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Exploring special non-cognitive factors related to young students' academic performance in STEM subjects

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Abstract
Students' academic success is influenced not only by their cognitive abilities and knowledge, but also non-cognitive factors. Studies show growing disinterest in science and math among students, especially females. Therefore this study aimed explore in depth the subject-specific motivation, mindset, mindfulness, cognitive persistence, mastery pleasure and subject-specific self-concept of 3rd and 4th grade students in relation to school performance by grades and by genders. Through student responses obtained by filling out questionnaires the results revealed a lot of correlations among the self-concept, motivational and other variables. It means that self-concepts and motivations connected to school subjects have significant relationship with the examined non-cognitive factors. The results also showed that the girls' mathematical self-concept is already less positive than boys' by grade 4. Furthermore the results of the ordinal regression analysis indicate that in the case of girls the predictors of academic achievement are more diversified, including more factors.

Keywords: subject-specific motivation, subject-specific self-concept, achievement predictors

INTRODUCTION

Science, technology, engineering, and mathematics (STEM) education addresses today's complex political, economic, social, and environmental issues by equipping students with essential 21st century skills like problem-solving, critical thinking, logical thinking, and communication (Bybee, 2010; National Research Council [NRC], 2010). Recognized as crucial for national development, economic productivity, and societal wellbeing, STEM education and research are key drivers in these areas (English, 2016).

Challenge: Decline in Learning and Intrinsic Motivation

Many countries report a "leakage" in the STEM pipeline, with students disliking STEM disciplines or not pursuing related careers after graduation (Ball et al., 2017; Doerschuk et al., 2016). According to Anderman and Maehr (1994), the decline in learning motivation generally begins around 3rd to 6th grade and continues into high school. Simultaneously, non-school-related motives strengthen. (Hidi, 2000). Józsa et al. (2014) indicates a decline in intrinsic motivation as American children progress through school, similar to trends observed in relation to Hungarian children. Several classic studies, including those by Harter (1981), Lepper et al. (1999), and Gottfried (1985) have documented this phenomenon. The questionnaire of Harter's (1981) "children's intrinsic versus extrinsic motivation in the classroom," showed a shift from intrinsic to extrinsic motivation from grade 3 to grade 9. The cross-sectional study of Lepper et al. (1999) confirmed a significant linear decrease in self-reported intrinsic motivation but did not find a corresponding increase in extrinsic motivation. Gottfried (1985) developed scales to assess academic intrinsic motivation in various subjects, including reading and math, and her longitudinal studies revealed a decline in intrinsic motivation from ages 9 to 17, particularly in math, science, reading, and general school motivation, with the steepest decline in math. This decline in intrinsic motivation, especially in math, predicted lower educational attainment by age 29, highlighting the critical role of intrinsic motivation in long-term academic success. These studies underscore

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Contribution to the literature

- This study makes contribution to the existing literature by demonstrating the existence of gender-sensitive patterns of predictive factors related to subject achievement in the field of STEM education.
- Our results demonstrate the relevance of exploring and identifying subject-specific non-cognitive factors to improve student achievement in STEM fields.
- This study enhances teachers' awareness of the necessity to employ appropriate classroom interventions from the earliest school years and to promote the psychological well-being of their students.

the importance of examining different domains of motivation and suggest that declines may be specifically related to school-related changes from elementary school to high school. Science subjects, such as physics, chemistry, and mathematics, are typically the least liked by students (Csapó, 2000).

Psychological Needs and Non-Cognitive Factors in Science Learning

Basic psychological needs (BPN) for autonomy, competence, and relatedness are essential for the well-being and motivation of students, particularly in basic education (age 6-age 14). When these needs are satisfied, students experience greater intrinsic motivation; frustration of these needs can negatively impact motivation (Niemiec & Ryan, 2009; Ryan & Deci, 2020) Teachers' support of autonomy significantly impacts students' perceptions of their own autonomy and competence, which positively predicts motivation and engagement in subjects like science (Lavigne et al., 2007). In the process of building and developing an integrated scientific knowledge and approach in grade 1-grade 4 in primary school, we need to raise awareness of the cognitive and non-cognitive characteristics of children aged 6-aged 11. We need to be aware of the school needs of primary school-age children and their needs are considered on the basis of Schneider and Oberlander (2008):

1. Safety: students want to feel physically and psychologically safe at school.
2. Hope: students want to believe that they will have the opportunity to show themselves in the future.
3. Dignity: students hope to be supported to develop a positive self-image.
4. Acceptance: students want to be recognized and valued and to feel part of the community.
5. Influence: students want to have an influence on events in school that affect them personally.
6. Joy: students will want to be involved in things that bring them joy and recognition.
7. Competence: students would like to be able to apply the knowledge they have acquired, to apply it to tasks and to solve tasks well.

These needs can also be associated with the non-cognitive factors that we have highlighted in our research. For example, the need for acceptance may be expressed in aspects of school well-being, the need for competence may be associated with mindset, joy may be expressed in the motivation to learn, the need for dignity may be associated with the self-image of learning, and the experience of influence may be associated with mindfulness and mindset.

