EMC relate to predisposition toward mathematics, logical intelligence, and diverse factors of school environment? And, finally, do these variables interact in a specific way when explaining the variability of the mathematics performance of these students?

Method

Participants

The sample was formed by children between 8 and 12 years of age who are currently enrolled in Chilean basic education and who were previously assessed in EMC between 2009 and 2010. To ensure appropriate traceability and comparison with their peers, the group of students in the same establishment during this period was considered. This selection criterion for the sample of participants was not probabilistic due to an accessibility criterion, since their inclusion in the study depended on them continuing at the establishment and their consent to participate. Table 1 shows the distribution in terms of course and gender.

Table 1
Distribution of the sample based on student gender and course attended

	Gender		
Current course	Female	Male	Total
Third year basic education	49	43	92
Fourth year basic education	86	82	168
Fifth year basic education	171	160	331
Sixth year basic education	15	21	36
Total	321	306	627

Most of the students in the sample attended private subsidized schools (70.18%) and the rest of the students attended public schools.

Tools

Early mathematical competencies. This variable was measured using the TEMT-U, analyzed depending on the total score given by the test (this test is a Spanish version of the *Early Numeracy Test*) (Van Luit, Van de Rijt, & Pennings, 1998). The version used has 40 items, so there is a maximum score of 40 points (one for each correct item). The test has an application time of 30 minutes approximately and should be administered individually. Eight components of the EMC are assessed, four of them logical-relational: concepts of comparison, classification, one-to-one correspondence, seriation; and four of a numerical type: verbal counting, structured counting (without indicating) and general knowledge of numbers.

The levels of competency are obtained from the direct scores of each child assessed regarding the age groups of reference. Based on this, a competency score is calculated that establishes the scales of each category in ascending order, from a level of *very good* to *very low* mathematical competence according to the following:

Very good level: comparable with 25% of the highest scores obtained by the children in their normative group. *Good* level: comparable with 25% of the scores slightly above the mean obtained by the children in their normative group. *Moderate* level: comparable with 25% of the scores slightly below the mean obtained by the children in their normative group. *Low* level: comparable with the 15% of scores below the mean obtained by the children in their normative group. *Very low* level: comparable with the 10% of the scores very far below the mean obtained by the children in their normative group.

Factor analysis shows adequate adjustment indices: χ^2SB = 35.119; p = .0135; CFI = .995; NNFI = .993, RMSEA = .036; IC (.016 - .055). On the other hand, the reliability index is adequate, since Cronbach's alpha is .90 (Cerda et al., 2012; Cerda, Pérez, & Ortega, 2014).

Logical intelligence. This variable was measured using the Elementary Logical Intelligence Test (TILE) (Cerda et al., 2010a). Inductive logical reasoning can be defined as the capacity that people have to see solutions and resolve problems, structure elements to make deductions and based them on valid arguments in accordance with their cognitive development depending on the Piagetian focus. This ability implies the capacity to recognize the general rule in a series of elements that governs or underlies those elements. In this tool, the construct *logical intelligence* functions as the score reached by a student on completing a set of exercises of incomplete figurative series (TILE score), where the scale of scores ranges from 0 to 50 points. Cronbach's alpha is .94. The results of the factor analysis of the instrument allow to conclude that the model of one factor shows the best adjustment indices: χ^2 (1.175) = 4,784.38, p = .001; CFI = .97; TLI = .97; RMSEA = .05. This allows the use of the overall score in the analysis (Cerda et al., 2010a).

Predisposition to mathematics. This is understood to be unfavorable predisposition to this school subject or activities related to school mathematics. It is expressed as disgust, displeasure, lack of perseverance, or disinterest in mathematics. The revised and adapted version of CATMa-Ch (Del Rey, Madera, & Ortega, 2011) was used. The Scale of Predisposition to Mathematics (EPMAT) is of the Likert kind and consists of six items, with a graduation of five categories that range from *agree very strongly* to *disagree very strongly* regarding the following assertions: «I know I'm not going to be successful in mathematics»; «my results in mathematics have always been bad»; «I'm not good at mathematics»; «I don't like mathematics »; «I can never work out the problems»; «I find operations with numbers easy». The adjustment indices for the confirmatory factor analysis show that the model of one factor is adequate: $\chi^2(9)$ = 29.28, p = .001, CFI = .98, TLI = .97, RMSEA = .06; and that the quality adjustment improves if there is freely estimated covariance between the errors of items 4 and 6 of the scale, in which case the new adjustment indices are $\chi^2(8)$ = 17.63, p = .02, CFI = .99, TLI = .98 and RMSEA = .05, with a correlation between the items indicated of r = -.18, p < .001. Regarding the reliability index, Cronbach's alpha is .82, which is adequate (Cerda, Ortega-Ruiz, Casas, Del Rey, & Pérez, in press).

