



Motivation and self-related beliefs as predictors of academic achievement in reading and mathematics: Structural equation models of longitudinal data



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ABSTRACT

This study examines the predictive power of motivational and self-related beliefs on reading and mathematics achievement. A representative sample (N = 2049 12–14-year-olds) was drawn for a large-scale longitudinal programme, with data collected at two measurement points separated by a two-year interval. In the research, two hypothesised models on the mediating role of self-related beliefs and motivational factors have been developed and tested. Results from structural equation modelling reinforced the mediating role of both self-related and motivational factors on academic achievement in Grades 6 and 8, although not each of the expected paths fit the model. Among the non-cognitive factors, self-concept had the highest effect on sixth graders' achievement and sixth graders' test results most dominantly determined eighth graders' achievement.

1. Introduction

Prior research has shown that effective learning cannot be explained solely with cognitive factors. Learning success is largely influenced by the learner's affective and metacognitive abilities, social skills and socio-economic status (Csapó, 2007a; Ganda & Boruchovitch, 2018; Habók & Magyar, 2019, 2020; Panadero, 2017). Successful learners are ready to learn, are aware of their own goals, monitor their learning process, apply their knowledge and skills, select their learning strategy according to the learning task and are motivated. This was acknowledged by the OECD PISA assessments and included in several instruments to gather information on students' non-cognitive characteristics (OECD, 2004, 2013, 2016). In the first assessment cycle, PISA introduced student characteristics in a learner's questionnaire that assesses student learning strategies, motivational preferences and self-related beliefs (OECD, 2004).

A vast number of studies have attempted to identify non-cognitive predictors of academic achievement. Despite the growing number of studies (Hattie, 2009; Lee & Shute, 2010; Lee & Stankov, 2013, 2018; Niepel, Brunner, & Preckel, 2014; Richardson, Abraham, & Bond, 2012; Seaton, Parker, Marsh, Craven, & Yeung, 2014; Stankov, 2013; Suarez-Alvarez, Fernandez-Alonso, & Muniz, 2014; Viljaranta, Tolvanen, Aunola, & Nurmi, 2004), there have been no convincing results on truly effective non-cognitive characteristics in predicting students' academic achievement. Most previous studies have addressed students' non-cognitive approaches in relation to particular skills or domains, such as reading, mathematics and science, but longitudinal dimension is often missing.

The aim of the present study was to investigate the causal relations of two non-cognitive factors on students' academic

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achievement in the middle stages of formal education. We adopted the tenets of PISA, namely, the regulation of the learning process (Artelt, Demmrich, & Baumert, 2001; Artelt, Baumert, Julius-McElvany, & Peschar, 2003; OECD, 2019a, 2019b) to examine the effect of certain motivational and self-related beliefs in predicting students' academic achievement in reading and mathematics. In the longitudinal research, the PISA 2000 questionnaire was completed by Hungarian students aged 12–13 and by the same students aged 14–15 two years later. The longitudinal design enabled us to compare the two sets of results and identify changes vis-à-vis how students' approaches towards learning were changing.

1.1. Theoretical framework

When starting school, most first-grade students possess the willingness and motivation to learn and leads in the development in self-appraisal (Demetriou & Kazi, 2006). However, learning motivation shows a decreasing trend in subsequent school years. Indeed, the more time someone spends in the school system, the lower their learning motivation towards school subjects becomes (Csapó, 2000, 2007a). The significance of learning motivation and learning-related beliefs has been confirmed in a number of studies (Csapó, 2007a; Habók, 2014; Habók & Magyar, 2019, 2020; Lee & Stankov, 2013; B. Németh & Habók, 2006; Ryan & Deci, 2000, 2009). Therefore it is important to understand how students manage and regulate their own learning in relation with their motivational and self-related beliefs (Alexander, Dinsmore, Parkinson, & Winters, 2011; Ganda & Boruchovitch, 2018; Habók, 2013; Habók & Babarczy, 2018; Habók & Magyar, 2018a, 2018b; Zimmerman & Schunk, 2011).

1.1.1. The role of self-regulation in learning

The interpretation of effective learning as self-directed learning has long been in the focus of research projects. A new field of research started in the late 1990s, which includes the issue of self-regulated learning (Dignath, Buettner., & Langfeldt, 2008; Perry & Rahim, 2011; Schunk & Usher, 2011; Schunk & Zimmerman, 1994; Zimmerman & Schunk, 2011). Pintrich defined the self-regulated learning process as “an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment” (Pintrich et al., 2000, 453). These processes aid the students in reaching their academic goals.

The interpretation of this area is very broad and complex; indeed, a fully unified and widely accepted theory has not yet been developed (de la Fuente et al., 2017; Panadero, 2017). Three trends have emerged from previous research on self-regulated learning: (1) some studies have focused on the selection and application of cognitive and metacognitive strategies and on planning, organisation and self-esteem as well as on dominant cognitive and intellectual components (see e.g. Israel et al., 2005); (2) other studies have addressed the question of motivation, self-concept, goals, self-efficacy, confidence and control activities (see e.g. Schunk & Zimmermann, 2008); (3) the third trend has concentrated more on social cognitive elements of learning that draw attention to social and learning-related situations and relationships, such as cooperative and competitive learning situations (Carver & Scheier, 1998; Simons et al., 2000).

Various conceptualisations and models flourish on these theoretical foundations of self-regulation, such as goal theories (e.g. Pintrich et al., 2000), expectancy-value theories (e.g. Wigfield, 1994; Wigfield & Eccles, 2000), interest and intrinsic motivation theories (e.g. Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005; Ryan & Deci, 2000), and self-efficacy and self-concept theories (e.g. Bandura, 1997; Marsh, 2007). These theories employ a number of different constructs, but the necessity of motivation and self-related beliefs plays a central role in all of them (Boekaerts & Niemivirta, 2000; Pintrich, 2003, 2004; Zimmerman & Schunk, 2011).

