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Emotional and motivational relationship of elementary students to mathematical problem-solving: a person-centered approach

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Abstract

Recent literature has shown that achievement emotions, their regulation, and perceived competence play a compelling role in mathematics learning and achievement. Studies that have looked at these variables have, for the most part, adopted a person-centered approach, which examines relationships between variables found to a similar degree in all individuals of the group. Yet, scholars have outlined emotional inter-individual differences, in particular, in terms of gender and past performance. The present study examined differences among upper elementary students in how achievement emotions are related to each other. Cluster analysis revealed four distinct profiles based on a sample of upper elementary students ($N = 354$): those with high levels of positive emotions and low levels of negative emotions (*positive*); those with high levels of boredom and low levels of the other emotions (*bored*); those with high levels of nervousness, worry, and fear and low levels of positive emotions (*anxious*); and those with high levels of the six negative distinct emotions assessed and low levels of positive emotions (*resigned*). Analyses of variance showed that the first profile stood out advantageously from the last two regarding math performance and perceived competence. Findings regarding emotion regulation confirm the risky nature of the resigned profile. The bored profile ascribes no value, whether extrinsic or intrinsic, to problem-solving tasks. Practical implications for educational practices and possible avenues for further research are discussed.

Keywords Academic emotions · Perceived competence · Mathematics performance · Cluster analysis · Elementary students

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Introduction

The last two decades have been marked by growing research on emotions and emotion regulation within the field of educational psychology, especially in the domain of mathematics. This growing interest has been partly fueled by the accumulating evidence for the profound effects exerted by emotions on students' mathematical learning processes and achievement (Ahmed et al. 2013; Hanin & Van Nieuwenhoven, 2016; Frenzel et al. 2007; Lichtenfeld et al. 2012; Peixoto et al. 2017) and, hence, for the need to regulate them appropriately (Hanin & Van Nieuwenhoven, 2018a; De Corte et al. 2011; Goetz et al. 2005).

Control-value theory (CVT) (Pekrun 2006) is acknowledged as one of the most comprehensive theoretical frameworks depicting the role played by the emotions in learning processes (Peixoto et al. 2017). CVT posits that perceived control and value are the closest determinants of achievement emotions. While numerous empirical studies have corroborated this assertion (Ahmed et al. 2010; Peixoto et al. 2017), they have tended to favor a variable-centered approach, that is, one that describes the associations between variables found to a similar degree in all individuals. The same applies for studies that have looked at the links between the strategies used by the students to regulate their emotions and the emotions felt (Ben-Eliyahu and Linnenbrink-Garcia 2013; Schmidt et al. 2010).

Yet, classroom composition is not homogeneous. Research has pointed to the existence of different patterns in emotions and motivation for students with high and low performance in mathematics (Hanin & Van Nieuwenhoven, 2018a; Monteiro et al. 2017) and for boys and girls (Frenzel et al. 2007; Monteiro et al. 2017). Taking into account inter-individual differences regarding the motivational-emotional profiles with which students begin to tackle mathematical tasks, that is, adopting a person-centered approach, is a critical issue not only for educational theorists but also for practitioners, as the heterogeneity of the student body often poses significant challenges for teachers (Lothaire et al. 2012; Maroy and Cattonar 2002). At the conceptual level, a person-centered approach reflects students' diversity in a more comprehensive way, while at the practical level, it allows for a more accurate and personalized assessment of students' needs and, thereby, tailoring of educational interventions accordingly.

The objectives of this research are twofold. The first is to identify distinct subgroups of upper elementary students (9–12 years old) with specific combinations of emotions regarding problem-solving tasks. The second is to explore how these distinct subgroups differ regarding perceived competence, emotion regulation, problem-solving performance, and gender composition.

With regard to the first objective, two rationales guided our decision to focus on problem-solving tasks. On the one hand, we wanted to align with studies highlighting the domain and subdomain specificity of emotions (Justicia-Galiano et al. 2017; Wu et al. 2012). On the other hand, we wanted to contribute to the seminal work that has been developed during the last few decades in response to the observation of the difficulties encountered by both learners and teachers with problem-solving tasks (Depaepe et al. 2015; Fagnant et al. 2003). With respect to upper elementary students, research has highlighted that negative emotions provoke feelings of alienation from learning and school from the fifth grade on (Artino 2009; Kramarski et al. 2010) and that the 9- to 11-year-old period is the most important for developing attitudes and emotional reactions to mathematics (Artino 2009).

Regarding the second objective, the present study focuses on one motivational dimension in particular, that is, perceived competence, as it is one of the most powerful predictors of mathematics achievement (Justicia-Galiano et al. 2017; Pajares and Graham 1999; Seaton

et al. 2014) and as it is more strongly correlated with emotions in the context of math class than its perceived value (Ahmed et al. 2010; Frenzel et al. 2007). Moreover, the examination of the developmental trajectories of middle and high school students' emotional and motivational characteristics has highlighted a decline in positive emotions and perception of competence, as well as an increase of negative emotions over time (Ahmed et al. 2013; Sorić et al. 2013), which calls into question what happens in the lower grades.

