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Toward Becoming a "Math-Person": Relationship between Achievement Emotions, Personal Beliefs, and Mathematics Identity*

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The current study explored the relationship between mathematics beliefs (MB) (perceived competence, intrinsic value, extrinsic value and cost), academic emotions (AE) (anxiety, boredom and enjoyment), mathematics identity (MI) and mathematics achievement (MA) among eight-, nine– and ten-year-old students. The model specified in path analysis proposed that MI is associated with MB and AE. Furthermore, according to this model, MI is associated with MA and perceived competence. Results show that the model fits the data, supporting the assumed relationship between the variables and thus possibly confirming MI has a strong influence on MB. However, the relationship between MB and AE was more ambiguous. Enjoyment was the only emotion linked to mathematics identity. Finally, MA was affected by perceived competence but not by mathematics identity. The findings confirm a robust circuit of associations between intrinsic value, enjoyment and MI, signalling the importance of tracking the development of student's interest and MI. The lack of association between MI and MA, points to the need for an educational system that prioritises mastery-oriented goals instead of achievement-oriented ones.

Keywords: Mathematics identity, motivation, academic emotions, mathematics achievement

Highlights:

- Identity formation in math is vital for the development of motivational beliefs.
- Enjoyment is the only tested emotion that affects mathematics identity.

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- There is a robust circuit between intrinsic value, enjoyment and mathematics identity.
- Mathematics identity does not influence mathematics achievement.

In 2015, the OECD Education Policy Committee launched a project to define a set of knowledge, skills, attitudes and values students will need to succeed in their adult life. Across all the specified skills and knowledge, mathematics was its main ingredient, thus representing the "core foundation" of future-needed skills like problem-solving, critical thinking, self-regulation, and analytical thinking (Cribbs et al., 2015; OECD, 2019; Putwain, 2020).

Many researchers attempted to understand better the influence of motivational and emotional processes on mathematics achievement (e.g., Forsblom et al., 2022; Peixoto et al., 2017; Schukajlow et al., 2017). All these produced numerous insights about the nature of motivation but also opened a set of new questions that remain unanswered. The latter led to the expansion of existing theories through paying greater attention to context, adding a variety of methods and diverse samples, and also adding new constructs (Eccles & Wigfield, 2020; Eccles, 2009; Graham, 2020; Ryan & Deci, 2020; Schunk & DiBenedetto, 2020; Urdan & Kaplan, 2020). One such example we find in the construct of academic identity. An extensive line of research was committed to exploring the influence of academic identity on motivation (e.g., Bohrnstedt et al., 2020; Darragh, 2013; Eccles, 2009; Master et al., 2019; Oyersman, 2014; Vincent-Ruz & Schunn, 2018). However, only a few studies empirically examined the interplay between academic identity, motivation, and emotions and their impact on academic achievement (e.g., Ainley & Ainley, 2011), while the corpus of research among elementary school students is even more scarce. The present study aims to bridge this gap by examining the relationship between mathematics identity, academic emotions, and motivational beliefs and their influence on mathematics achievement among third-, fourth-, and fifth-grade students.

Motivation and Emotions Through the Lens of Expectancy-value Theory and Control-value Theory

Expectancy-value and Control-value theory

Among the achievement motivation theorists, the Expectancy-Value theory (EVT) is among the most prominent perspectives. Essentially, EVT proposes that student's choice, persistence, and performance of tasks depend on their personal beliefs about how well they will perform on the activity (i.e., expectancy for success (ES)) and the extent to which they value the activity (i.e., task value) (Wigfield & Eccles, 2000; Eccles, 2009).

Task value is composed of intrinsic value, attainment value, utility value, and cost. Intrinsic value is the anticipated enjoyment a person gets from participating in a particular task and the pleasure it provides while engaging in the activity. Attainment value is defined as the personally-based importance that an individual attaches to engaging in certain activities. Utility value is conceptualised as usefulness a person attaches to a particular activity or task in terms of one's current plans. Finally, the cost is defined as a subjective evaluation of how much effort will be taken to accomplish the activity and its emotional cost (Wigfield & Eccles, 2000; Eccles, 2009; Eccles & Wigfield, 2020).

While EVT primarily focuses on motivational beliefs, the Control-value theory (CVT) puts greater focus on achievement emotions, defined as a set of affective, cognitive, motivational, expressive, and peripheral coordinated processes which are tied directly to achievement activities or outcomes (Pekrun, 2006; Pekrun & Perry, 2014). Achievement emotions that are especially important for school context due to the frequency of their occurrence are anxiety, boredom, and enjoyment.