School Well-Being

School well-being surveys assess the subjective well-being of students' by examining their experiences in the school environment (Hascher, 2004, 2011; Pollard & Lee, 2003; Soutter et al., 2010, 2014). High well-being is linked to positive school experiences, strong peer relationships, and high self-esteem (Hascher, 2004, 2008; Pollard & Lee, 2003; Réthy, 2016). Conversely, low well-being can stem from negative school experiences, exhaustion, peer issues, and negative attitudes towards learning. The Kuno school well-being model is an influential framework developed to understand and enhance the overall well-being of students in educational settings. The model emphasizes a holistic view of well-being, incorporating multiple dimensions that contribute to academic and personal success of students. The school well-being model (Konu et al., 2002) identifies four dimensions affecting well-being: school context, peer relationships, personal factors, and health. Personal factors, such as self-image, motivation, and learning strategies, are crucial for self-actualization and future success of students. Fredricks et al. (2004) emphasized the importance of emotional engagement, including feelings of interest, enjoyment, and attachment to school, as a predictor of academic success. This is particularly relevant in STEM education, where sustained interest and motivation are necessary for mastering complex subjects.

Implicit Theories of Intelligence

Implicit theories of intelligence, specifically fixed versus growth mindsets, are pivotal in shaping students' self-efficacy and their response to academic challenges. According to Dweck (2007), a growth mindset–believing that abilities can be developed through effort–enhances self-efficacy and promotes persistence. In contrast, a fixed mindset–viewing abilities as innate and unchangeable–can undermine confidence and lead to disengagement from challenging tasks. Hong et al.

(1999) explored students with a growth mindset are more motivated to learn and succeed in STEM subjects, showing higher levels of intrinsic motivation. Rattan et al. (2012) illustrated that mindset affects responses of students to challenges in STEM courses, with growth-minded individuals showing greater resilience and effort. The meta-analysis performed by Sisk et al. (2018) indicate that students with a growth mindset are more likely to persist in STEM fields despite difficulties. Estrada et al. (2011) claimed that students' beliefs in their ability to grow and improve were strongly correlated with their intentions to remain in STEM disciplines. Motivational beliefs, including perceptions of ability, effort, and the value of math, vary by gender and influence career aspirations. Degol et al. (2018) emphasized that mindset and motivation are critical in shaping math performance and STEM aspirations. Females often perceive higher effort as necessary for success in STEM, which can discourage their pursuit of such fields (Smith et al., 2013). Mindsets also shape academic and career decisions of students through cost/benefit appraisals. Eccles (2009) suggested that if math is associated with high emotional costs, students, especially females, may avoid it. Interventions promoting growth mindsets have been effective in reducing these perceived costs and improving math performance and motivation, particularly for females (Blackwell et al., 2007; Dweck, 2007). Practical interventions should focus on promoting growth mindsets for both genders but especially for girls. Good et al. (2012) found that interventions promoting a growth mindset improved the performance of female students' and reduced the gender gap in STEM courses. Dar-Nimrod and Heine (2006) discussed how promoting a growth mindset helps reduce the negative impact of stereotypes on women's math performance.

Mindfulness

Mindfulness, defined as a state of activeness, open attention to the present, is explored for enhancing cognitive and emotional outcomes in education. Mindfulness practices aim to improve focus, emotional regulation, and overall well-being of students. Kabat-Zinn (2003) laid the foundation for mindfulness-based stress reduction programs, later adapted for educational contexts. Langer (2000) emphasized mindfulness as fostering cognitive flexibility and creativity, critical in STEM. Roeser et al. (2013) found that mindfulness training improved attention, working memory, and executive function of high school students, essential for mastering STEM subjects. Bakosh et al. (2016) supported these findings, demonstrating improved standardized test scores in mathematics. Mindfulness also enhances attention span and concentration (Meiklejohn et al., 2013).

Mindfulness helps reduce stress and anxiety, common in STEM students due to demanding fields (Roeser et al., 2013) and fosters resilience for coping with academic challenges (Hölzel et al., 2011). It addresses gender disparities; Biegler et al. (2016) found it reduced anxiety and improved self-efficacy among female STEM students, promoting gender equity. Mindfulness improves classroom behavior and creates a positive learning environment, beneficial in collaborative STEM activities (Schonert-Reichl et al., 2015). It promotes empathy, emotional regulation, and better peer relationships (Jennings et al., 2011). The effectiveness of mindfulness varies by age, practice duration, and individual differences (Zenner et al., 2014).

Mastery Motivation

Mastery motivation refers to the intrinsic drive to explore and master one's environment, identified as a critical developmental concept in the National Academy of Science report, *from neurons to neighborhoods* (Shonkoff & Phillips, 2000). Morgan et al. (1990) describe mastery motivation as a multifaceted psychological force that drives individuals to attempt moderately challenging tasks. It comprises two major aspects: instrumental and expressive (Barrett & Morgan, 1995). The instrumental aspect motivates focused and persistent problem-solving efforts, while the expressive aspect generates affective reactions during or after task completion (Morgan et al., 1990). Mastery motivation is foundational for learning in infants and remains active throughout preschool, school age, and adulthood (Morgan et al., 2017). This motivation significantly impacts cognitive, social, and psychomotor development (Wang & Barrett, 2013; Morgan et al., 2017). Some studies suggest mastery motivation may better predict cognitive development than intelligence, thereby playing a crucial role in school achievement (Józsa & Morgan, 2014; Yarrow et al., 1975). Shonkoff and Phillips (2000) emphasize the importance of assessing mastery motivation as part of evaluating a child's development due to its role in personality development.