1.1.2. The role of motivation in academic achievement

The motivational aspects of learning are a broadly researched area in relation to cognitive achievement. A number of studies have confirmed that students' motivation plays a dominant role in their academic achievement (Aunola, Leskinen, & Nurmi, 2006; Marsh et al., 2005; Smith, Smith, Gilmore, & Jameson, 2012).

Researchers have made a fundamental distinction between intrinsic and extrinsic motivation. Extrinsic or instrumental motivation focuses on external rewards for well-implemented tasks. Extrinsically motivated students are more likely to learn for instrumental or other reasons, e.g. positive feedback from teachers, better school marks or better jobs (Ryan & Deci, 2000). Extrinsic motivation is regarded as a multidimensional construct. Self-determination theory (SDT) distinguishes four types of extrinsic behavioural regulation: external regulation, introjected regulation, identified regulation and integrated regulation (Ryan & Deci, 2000). These constructs are situated on a continuum. While external regulation represents the lowest level of motivation, integrated regulation represents the highest level of self-determination (Ryan & Deci, 2009). Studies have investigated the effects of extrinsic motivation on learning achievement and found that students who are extrinsically motivated are more likely to have lower academic achievement (Becker, McElvany, & Kortenbruck, 2010; Lepper, Corpus, & Iyengar, 2005).

Intrinsic motivation emphasizes involvement in a behavior for its personally rewarding value (Lee, Reeve, Xue, & Xiong, 2012). It is important that the task itself be enjoyable, with no external reward being expected for it. Intrinsically motivated students invest a great deal of time and effort in performing the task, even if it is too difficult or complex for them. The concept of interest is often associated with intrinsically motivated behaviour; if a person is interested in something, he/she is engaged in an activity for its own sake. However, interest is a more specific concept within intrinsic motivation. Interest is strongly connected to the person's needs, desires and capacities, and when these engage with the activity, one experiences interest (Hidi, 2001; Pintrich et al., 2000). Researchers make a distinction between individual and situational interest. While individual interest refers to a relatively constant orientation toward something, situational interest is a mental state stimulated by a special activity or a task (Wigfield et al., 2015).

There is evidence that individual subject matter interest is positively related to school achievement. Aunola et al. (2006) reported

a correlation between first-grade children's performance and motivation in maths, with high maths achievement and motivation also predicting children's performance in subsequent school years. Köller et al. (2001) reported that interest significantly influenced achievement and high achievers showed higher level of interest than low performing students. Some of the research on situational interest has focused attention on the characteristics of academic tasks that can arouse interest and has provided strong evidence on the relation between situational interest and text comprehension and recall (Hidi, 2001).

1.1.3. The role of self-related beliefs in academic achievement

In educational research, self-concept is referred to as students' self-perception about their abilities within the academic environment (Marsh & Hattie, 1996, 58). It is formed through the person's interrelationship with the learning environment. Academic self-concept is assumed to be hierarchically organised and highly specific to the different domains of school subjects. In general, verbal self-concept is connected more strongly with verbal outcomes, while mathematics self-concept is more strongly related to mathematics outcomes. Numerical research has demonstrated the domain specificity of mathematics and verbal self-concept in connection with academic achievement (e.g. Arens, Yeung, Craven, & Hasselhorn, 2011; Marsh, Lüdtke, Nagengast, Trautwein, & Abduljabbar, 2015).

Self-efficacy has been defined as an individual's belief in his/her ability to learn, solve a problem or achieve a task (Bandura, 1997). Self-efficacy beliefs are often considered in relation to emotional directives towards successful achievement. Students form beliefs about their future performance and compare their competences with those of others. If their peers can achieve a task successfully or perform well, they also believe that they can do so, and this feeling improves their self-efficacy. In addition, teachers and parents can foster students' self-efficacy by encouraging them (Schunk, 2003).

Prior research has also investigated the role of both self-related constructs in relation to students' cognitive achievement and found that measures of self-related beliefs (self-efficacy and self-concept) were the best non-cognitive predictors of cognitive results (Lee & Stankov, 2013; Stankov & Lee, 2014). Marsh et al. (2005) demonstrated that self-concept predicts school grades and standardized test scores. Contrary to this, Viljaranta et al. (2004) found that although reading and maths achievement predicts self-concept of ability; however, their data did not support the hypothesis that self-concept of ability or interest predicts students' future maths and reading achievement. The authors also found that prior maths interest has a slight influence on students' subsequent self-concept in maths. Cvencek, Kapur, and Meltzoff (2015) demonstrated that self-concept in maths and maths achievement correlate significantly. Ehm, Lindberg, and Hasselhorn (2014) constructed a model based on reading, maths and writing and domain-specific academic self-concepts. They pointed to a negative effect of maths achievement on reading self-concept in Grade 3 and a significant positive effect of maths achievement on maths self-concept in every grade. Reading achievement had a positive effect on reading self-concept. One of the outcomes of these studies is that academic self-concept and academic achievement are often reciprocally related and mutually reinforce each other; that is, advanced academic self-concept results in higher academic achievement, and advanced academic achievement leads to higher academic self-concept (Guay, Marsh, & Boivin, 2003; Marsh & Craven, 2006; Niepel et al., 2014).