In the context of CVT, enjoyment can be defined as a positive, activity-oriented emotion with the perception of having high control over activity in focus. Although enjoyment positively affects achievement through reinforcement of attention, intrinsic motivation, information processing and self-regulation, it tends to decline in adolescence (Boekaerts & Pekrun, 2015; Pekrun et al., 2000). Boredom is also an activity-focused emotion but unpleasant and deactivating. It tends to increase with age and has adverse effects on students' attention, effort, motivation, and engagement, leading to low achievement (Haager et al. 2018; Pekrun et al. 2010; Tze et al. 2016). Lastly, anxiety is a negative emotion with lower levels of perceived control focused on the prospective outcome. Besides negatively affecting attention, intrinsic motivation, information processing, and achievement, anxiety tends to be more present among older students (Boekaerts & Pekrun, 2015; Pekrun et al., 2017; Zhang, Zhao & Kong, 2019).

The links between cognitive appraisals, academic emotions, and achievement

According to CVT, determinants of achievement emotions are two types of cognitive evaluations: control appraisals and value appraisals. Control appraisals are people's perceptions of competence and control over achievement-related activities and outcomes. They include perceived competence, causal expectations, and causal attributions. Regarding EVT, expectancy for success could correspond to control appraisals in CVT. Value appraisals refer to individuals' positive or negative values with perceived activity. They can also be differentiated as intrinsic and extrinsic values (Forsblom et al., 2022; Pekrun, 2006). If we draw parallels between CVT and EVT on value appraisals, attainment and utility from EVT could be brought under extrinsic value from CVT because the learning activity or outcome is used to achieve another goal (Putwain et al., 2020). On the other hand, the intrinsic value from CVT is equivalent to the intrinsic (interest) value in Eccles's theory.

Several studies examined the relationship between cognitive appraisals, academic emotions, and academic achievement. These show that cognitive appraisals relate positively with enjoyment and negatively with boredom and anxiety. However, when we simultaneously include academic emotions in the model with control and value appraisals, their impact on academic achievement is lost (Forsblom et al., 2022; Peixoto et al., 2017). Lack of effect is most often explained by the high interrelationships between emotions on the one hand and cognitive appraisals on the other, thus weakening the model's power. Such an explanation is a plausible analytical answer but not a sufficient one from a theoretical point of view. We propose that tested models were missing one additional construct that mediates between cognitive appraisals and academic achievement—identity.

Mathematics Identity

Mathematics identity can be defined as a set of beliefs about one's self as a mathematics learner and a perception of how others see a person in a mathematics-related context (Anderson, 2007; Nosek et al., 2002). Subject-related identity is crucial because it influences persistence, intrinsic motivation, subjective task values, science-related choices and academic achievement. (Aschbacher, Li & Roth, 2010; Bohrnstedt et al., 2020; Oyserman, 2014; Shanahan, 2009). As Boaler et al. (2000) noted, in mathematics class, students learn not only mathematics but also what it is like to be a member of the mathematics community and whether they want to be members. Students develop a sense of belonging by participating in classroom activities, which is crucial for identity formation (Darragh, 2013).

Despite empirical evidence of the importance of identity, conceptual overlaps make it harder to differentiate identity from other cognitive, motivational, and emotional constructs. For some authors, academic identity is part of the broader construct like motivation (Bohrnstedt et al., 2020), while for others, academic identity includes items closely related to concepts like interest, values, competency beliefs, commitment, and performance (Chang et al., 2016; Hazari et al., 2013; Trujillo & Tanner, 2014). For these reasons, Vincent-Ruz and Schunn (2018) studied the nature of science identity and demonstrated it to be a construct distinct from fascination (interest and positive affect toward science), values, and competency beliefs, all of which are often attributed to academic identity.

Since mathematics identity has proved to be an independent construct with discriminant and predictive validity, the question follows: How is mathematics identity related to motivational and emotional factors? Some authors, like Miller and Wang (2019), examined the relationship between the cognitive aspect of motivational beliefs and mathematics identity formation. However, they didn't consider the affective element of motivation or achievement activities. Whether mathematics identity mediates motivational beliefs and academic emotions remains an unanswered question.