Research indicates a strong relationship between mastery motivation and school achievement. Gilmore et al. (2003) found that mastery motivation predicts school-related skills. Mokrova et al. (2013) demonstrated that mastery motivation predicts kindergarten academic skills in language and math. Mercader et al. (2017) showed that persistence in preschool significantly predicts 2nd grade mathematics achievement. Additionally, Józsa and Morgan (2014) found a significant relationship between mastery motivation in 4th grade and GPA in 8th grade, while Józsa and Molnár (2013) found associations between instrumental mastery motivation and GPA, as well as achievement in specific school subjects in 3rd and 6th graders.

Domain-Specific Mastery Motivation

In recent decades, it has been recognized that learning motives are highly domain-specific, with characteristics and functions varying significantly within an individual across different skill or subject areas. This domain-specific interpretation of learning motives is supported by research across fields, including studies on learning goals in mathematics (Hannula, 2006; Fejes & Vígh, 2012), flow experiences in music (Janurik, 2009), and self-efficacy in reading and writing (Schunk, 2003). These studies indicate that domain-specific motives not only differ across areas but also more accurately predict academic success within particular domains compared to non-domain-specific motives (Eccles et al., 1983).

Wigfield et el. (2004) argue for the domain specificity of academic motivation, highlighting that

(1) students perceive varying self-efficacy across domains,

(2) they exhibit different interests and intrinsic motivations in subjects,

(3) distinct skills are needed for success in different academic areas, and

(4) the separation of school subjects fosters subject-specific motivation.

Research on self-concept supports this view, showing differences in self-concept by subject, such as mathematics versus reading (Marsh, 1990a; Zanobini & Usai, 2002). Empirical evidence confirms differentiation of academic motivation across subjects (Wigfield et al., 2004). This theoretical background is rooted in self-concept theory (Bong, 2001) and factor-analytic studies of self-efficacy and competence beliefs (Wigfield&Guthrie, 1997). Research on subject-specific motivation often focuses on individual subjects, such as reading (Józsa & Józsa, 2014; Szenczi, 2010, 2013; Wigfield & Guthrie, 1997) and mathematics (Hannula et al., 2016), or multiple subjects simultaneously (Bong, 2001; Green et al., 2007; Leaper et al. 2012).

Academic Self-Concept

According to the self-concept theory (Shavelson et al., 1976), self-concept is multifaceted and varies across different contexts (Marsh, 1986, 1990). Academic self-concept, specific to academic activities, also varies by subject (e.g., math or reading; Gogol et al., 2016) and impacts both current and future achievement (Susperreguy et al., 2018). Current models suggest a reciprocal relationship between academic self-concept and achievement, where each influences the other (Marsh & Craven, 2006). This was supported by a longitudinal study of German students, showing that self-concept predicts future achievement (Arens et al., 2020).

Children lack a global academic self-concept for overall success in school, with distinct self-concept components between subjects, especially sciences and humanities. For example, positive self-concepts in humanities differ from those in mathematics (Kőrössy, 1997; Marsh et al., 1988). Limited studies on elementary school children (Faber, 1992; Möller et al., 2009, 2011) indicate they often have overly positive self-evaluations due to difficulty distinguishing actual from desired attributes and in using social comparisons (Harter, 1999). However, from 1st grade, children can report self-perceptions and recognize relative strengths and weaknesses across domains (Marsh et al., 1991, 2002). Simpkins et al. (2006) found that perceptions of abilities in math and science during elementary school strongly predict later interest and enrollment in advanced STEM courses in high school.

Marsh et al. (2005) found that academic self-concept predicts achievement in math and science, where a positive self-concept is linked to better performance and persistence in STEM. Guay et al. (2010) highlighted the mediating role of academic self-concept between intrinsic motivation and achievement in STEM, suggesting belief in abilities leads to motivation and success. A longitudinal study (Gottfried et al., 2001) showed that academic self-concept in math and science during early adolescence predicts STEM career aspirations and attainment in adulthood.

Mathematical self-concept (MSC) significantly affects interest in STEM fields, with women's underrepresentation often linked to consistently lower MSC compared to men (Bong & Skaalvik, 2003). Female students with lower MSC are less likely to pursue STEM majors, perceiving these fields as requiring high mathematical abilities. Women in STEM may also face challenges that diminish their self-perceived ability, such as interactions with faculty and competitive environments (Sax, 1994), contributing to the STEM gender gap (Aronson & Steele, 2005; Sax et al., 2005).

The gender gap in MSC is often attributed to gender stereotypes and socialization. Mathematics is traditionally viewed as a "male" domain, while reading and languages are seen as "feminine" (Shavlik & Shavlik, 2006). During adolescence, girls may internalize these stereotypes, leading to lower math self-ratings compared to boys (Eccles, 1994; Watt, 2006). Some research suggests this gap is narrowing, and perceptions of math as masculine are changing (Marsh & Yeung, 1998; Watt, 2000), but stereotypes still affect MSC and gender disparities in STEM fields (Skaavlik & Skaavlik, 2006).

Gender Gap

Studies show growing disinterest in science among students, especially females, who often have negative attitudes that discourage them from pursuing STEM.

Research highlights gender disparity in STEM fields, noting the underrepresentation of women and their disinterest in STEM careers. Understanding how female students' STEM identities disintegrate is crucial to reversing this trend (Corrigan & Aikens, 2020). Gender stereotypes impact women's STEM career choices, as they are often socialized to believe that men are more suited for these fields. Cheryan et al. (2017) found that exposure to stereotypically masculine environments can discourage women, even with the necessary qualifications. Implicit biases in academic and professional settings contribute to gender disparities. Research shows that both men and women tend to favor male candidates for STEM positions, leading to unequal opportunities for women in hiring, promotions, and mentorship (Moss-Racusin et al., 2012). Mentorship is crucial for retaining women in STEM. Female students and professionals benefit from mentors who guide their careers, and those with supportive role models are more likely to persist in the field (Dasgupta & Stout, 2014). Gender-targeted programs, like those encouraging girls' early engagement in STEM, have been effective in narrowing the gender gap. These programs foster self-efficacy and challenge stereotypes, particularly when girls work in hands-on, collaborative environments (Master et al., 2016).