Achievement emotions

Achievement emotions are emotions that are directly related to achievement activities or to achievement outcomes (Pekrun et al. 2017). A distinction is made between state and trait achievement emotions. State achievement emotions are momentary emotional experiences that occur within specific situations and over brief periods of time, while trait achievement emotions are typical emotional states associated with specific situations, which are relatively stable (Pekrun 2006). Further, drawing on the circumplex model of affect (Feldman-Barrett and Russell 1998), Pekrun (2006) defined achievement emotions according to their degree of physiological activation (activating vs. deactivating) and their valence (positive vs. negative). Based on such a conceptualization, Pekrun distinguished four groups of achievement emotions: positive activating emotions (e.g., pride, enjoyment), positive deactivating emotions (e.g., relief, satisfaction), negative activating emotions (e.g., shame, fear), and negative deactivating emotions (e.g., hopelessness, boredom).

The differences in the metrics used to assess students' emotions in the extant empirical literature call for caution when it comes to establishing a dialog between the results obtained. We will therefore talk about the tendency of math-related emotions to be more positive than negative among upper elementary students (Frenzel et al. 2007; Monteiro et al. 2017; Peixoto et al. 2017). More precisely, pride seems to be the emotion most often felt while anger seems to be the least felt. With regard to boredom, a study conducted with fifth to tenth graders reported that 44% of the participants frequently experienced boredom in mathematics class (Daschmann et al. 2011). The authors concluded that boredom is a common emotion among students. When problem-solving tasks are specifically targeted, findings show that novice problem-solvers experience mainly negative emotions such as hopelessness, nervousness, fear, worry, and boredom (Hanin & Van Nieuwenhoven, 2018b).

Based on these findings and on the recommendation of parsimony in the selection of clustering variables (Brusco and Cradit 2001; Milligan 1989), the present study focuses on ten trait-like achievement emotions commonly experienced by upper elementary students when dealing with problem-solving tasks. These include three activating positive emotions (pride, enjoyment, hope), four negative activating emotions (fear, worry, nervousness, shame), and three negative deactivating emotions (hopelessness, sadness, boredom).[1] Trait-like emotions were chosen, as the present study targets students' habitual, reoccurring emotions during problem-solving tasks. *Enjoyment* of mathematics refers to the satisfaction felt after the fulfillment of a mathematical task (Pallascio and Lafortune 2000). *Pride* denotes a sense of self-satisfaction after a success (Legendre 1993). *Hope* and *fear* are felt when one is unsure

[1] Positive deactivating emotions are mainly retrospective (e.g., relief, satisfaction). However, the purpose of the present study is to identify the emotional profiles with which students launch into problem-solving tasks. Therefore, positive deactivating emotions were not assessed.

about his/her ability to succeed on an upcoming task (Pekrun and Stephens 2010). In the case of hope, attention focuses on the possibility of success, while in the case of anxiety, attention focuses on the possibility of failure. Worry and nervousness are two components of anxiety (Liebert and Morris 1967). *Worry* is the cognitive component of anxiety and refers to cognitive concerns about doing well in mathematics (Wigfield and Meece 1988), while *nervousness* covers the affective component of anxiety. *Shame* is a negative emotion experienced after failure. It stands at the heart of the negative self-esteem affects that frequently involve devastating emotions of self-disparagement (Pekrun 2007). *Hopelessness* is experienced when the expectations of success are weak or when the expectations of failure are high. *Sadness* results from performing poorly (Pekrun 2007). Finally, *boredom* is due to a sense that the subject matter is monotonous and lacking in meaning, as well as students being either over-challenged or under-challenged (Daschmann et al. 2011).

Mathematical performance

According to the control-value theory (Pekrun 2006), the overall effects of emotion on academic achievement are assumed to be contingent on a set of motivational and cognitive mechanisms, such as the cognitive resources available, the kind of learning and self-regulation strategies adopted, and learner effort and motivation, all of which are directly correlated with academic achievement. In line with the assumptions of CVT, empirical research conducted with upper elementary students revealed that positive emotions have a beneficial effect on students' mathematical achievement and that negative emotions impair it (Frenzel et al. 2007; Peixoto et al. 2017; Pekrun et al. 2017). More precisely, positive activating emotions (e.g., enjoyment and pride) were found to be positively related to mathematical achievement. However, it seems that the relationship between positive deactivating emotions and mathematical achievement has not yet been investigated. Anxiety and shame, two negative activating emotions, appeared to be negatively related to math achievement. The same relation was found for hopelessness, a negative deactivating emotion. Among the emotions most often experienced in an academic context, the strongest links were observed with hopelessness, shame, and anxiety (which explained between 10 and 18% of the total variance).