Similarly, a large number of studies have investigated and demonstrated the strong relationships between self-efficacy on academic achievement. Jiang, Song, Lee, and Bong (2014) found a strong relationship between self-efficacy and academic achievement in elementary and secondary school samples. Stankov and Lee (2014) reported a correlation of .41 between accuracy scores and self-efficacy. Britner and Pajares (2006) reported that maths-specific self-efficacy is a strong predictor of maths grades. Viljaranta et al. (2004) found that students' academic achievement and related feedback had an effect on beliefs about their own person and task motivation.

2. Model development

This study is based on the assumption that certain motivational and self-related factors can foster achievement in different domains. Our main concern was to explore the relationships among these non-cognitive factors and examine their effect on reading and mathematics achievement.

Other studies have also investigated these relationships between motivation, self-related beliefs and academic achievement, and a range of models have been proposed. Most of the studies included self-concept or self-efficacy as self-belief constructs, while extrinsic and intrinsic motivation or interest were often employed as motivational constructs. Based on different theoretical foundations, three kinds of directions were often proposed: (1) Consistent with SDT (Ryan & Deci, 2000, 2009) and self-concept theory (Marsh, 2007), some models proposed that academic motivation mediated the contribution of academic self-concept to academic achievement (e.g. Guay, Ratelle, Roy, & Litalien, 2010; Marsh et al., 2005). That means when students have higher level self-beliefs, they become motivated and perform better. (2) Others proposed that academic self-concept mediated the contribution of academic motivation to academic achievement (e.g. Guay, Boggiano, & Vallerand, 2001). In other words, when students are motivated, their self-belief increases and they can achieve more. (3) A few research have proved that both motivation and self-belief directly determine academic achievement (e.g. Suarez-Alvarez et al., 2014). Overall, previous models have not shown the superiority of one particular directional path of these structures over others. However, as Guay et al. (2010) have pointed out, studies employing the mediation model of academic self-concept are more meticulous than those that have used the mediation model of academic motivation. To investigate these contradictions, and provide a more comprehensive account, in our study we partially replicate two of these three models. In the research two models have been developed for two different academic domains (mathematics and verbal competences), as shown in Fig. 1. Both models include six constructs: two motivational: (1) instrumental motivation and (2) interest (reading and mathematics); two self-related constructs: (3) self-concept (verbal and mathematics) and (4) self-efficacy and (5) academic

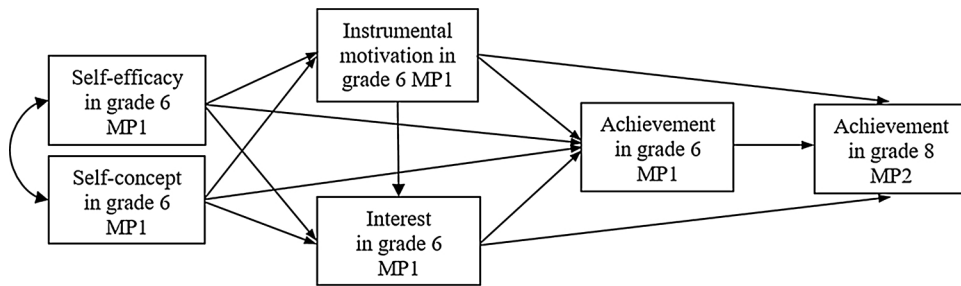


Fig. 1. The hypothesised path model depicting the mediation effect of motivation between self-related beliefs and achievement (Note: MP1 = 1 st measurement point; MP2 = 2nd measurement point).

achievement of reading/mathematics in Grade 6 and (6) academic achievement in Grade 8. In the first model we proposed the mediation effect of motivation between self-related beliefs and achievement; therefore, two exogenous constructs were employed, the self-concept in reading/mathematics and self-efficacy, and four endogenous constructs, which were instrumental motivation, interest in reading/mathematics and academic achievement in Grades 6 and 8 (Fig. 1). In the second model the mediation effect of the self-related beliefs were proposed; therefore, the two exogenous constructs were instrumental motivation and interest in reading/mathematics, and the four endogenous constructs were self-concept in reading/mathematics, self-efficacy and academic achievement in Grades 6 and 8 (Fig. 2). Direct effects were hypothesised among the two motivational factors, on each of the self-related constructs and on achievement in Grades 6 and 8 in both models. The motivational and self-related constructs were assessed with self-response scales, and achievement was measured with reading comprehension/mathematics test results.

3. Aims of the study

The present study is based on the assumption that by the end of sixth grade, most students have acquired the basics of mathematics and reading, and the levels of the affective components of learning that determine development have been established (Demetriou & Kazi, 2006). We endeavour to shed light on the relationship between (1) reading and mathematics achievement and (2) self-related beliefs of learning mathematics and reading that emerge by ages 12–13, which mark the end of the first stage of psychological development. Keeping the PISA results (Artelt et al., 2003) in mind, our study focuses on certain motivational and self-related beliefs and factors that encourage and maintain learning activities: (1) instrumental motivation and (2) interest (reading and mathematics), (3) self-concept (verbal and mathematics) and (4) self-efficacy.

We focus on an analysis of interactions between these self-related variables and their effects on mathematics/reading achievement. We explore the persistence of the effects of motivational and self-related characteristics of 12–13-year-old (sixth-grade) students, i.e., whether these effects can be detected in the achievement of eighth graders. Based on the relevant literature, all these factors were included in a theoretical model to be tested to provide a more comprehensive picture of these processes. We attempt to answer the following research questions:

RQ1. What connections exist among the investigated constructs of self-related beliefs, motivational factors and mathematics/reading achievement in Grades 6 and 8?

RQ2. What causal relationship can be discovered among the investigated constructs of self-related beliefs, motivational factors and reading/mathematics achievement in Grades 6?

RQ3. Which construct has the most powerful predictive effect on academic achievement in Grades 6?