Current Research

The present study explores the relationship between motivational beliefs (MB), class-related academic emotions (AE), mathematics identity (MI), and mathematics achievement (MA) among eight-, nine– and ten-year-old students. We've decided to test class-related emotions because previous studies show more robust associations between cognitive appraisals and class-related emotions than test-related emotions (Peixoto et al., 2017; Goetz et al., 2012). The authors explain that classroom life is more regular than test situations, where students get feedback about their progress, difficulties, and failures. In the context of MI, we assume that class-related emotions are significant because the sense of belonging, the crucial aspect of identity formation, will be most often built-in in everyday class situations (Boaler et al., 2000; Darragh, 2013).

Having in mind that the presence and intensity of constructs vary in different stages in life (e.g., a decline of enjoyment and interest and an increase in boredom and anxiety; Camacho-Morles et al., 2020; Cribss et al., 2015), it is vital to examine the relationship of mentioned constructs across diverse developmental stages. We have decided to conduct our research in the preadolescent phase since most earlier studies focused on adolescents and young adults. The current study is part of an international project, Co-constructing mathematics motivation in primary education–A longitudinal study in six European countries (MATHMot[3]) focusing on children's motivation for learning math. Four hypotheses were tested in the present study.

- MI will be positively related to MB (i.e. perceived competence, intrinsic value, utility and attainment), except for cost, which will be negatively associated with MI (Eccles, 2009; Miller & Wang, 2019; Perez, Cromley & Kaplan, 2014).
- MB will be associated with class-related emotions—enjoyment positively, while boredom and anxiety negatively. The direction of cost association would be reversed (i.e., negative for enjoyment and positive for boredom and anxiety) (Forsblom et al., 2022; Peixoto et al., 2017; Putwain et al., 2020).
- Class-related emotions will be positively linked with MI– enjoyment, while anxiety and boredom will be related negatively.
- Perceived competence and MI will be linked with MA (Bohrnstedt et al., 2020; Wigfield & Eccles, 2000; Eccles & Wigfield, 2020). The influence of other MB on MA was purposefully left behind since previous studies show that they are more associated with engagement and academic career choices (Eccles & Wigfield, 2020; Forsblom et al., 2022; Schukajlow, Rakoczy & Pekrun, 2017).

3 Co-constructing mathematics motivation in primary education - A longitudinal study in six European countries (MATHMot) has received funding from the Research Council of Norway within FINNUT Programme for Research and Innovation in the Educational Sector (grant number 301033).

Method

Sample and Procedure

The survey was administered in the paper-and-pencil format during regularly scheduled classes by school psychologists and teachers trained by the researchers. Informed consent was obtained from students' parents and teachers who participated in the study.

In this study, we focus on the Serbian subsample alone—consisting of 437 third-, fourth– and fifth-grade students (33% third-grade– 9-year-old, 39% fourth grade-10-year-old, 49% male– 11-year-old) in primary schools across Belgrade.

Instruments

Motivational beliefs: Cost, attaintment, utility, interest value and perceived competence were measured using the Expectancy Value Scale (EVS, Peixoto et al., 2023). Five items were used to measure attainment (e.g. "Being good in math is very important for me personally"), while utility (e.g. "When I grow up, it will be useful to know math"), interest (e.g. "I like doing math"), and perceived competence (e.g. "I can easily solve different math problems ") consisted of six items and cost subscale with four items (e.g. "I have to give up too much to do well in math"). Answers to these measures were given on a 4-point Likert scale (1 = a lot of times to 4 = never). Scores for each construct were calculated by averaging all the items within the specified construct. Cronbach's Alpha ranged from .74 for the cost to .90 for the interest value dimension.

Class-related emotions—boredom, anxiety, and enjoyment, were measured using the AEQ-ES scale (Lichtenfeld et al., 2012), which consisted of 28 items. For this study, we used only items related to the class situation (e.g., "During math class, I worry that everything is too difficult for me"; "I look forward to math class"; "I find math class so boring that I would rather do something else"). Each class-related emotion consisted of 4 items that were measured on a 5-point Likert scale (1 = not at all to 5 = very much) paired with five graphical displays of faces showing increasing emotional intensity. Scores for each emotion were calculated by averaging its items. Cronbach's Alpha for class-related anxiety was .77, enjoyment was .95, and boredom was .91.

The mathematics identity scale consisted of 6 items on a 4-point Likert scale (1 = a lot of times to 4 = never), developed for the project we draw the sample from. Influenced by the work of Vincent-Ruz and colleagues (2018) and Miller and Wang (2019), the scale was adapted and further developed. The scale is a combination of perceived personal mathematics identity items ("I think I am a math person ") and perceived recognised mathematics identity items, where students perceive that significant others (friends, family, math teacher) see them as math persons ("My family thinks of me as a math person"). Cronbach's Alpha for mathematics identity was .80.