School environment. This is understood as a way of building relationships between the people in a community, based on mutual respect and reciprocal solidarity, expressed in harmonious interaction without violence between the different actors and levels of the educational institution (Mineduc, 2013). It is used through the score obtained on the Scale of School Environment (ECE by its Spanish acronym), (Del Rey, Casas, & Ortega-Ruiz, under review). The ECE scale is of the Likert type, with five categories that range from *never* to *always* and examines the dimensions of: *positive interpersonal management* (with 11 items of the type «teachers do well with each other »; «there are good relations between the teachers and the students»)*; victimization* (with 6 items of the type «I have been afraid to come to school»; «a schoolmate has hit me»); *disruptiveness* (with 6 items of the type «there are children who don't allow the class to be given»; «there are students who don't respect the rules», *social network of peers* (with 9 items of the kind «my schoolmates are interested in me»; «my schoolmates help me when I need it»), *aggression* (with 4 items of the type «I have threatened another person or scared another person»; «I have hit a schoolmate»), *normative adjustment* (with 5 items of the kind «I let the others work without bothering them»; «I ask to speak and wait my turn to speak»), *indiscipline* (with 4 items of the kind «I only comply with the rules that are convenient to me»; «how many times have you been punished?»), and *teachers' apathy* (with 5 items of the kind «the teachers only explain things to the cleverest children in the class»; «teachers do boring activities». This variable of an ordinal quantitative nature and is expressed as the score obtained in the revised version of the Questionnaire on School environment, the scale of which was determined by the score obtained for each of the eight factors contained in the instrument and which reflects the perception of each student assessed regarding general aspects of coexistence within their school. The factor analysis confirms the model of eight factors of the construct of the ECE scale, since it has adequate adjustment indices: χ^2SB = 2,708.8370; p =.000; CFI = .969; NNFI = .966, RMSEA = .035; IC (.033 - .036). Cronbach's alpha is .80.

Procedure

Several visits were made to the schools in order to locate the students previously assessed on their EMC level, as well as to administer the new instruments mentioned above. For all purposes, the consent of the parents and teachers of the students was obtained, in addition to the consent of the students called to participate.

The research is a quantitative study with a descriptive correlational design. For this reason, the analysis of results was performed on two levels. First, the predictive value of the variables was calculated in relation to the average mathematics scores. Then, a profile of the students was provided regarding the different variables examined and their bivariate relationships, using the Pearson product-moment correlation coefficient and the Chi-square test, and comparative analysis of mean difference using the *t* test and ANOVA. A stepwise multivariate multiple linear regression analysis technique was chosen in order to determine how certain variables traditionally regarded in the specialized literature as predictive or explanatory are related to the *criterion* variable. On completion of the assessments, we proceeded to perform statistical analysis using the statistical software SPSS® version 19.

Results

The research is intended to establish and quantify the predictive value of the different variables considered regarding the academic performance of students in the subject of mathematics that they may have within the four-year period (2010-2013). The distribution of the dependent variable showed values of skewness and kurtosis within the expected range, with a slight negative asymmetry (g1 = -.462; g2 = -.470). It was also found that the distribution of the students' scores by gender in both groups is also normal and there are no significant differences when comparing their average performances ($F(1.625) = 0.019$, $p > .891$), in addition to checking the homoscedasticity (Levene test =. 068; p> .05).

Regarding the levels of EMC, logical intelligence, favorable predisposition to mathematics and factors of school environment

The scores for EMC in the logical-relational and numerical dimension produced a score and a category of mathematical competency in accordance with their age when taking the test. Table 2 shows the number of students in the sample classified into each category of competency and the average grades that those students obtained in the period from 2010-2013 in the subject of mathematics.