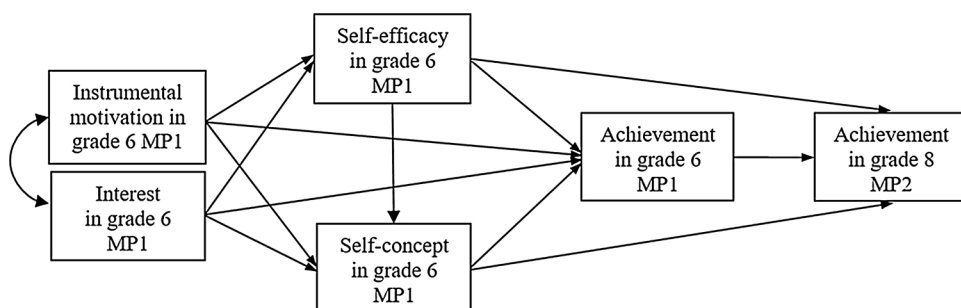


Fig. 2. The hypothesised path model depicting the mediation effect of self-related beliefs between motivation and achievement (Note: MP1 = 1 st measurement point; MP2 = 2nd measurement point).

4. Methods

4.1. Participants

Data were gathered from 4079 students (50.7 % male) as part of the Hungarian Educational Longitudinal Program (Csapó, 2007b). In total, 127 schools were involved in the longitudinal programme proportionally representing the seven statistical regions of Hungary. The schools include small (4–9), medium-sized (10–20) and large (21–35) classes and institutions attended by several parallel groups of students per grade. At the first measurement point, the questionnaire was completed by 3327 sixth graders. The reading test was done by 4079 sixth graders, and the mathematics test was done by 3906 students. At the second measurement point, in Grade 8, 3251 (79.7 %) students took the reading test, while the mathematics test was completed by 3094 (79.2 %) students. The questionnaire was not included in the test battery at the second measurement point. We reviewed the longitudinal sample and found that there were students who did not complete all the measurement tools. Therefore, we selected students ($N = 2049$; 49 % male) who have all the test results available and have their responses in every area of the questionnaire. Their average age was 11.65 ($SD = .52$) at the first measurement point.

4.2. Instruments and materials

The study analysed students' personal characteristics, self-concept and motivation regarding mathematics and reading competences using the subscales of the PISA 2000 student questionnaire for measuring student characteristics (Artelt et al., 2003). The choice of this questionnaire was motivated by two factors: the PISA 2000 scale explores both motivational and self-related beliefs of learning, which is a reliable and validated approach for 12–13-year-olds (Artelt et al., 2003). The results of the PISA survey (Artelt et al., 2003) provided some support in interpreting the collected data, although direct comparisons could not be made.

The questionnaire contained 20 items; students indicated on a four-point Likert scale the extent to which they agree (from strongly disagree to strongly agree) with the statement of a given item or the frequency (from never to always) with which the statement applies to them. The current study discusses the results of the following four subscales: (1) instrumental motivation (three items: e.g. "I study to increase my job opportunities."); (2) interest in reading (three items: e.g. "Because reading is fun, I wouldn't want to give it up.") and mathematics (three items: e.g. "Because doing mathematics is fun, I wouldn't want to give it up."); (3) self-efficacy (four items: e.g. "I'm confident I can do an excellent job on assignments and tests."); and (4) self-concept of verbal (four items: e.g. "I'm hopeless in Hungarian language classes." (Reversed item) and mathematical competencies (three items: e.g. "I have always done well in mathematics."). The Cronbach's alpha values for the subscales obtained in the PISA 2000 survey were the following: instrumental motivation: .82; interest in reading: .82; interest in mathematics: .75; self-efficacy: .77; self-concept of verbal competencies: .73; and self-concept of mathematical competencies: .88.

The data on academic achievement were collected with tests developed by the MTA–SZTE Research Group on the Development of Competencies for the sixth graders and by the Centre for Research on Learning and Instruction (Csapó & Molnár, 2019; Molnár & Csapó, 2019) for the eighth graders. Reading comprehension was measured with a pencil-and-paper test with 68 items for Grade 6 and 45 items for Grade 8. The reading tests covered the same content and constructs in both grades and included three subtests with continuous, non-continuous and mixed-format texts. The mathematics tests were also similar to the instruments used in large-scale international surveys (e.g. TIMSS), but their content also met the requirements of the Hungarian National Core Curriculum for Grades 6 and 8. The content of the tests was thus changed from Grades 6–8, but the structure of the tasks remained similar. The 61 items for Grade 6 and 45 items for Grade 8 measured mathematical core knowledge and its application. In both of the tests, all the items were scored dichotomously.

4.3. Procedure

4.3.1. Data collection

The measurement tools were completed by the sixth graders' sample at the first measurement point. The same sample of students who were eighth graders two years later completed the measurement tools at the second measurement point. Entire classes of students participated, and the tests were administered by local investigators. Participants took part on a voluntary basis with parents' consent. Data collection took place at the very end of the school year after the entire syllabus had been covered for that year. Students had 25–30 min to complete the questionnaire and 45 min (one school lesson period) to do each of the tests. These tests were achievement tests without high stakes. Students spent about three school lessons completing the measurement tools.

4.3.2. Data analysis

Data analysis was implemented in three stages. First of all, we verified if the questionnaire exhibits the same structure as provided in the PISA study. First, exploratory factor analysis (EFA) using the principal component method with varimax rotation was performed on all the scales to estimate the factor structure of the scale. Next, by taking the factors extracted in the EFA as observational variables, confirmatory factor analysis (CFA) was conducted to test the goodness of fit and stability of the measurement models. Finally, a path analysis was carried out to examine the interactions between learning-related variables and achievement.