Mathematics test covering major curricular topics for each grade was used for measuring mathematics achievement and had satisfactory reliability (α = .80).

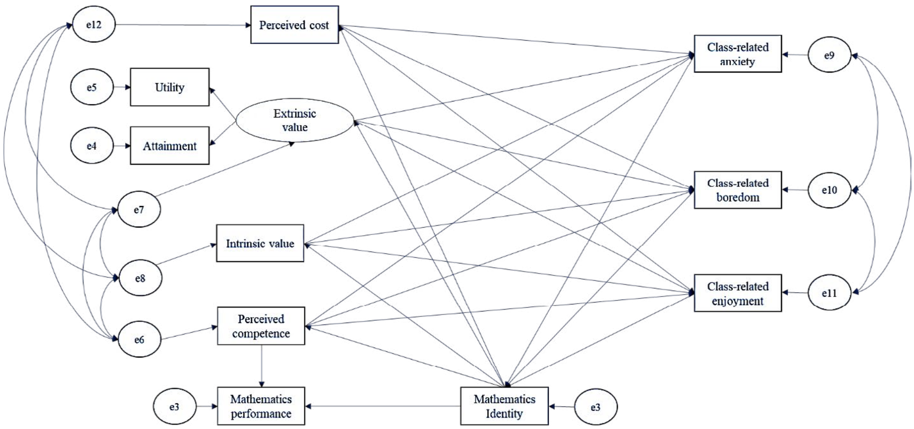
Data Analysis

Path analyses (in AMOS) were employed to analyse the relationship between MB, AE, MI, and MA. The model assumed that MI affects MB, which in turn affects AE. Anxiety, boredom, and enjoyment, in turn, influence MI. Finally, MA is affected by perceived competence and MI. Assumed relationships in the model were interpreted with the notion that the current investigation uses cross-sectional data. We've decided to subsume attainment and utility under one latent variable– extrinsic value for two reasons: 1. From a theoretical point of view, attainment and utility in EVT theory are more similar to the extrinsic value in CVT, while interest in EVT is equivalent to intrinsic value (Forsblom et al., 2022; Pekrun, 2006) 2. From an empirical point of view, when three constructs are simultaneously put in the model, the correlation between attainment and utility is much higher (r = .82, p = .00) than between interest and attainment (r = .62, p = .00) and interest and utility (r = .62, p = .00). Our a priori path model is presented in Figure 1.

Before analysing data, we screened all variables for multicollinearity assumptions with univariate and multivariate normality. Based on the standardised skewness-kurtosis and Shapiro-Wilk test of normality, we concluded that none of the variables meet the normality assumption. The violation of multivariate normality was also confirmed with the Mardia coefficient, which had a critical ratio higher than 5 (Raykov & Marcoulides, 2008). Based on the binary correlations between variables with values lower than .80, a variance inflation factor (VIF) lower than 10, and a tolerance value higher than 0.2, we concluded that the multicollinearity assumption is met.

Figure 1
A priori path model

Considering the violation of multivariate normality, we performed a maximum-



likelihood estimator and Bollen-Stine bootstrap on 10,000 samples. Missing data were imputed with the regression method. We used the following fit statistics to assess the model fit: Bollen-Stine bootstrap, ratio χ^2/df, RMSEA, CFI, NFI and TLI. Finally, significant effect sizes in the model were interpreted as follows: .15 indicates small, .25 medium and .35 and higher a major effect (Gignac & Szodorai, 2016).

Results

Descriptive Statistics and Correlation Coefficients

Descriptive results for the variables are presented in Table 1. The distribution of interest is negatively skewed and platykurtic, indicating that students show a higher interest than average, but the distribution is dispersed. Attainment and utility have a negatively skewed but leptokurtic distribution, meaning that most students report higher attainment and utility value. Cost and perceived competence usually have normally distributed scores, but the cost in our study is positively skewed, while perceived competence is negatively skewed.

Regarding class-related emotions, boredom and anxiety are positively skewed with the leptokurtic distribution, while enjoyment and mathematics identity are negatively skewed with the platykurtic distribution. We conclude that most of the eight-, nine– and ten-year-old students are experiencing low levels of boredom and anxiety. Conversely, higher levels of enjoyment and mathematics identity are present, but distribution is more dispersed.