Table 2
Distribution of means and variances of the scores associated with the levels of early mathematical competences

Mathematical competency	Frequency	M	DT
Very low	42	4.996	.602
Low	26	5.267	.658
Moderate	227	5.640	.658
Good	199	5.884	.603
Very good	133	6.188	.540
Total	627	5.775	.687

It can be clearly observed that students who originally obtained the highest scores in EMC achieve significantly higher grades than those with lower EMC scores in the previous assessment [$F(4.622) = 15.365$, $p < .001$], and those differences can be seen in all pairs of comparisons [Tukey $p < .05$]. In the same regard, when comparing the classifications of the EMC levels (5 levels of performance) by gender, no significant differences are observed at 99% confidence ($\chi^2(4) = 3.430$, *p,* n.s.), but differences are seen when comparing these classifications by the course that these students are currently attending ($\chi^2(12) = 43.571$, $p < .001$).

In terms of the logical-relational and numerical competency scores, the results obtained ($M = 16.85$; $DT = 2.64$ and $M = 14.45$; $DT = 4.45$, respectively) reveal that, at the time of assessment, on average the students resolved a greater number of logical-relational tasks than numerical tasks.

Predisposition to mathematics shows close mean and median values and relatively homogenous distribution ($M = 12.64$; $Md = 12$; $DT = 5.05$; I.C. 12.15 – 13.04), with an asymmetry of .568 and a negative kurtosis of -.233 points. No significant differences are observed between male and female students (M =12.74 and M = 12.53, respectively) ($t(618) = .205$, $p > .600$), neither either with the course which the students currently attend ($F(3.623) = 2.260$, $p > .08$).

The logical intelligence scores (M = 27.04; Md = 27; DT = 11.54; I.C. 26.13 – 27.94), with a negative asymmetry of -.129 and a negative kurtosis of -.932 points, is classified as normal performance, or when considering the current course regarding the scales of their reference group (Cerda et al., 2010a). No significant differences are observed between male and female students (M = 27.60, DT = 11.77 and M =26.49, DT = 11.29, respectively), ($t(625)=1.207$, $p > .228$). However, there are differences in function of the course which they attend [$F(3.623) = 19.658$, $p < .001$] and those differences are mainly observed when comparing students in the third year of basic education regarding the other courses, but not among the latter.

Regarding factors of school environment, significant differences are seen in function of the gender of the students, which favor the female group in factors of positive interpersonal management [$F(1.625) = 8.532$, $p < .004$], normative adjustment [$F(1.625) = 20.596$, $p < .001$] and social network of peers [$F(1.625) = 11.821$, $p < .001$]. Meanwhile, the differences are significant in favor of male students when comparing their perception of teacher apathy [$F(1.625) = 8.944$, $p < .003$] and also in their perceptions of aggression and indiscipline, although the homogeneity of variances in these could not be verified with the Levene test, and the robust Welch test was applied, which produced the following results: (Welch F(1,546.806) = 31.752, $p < .001$; Welch F(1,595.328) = 17.921, $p < .001$ respectively).

Analysis of correlations between variables

There is a direct and significant relationship between EMC levels and the average grades in mathematics obtained in the period 2010-2013 [$r(627) = .469$, $p < 0.001$]. The same is true when the score of the TILE test and the performance in the four years is analyzed [$r(627) = .375$, $p < .001$]. A significant inverse relationship can also be seen between unfavorable predisposition to mathematics and the average of the grades [$r(627)= -.526$, $p < .001$].

There is a positive and significant relationship between three of the factors of school environment and general performance in mathematics: positive perception of interpersonal management ($r(627) = .124$, $p < .002$); social network of peers ($r(627) = .105$, $p < .001$); and normative adjustment ($r(627) = .240$, $p < .001$). Likewise, the relationship with performance in mathematics is negative and significant with the other five factors: victimization ($r(627) = -.209$, $p < .001$); disruptiveness ($r(627) = -.146$, $p < .001$); aggression ($r(627) = -.193$, $p < .001$); indiscipline ($r(627) = -.323$, $p < .001$) and teacher apathy ($r(627) = -.165$, $p <.001$).

Linear regression model

Finally, a stepwise linear regression analysis was performed after analysis of the variables to be incorporated into the model. The variables with the greatest weight of correlation, around .25 or above, were included in the model as predictors and the results can be observed in Table 3.