We regarded two measures of reliability, the internal consistency reliability (Cronbach's alpha) and the composite reliability (CR; McDonald's coefficient omega; Raykov, 1997). Both values vary between 0 and 1, with greater values indicating higher levels of reliability. Values between .70 and .90 are regarded as satisfactory. Convergent and discriminant validity was also investigated. A

common measure to establish convergent validity on the construct level is the average variance extracted (AVE). AVE value of .50 or higher shows that, on average, the construct explains more than half of the variance of its indicators. The cross loadings were regarded to assess the discriminant validity of the indicators. An indicator's outer loadings on a construct should be higher than all its cross-loadings with other constructs (Hair, Hult, Ringle, & Sarstedt, 2017).

We performed a confirmatory factor analysis (CFA) with IBM SPSS AMOS 24.0. The goodness of fit indices of the model with the data was analysed using several indices: the Chi-square test, comparative fit index (CFI), Tucker–Lewis Index (TLI), normed fit index (NFI) and root mean square error of approximation (RMSEA) (Kline, 2015). CFI, TLI and NFI range from 0 to 1, with a cut-off value of .90 indicating an acceptable model fit. The RMSEA value also calculates the model fit and also ranges from 0 to 1, with smaller values indicating a better model fit. A value of .05 or less usually represents a good model fit; a value of .08 or less is an eligible model fit (Kline, 2015).

The hypothesised path model was also tested with SPSS AMOS. The path model parameters were set with reference to the findings in the literature and to the correlation coefficients and the results of the multiple linear regression analysis. The goodness of fit indices of the model were analysed with the same indicators as were implemented in the CFA analysis (Hair et al., 2017).

5. Results

5.1. Confirming the factor structure of the questionnaire

First, we analysed if we could confirm the factor structure of the questionnaire for the whole sample and subjected our data to factor analysis with varimax rotation. The result for the factor analysis showed that the factors could be organised in well separated dimensions. The factor loadings ranged from .564 to .875. The Kaiser–Meyer–Olkin index was considered appropriate (KMO = .852, $\chi^2 = 15682.832$, $df = 190$, $p < .000$). The confirmatory factor analysis (CFA) also reconfirmed the validity of the model. We found a well fitted model ($\chi^2 = 1654.317$, $df = 231$, $p = .000$, NFI = .917, TLI = .906, CFI = .928, RMSEA = .055).

We studied internal consistency to investigate the reliability of our questionnaire. The Cronbach's alpha values were acceptable and good for the questionnaire fields (Cronbach's alpha = .735–.843). The highest reliability was found for instrumental motivation (Cronbach's alpha = .843), and the lowest reliability for self-efficacy fell slightly below that (Cronbach's alpha = .735). The McDonalds omega coefficients also showed good reliability for each field ($\omega = .794$ –.898). We registered the highest omega coefficients for instrumental motivation ($\omega = .898$), while the lowest coefficients were for self-efficacy ($\omega = .794$). The correlation coefficients were significant between the questionnaire fields. The AVE value was also acceptable in each of the fields.

Correlations among latent constructs are also presented in Table 1. We found the highest correlation between self-concept of mathematics and interest in mathematics ($r = .528$). The lowest but significant correlations were observed between interest in reading and instrumental motivation ($r = .103$) and between self-concept of verbal competencies and interest in mathematics ($r = .113$).

Reliabilities for the reading tests produced Cronbach's alpha values of .89 for the sixth grade and .90 for the eighth grade. The Cronbach's alpha for the mathematics tests was .93 for Grade 6 and .92 for Grade 8. It can be concluded that the values were very high for each cognitive field.

5.2. Descriptive analysis of students' motivation, self-related beliefs and academic achievement in reading and mathematics

We converted students' test results into percentages, and Table 2 shows the test results in percentage points. Students' results for the questionnaire fields were indicated on a four-point scale. As for the cognitive tests, we found significant differences between the test results. In reading, sixth-grade students achieved significantly better ($t = 9.042$, $p < .001$). In mathematics, eighth-grade students performed significantly better ($t = -8.135$, $p < .001$).

Table 1

Internal consistency reliability (CRB), composite reliability (CR), average variance extracted (AVE) and inter-correlations for the 6-factor correlated model.

Factors	CRB	CR	AVE	1	2	3	4	5
1. Instrumental motivation	.843	.898	.747					
2. Interest in reading	.816	.869	.688	.103				
3. Interest in mathematics	.735	.809	.586	.141	.161			
4. Self-efficacy	.764	.794	.663	.279	.270	.261		
5. Self-concept of verbal competencies	.778	.832	.742	.166	.403	.113	.438	
6. Self-concept of maths competencies	.825	.803	.579	.156	.180	.528	.410	.236

Note. All correlations were statistically significant at $p < .001$.

Table 2
Reading and mathematics test and questionnaire results in the longitudinal sample.

Factors	M	SD
Reading test Grade 6	75.46	12.37
Reading test Grade 8	72.88	14.65
Maths test Grade 6	47.56	18.57
Maths test Grade 8	50.66	21.18
Instrumental motivation	3.52	.63
Interest in reading	2.61	.84
Interest in mathematics	2.45	.73
Self-efficacy	2.79	.58
Self-concept of verbal competence	2.89	.60
Self-concept of maths competence	2.58	.77

As for the questionnaire, the highest mean was observed in instrumental motivation ($M = 3.52$, $SD = .63$), followed by self-concept of verbal competencies ($M = 2.89$, $SD = .60$). We found the lowest means in the field of interest in mathematics ($M = 2.45$, $SD = .73$).