Emotion regulation strategies

Since emotions can impair students' motivation, learning, and academic achievement, it is important that students employ successful strategies in order to influence the occurrence, duration, and intensity of the emotions experienced; in other words, it is important that they regulate their emotions (Burić et al. 2016; De Corte et al. 2011; Gross 1998). In response to the lack of literature regarding the emotion regulation strategies used by students in compulsory educational settings, in a previous study, Hanin, Grégoire, Mikolajczak, Fantini-Hauwel, & Van Nieuwenhoven (2017) investigated the strategies used by upper elementary students to regulate their negative emotions when solving mathematical problems. Based on the three major theoretical models in this field, those of Folkman and Lazarus (1988), Gross (1998), and Mikolajczak (2012), six emotion regulation strategies were revealed. *Negative self-talk* or *rumination* involves focusing on the negative aspects of the situation, by dramatizing them, by constantly thinking them over, or by convincing oneself that they are beyond one's control. *Dysfunctional*

avoidance consists of avoiding dealing with the task, despite the fact that its completion is beneficial in the long run. *Emotion expression* refers to the social sharing of one's emotions. *Task-utility self-persuasion* or *utility value reappraisal* consists of convincing oneself of the personal utility of the task, despite the fact that the task generates unpleasant emotions. *Help seeking* is about seeking peer and teacher assistance. Finally, *brief attentional relaxation* involves releasing attention for a few seconds through distraction or by relaxing. Theoretically, the first two are considered maladaptive and the last four adaptive (Eccles and Wigfield 2002; Mikolajczak 2012). While researchers generally agree that engaging in ruminative negative thoughts (Garnefski et al. 2007; Nolen-Hoeksema et al. 2008) and avoiding situations that generate short-term negative emotions but that are beneficial in the long run (De Corte et al. 2011; Mikolajczak 2012) are maladaptive per se, this is not the case for the other four strategies. In this regard, recent research conducted with undergraduate students has shown that several emotion regulation strategies are not per se adaptive or maladaptive, but rather that this depends on the context, the frequency and intensity of use, the pattern of strategies used, and the individual (Ben-Eliyahu and Linnenbrink-Garcia 2013; Burić et al. 2016; Schmidt et al. 2010).

What use do upper elementary students make of these strategies? Our findings showed that, apart from the task-utility self-persuasion strategy, students have weak practice of emotion regulation (Hanin et al. 2017). This observation aligns with previous research (De Corte et al. 2011; Garnefski et al. 2007; Viguer et al. 2017).

The relation between emotion regulation and achievement emotions has mainly been investigated in high school and university students and has revealed inconsistent results. Ben-Eliyahu and Linnenbrink-Garcia (2013) found that reappraisal positively predicted positive emotions in both favorite and least favorite courses and negatively predicted negative emotions in favorite courses only. Rumination was found to predict positively negative emotions across contexts and to negatively predict positive emotions in the least favorite course only. Schmidt et al. (2010) examined the reverse association. They observed that anxiety/fear negatively predicted distancing[2] and positively predicted problem-focused strategies[3] and seeking social support. Frustration/powerlessness positively predicted distancing and seeking social support. Positive emotions positively predicted reappraisal, problem-focused strategies, and seeking social support. Burić et al. (2016) observed a negative bidirectional link between respiration and positive emotions as well as a positive bidirectional relation between both respiration and reappraisal, and negative emotions. Similarly, Hanin & Van Nieuwenhoven, (2018a), in their study conducted with upper elementary students, found that problem-solving anxiety was predicted not only by dysfunctional avoidance and negative self-talk but also by the expression of emotion, brief attentional relaxation, and help seeking. However, it is important to note that, except for negative self-talk, the variance explained was marginal. Taken together, these findings echo the observation mentioned above that the degrees of adaptability and adaptivity of emotion regulation strategies depend on different factors (e.g., the individual, the context, the pattern of strategies used). This has led scholars (Burić et al. 2016; Ben-Eliyahu and Linnenbrink-Garcia 2013) to underline the challenge for the educational literature to explore the factors,

[2] Distancing consists in distancing oneself from the task by engaging in fun activities, trying to take one's mind off it. This strategy presents some overlap with the dysfunctional avoidance strategy.
[3] Problem-focused strategies cover strategies that consist of focusing on the task.

both background variables and emotional characteristics, that explain the use of one strategy over another.

Perceived competence

In CVT, control appraisals are determined by causal expectations of success or failure and by causal attributions (Pekrun 2006). Among the determinants of causal expectations, perceived competence has received the greatest attention from scholars in the field of mathematics. Building on Bandura's (1997) theory, perceived competence is conceptualized in CVT as an individual's judgment of his/her personal ability to organize and execute a course of action in order to attain self-set goals. Like many scholars, we consider that when assessed at a domain-specific level, self-concept, perceived competence, and self-efficacy belief reflect the same reality (Ahmed et al. 2012; Bouffard and Vezeau 2010; Valentine et al. 2004). As outlined above, according to CVT, perceived competence is one of the most proximal determinants of achievement emotions. Thus, doubting or being confident about one's capabilities is assumed to lead the learner to experience different emotions (Pekrun 2006). The little empirical research that has looked at the connection between upper elementary students' emotions and perceived competence in the mathematics context has aligned with CVT assumptions, demonstrating that perceived competence correlates negatively with negative emotions and positively with positive emotions (Hanin et al. 2018b; Frenzel et al. 2007; Peixoto et al. 2017). The strongest relationships were observed for pride, hopelessness, and anxiety.