Research Questions

Based on the literature review, this study aims to explore in depth the subject-specific (reading, mathematics, environmental science) motivations and subject-specific self-concept of 3rd and 4th grade students in relation to school performance. Moreover, these psychological variables are also associated with additional non-cognitive factors such as school well-being and mindset. Three questions were asked:

1. What gender and grade differences can be confirmed between non-cognitive factors?
2. What correlations can be found between the variables studied? This question is interesting because, according to our knowledge, subject-specific mastery motivation and subject-specific self-concept have not yet been investigated in such a context.
3. Can different patterns of non-cognitive factors predicting school performance be confirmed between boys and girls in this age group?

MATERIALS AND METHODS

Research Design

We selected students in grade 3-grade 4 in 7 schools in the eastern region of Hungary. The SES background of the students was similar in different grade levels. The schools were located in 5 different towns, from small to medium size cities. The data collection procedure was the same in all schools. Children filled out the questionnaires in class, which required about 30-35 minutes. Teachers helped with the data collection. We designed two studies. The authors collected the data in the first half of 2023 and in January 2024. There was a pilot study in 2023 to examine the psychometric properties of the scales we intended to use. In the main study the adjusted scales were used. Data were collected by selecting two 3rd and two 4th grade classes from a list of the research team's partner institutions during the months of May-June 2023 until the end of the school year. The target group of our study is the 3rd grade, because this is when environmental studies as an independent subject starts to be taught in Hungary. And the study of 4th graders allows us to detect changes by the end of the lower primary school.

Table 1. Participants according to gender and school grade

			Grade		Total
			3	4	
Gender	Boy	Count	105	80	185
		% within gender	56.8	43.2	100
		% within grade	53.8	40.2	47.0
		% of Total	26.6	20.3	47.0
	Girl	Count	90	119	209
		% within gender	43.1	56.9	100
		% within grade	46.2	59.8	53.0
		% of Total	22.8	30.2	53.0
Total		Count	195	199	394
		% within gender	49.5	50.5	100
		% within grade	100	100	100
		% of Total	49.5	50.5	100

Participants

The pilot study involved 134 pupils. After data cleaning 115 students' questionnaires were evaluated.

In the main study the final sample size was N = 394. There were n = 209 (53%) girls and n = 185 (47%) boys in the sample. Children were evenly distributed from grades 3 (n = 195, 49.5%) and 4 (n = 199, 50.5 %), see **Table 1** for details.

Data Collection Instruments

The information regarding the instruments used to collect data in research is presented in sub-titles below.

Dimensions of mastery questionnaire

The dimensions of mastery questionnaire (DMQ 18) Morgan et al., 2019) uses Likert-type items rated from 1 to 5 and has four official language versions: English, Chinese, Spanish, and Hungarian. In each of these languages, there are four parallel age-related versions of the DMQ: infant, preschool, school-age rated by adults, and school-age self-report. The school-age self-report version contains 41 items reworded to allow students from approximately 3rd grade through high school to rate themselves. Each version includes seven scales: four scales assess the instrumental aspects of mastery motivations, two scales measure the ex-pressive aspects of mastery motivation, and one scale evaluates competence or the ability to master tasks (Morgan et al. 2019). In our research we used only two scales of the questionnaire: cognitive persistence scale and mastery pleasure scale. For the school-age DMQ 18, internal consistency measures for Hungarian 10-11 year-old children self-reporting their motivation are, as follows: cognitive persistence has a Cronbach's alpha of .79, and mastery pleasure has a Cronbach's alpha of .66 for 4^{th} grade Hungarian children (Morgan et al., 2019).

The subject specific mastery motivation questionnaire

Józsa (2014) explored additional dimensions of mastery motivation, proposing that mastery motivation possesses school-specific dimensions that can vary across different school subjects. To measure these domain-specific dimensions, he developed new scales. Likert-type items were created for the following subjects: reading, mathematics, science, English and German as foreign languages, music, and art. These items were based on several related definitions of mastery motivation (Barrett & Morgan, 1995; Busch-Rossnagel & Morgan, 2013; Morgan et al., 1990), the DMQ scales by Morgan et al. (1993), and their Hungarian adaptation (Józsa, 2007). A pilot study involving 775 children supported the validity and reliability of these scales for Hungarian students studying English and German in school. The correlations between these foreign language mastery motivation scales and language achievement ranged from medium to strong (Józsa, 2014). In our research we used reading, mathematics and science self-concept scales of subject specific mastery motivation questionnaire.

Self-description questionnaire-I

The self-description questionnaire-I (SDQ-I), developed by Marsh in 1990, is a 76-item self-assessment tool based on a multicomponent hierarchical model of self-image (Marsh, 1990a, 1990b). It evaluates the following subscales: physical ability self-image, body image, read-ing self-image, mathematics self-image, peer self-image, parent self-image, general self-image, and school self-image. When the Hungarian adaptation (SDQ-I-H) by Szenczi and Józsa (2022) was tested using exploratory factor analysis to verify its validity, the results supported the structure of the original instrument. The reliability indices for each scale of the SDQ-I-H range from 0.72 to 0.91. In our examination we used only the subject-related scales of SDQ-I.