Table 3
Stepwise linear regression analysis

Model	R	R^2	R^2 corrected	Statistical change: Stand. error estimate	Change in R^2	Change in F	Sig. change F	Durbin Watson
1	.526[a]	.276	.275	.585	.276	238.550	.000	
2	.650[b]	.422	.420	.523	.146	157.170	.000	
3	.681[c]	.464	.461	.504	.042	48.752	.000	
4	.690[d]	.476	.472	.499	.012	14.280	.000	1.820

Note: a. Predictor variables: (constant), unfavorable predisposition to mathematics; b. Predictor variables: (constant), unfavorable predisposition to mathematics, EMC level; c. Predictor variables: (constant), unfavorable predisposition to mathematics, EMC level, Elemental Logical Intelligence Test; d. Predictor variables: (constant), unfavorable predisposition to mathematics, EMC level, Elemental Logical Intelligence Test, indiscipline; e. Dependent variable: Average grades in mathematics for period 2010-2013.

As can be observed in Table 3, the regression analysis produced four models, each with its own explanatory power. For model 4, the correlation coefficient multiple was R = .690 and the coefficient of determination was R^2 = .476, which was adjusted to R^2 = .472. Therefore, 47.2% of the variance in mathematics grades can be explained by the following four variables: unfavorable predisposition to mathematics, level of early mathematical competency, level of logical inductive intelligence, and the environmental factor denominated as *indiscipline*. It can also be observed that, with a more parsimonious approach, model 3 could be considered with only three variables, since it has an explanatory power of 46.1%, although the Durbin-Watson statistic value = 1.768 is slightly lower than in the first model.

We opted to maintain the model of four variables, since it includes important information about school environment, such as the perception of indiscipline experienced by the students. Table 4 shows that the value of t is associated with a probability of error of less than.05 in the four variables included in the proposed model.

Table 4
Coefficients from the multiple linear regression model

Model		Non-standardized coefficients		Standardized coefficients			Collinearity statistics	
		B	Stand. error	*Beta*	*t*	Sig.	Tolerance	FIV
4	(Constant)	5.11	.112		48.301	.000		
	Unfavorable predisposition to mathematics	-.052	.004	-.385	-12.443	.000	.878	1.139
	Level of early mathematical competency	.203	.018	.338	11.182	.000	.922	1.085
	Elemental Test of Logical Intelligence	.012	.002	.206	6.779	.000	.921	1.086
	Indiscipline	-.022	.006	-.116	-3.779	.000	.894	1.118

The variables that showed the greatest weight were: unfavorable predisposition to mathematics (β = -.385), level of early mathematical competency (β = .338), logical intelligence, or logical inductive reasoning (β = .206), and perception of indiscipline (β = -.116).

These standardized regression coefficients show that unfavorable predisposition towards mathematics is the predictor with the greatest relative weight among the four variables incorporated into the model and predictors; although the other variables also have a positive relative weight when explaining the average grades in mathematics.

On the other hand, it can be observed from the results of the t test and testing of the null hypothesis that the four variables favor the explanation of the variance in the dependent variable.

To ensure the validity of the model, the independence of the residuals was analyzed. The statistic D of Durbin-Watson obtained a value D = 1.820, confirming the absence of positive autocorrelation (values close to 0) and negative autocorrelation (values close to 4). Likewise, we assumed that the absence of collinearity and, therefore, the stability of the estimates, by obtaining high values of tolerance and low values in the *variance inflation factors* (VIF; see Table 4). The very small tolerance values indicate that this variable may be explained by a linear combination of the other remaining variables, which would indicate the existence of collinearity (values close to 0.01), but this is not the case. On the other hand, the VIF are the reciprocals of the tolerances, and the higher the VIF of a variable, the greater the variance of the corresponding regression coefficient and, therefore, there would be instability in the estimates, but this is not the case either (see Table 4).

When the model is analyzed, dividing the sample into two groups, namely basic education courses with a high educational level (fifth and sixth years) and courses with a lower educational level (third and fourth years), the variability of performance in mathematics explained by the model increases by more than 5%. However, in the group of younger students, the *indiscipline* variable stop having a relative weight in the explanation of the variability of this performance, while the leading role of the other three variables is maintained.

We confirmed the initial hypothesis that when there is a higher level of development of early mathematical competencies (expressed on a scale of five degrees), the subsequent academic performance of students tends to be better. Similarly, students who performed well in the TEMT-U test tend to have high scores in the assessment of logical inductive reasoning. This can be explained from a theoretical perspective. In this regard, Van de Rijt and Van Luit (1998) state that the development or internalization of early mathematical competencies implies placement or explanation of fundamental skills that obey rational logic. It is because of this that the results seem to be captured by this tool. That is to say, for example, that if a child needs to develop a mathematical task that involves logical-mathematical reasoning, such as a logical sequence, and they have developed the ability of seriation and classification, they will probably be able to carry out the task of discovering an underlying rule, like that of the tool, and will be able to achieve it without any major difficulties.