Gender

The control-value theory implies that gender should influence achievement emotions by affecting control and value appraisals in the first place (Pekrun and Perry 2014). More precisely, gender-linked stereotypes are expected to influence students' perception of their competence and the value they grant to mathematical tasks, which, in turn, affect their achievement emotions. Empirical evidence has confirmed that, already in primary school, girls reported more maladaptive emotions (e.g., anxiety, shame, hopelessness) and fewer positive emotions (e.g., pride, enjoyment) than boys (Frenzel et al. 2007; Goetz et al. 2013; Pekrun et al. 2017) and that these differences proved to be mediated by differences in motivational beliefs, with girls reporting lower perceived competence in mathematics and less intrinsic value for the domain of mathematics (Goetz et al. 2013; Pekrun et al. 2017). Nonetheless, a recent meta-analysis pointed out that gender differences in emotions are negligible in childhood (3–12 years) and increase in adolescence (Else-Quest et al. 2012). These inconsistent findings indicate the need to question gender differences in the present study.

Research questions

The literature reviewed above has pointed out the key role played by achievement emotions in mathematical settings and, more particularly, in problem-solving tasks. In line with the current literature (Fagnant et al. 2016; Schukajlow et al. 2012; Tzohar-

Rozen and Kramarski 2017), we conceptualized problem-solving tasks as problems for which the solutions are not immediately evident, and the resolution of which is not based on the procedure just seen in class but rather requires the student to consider the problem as an everyday situation in life that can be modeled mathematically. These problems are described as "non-routine" given their sparsity in regular classrooms.

Although research conducted so far has produced important insights into the relationships between achievement emotions, none of it has looked at their complex combinations within upper elementary students and the way these relate to perceived competence, emotion regulation, problem-solving performance, and gender composition. This issue requires a shift from a variable-centered approach to a person-centered approach. While the former approach takes the variables under study as the focal point, the latter focuses on particular combinations of variables as they exist within groups of individuals (Hayenga and Corpus 2010). The issue at stake here is to identify discriminable, homogeneous groups of students with similar emotional characteristics that may impact the groups' perceived competence, emotion regulation, problem-solving performance, and gender composition. As our approach is based on hypothetical predictions and not on a strong model, that is, it has an exploratory character, we opted for cluster analysis (Magidson and Vermunt 2002; Muthén and Muthén 2000).

The present study aimed to overcome some of the limitations of the extant literature by addressing the following three research questions:

- Can meaningful distinct subgroups of upper elementary problem solvers with specific combinations of achievement emotions be identified?
- Do these distinct subgroups differ regarding perceived competence, emotion regulation strategies, and problem-solving performance?
- Do these distinct subgroups differ regarding gender?

Considering that no study to date has attempted such a cluster analysis, our predictions are speculative. Based on previous findings, we would expect there to be at least two groups of students: those presenting a disadvantageous profile who would feel mainly negative emotions and those with an advantageous profile who would experience only positive emotions. What is unclear is whether intermediate profiles exist or if there are a variety of advantageous and disadvantageous profiles. With regard to our second research question, based on the literature reviewed above, we anticipated that the students with an advantageous profile would be confident in their problem-solving capabilities and have the highest problem-solving performance, while students with a disadvantageous profile would doubt about their problem-solving competence and display low performance. With respect to emotion regulation strategies, considering the little empirical evidence on this subject and their relative nature, it is difficult to make strong assumptions. Nonetheless, as the six emotion regulation strategies presented above aim to downregulate negative emotions, we might expect that the advantageous profile would rely less frequently on them than the disadvantageous profile. The latter is assumed to rely more heavily on the two less adaptive forms of emotion regulation, that is, dysfunctional avoidance and negative self-talk. Considering our third research question, based on the literature presented above, we postulate the presence of a larger proportion of boys with an advantageous profile and the reverse pattern for the disadvantageous profile.

Method

Sample and procedure

The study involved 354 upper elementary students (mean age, 10.5 ± .61 years[4]) from five different schools in the French-speaking part of Belgium (Table 1). In line with Leiss et al.'s (2010) findings, students with reading difficulties were excluded from the data analysis; these included three participants scoring 2 standard deviations below the mean in Lobrot's Lecture 3 reading test (Lobrot 1967). The sample represented a wide range of students in terms of socio-economic background. Students who were absent during data collection completed the problem-solving test and the three self-report scales once back in class, so that no students were removed from the study. The respondents were solicited by their teacher, during the math class, to complete the questionnaires. The problem-solving test was given first so that students could respond to the scales with examples of problems in mind. After ensuring the confidentiality of the data, items were read aloud by the teacher and students were encouraged to follow along instead of working ahead. They were invited to express themselves if they did not understand an item. The entire session lasted approximately 1 h.

Measures

Problem-solving perceived competence was assessed through seven items adapted from Boekaerts' (2002) Online Motivation Questionnaire (e.g., "How good do you think you are at problem-solving tasks?", $\alpha = .88$). The items were rated on a 4-point scale.

Trait achievement emotions typically experienced by upper elementary students in mathematical problem-solving tasks were evaluated through a questionnaire presenting facial expressions (one pictorial item per emotion). These included three positive activating emotions (enjoyment, pride, hope), four negative activating emotions (shame, fear, worry, nervousness), and three negative deactivating emotions (sadness, hopelessness, boredom) (Frenzel et al. 2007; Lichtenfeld et al. 2012; Peixoto et al. 2017). Students were asked to indicate to what extent they felt each emotion when solving a math problem, using a 5-point Likert scale.