Table 1
Cronbach alpha coefficients and descriptive statistics

Scale	SW test	Range	*M*	*SD*	ZSk	Zku	α
Interest	.96**	1.00-4.00	2.80	.80	-2.21	-3.84	.90
Attainment	.89**	1.00-4.00	3.37	.62	-8.57	2.84	.84
Utility	.87**	1.17-4.00	3.46	.57	-10.58	5.64	.80
Cost	.96**	1.00-4.00	2.19	.65	4.68	-1.59	.74
Perceived competence	.97**	1.00-4.00	2.93	.64	-3.77	-.77	.81
Class anxiety	.74**	1.00-5.00	1.50	.70	17.67	20.66	.77
Class enjoyment	.95**	1.00-5.00	3.38	1.12	-2.34	-3.61	.95
Class boredom	.78**	1.00-5.00	1.71	.88	15.35	13.82	.91
MI	.95**	1.17-4.00	3.01	.67	-3.54	-3.26	.80
MA	.98**	0.00-1.00	.54	.25	-1.38	-3.39	.80

Note. Shapiro-Wilk, M = mean; SD = standard deviation; α = reliability coefficient; ** Significance at $p < .01$

Correlations between study variables are presented in Table 2. As expected, interest, attainment and utility are highly correlated. Perceived competence has a notably high correlation with interest and a medium correlation with attainment and utility. Cost negatively correlates with all motivational constructs and is strongly associated with perceived competence and interest.

AE significantly correlate with each other and MB as expected. Interestingly, the highest bivariate correlation is between enjoyment and boredom. Finally, MI has the highest positive correlation with perceived competence and enjoyment but significantly correlates with other constructs. MA had significant associations with all constructs except utility. All correlations are small to medium, with the highest link between MA and Cost and between MA and Perceived competence.

Table 2
Correlation Coefficients of the Variables

Scale	1	2	3	4	5	6	7	8	9	10
1. Interest	1									
2. Attainment	.53**	1								
3. Utility	.52**	.67**	1							
4. Cost	-.42**	-.10*	-.15**	1						
5. Perceived competence	.63**	.35**	.31**	-.49**	1					
6. Class anxiety	-.28**	-.10*	-.19**	.36**	-.38**	1				
7. Class enjoyment	.60**	.34**	.30**	-.29**	.47**	-.44**	1			
8. Class boredom	-.51**	-.31**	-.30**	.38**	-.41**	.54**	-.76**	1		
9. MI	.67**	.54**	.48**	-.34**	.71**	-.28**	.49**	-.39**	1	
10. MA	.16**	.10*	.08	-.25**	.27**	-.14**	.16**	-.14**	.20**	1

Note: **Significance at $p < .01$; *Significance at $p < .05$

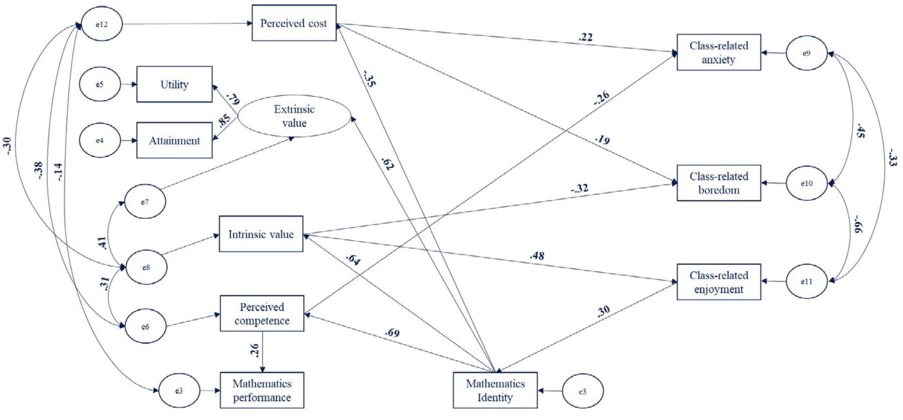
The Path Model and Effects

After testing the a priori model, modification indices suggested adding a correlational path between *MA* and cost errors, which we adopted. Furthermore, we excluded covariance between *perceived competence* error and *extrinsic value* error as well as *cos*t error and *extrinsic value* error. All mentioned modifications significantly improved the model fit (see Figure 2). Regarding the model fit, the value of the Bollen-Stine bootstrap estimate is .149, indicating a good fit. The fit is further confirmed with the following statistics—ratio $\chi^2/df = 1.544$, CFI = .996, TLI = .988, NFI = .990 and RMSEA = .035.