School well-being questionnaire

The questionnaire was developed by Hascher (2004) with the aim of investigating school well-being over several years and exploring the relationships between factors in primary school children. The questionnaire's six subscales measure school well-being using a total of 33 statements, with participants indicating the frequency of the occurrence of the statements on a six-point Likert scale, looking back over the past week. The Hungarian version of the questionnaire is based on a five-point Likert scale (Nagy,2021). Accordingly, the questionnaire contains statements along two dimensions, which are grouped into three positive (positive attitude and feeling of joy, positive self-image, self-efficacy) and three negative factors (social problems, worries, physical complaints at school). Co-occurrences between factors of the same dimension have been repeatedly confirmed in research using the questionnaire (Hascher, 2004, 2008, 2011; Tobia et al., 2022). We applied only two scales of this instrument: positive attitude and self-efficacy Scales.

The Child and Adolescent Mindfulness Measure

The child and adolescent mindfulness measure (CAMM), developed by Greco et al. (2011) is a valuable tool for assessing mindfulness skills in school-aged children and adolescents. The authors reduced the original pool of 25 items to 10 through exploratory factor analysis and validated it with a cross-validation sample. The findings suggest that the CAMM is a developmentally appropriate measure with satisfactory internal consistency. For example the French version of the CAMM demonstrates good psychometric qualities and remains faithful to the original scale. Results indicate a one-factor structure and suggest strong internal consistency. Additionally, the CAMM showed a positive correlation with another mind-fulness questionnaire (Roux& Philippot, 2020).

Implicit Theories of Intelligence Scale for Children

The scale consists of six items: three entity theory statements (e.g., ''You have a certain amount of intelligence, and you really can't do much to change it''); and three incremental theory statements (e.g., ''You can always greatly change how intelligent you are''; Dweck, 1999). The incremental theory items were reverse scored and a mean theory of intelligence score was calculated for the six items, with the low end (1) representing a pure entity theory, and the high end (6) agreement with an incremental theory. The internal reliability of the theory measure was .78 (N = 373), with a mean of 4.45 and a SD of .97 (range 1-6). The test-re-test reliability for this measure over a 2-week period was .77 in the sample of junior high school students (Blackwell et al., 2007). We used the Hungarian translation of the scale (Lukács-Nagy & Fodor, 2018) On the basis of the experience of the pilot study, the term intelligence has been replaced by smartness to make it easier to understand, in line with the age characteristics of the sample.

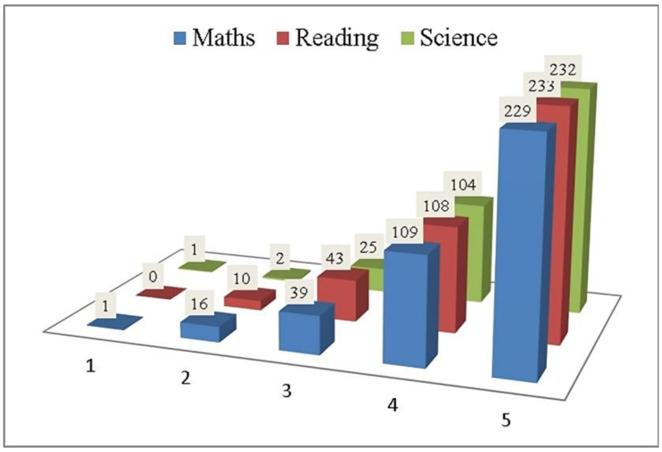

Figure 1. Distribution of marks received in the subject (Source: Authors' own elaboration)

School Marks

School marks in math, reading, and science were also administered as measurements of achievement in these subjects. Children mainly had good marks in all three subjects (**Figure 1**). Most of them had the best marks (5). There were missing data in science marks, 30 children's data were missing. In the Hungarian education system, grades range from one to five. One is the worst and a five is the best evaluation.

RESULTS

Data Analysis

We used RStudio and lavaan package for confirmatory factor analysis, and to obtain reliability measures. For analyzing our data, we used parametric methods conducted with IBM SPSS statistics 29.0. Independent sample t-test was used for comparing means. Ordinal regression was used for predicting achievement in school subjects. The level of significance was accepted at $p \leq 0.050$ according to conventions. The correlation coefficient was classified according to Cohen (1988) as weak between .10-.29, medium between .3-.49, and strong above .5.

Pilot Study

In the pilot study we examined the validity and reliability of the scales intended to be used in the analysis. The CAMM (Greco et al., 2011) resulted unacceptable fit according to confirmatory factor analysis (X^2 [35] = 72.249, $p < .001$; CFI = 0.859, TLI = 0.819, RMSEA = 0.098, SRMR = 0.102), therefore only four items were kept (one in each dimensions, item 1: "I get upset with myself for having feelings that do not make sense" , item 2: "At school, I walk from class to class without noticing what I am doing", item 3: "I keep myself busy so I do not notice my thoughts or feelings", and item 7 :"I think about things that have happened in the past instead of thinking about things that are happening right now."). Item selection was obtained in the scales mindset (item 4 was removed), positive attitude (item 5 was removed), efficiency (item 3 was removed), and SDQ-I (item 14 and item 17 were removed). Furthermore, moderate to strong correlation coefficients were found among the self-concept, motivational and other variables, which suggested that self-concepts and motivations connected to school subjects have significant relationship with the examined non-cognitive factors.