Emotion regulation strategies were appraised using the Children's Emotion Regulation Scale in Mathematics (CERS-M) (Hanin et al. 2017). This questionnaire consists of 14 items rated on a 4-point Likert scale and targets six strategies commonly used by fifth and sixth graders to regulate their emotions when solving mathematical problems (see Table 2). Exploratory factor analysis revealed six factors (eigenvalue higher than 1) explaining more than 71% of the variance. Factor loadings ranged from .71 to .89.

Problem-solving performance was assessed by means of a standardized test made up of four non-routine word problems ($\alpha = .65$). This test was designed on the basis of the expertise of the first author, in collaboration with five of the 16 teachers involved in the present study. In order to measure students' competence in solving non-routine problems and not their mathematical knowledge or technical ability, only application problems were offered, and the use of the calculator was permitted. Accuracy of problem responses was scored on a 0–1 continuum, with 0 reflecting a completely erroneous response, 0.5 reflecting a partially correct response, and 1 reflecting a completely correct response. For each student, a global score was computed

[4] Similar data are observed within the reference population (General Service of the Management of the Educational System 2016).

Table 1 Characteristics of the sample

	Grade 5	Grade 6	Total
Girls	90	82	172
Boys	91	91	182
Total	181	173	354

by summing his/her four scores. Interrater reliability for two independent blind scorers was excellent ($k = .96$) (Cohen 1960).

Students' previous problem-solving performance, included as a control variable, was assessed 3 months before the start of the study, using a standardized test made up of four non-routine word problems similar to those used to assess students' actual performance. Accuracy of problem responses was scored using the same procedure ($k = .90$; $\alpha = .66$).

The schools' socio-economic index score, included as a control variable, was collected on the Ministry of the French Community of Belgium's website. This index classifies schools on a scale of 1 (the lowest index) to 20 (the highest index). It is calculated from five factors measured for each student: the per capita income, the level of qualification, the unemployment rate, the professional activities, and the housing conditions. The index score of each school is then defined on the basis of the average of the indices of its population. The average socio-economic index score for both fifth and sixth grade elementary students is 12.2.

Results

There were very little missing data in the self-report measures, due to the fact that after the completion of each scale, the first author checked that students had not left particular items blank. When this occurred (2% of cases), she returned the scale to the student to complete the item(s) concerned.

Preliminary analysis

Table 3 displays the zero-order correlations and summary statistics for each variable under research. Sadness, shame, and emotion expression presented a leptokurtic distribution (positive

Table 2 Description of the emotion regulation strategy scale

Scale name	Number of items	Sample item
Help-seeking	2	"I ask the teacher to help me to solve the problem"
Brief attentional relaxation	3	"I put down my pen for a few seconds and stretch my arms"
Task-utility self-persuasion	2	"Even if I do not like solving math problems, I tell myself that it is important to do so in order to be able to understand them and thereby to succeed"
Emotion expression	2	"I tell my neighbor that the problem makes me angry, sad, hopeless, or bored"
Negative self-talk	3	"I tell myself that it is terrible not being able to solve the problem and that I am sure that it only happens to me"
Dysfunctional avoidance	2	"In order not to experience an unpleasant moment, I tell myself that I will solve the problem later"

kurtosis), with many scores found in the tails and a pointy distribution (DeCarlo 1997). As expected, negative emotions correlated negatively with problem-solving performance. However, no significant correlation was found between positive emotions and problem-solving performance. With respect to problem-solving perceived competence, as predicted, this variable correlated positively with positive emotions and negatively with negative ones. As for emotion regulation strategies, our data indicated that positive emotions were moderately associated with task-utility self-persuasion (positively) and negative self-talk (negatively). With regard to negative emotions, strong correlations were found with negative self-talk whereas weaker correlations were found for the other strategies. Positive emotions appeared to be less tied to emotion regulation strategies than negative ones, indicating that these strategies are better at increasing/decreasing the experience of negative emotions than at decreasing/increasing the experience of positive emotions. Overall, these results lend support to the relevance of the ten entrance variables in accounting for students' problem-solving performance, perceived competence, and emotion regulation

Cluster analysis

Entrance variables were standardized through Z-transformations before starting the cluster analysis. Hierarchical cluster analysis using Ward's linkage method and squared Euclidean distances as the measure of similarity was then used to identify the number of clusters and to fix cluster centers (Aldenderfer and Blashfield 1984). On examination of the dendrogram, it was determined that four clusters fit the data best. Furthermore, the four-cluster solution was interpretable and had a good distribution of cases across clusters. Next, a *K*-means cluster procedure with a four-cluster solution was run to construct the final solution (Bergman 1998). Specifically, the four clusters revealed by Ward's analysis were used as the initial cluster centers. The final cluster centroids for the four clusters are displayed in Table 4 and illustrated in Fig. 1. Centroids reflect students' means for each of the achievement emotions in each cluster. It is worth mentioning that, as scales were standardized, a positive centroid indicates a higher score than the overall sample mean and a negative centroid reflects a lower score than the average student from the sample.

The reliability of this solution was also examined through MANOVA, as described below. It is important to note that preexisting individual differences were controlled for by including four covariates acknowledged to predict students' achievement emotions in the analyses: specifically students' previous problem-solving performance (Pajares and Graham 1999; Seaton et al. 2014), grade level (fifth or sixth) (Goetz et al. 2010; Goetz et al. 2007), gender (Frenzel et al. 2007; Lichtenfeld et al. 2012; Stipek and Gralinski 1991), and the school's position in the socio-economic index (Alivernini and Lucidi 2011; Phinney et al. 2005).