Table 3
Correlations between cognitive tests and questionnaire fields.

Factors Grade 6	Reading test		Maths test	
	Grade 6	Grade 8	Grade 6	Grade 8
Instrumental motivation	.091***	.085***	.107***	.079***
Interest in reading	.302***	.325***	.211***	.212***
Interest in mathematics	n. s.	n. s.	.067**	.064**
Self-efficacy	.238***	.203***	.251***	.224***
Self-concept of verbal competence	.344***	.318***	.239***	.235***
Self-concept of maths competence	.271***	.199***	.429***	.348***

** Correlation is significant at the $p < .01$ level.

*** Correlation is significant at the $p < .001$ level.

5.3. Relationships between the variables under analysis and reading and mathematics achievement

We examined the relationships between the questionnaire fields and cognitive tests to analyse internal relationships (Table 3).

The correlation coefficients between the test and questionnaire fields showed moderate strength in all cases in Grade 8. All of the test results showed similar correlation levels with instrumental motivation. Interest demonstrated the greatest variation in the strength of correlation with the test results in the two literacy domains. While there was a weak correlation between interest in mathematics and mathematics achievement, there was no significant correlation for reading. Interest in reading, indicated a somewhat stronger correlation in Grade 6 than in Grade 8. Of all the variables studied here, the strongest correlation with the test results was with self-concept in both literacy domains. Both self-efficacy and self-concept of verbal competence indicated significant strong relationships with the reading test in Grade 6 and in Grade 8. Self-concept of mathematics competence and the reading test also showed significant correlation coefficients in the grades.

5.4. Testing the measurement models

Both models proved to be valid in both domains with some differences in the standardized regression weights (Table 4).

5.4.1. Mediation model of motivation

An analysis of the hypothesised path model found a good fit between the model and the data in both fields of reading and mathematics (Table 4), although not all the hypothesised paths were statistically significant. The models explained 33 % of reading achievement and 40 % of mathematics achievement in the eighth grade. A path analysis found that both self-related constructs had significant direct effects on motivational factors; however, the strongest effect of self-concept was observed on interest in both fields, in

Table 4
Structural equation modelling analyses: model fit statistics.

Model	Description	χ^2	df	p	CFI	TLI	NFI	RMSEA
Model 1 Reading	Mediation model of motivation (Fig. 3)	28.074	6	.000	.990	.974	.987	.042
Model 1 Maths	Mediation model of motivation (Fig. 3)	61.695	7	.000	.981	.960	.979	.062
Model 2 Reading	Mediation model of self-related beliefs (Fig. 4)	66.698	6	.000	.971	.929	.969	.070
Model 2 Maths	Mediation model of self-related beliefs (Fig. 4)	55.079	7	.000	.984	.965	.981	.058

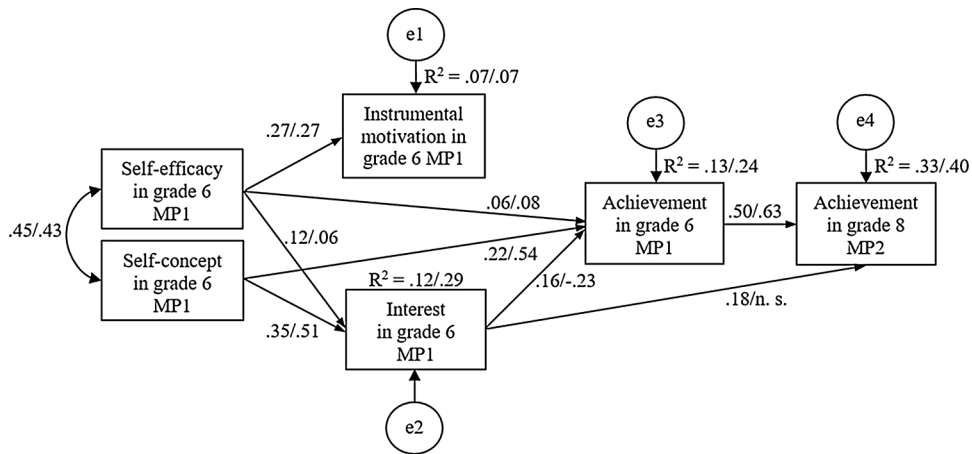


Fig. 3. Mediation model of motivation with standardized path coefficients (β) and explained variance (R^2) for each dependent variable in reading/mathematics (Note: MP1 = 1st measurement point; MP2 = 2nd measurement point).

reading and mathematics ($\beta = .35/.51$). Self-efficacy had a significant impact on instrumental motivation ($\beta = .27/.27$) and interest ($\beta = .12/.06$). Both self-related beliefs had significant effects on academic achievement in Grade 6 in both domains; however, self-concept was a better predictor than interest ($\beta = .22/.54$). Contrary to our expectations, self-concept was not related to instrumental motivation, and instrumental motivation did not show any further relations to other constructs. Interest had a positive direct effect on achievement in reading in Grade 6 ($\beta = .16$) and a negative direct effect on achievement in mathematics in Grade 6 ($\beta = -.23$).

The strongest effect on students' reading and mathematics achievement in Grade 8 was exerted by their sixth-grade achievement ($\beta = .50$ and $\beta = .63$, respectively), which represented the predictive effect of prior knowledge. The main difference between the mediation model in reading and mathematics was that we observed the predictive direct effect of interest in reading on reading achievement in Grade 8 ($\beta = .18$), while we did not find the same direct effect on the mathematics field (Fig. 3).