Table 2. Descriptive statistics and reliability measures of the scales

	M	SD	Min	Max	α
Item 1 of CAMM* "I get upset with myself for having feelings that don't make sense."	3.59	1.22	1.00	5.00	-
Item 2. of CAMM* "At school, I walk from class to class without noticing what I'm doing."	3.61	1.47	1.00	5.00	-
Item 3. of CAMM* "I keep myself busy so I don't notice my thoughts or feelings."	3.07	1.41	1.00	5.00	-
Item 7. of CAMM* "I think about things that have happened in the past instead of thinking about things that are happening right now."	3.09	1.39	1.00	5.00	-
Growth mindset	3.91	1.13	1.20	6.00	0.68
Positive attitude	3.84	0.84	1.00	5.00	0.75
Academic self -efficacy	3.82	0.83	1.00	5.00	0.72
School well-being	3.83	0.72	1.22	5.00	0.80
Reading self-concept	3.91	0.80	1.00	5.00	0.87
MSC	3.97	1.02	1.00	5.00	0.91
Science self-concept	3.98	0.96	1.00	5.00	0.90
Math mastery motivation	4.12	0.79	1.00	5.00	0.76
Science mastery motivation	3.66	0.93	1.00	5.33	0.78
Reading mastery motivation	4.06	0.92	1.00	6.00	0.85
Cognitive persistence	3.85	0.76	1.00	5.00	0.71
Mastery pleasure	4.18	0.75	1.20	5.00	0.67
Mastery motivation	4.00	0.65	1.91	5.00	0.77

Note. M: Mean & SD: Standard deviation

Descriptive Statistics and Reliability Measures

Means were calculated for each scales, except CAMM items, where the single variables were used. As a result the reversed items of mindfulness and the calculated means were used as variables in the analysis. Descriptive statistics can be seen in **Table 2**.

Cronbach's alpha was used to obtain reliability of the measures. Mastery pleasure and growth mindset scales' reliability were questionable, all other scales showed acceptable to excellent reliability (**Table 2**).

Table 3. Results based on gender differences

	t	df	p	Cohen's d	Mean	
					Boys	Girls
Item 7 of CAMM	2.233	392.000	0.026	0.225	3.25	2.94
Reading self-concept	-2.743	392.000	0.006	-0.277	3.79	4.01
MSC	5.804	392.000	< 0.001	0.581	4.27	3.70
Science mastery motivation	-2.330	365.515	0.020	-0.377	3.55	3.77
Mastery pleasure	-2.008	392.000	0.045	-0.300	4.10	4.25

Table 4. Results based on grades

	t	df	p	Cohen's d	Grade	
					3	4
Item 2 of CAMM	-2.716	380.459	0.007	-0.274	3.41	3.80
MSC	3.841	392.000	< 0.001	0.378	4.17	3.78

Table 5. Pearson correlation coefficients between the examined variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	-													
2	.098	-												
3	.078	.146**	-											
4	.180**	.102*	.081	-										
5	.214**	.241**	.188**	.182**	-									
6	.065	.167**	-.047	.222**	.093	-								
7	.062	.122*	-.063	.147**	.135**	.478**	-							
8	.010	.027	-.095	.019	.026	.428**	.489**	-						
9	-.133**	.035	-.238**	-.072	-.011	.289**	.233**	.457**	-					
10	.056	.054	-.086	.111*	.100*	.433**	.512**	.455**	.289**	-				
11	.201**	.024	-.078	.130**	.114*	.282**	.443**	.318**	.142**	.131**	-			
12	.103*	.093	-.091	.146**	.106*	.484**	.449**	.403**	.248**	.481**	.222**	-		
13	-.018	.070	-.127*	.061	.049	.441**	.452**	.646**	.437**	.548**	.198**	.393**	-	
14	.035	.029	-.099*	.101*	.057	.426**	.484**	.586**	.344**	.356**	.487**	.330**	.582**	-
15	-.129*	.036	-.132**	-.048	-.071	.366**	.297**	.558**	.413**	.320**	.097	.485**	.562**	.426**

Note. 1: Item 1 of CAMM; 2: Item 2 of CAMM; 3: Item 3 of CAMM; 4: Item 7 of CAMM; 5: Growth mindset; 6: Positive attitude; 7: Academic self-efficacy; 8: Cognitive persistence; 9: Mastery pleasure; 10: Reading self-concept; 11: MSC; 12: Science self-concept; 13: Reading mastery motivation; 14: Math mastery motivation; 15: Science mastery motivation; *p < .05; & **p < .01

Results on Gender Differences

First, we examined if there are gender differences in the constructs we used. **Table 3** displays significant results. Boys seems to have a higher score on item 7 of CAMM and better MSC. While girls have better reading self-concept, science mastery motivation, and have mastery pleasure. Effect size is medium for MSC, but small in all other cases. Boys seem to focus better on the present happenings, compared to girls, and have a more positive picture of themselves in math, while girls have better picture them-selves in reading, are more motivated to study science and have more pleasure in learning something new.

Results on Differences based on Grades

Differences between grades were significant only for item 2 of CAMM and MSC. Item 2 of CAMM is higher in 4^{th} grade than in 3^{rd} grade, while MSC is lower. This means that in 4^{th} grade they are more aware of what they are doing but have a less positive image of themselves in math (**Table 4**).

Interestingly, while boys' MSC does not change during the grades, girls' seem to significantly decrease (t = 2,751, df = 207, $M_{grade\ 3}$ = 3.92, $M_{grade\ 4}$ = 3.53).