Validation of the cluster solution

A one-way MANOVA was computed with cluster membership as the between-subjects factor and the ten cluster variables as dependent variables. The overall MANOVA was significant (Pillai's trace = 1.53, $F(30,1011) = 36.93$, $p < .001$). Given the significance of the overall test, the univariate main effects were considered. As shown in Table 4, the univariate tests for each cluster variable were all significant and cluster membership explained between 10 and 54% of the variance in the ten variables used to create the clusters. Results suggest that the composition of each cluster is significantly different from that of the others.

Table 3 Means, standard deviations, skewness, kurtosis, and correlation matrix for the study variables

	M	SD	*S*	*K*	1	2	3	4	5	6	7	8	9
Cluster													
1. Hope	2.99	1.32	.16	−1.1	1								
2. Pride	2.60	1.12	.70	−.36	.30**	1							
3. Enjoyment	2.82	1.37	.30	−1.14	.27**	.41**	1						
4. Hopelessness	1.87	1.01	1.25	1.20	−.02	−.10	−.18**	1					
5. Worry	2.44	1.25	.76	−.40	.03	−.08	−.14**	.53**	1				
6. Sadness	1.68	1.01	1.63	2.12	.03	−.10	−.07	.58**	.50**	1			
7. Nervousness	2.51	1.29	.58	−.75	−.01	−.11*	−.17**	.46**	.66**	.49**	1		
8. Fear	1.92	1.16	1.28	.78	.00	−.12*	−.09	.47**	.69**	.48**	.62**	1	
9. Shame	1.68	1.02	1.68	2.29	.00	−.08	−.10	.50**	.54**	.53**	.46**	.50**	1
10. Boredom	2.22	1.18	.95	.17	−.02	−.05	−.12*	.18**	.16*	.18**	.16**	.11*	.15**
11. Competence	2.70	.55	−.39	.41	.24**	.38**	.42**	−.29**	−.43**	−.24**	−.35**	−.36**	−.37**
Emotion regulation strategies													
12. Help-seeking	2.23	.75	.40	−.03	.13*	.06	.06	.20**	.18**	.13*	.18**	.20**	.15*
13. Brief attentional relaxation	2.30	.80	.38	−.57	.11*	−.003	.001	.17**	.21**	.08	.17**	.15**	.10
14. Task-utility self-persuasion	2.94	.86	−.53	−.57	.27**	.26**	.17*	−.01	.12*	.04	.10*	.17**	.07*
15. Emotion expression	1.44	.62	1.57	2.33	-.10	−.15**	−.07	.25**	.17**	.17**	.20**	.12*	.18**
16. Negative self-talk	1.84	.77	.71	−.25	−.07	−.17**	−.20**	.44**	.50**	.41**	.44**	.48**	.50**
17. Dysfunctional avoidance	1.63	.65	.86	.16	−.03	−.02	−.02	.22**	.19**	.23**	.18**	.14**	.24**
18. Problem-solving performance	.36	.28	.36	−.67	.01	−.01	.06	−.15**	−.20**	−.12*	−.22**	−.18**	−.19**

	10	11	12	13	14	15	16	17	18
Cluster									
1. Hope									
2. Pride									
3. Enjoyment									
4. Hopelessness									
5. Worry									
6. Sadness									
7. Nervousness									
8. Fear									

Table 3 (continued)

	10	11	12	13	14	15	16	17	18
9. Shame									
10. Boredom	1								
11. Competence	−.14**	1							
Emotion regulation strategies									
12. Help-seeking	−.01	−.16**	1						
13. Brief attentional relaxation	.15**	−.15*	.17**	1					
14. Task-utility self-persuasion	−.09	.05	.02	−.03	1				
15. Emotion expression	.19**	−.17**	.22**	.22**	−.12*	1			
16. Negative self-talk	.17**	−.53**	.22**	.16**	.08	.27**	1		
17. Dysfunctional avoidance	.10	−.25**	.17**	.32**	.06	.21**	.33**	1	
18. Problem-solving performance	−.05	.35**	−.10	−.10	−.12*	−.01	−.25**	−.15**	1

$N = 354$

*$p < .05$; **$p < .01$

Table 4 Cluster centroids and multivariate analysis of variance

Cluster patterns	Cluster 1: bored	Cluster 2: anxious	Cluster 3: resigned	Cluster 4: positive	$F(3)$	η^2
n (%)	76 (21.5)	56 (15.8)	41 (11.6)	181 (51.1)		
Hope	− .34 a	.14 b	− .03 ab	.13 b	3.89**	0.10
Pride	− .29 a	− .06 ab	− .39 a	.23 b	7.07***	0.10
Enjoyment	− .56 ab	− .07 cd	− .32 bc	.33 d	17.46***	0.15
Hopelessness	.19 b	.14 b	1.70 c	− .51 a	91.36***	0.44
Worry	− .21 b	.95 c	1.56 d	− .56 a	135.68***	0.54
Sadness	− .05 b	.23 b	1.82 c	− .46 a	102.34***	0.47
Nervousness	− .14 b	1.01 c	1.35 c	− .56 a	102.29***	0.47
Fear	− .33 a	.92 b	1.50 c	− .49 a	108.40***	0.49
Shame	− .31 a	.12 b	2.01 c	− .36 a	134.49***	0.54
Boredom	1.01 d	− .14 b	.41 c	− .47 a	65.80***	0.37