5.4.2. Mediation model of self-related beliefs

The fit indices of the reading and mathematical model for the mediation model of self-related beliefs were within the acceptable limits (Table 4). The models explained 32 % of reading achievement and 40 % of mathematics achievement in the eighth grade. The path analysis further showed that both motivational factors indicated a strong direct effect on self-efficacy ($\beta = .24/.23$; $\beta = .25/.24$). The most intense influence was on self-concept of interest ($\beta = .30/.46$). Interest also directly influenced achievement in Grade 6; however, the effect was positive in the reading domain ($\beta = .17$) and negative in the mathematics domain ($\beta = .23$). Contrary to our expectations, instrumental motivation was not linked to self-concept or achievement in Grade 6. Self-efficacy directly influenced self-concept ($\beta = .36/.30$), but it had no other direct effect on any other variables.

With regard to students' academic achievement, we also observed the strongest significant impact of sixth graders' achievement on the students' eight-grade achievement in both reading and mathematics ($\beta = .51/.63$, respectively). Self-concept proved to be a decisive predictor of achievement in Grade 6 ($\beta = .25/.57$); however, it indicated low direct effect on eighth graders' reading test

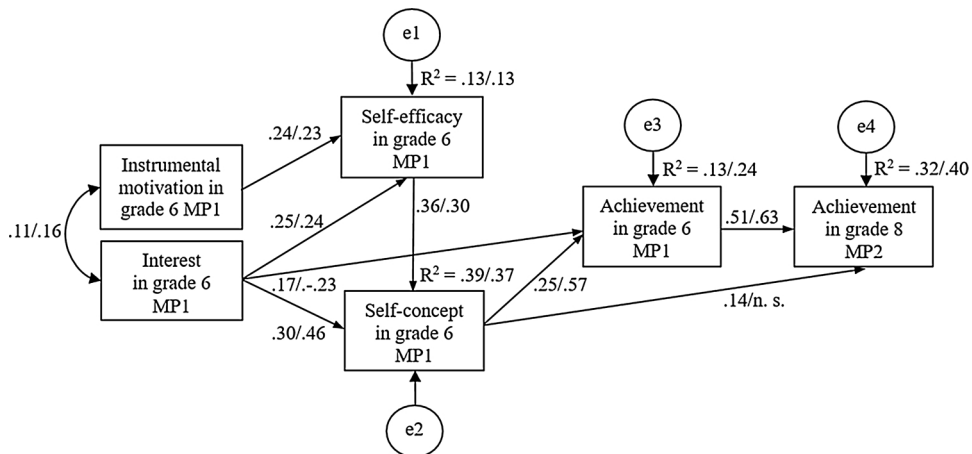


Fig. 4. Mediation model of self-related beliefs with standardized path coefficients (β) and explained variance (R^2) for each dependent variable in reading/mathematics (Note: MP1 = 1st measurement point; MP2 = 2nd measurement point).

achievement ($\beta = .14$), and this result did not occur in the mathematics domain. In this case, there was no significant direct path.

6. Discussion

This study explores the relationship between certain non-cognitive factors that characterise students' approaches towards learning and academic achievement. According to previous research, two approaches emerge in the literature. The first view emphasizes the mediating effect of motivation; the second highlights the impact of self-related beliefs. A central aim of our study is that we investigated both perspectives for the same longitudinal sample. Based on the literature, we built and tested two hypothesised models. In the first model, we proposed the mediation role of motivation between self-related beliefs and achievement in reading and mathematics, while in the second model we assumed the mediation effect of self-related beliefs. Two measurement tools were employed for data collection, the subscales of the PISA 2000 student questionnaire (Artelt et al., 2003) and cognitive tests to measure students' verbal and mathematics competences. As a preliminary analysis, we validated the factor structure of the questionnaire that proved to be valid and reliable.

With regard to the questionnaires, we observed the highest ratings towards instrumental motivation; however, students judged interest in mathematics at the lowest rates. We also investigated the relationships among the observed constructs and found significant, but moderate relations between the variables in almost all of the fields. We have found very low correlation between instrumental motivation and interest that implies that these constructs are not identical. However, we could not detect a significant connection between reading achievement and interest in mathematics. In line with the corresponding literature, the greatest relationship existed among self-concept and both literacy domains in both grades. The values measured were similar to those in other related research (Cvencek et al., 2015; Lee, 2009; Morony, Kleitman, Lee, & Stankov, 2013). As for self-efficacy, we identified somewhat weaker relations with achievement in both areas compared to those in the relevant literature. Jiang et al. (2014) reported $r = .56$ correlation coefficients with academic achievement for their middle school sample and $r = .42$ for their elementary school sample. Stankov and Lee (2014) found $r = .41$ between their mathematics test and mathematics self-efficacy. However, our findings are similar to those of Smith et al. (2012), who found a reduced link between self-efficacy and reading achievement compared to subsequent years among 8–12-year-olds. While reading achievement increased considerably from age 8 to age 12, reading self-efficacy declined. Our central objective was to test our hypothesised models. The model comparison discovered that both models worked for both literacy domains. The path analysis of the mediation model of motivation showed strong links between the self-related factors, as in Scherer (2013), and a strong dependence relationship between the motivational constructs. That means that students who feel competent in completing the task believe that they can perform well, they become more motivated and more interested in the task, and that leads them to achieve better (Guay et al., 2010). We also reinforced the SDT theory (Ryan & Deci, 2009), which also claims that positive self-concept increases motivation.

Self-concept in mathematics had the strongest direct effects on the mathematics achievement domain in Grade 8, a finding which is in line with Cvencek et al. (2015) and Marsh et al. (2005). A direct relation between self-efficacy and academic achievement was only observed for sixth graders, however, it was quite a weak link in both domains, a finding which is consistent with Jiang et al. (2014) and Stankov and Lee (2014).