The first hypothesis proposed that *MI* would be linked with all MB, which was confirmed. MI had a strong positive association with *perceived competence* ($r = .69$, $p = .00$), *intrinsic value* ($r = .64$, $p = .00$) and *extrinsic value* ($r = .62$, $p = .00$), and negative medium relation to cost ($r = -.35$, $p = .00$).

We assumed that MB would relate to AE in the second hypothesis. Class-related *anxiety* was moderately associated with *cost* ($r = .22$, $p = .00$) and *perceived competence* ($r = -.26$, $p = .00$) but not with *extrinsic* and *intrinsic* value. *Cost* also had a small association with class-related *boredom* ($r = .19$, $p = .00$). In addition, *boredom* was moderately and negatively linked to *intrinsic value* ($r = -.32$, $p = .00$). *Extrinsic value* and *perceived competence,* on the other hand, were not significantly related to boredom.

Figure 2
Final path model



Note. Correlations and nonsignificant paths across the model were removed for clarity.

Class-related *enjoyment* was strongly positively associated with *intrinsic value* (r = .48, p = .00), but interestingly, none of the other MB impacted this emotion; thus, the second hypothesis was partially confirmed.

The third hypothesis posited that the AE is associated with MI. Path model showed that only class-related *enjoyment* had a medium positive correlation with MI (r = .30, p = .00), while anxiety and boredom didn't significantly associate with each other. Overall, it may be said that the third hypothesis is partially confirmed.

Lastly, we assumed that perceived competence and MI would be related to MA. While *perceived competence* had a medium positive association with *MA* (r = .26, p = .00), *MI* didn't have a significant association. With this in mind, the fourth hypothesis is also only partially confirmed. Appendix 1 represents standardised regression coefficients from the path model.

Discussion

The transition from late childhood to early adolescence can be a turbulent developmental period full of new expectations, and the school system is no exception. In the shift from elementary to middle school, students are exposed to more subjects, more classes on a daily level, and demands that are usually higher compared to lower grades. Being aware of motivational, emotional and cognitive effects on academic achievement and, more importantly, the well-being of the students, many scholars tried to understand factors that can improve the current situation. The present study attempts to contribute to the corpus of this knowledge by examining the relationship between MB, AE, MI and MA of elementary school students.

Relationship between MI and MB

Path analysis showed that MI was positively associated with extrinsic value, intrinsic value and perceived competence. The firm, positive relation between MI, on the one hand, and values and competence, on the other hand, was in line with previous studies (Colantonio et al., 2021; Cribbs et al., 2015; Miller & Wang, 2009; Perez, Cromley & Kaplan, 2014; Verdin, 2021). The relationship between MI and the cost was negative and at mid-level, which poses the question, why is the relationship between MI and cost weaker than other MB? Previous studies have confirmed the importance of cost for participation in mathematics (Eccles, 2009; Wigfield & Cambria, 2010). Conversely, Miller & Wang (2019) found that cost wasn't associated with MI. A possible explanation may be that some aspects of an individual's context may make the cost more or less prominent feature. For example, Seymour & Hewitt (1997) argued that cost is more salient in the context of stricter grading policies, a competitive climate and workload. Our sample consisted of third-, fourth– and fifth-grade students, for whom we can assume that the above school aspects are not as widespread as we would expect with the older students.

Relationship between MB and AE

MB significantly impacted AE, but not every task value and perceived competence was associated with enjoyment, anxiety and boredom, as was suggested in some earlier studies (Forsblom et al., 2021; Peixoto et al., 2017; Pekrun, 2006; Pekrun et al., 2011; Putwain et al., 2018). More precisely, class-related anxiety was negatively related to perceived performance and positively to cost. The less competent the student perceives him/herself to be regarding mathematics, and the more effort he/she feels is necessary for achieving the goal, the more anxious he/she will be. However, the intrinsic and extrinsic values 'weren't linked to anxiety. What intrinsic value did affect was class-related boredom (negatively) and class-related enjoyment (positively). Boredom was also positively associated with cost but not to the same extent as its association with intrinsic value. Essentially, the more interested students were in mathematics, the more enjoyment and less boredom they reported in classes. A significant impact of intrinsic value was in line with previous studies, but the absence of perceived competence on boredom and enjoyment was not (Forsblom et al., 2021; Peixoto et al., 2017; Pekrun, 2006; Pekrun et al., 2011; Putwain et al., 2018). Considering the strong association between anxiety, boredom and enjoyment, it is also possible that perceived competence indirectly affects boredom and enjoyment through anxiety.