The letters indicate post hoc comparison grouping based on the Bonferroni test; cluster centroids with different letters differ significantly

**$p < .01$; ***$p < .001$

Further, a cross-validation procedure was set up to assess the replication of the four-cluster solution (Breckenridge 2000; Tibshirani and Walther 2005). To do so, the data set was randomly divided into two samples (sample 1 [$n = 176$] and sample 2 [n=180]). *K*-means clusters—specifying a four-cluster solution—were performed separately on samples 1 and 2 using the cluster centroid derived from the global sample. According to Cohen's (1960) recommendation, the agreement between the cluster solutions for the whole sample and for the two subsamples was substantial (average kappa = .73).

Description of the clusters

The four-cluster solution, with the clusters' relevance confirmed by both theoretical and statistical criteria, revealed meaningful emotional profiles highlighting specific patterns of variables. Background variables are described in order to refine the characterization of each cluster (Table 5).

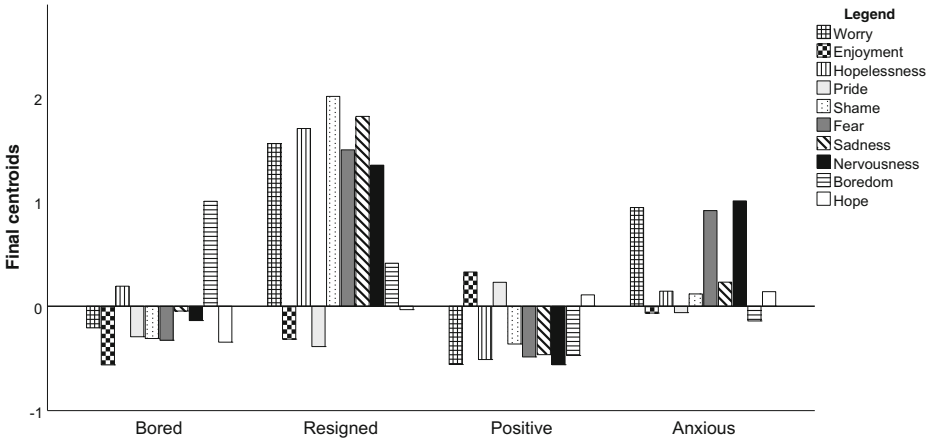

Fig. 1 Standardized means of cluster variables for each profile

1. Bored ($n = 76$; 21.5%): the first cluster was named the *bored profile* due to a substantial high centroid on boredom. Students in this cluster presented low centroids on all the other emotions. More precisely, they felt less pride, enjoyment, hope, nervousness, fear, worry, sadness, shame, and hopelessness. This difference was slightly stronger for positive emotions than for negative ones. This cluster was composed mainly of boys (61.8%) and sixth graders (64.5%).
2. Anxious ($n = 56$; 15.8%): the second cluster was labeled the *anxious profile*, due to its having higher positive centroids on worry, nervousness, and fear in comparison to the other negative achievement emotions. As regards those other negative achievement emotions, above-average scores were reported regarding sadness, shame, and hopelessness, and a below average score was recorded regarding boredom. As for positive emotions, this cluster was characterized by average pride and enjoyment and above-average hope. A typical student from this cluster would thus feel more worry, nervousness, and fear when dealing with mathematical problem-solving than the average student. This cluster was made up mostly of girls (66.1%) and fifth graders (60.7%).
3. Resigned ($n = 41$; 11.6%): the third cluster includes the students with the most at-risk profile and, hence, was entitled the *resigned profile*. Compared to the anxious profile, these students displayed not only higher positive centroids for worry, nervousness, and fear but also the highest positive centroids for hopelessness, sadness, and shame. As for positive emotions, students in this cluster displayed a similar score for hope, pride, and enjoyment as bored and anxious students. Such students were mostly girls (78%) and sixth graders (53.7%).
4. Positive ($n = 181$; 51.1%): the final and largest cluster included students with high positive centroids on enjoyment, pride, and hope and, hence, was labeled the *positive profile*. In contrast to both the resigned and the anxious profiles, these students experienced more positive emotions and fewer negative emotions—whether activating or deactivating. This cluster was predominantly composed of boys (58.9%) and fifth graders (56.7%).

Clusters and outcomes

To look at the differences between the clusters on the three outcome variables assessed in the present study (i.e., problem-solving performance, perceived competence, emotion regulation), multilevel analyses were performed (SPSS software), so as to take the nested structure of the data (i.e., students being nested within classrooms that are grouped together within schools)

Table 5 Background variables for each cluster

	Sample (%)	Cluster 1: bored (%)	Cluster 2: anxious (%)	Cluster 3: resigned (%)	Cluster 4: positive (%)	Statistics
Gender (girl)	51.3	38.2	66.1	78	41.1	($\chi^2(3) = 28.09; p < .001, v = .28$)
School level (grade 5)	51.1	35.5	60.7	46.3	56.7	($\chi^2(3) = 11.91; p = .008, v = .18$)

into account. Multilevel modeling is a statistical approach that allow simultaneous consideration of variables at the student level (L1), at the classroom level (L2), and at the school level (L3) (Bressoux 2010; Marsh et al. 2012). This approach is of particular interest here, in that it allows identification of the variations in problem-solving performance, perceived competence, and emotion regulation that are strictly explained by the students' characteristics, by controlling for the variability due to classroom and school characteristics. Therefore, two random intercepts were included in the model: one for the classroom and one for the school. To control for preexisting individual differences, the same four covariates (students' prior problem-solving performance, school level, gender, and schools' socio-economic index score) were included in the model too.