Results on Relationships Between Self-Concepts and Motivations Connected to School Subjects and the Examined Non-Cognitive Factors

Table 5 shows correlations between the examined variables. Week to strong correlations were found.

The analysis of the correlations between domain-specific academic self-concepts and the corresponding subject-specific mastery motivations showed a medium-strong correlation in all cases. The correlation coefficient between science self-concept and science mastery motivation is .485, between mathematics self-concept and mathematics mastery motivation is .487, and between reading self-concept and reading mastery motivation is .548. This means that the more positive the

Table 6. Predicting math achievement

	Estimate	Standard error	Wald	df	p
Whole sample: Pseudo R-square (Nagelkerke) = 0.298; χ^2 (15) = 86.599, & p < 0.001					
Item 2 of CAMM	0.182	0.076	5.729	1	0.017
Item 3 of CAMM	0.163	0.081	4.048	1	0.044
Growth mindset	0.214	0.106	4.069	1	0.044
Academic self-efficacy	0.367	0.175	4.401	1	0.036
Reading self-concept	0.360	0.179	4.049	1	0.044
MSC	0.805	0.131	37.585	1	< 0.001
Boys: Pseudo R-square (Nagelkerke) = 0.369; χ^2 (15) = 72.917, & p < 0.001					
MSC	0.907	0.219	17.226	1	< 0.001
Girls: Pseudo R-square (Nagelkerke) = 0.289; χ^2 (15) = 60.560, & p < 0.001					
Reading self-concept	0.709	0.281	6.393	1	0.011
MSC	0.939	0.190	24.499	1	< 0.001
Reading mastery motivation	-0.595	0.281	4.481	1	0.034

student's self-reflection on the special subject is, the more motivated they will be to engage in the active acquisition of learning skills necessary for learning the subject and solving tasks that are at least moderately challenging. As might be anticipated, the self-concepts associated with mathematics and science are more closely linked than those related to reading.

The relationship between domain-specific academic self-concepts and additional non-cognitive factors is more diverse. As can be seen the phenomena of mindset and mindfulness show little or no correlation with self-concepts and the other variables as well. In accordance with the developmental and psychological characteristics of the age group under our examination, their metacognitive awareness is not yet sufficiently developed. Consequently, the presence or absence of a growth mindset–although already emerging–does not yet exert a significant influence on their scholastic performance. The same is true for the various components of mindfulness.

A strong relationship (r = .512) was found between cognitive persistence and reading self-concept, a medium relationship (r = .318) between cognitive persistence and MSC, and a medium relationship (r = .403) between scientific self-concept and cognitive persistence.

Another interesting finding is that mastery pleasure is more loosely related to all three subject self-concepts than perceived self-efficacy. In the former case, the correlation coefficient ranges from .142 to .289. In the latter case, the correlation coefficient is between .403 and .512.

The correlation matrix data suggest that the relationship between subject-specific mastery motivation and cognitive persistence is strong. The correlation coefficient is between .558 and .646. Mastery pleasure and positive school attitudes show a medium level of correlation with subject-specific self-concepts. It can be inferred that an increase in positive emotions, positive attitudes towards school and cognitive persistence experienced by a student during the learning process will result in a corresponding enhancement of subject-specific mastery motivation. This relationship is most evidently manifest in the context of cognitive persistence.

Results on Prediction of School Achievement

When examining predictors of mathematical achievement, the model was statistically significant for the whole sample, also for both genders (**Table 6**). Concerning the whole sample, mathematical achievement can generally be predicted by MSC, as the strongest predictor. Reading self-concept, academic self -efficacy, growth mindset, item 2 and item 3 of CAMM also seem to contribute to the achievement. All the predictors have positive effects. In the case of boys, MSC is the only positive predictor. Girls seem to be affected by reading self-concept, and reading mastery motivation, as well. While MSC is still the strongest predictor, reading self-concept also positively predicts achievement in math; while reading mastery motivation has negative effect on achievement.

Based on the above boys seem to have better achievement in math, if they have a better image on themselves in math. The same holds for the girls, but better image of themselves in reading, and less motivation to read also contributes to their better achievement in math. Generally, being more aware of their actions and feelings also helps children to have better marks in math.

Achievement in reading is predicted positively by reading self-concept and MSC over the samples (**Table 7**). Therefore children with a more positive image of them-selves in reading and math, both attributes better marks in subject reading.

Item 3 of CAMM, academic self-efficacy, MSC, science self-concept, and math mastery motivation predicts achievement in science in the whole sample (**Table 8**). Item 3 of CAMM had the weakest effect, the effect of other variables' were fairly equal. Math mastery motivation has negative effect, everything else positive.

Table 7. Predicting reading achievement

	Estimate	Standard error	Wald	df	p
Whole sample: Pseudo R-square (Nagelkerke) = 0.230; χ^2 (15) = 87.391, & p < 0.001					
Item 2 of CAMM	0.147	0.075	3.814	1	0.050
Reading self-concept	0.949	0.179	28.101	1	< 0.001
MSC	0.281	0.128	4.833	1	0.028
Boys: Pseudo R-square (Nagelkerke) = 0.315; χ^2 (15) = 60.988, & p < 0.001					
Reading self-concept	0.922	0.239	14.902	1	< .001
MSC	0.503	0.207	5.887	1	0.015
Girls: Pseudo R-square (Nagelkerke) = 0.289; χ^2 (15) = 60.560, & p < 0.001					
Reading self-concept	0.922	0.239	14.902	1	< .001
MSC	0.503	0.207	5.887	1	0.015