We could not discover any significant impact of instrumental motivation on any other fields. Some possible explanations for the rather weak connection between instrumental motivation and academic achievement is that at this stage, most students do not yet have a specific learning goal or that students in the Hungarian education system, which is centred on scholarly disciplines and imparts mostly academic values, do not realise that studying is a means to achieving their goals. The main outcome of the model is the difference between the two mediation models of the two domains in that a predictive direct effect of interest on reading achievement was observed in Grade 8, while we could not detect the same in the mathematics domain. Our results are thus comparable to those found in studies of older cohorts of students: interest has a relatively small or no direct effect on academic achievement, especially for mathematics (Marsh et al., 2005). Our results also demonstrate that in spite of the weak direct relation between interest in reading and reading achievement, students who are keen readers and find pleasure in reading in their free time in sixth grade will likely be better readers two years later (in eighth grade) than their less interested peers. However, the strong direct effect of interest was observed on self-concept; that is, students interested in a subject are more likely to completing a task.

The analysis of the mediation model of self-related beliefs demonstrated a strong direct effect of motivation on self-related beliefs, a result which is in line with other studies (Guay et al., 2010; Marsh et al., 2005). Instrumental motivation only had a significant impact on self-efficacy. Self-efficacy had a direct effect on self-concept, and it had no other connection. As with the previously mentioned models, self-concept had a significant effect on sixth graders' achievement in the mathematics domain and no direct effect on eighth graders' achievement in that domain.

A further issue addressed in this study is the strongest mediation effect on academic achievement in relation to literacy domains. Results found the strongest correlation with self-concept in the field of mathematics, a finding which is consistent with other research (Artelt et al., 2003; Köller, Baumert, & Schnabel, 2001). The self-concept of verbal competencies also had a significant correlation with sixth graders' achievement, although substantially weaker than in the mathematics domain. The most powerful predictive effect on eighth graders' achievement was sixth graders' achievement in the corresponding literacy domains, thus highlighting the crucial role of prior knowledge.

Comparing the four models, the similar values show the equally important effects of motivational and self-related constructs on reading achievement, a finding which is consistent with other studies (Arens, Yeung, Nagengast, & Hasselhorn, 2013; Guay et al., 2010; Seaton et al., 2014; Suarez-Alvarez et al., 2014). We should also note that with regard to the sign of the effects, the analysis found a negative direct effect, indicating that students interested in mathematics show poorer achievement in the sixth grade. Further, in our models, although there was no direct connection between interest and mathematics achievement in the eighth grade, on the one hand, and self-concept and mathematics achievement, on the other, there can be no doubt that intrinsic motivation, interest and self-related factors in the face of difficulties play an important role in successful learning or in successfully completing any task.

Our results complement the findings of other studies (Guay et al., 2010); they provide further evidence or shed a different light on them. Through the causal relationship they show that non-cognitive factors can also be used to encourage persistent learning. The path analysis mapped the similarities and differences between the two literacy domains and the factors with longer-term effects (from sixth to eighth grade). As predicted, self-concept and interest showed the strongest predictive effect on mathematics and reading achievement. Achievement in both domains was considerably more reflected on self-concept than on interest.

7. Conclusions

The study drew our attention to the significance of non-cognitive personal characteristics that motivate and sustain learning, in the fields of reading and mathematics. We investigated the longitudinal effect of self-related beliefs and motivational factors on academic achievement. Our findings revealed the mediating role of both the self-related and motivational factors. Most of these non-cognitive factors noticeably predict academic achievement among lower secondary school students. These results have significant outcomes not only on ongoing research projects, but on teaching practices as well. In the classroom, it is worth paying attention to the development of learning motivation; programmes aiming to enhance students' learning and the cognitive components of knowledge may be more effective and their effects may last longer if, in addition to teaching cognitive skills and content, they also reinforce students' self-concept and confidence in their own abilities and show students that it is worth investing time and effort in learning because it is an investment with ample returns.

8. Limitations of the study

The limitation of our research is that the sixth-grade students only completed the questionnaire on their learning-related beliefs at the first measurement point. At the second measurement point, the eighth-grade students did not complete the questionnaire again, so we can only describe the predictive effect of students' views. Concrete evidence can be presented through a new survey at the next measurement point. Thus, from a perspective of four years, we can draw longer-term conclusions.

Moreover, the learning environment, such as teaching methods, can probably influence students' view on learning-related beliefs and results. Although we have studied several components of learning, the results that may affect learners' achievement can be extended to analyse additional factors.

A further limitation of our research is that the students completed the questionnaire and tests in paper-and-pencil format, but we are already switching to computer-based measurements, which offer a number of new possibilities, foster data collection, and make it possible to employ innovative task types. Indeed, the PISA studies have also switched to computer-based assessment.

9. Educational implications

The equal values in the four models show not only that the perceived relations may be useful in reading or mathematics instruction, but also that education in general may rely on the relationship between motivation and self-related beliefs.

The PISA 2012 study also stressed that students who have an extensive knowledge of mathematics are more confident and can solve problems that they did not think they could before. The role of teachers is important in this process; namely, they have to encourage students to understand that they are able to solve complex problems.

Through positive feedback and optimal challenges, teachers can develop motivation and self-concept. Hence, while the main objective of education should be children's cognitive development, motivational factors also need to be established and developed in the classroom.

In mathematics, an enhanced self-concept has the best chance of improving achievement; it is important to convince students that they learn mathematics quickly and well that leads to their achievement. In reading, it is worth making an effort to raise students' interest, thus letting them discover the joys of reading, to help them judge their reading abilities better and to reinforce their confidence in their own knowledge.

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Declaration of Competing Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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