In addition, it is interesting that extrinsic value (i.e., comprised of attainment and utility) was not associated with boredom, anxiety or enjoyment. From a theoretical perspective, lack of impact can be related to a student's developmental stage, where intrinsic motivation is still the most dominant driver of emotions. In early adolescence, interest is based primarily on the affective component. During subsequent years, interest transitions its focus to cognitive components (Frenzel et al., 2012). Yet, the lack of effects in a complex model like ours can also be explained from a methodological point of view. Namely, these results were likely due to the interrelations between emotions and values (Burić & Sorić, 2012; Pinxten et al., 2014).

The Role of MI in the Mastery-oriented Circuit

To our knowledge, no research study examined the relationship between AE and MI. Research findings show that enjoyment is positively associated with MI, while boredom and anxiety are unrelated to MI. However, such results are somewhat expected, considering enjoyment is the most present in early grades and tends to decline over the years. On the other hand, boredom and anxiety tend to increase with transitioning to higher grades (Camacho-Morles et al., 2020; Zhan et al., 2019).

In line with our expectations, perceived competence was positively associated with MA (Eccles & Wigfield, 2002; Forsblom et al., 2021; Peixoto et al., 2017), but MI was not related to students' performance. This lack of association could be because MI is more associated with career aspirations and engagement in formal and informal school activities (Vincent-Ruz & Schunn, 2018) than tests and grades. In achievement goal theory, we can assume that school tests and grades are associated with performance-avoidance or performance-approach goals. At the same time, MI is more related to the mastery-oriented goal (Urdan & Kaplan, 2020). Similarly, enjoyment and intrinsic value are more associated with mastery-oriented goals, participation in informal school activities and career aspirations than achievement (Eccles & Wigfield, 2020; Nagengast et al., 2011; Wigfield & Eccles, 2000).

Therefore, a robust circuit between intrinsic value, class-related enjoyment, and MI is a somewhat expected finding. The more internalised interest, the more enjoyment the student feels about mathematics class, which leads to interest becoming part of a learner's identity (Hidi & Renninger, 2006; Renninger, 2009). Skinner and colleagues (2017) reported that satisfaction as a basic need was related to engagement and performance in STEM courses and greater identification of oneself as a scientist. Thus, it is of crucial importance to keep this "circuit" going for as long as possible, keeping in mind that interest can be a resilient factor for people in stereotypically unexpected contexts like women and minorities in STEM, students with lower socio-economical status or just lower school achievement (Colantonio et al., 2021; Heffernan & Newton, 2019; Verdin, 2021).

The circuit between interest, enjoyment and MI implies that it is insufficient to promote only interest or a positive atmosphere. As Renninger (2009) explained, teachers must consider the phase of students' interest and age-related expectancies for identity development in class. For example, in earlier stages of interest, we need to provide the learners with external supports that trigger and sustain interest while considering age-related vulnerabilities associated with the developmental phase of identity. It is also essential to remember that interest can always decline to the previous developmental stage and is often contextually conditioned (Draijer, Bronkhorst & Akkerman, 2022). Taking all into consideration, empirical findings imply that some aspects still need to be better understood regarding the nature of the relation between intrinsic value, enjoyment and mathematics identity in different developmental stages, as well as the formation processes that happen when these three constructs interact.

Limitations and Recommendations for Future Research

Although the present study contributes to the literature on the relationship between MB, AE, MI and MA, some limitations should be considered when interpreting results. From a methodological perspective, the current study is based on a convenient sample and should be validated on a larger, more representative sample of students. Furthermore, the same student reported on all variables, so the shared bias could influence the estimated associations between variables. This limit can be overcome by measuring the same variable from different respondents (e.g., teacher, parent and student report) or by adding additional methods. Lastly, the current research is a cross-sectional study. The model must be validated based on longitudinal data because MI can change over time (Berry et al. 2011).

For the following research, it is recommended to explore how these relations may differ as a function of theory-relevant factors like gender, nationality of students, and the subject domain, as well as methodological factors like the type of performance measure (test scores vs grade scores) (Camacho-Morles, 2020; Colantonio et al., 2021; Pekrun et al., 2017). The second aspect that should be considered in the future is related to indirect effects and interaction of examined constructs since previous studies show that it is essential to take into account non-linear patterns as well when researching complex dynamics between motivation, emotion and identity processes (Colantino et al., 2021; Kogler & Gollner, 2018; Pekrun, 2006).