Table 8. Predicting science achievement

	Estimate	Standard error	Wald	df	p
Whole sample: Pseudo R-square (Nagelkerke) = 0.2568; χ^2 (15) = 119.286, & p < 0.001					
Item 3 of CAMM	0.210	0.090	5.477	1	0.019
Academic self-efficacy	0.550	0.197	7.773	1	0.005
MSC	0.517	0.140	13.656	1	< 0.001
Science self-concept	0.477	0.157	9.274	1	0.002
Math mastery motivation	-0.425	0.215	3.904	1	0.048
Boys: Pseudo R-square (Nagelkerke) = 0.315; χ^2 (15) = 50.057, & p < 0.001					
Item 3 of CAMM	0.381	0.141	7.287	1	0.007
MSC	0.591	0.229	6.674	1	0.010
Science self-concept	0.518	0.243	4.525	1	0.033
Girls: Pseudo R-square (Nagelkerke) = 0.294; χ^2 (15) = 52.841, & p < 0.001					
Academic self-efficacy	0.879	0.300	8.617	1	0.003
Reading self-concept	0.803	0.312	6.618	1	0.010
MSC	0.533	0.206	6.694	1	0.010
Science self-concept	0.468	0.224	4.385	1	0.036
Math mastery motivation	-0.902	0.343	6.919	1	0.009

Examining the sample of boys, there were only three significant predictors, namely item 3 of CAMM, MSC, science self-concept, with positive effect on achievement. Girls' achievement was predicted mainly by math mastery motivation, but negatively. Academic self-efficacy, reading self-concept, MSC, and science self-concept seem to have positive effects.

Boys' better achievement in science is mainly contributed by better opinion of themselves in math and science, and a better consciousness of their feelings. Girls seem to have better marks in science if they are less motivated in math and feel a strong academic self-efficacy, have a positive image of themselves in reading, science and math.

DISCUSSION

In general, our results are similar to the literature in the areas studied. For example, research indicates that boys often have a higher MSC than girls, even when their actual performance is similar. This difference can emerge as early as the first few years of schooling and may be influenced by societal stereotypes that suggest boys are naturally better at math. Conversely, girls typically report a higher reading self-concept than boys. This trend is often linked to better reading performance in girls, but it also ties into gender norms that associate reading with feminine traits (Eccles et al., 1993; Marsh & Yeung, 1998). It is worth noting that teachers' and parental expectations, attitudes and perceptions of students' abilities can significantly impact students' self-concepts (Jussim & Harber, 2005; Wigfieled & Eccles, 2000).

However, our research points out that while more straightforward influences and relation-ships are identified for boys, the picture is more complex and nuanced for girls. Moreover, the effects are sometimes ambiguous and contradictory, suggesting that this is a good basis for further lines of investigation. What is clear is that interventions should not focus on aca-demic self-image alone but should address the girls' situation in a more complex context. Exploring the transfer effects is essential for understanding.

In terms of mindfulness (CAMM 7) and time perspective, we also see a similar trend, with boys focusing on present events, while girls are more influenced by past events.

Boys' self-concept in math remains stable across grades, while girls' MSC declines significantly. This is a well-documented phenomenon often linked to broader discussions about gender stereotypes, self-efficacy, and academic performance. Research shows that gender stereotypes, where math is seen as a male domain, play a significant role in shaping MSC among students. (Muntoni et al., 2021).

An important finding of our research is that girls' MSC declines between grade 3 and grade 4, i.e., in very early years. This is also important because in Hungarian schools, the science subject called environmental studies is introduced in 3rd grade. 4th graders are significantly more aware than 3rd graders and therefore react more reflectively to the impacts they are exposed to.

A cross-national meta-analysis found that boys generally have slightly higher self-confidence in mathematics than girls, both in 4th and 8th grades. This difference, while statistically significant, was small. Boys also tend to have slightly better motivational profiles, including higher self-concept and self-efficacy in mathematics, which are linked to better performance outcomes. Girls, on the other hand, report lower levels of MSC, especially as they progress to higher grades, and this can negatively impact their performance and interest in math-related fields (Ghasemi & Burley, 2019).

A meta-analysis by Huang (2011, 2016) found that self-concept was a significant predictor of academic achievement, with a stronger effect for MSC among boys com-pared to girls. Our research also shows that, in relation to mathematical performance, mathematical self-concept is an important element for both boys and girls, but for girls a seemingly more distant factor–the attitude towards reading–plays a key role. Our research con-firms that there is a case for investigating non-cognitive factors and clarifying gender differences associated with up to the early school years. Previous interventions have probably not led to the expected results because they have not considered the transference effects and complexity that underlie the problem in girls.

CONCLUSIONS

Gender-specific interventions in STEM education are needed from the early school years, along with consideration of BPNs. To enhance the effectiveness of these interventions, it is essential to explore and understand the different patterns of psychological constructs that influence the performance of boys and girls. Awareness of the gender-sensitive socio-emotional profiles of learners enables educators to employ appropriate class-room techniques and promote the psychological well-being of their students. This latter fac-tor plays an important role in reducing the dropout rate of girls in STEM fields.

In the present study, we have employed a novel methodological approach, combining tools that have not previously been used as a basis for exploratory research. A limitation of the research, apart from the sample size, is the adaptation of the questionnaires used for the specific age groups, which has been altered compared to the pilot study. The limitations and experience gained from this fact will be taken into consideration in the planning of future research.

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