In the study, a negative correlation has also been demonstrated between unfavorable disposition to mathematics and academic performance in mathematics. This is to say that, in general, students with higher scores in the EPMAT tend to have lower average grades in mathematics. This can be explained by the fact that these students probably have a negative attitudinal disposition to mathematics and also have lower expectations of their achievements in the subject, lower confidence in themselves, or low interest in mathematics learning. Performance and attitude are closely linked, with the knowledge that low performances tend to appear when there is a negative attitude towards mathematics or they are associated, according to other studies, with low levels of motivation or excessive expression of anxiety (Akin & Kurbanoglu, 2011; Nasiriyan, Khezri-Azar, Noruzy, & Reza-Dalvand, 2011; Samuelsson & Granstrom, 2007). Students' attitudes towards mathematics necessarily influence the time and effort spent working on relative and fundamental matters in this subject, and this has repercussions on the performance and the grades obtained. A positive attitude favors learning and a negative attitude makes it more difficult. This relationship was reaffirmed by the stepwise linear regression analysis, where the existence of this inverse relationship and its important predictive power was confirmed. Likewise, the roles of EMC, logical intelligence and an important aspect of school environment like indiscipline also is outlined. When considering the joint interaction of variables, the explanatory model predicts a significant part of the observed variability seen in student performance in mathematics, particularly if this considers a sufficient period of years for a certain regularity of performance in the subject to become apparent. Within this percentage, this attitudinal or motivational character associated with mathematics learning, which must be addressed early, is revealed, as it can come to solidify a kind of learned desperation regarding the learning of this school subject. Moreover, the explanatory model confirms that the level of EMC is a very good predictor of academic performance in mathematics, especially skills dealing with basic calculation and problem solving, which is consistent with other studies (Jordan, Mulhern, & Wylie, 2009; Kroesbergen, Van Luit, Van Lieshout, Van Loosbroek, & Van De Rijt, 2009). These results suggest the need to quickly address affective factors linked to learning mathematics, as they could become a protective or modulating factor of negative emotions towards mathematics, which tend to increase as the student goes through the school program (Bazán & Aparicio, 2006). Similarly, the role of logical intelligence is relevant, since not only is it positively associated with performance in mathematics, but it is also positively related to the EMC levels evaluated early in students and to better predisposition towards mathematics.

It is clear that the assessment of EMC of a logical relational or Piagetian type is strongly linked to the processes assessed by the TILE test, since the latter implies logical inductive reasoning to find the image that completes a series of figurative elements, since it includes the rule that gives meaning to all of them. This ability to think coherently is a fundamental element when addressing a problem and the possible strategy for solution in the mathematical field and in many school tasks or other subjects, strengthening the possibility of a successful encounter with them.

Although the study seeks to determine the level of predictability of early mathematics competencies of a logical-relational type and numerical skills regarding grade point average in mathematics over a period of four years, this has a significant limitation: The scores of students that have been assessed previously and who attend the various schools do not necessarily have similar or comparable performance behavior, either in the type of skills and in the mathematical tasks included in the different assessment instruments that produce the grades that the students eventually achieve. Based on this fact, it would be important in the future to consider some type of common tool of an external nature to properly assess some of the mathematical competencies initially evaluated, or to consider an assessment that is transversal to the education system, as the SIMCE test could be in the area of mathematics or another test of mathematics skills implemented by the Ministry of Education in this area. In so doing, there could be an assessment that has cognitive demands with similar levels of conceptual and procedural requirements for each course and not just a grade point average.

In conclusion, the emerging role of student perception should be underlined with regard to acts or behavior of indiscipline that take place within the school or in which they are involved, since this repositions the role of the appropriate environment for learning and demonstrates a close link between an unfavorable predisposition to mathematics and a greater chance of being involved in acts of indiscipline or disruptive behavior during classes.

Finally, the difficulty associated with the dependent variable should be stated as a possible limitation of the study, because although performance in mathematics is determined by grade point average in mathematics for a period of four years, it is not possible to determine whether the grades assigned by teachers represent similar or comparable levels of achievement because of the probable dissimilarities between evaluative criteria. It is therefore suggested that this study be extended using a tool more suitable for that purpose, such as multilevel hierarchical analysis.

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