Conclusion

The present study aimed to shed light on the relationship between motivational beliefs, academic emotions, mathematics identity and mathematics achievement among elementary school children. The analysis confirmed the strong influence of mathematics identity on perceived competence, intrinsic value, extrinsic value and cost. It once again confirmed the importance of identity formation for the mathematics domain. Perceived competence and cost were related to anxiety, intrinsic motivation and cost were related to boredom, while enjoyment was associated with intrinsic motivation only. The study's main finding is a robust circuit between intrinsic value, enjoyment and mathematics identity. One of the conditions for mathematics identity formation seems to be mathematics-related interest that slowly transitions from situational interest to well-developed individual interest, fully internalised into a student's identity. Similar to previous studies, present results unequivocally point to the need for reforming a school system that prioritises mastery-oriented goals instead of achievement-oriented ones. Our study is one of the first empirical attempts to observe the dynamics between motivation, emotion, identity and achievement in mathematics class among elementary school children. However, we still need to unravel how these motivational, emotional and identity processes interact through different developmental stages, contexts and student subgroups.

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Ka tome da postanete "matematička osoba": odnos između emocija postignuća, ličnih uverenja i matematičkog identiteta

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Prikazana studija je istraživala odnos između matematičkih uverenja (MB) (opažena kompetencija, unutrašnja vrednost, ekstrinzična vrednost i cena), akademskih emocija (AE) (anksioznost, dosada i uživanje), matematičkog identiteta (MI) i postignuća iz matematike (MA) među učenicima uzrasta osam, devet i deset godina. Model naveden u analizi puteva (eng. path analysis) je predložio da je MI povezan sa MB, i sa AE. Štaviše, MI je povezan sa AE i sa i sa percipiranom kompetencijom. Rezultati su potvrdili mogućnost da postoji snažan uticaj MI na MB, međutim odnos između MB i AE je bio dvosmisleniji. Uživanje je bila jedina emocija koja je, prema modelu, povezana sa matematičkim identitetom. Konačno, na MA je uticala percipirana kompetencija, ali ne i matematički identitet. Nalazi potvrđuju čvrsti krug veza između unutrašnje vrednosti, uživanja i MI, signalizirajući važnost praćenja razvoja interesovanja učenika i MI. Nedostatak povezanosti između MI i MA ukazuje na potrebu za obrazovnim sistemom koji daje prioritet ciljevima orijentisanim na ovladavanje umesto onih koji su orijentisani na postignuće.

Ključne reči: matematički identitet, motivacija, akademske emocije, postignuća iz matematike

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Appendix 1.

Table 1a
Path analysis results regarding the relationship between variables

Paths			Bootstrap values		Bias (%95 CI)	
			B	*SE*	Lower Bound	Upper Bound
Perceived competence	<--	MI	0.69	0.03	0.62	0.76
Intrinsic value	<--	MI	0.64	0.04	0.55	0.72
Extrinsic value	<--	MI	0.62	0.03	0.52	0.71
Perceived cost	<--	MI	-0.35	0.04	-0.48	-0.23
Class anxiety	<--	Perceived competence	-0.26	0.07	-0.42	-0.10
Class anxiety	<--	Intrinsic value	-0.01	0.06	-0.18	0.15
Class anxiety	<--	Extrinsic value	-0.03	0.10	-0.23	0.16
Class anxiety	<--	Perceived cost	0.22	0.05	0.11	0.34
Class boredom	<--	Perceived competence	-0.07	0.09	-0.23	0.08
Class boredom	<--	Intrinsic value	-0.32	0.07	-0.50	-0.15
Class boredom	<--	Extrinsic value	-0.12	0.12	-0.31	0.05
Class boredom	<--	Perceived cost	0.19	0.06	0.09	0.30
Class enjoyment	<--	Perceived competence	0.10	0.10	-0.04	0.23
Class enjoyment	<--	Intrinsic value	0.48	0.09	0.33	0.62
Class enjoyment	<--	Extrinsic value	-0.02	0.14	-0.17	0.12
Class enjoyment	<--	Perceived cost	-0.01	0.08	-0.11	0.08
MI	<--	Class anxiety	0.01	0.13	-0.20	0.26
MI	<--	Class boredom	0.20	0.15	-0.10	0.64
MI	<--	Class enjoyment	0.30	0.11	0.04	0.59
MA	<--	MI	0.03	0.02	-0.11	0.15
MA	<--	Perceived competence	0.26	0.03	0.12	0.38