Problem-solving performance

Significant differences were found between the clusters for problem-solving performance ($F(3,30.32) = 5.19$, $p = .001$) (see Table 6). More precisely, post hoc comparisons based on the Bonferroni test showed that the anxious ($M = .21$, standard error (SE) = .03) and the resigned ($M = .20$, SE = .04) profiles scored the lowest on problem-solving. While the two profiles did not differ significantly from each other, they both displayed significantly lower performance than the positive profile ($M = .35$, SE = .02). No significant difference was found between these three profiles and the bored profile ($M = .31$, SE = .03).

Problem-solving perceived competence

Significant differences were found between the clusters for problem-solving performance ($F(3, 6.02) = 14.16$, $p = .001$) (Table 6). Post hoc comparisons based on the Bonferroni test showed that the anxious ($M = 2.52$, SE = .13) and the resigned ($M = 2.21$, SE = .13) profiles scored the lowest on perceived competence. While these two profiles did not differ significantly from each other, they both presented significantly lower perceived competence than the positive profile ($M = 2.96$, SE = .11). No significant difference was found between these three profiles and the bored profile ($M = 2.54$, SE = .12).

Table 6 Post hoc comparison among the four profiles on problem-solving performance, perceived competence, and emotion regulation strategies

	Cluster 1: bored	Cluster 2: anxious	Cluster 3: resigned	Cluster 4: positive	*F*
Problem-solving performance	.31 ab	.21 a	.20 a	.35 b	5.19**
Perceived competence	2.54 ab	2.52 a	2.21 a	2.96 b	14.16**
Help-seeking	2.78 a	2.83 a	2.79 a	2.68 a	1.30
Brief attentional relaxation	2.49 b	2.68 b	2.54 b	2.21 a	6.28**
Task-utility self-persuasion	2.73 a	3.20 b	3.16 b	3.04 b	5.57**
Emotion expression	1.61 b	1.66 b	1.66 b	1.32 a	8.40***
Negative self-talk	1.89 b	2.14 b	2.82 c	1.52 a	33.28***
Dysfunctional avoidance	1.69 ab	1.72 ab	1.93 b	1.52 a	4.83**

The letters indicate post hoc comparison grouping based on the Bonferroni test; means with different letters differ significantly

**$p < .01$; ***$p < .001$

Emotion regulation strategies

First, no significant difference was found between the four profiles regarding the help-seeking strategy, indicating that upper elementary students, whatever their emotional entrance characteristics, asked for teacher or peer assistance at a similar frequency. Second, the positive profile ($M = 2.21$, SE = .12) reported a significantly lower use of brief attentional relaxation than did the other three profiles (anxious: $M = 2.68$, SE = .15; resigned: $M = 2.54$, SE = .16; bored: $M = 2.49$, SE = .14). No significant difference was found between these three profiles. Third, as for the task-utility self-persuasion strategy, the bored profile ($M = 2.73$, SE = .10) resorted significantly less to it as compared to the anxious profile ($M = 3.20$, SE = .11), the resigned profile ($M = 3.16$, SE = .13), and the positive profile ($M = 3.04$, SE = .08). Fourth, the positive profile ($M = 1.32$, SE = .09) displayed significantly lower levels of emotion expression than the other three profiles: the anxious ($M = 1.66$, SE = .11), the resigned ($M = 1.66$, SE = .12), and the bored ($M = 1.61$, SE = .10) profiles. Fifth, regarding the negative self-talk strategy, the resigned profile ($M = 2.82$, SE = .11) was significantly higher than the other three profiles (positive: $M = 1.52$, SE = .07; anxious: $M = 2.14$, SE = .11; bored: $M = 1.89$, SE = .10), while the positive profile was significantly lower than the other three profiles. Finally, with respect to the dysfunctional avoidance strategy, a significant difference was found between the positive profile ($M = 1.52$, SE = .05) and the resigned profile ($M = 1.93$, SE = .11).

Discussion

This study was designed to reveal the various combinations of achievement emotions in upper elementary students as they deal with problem-solving tasks and to highlight how these combinations are gender-related and explain differences in problem-solving performance, perceived competence, and emotion regulation.

Can meaningful distinct subgroups of upper elementary problem solvers with specific combinations of emotional characteristics be identified?

Cluster analysis revealed four distinct profiles that varied meaningfully regarding achievement emotions. These findings echo those of previous studies showing that students embark on academic tasks with a set of specific emotional characteristics that are a function of the academic domain being addressed (Ahmed et al. 2013; Pekrun 2006). More precisely, in addition to a fully adaptive profile and a fully maladaptive profile, the cluster analysis brought out two more complex profiles that include a combination of high and low scores on the ten entrance variables. Not surprisingly, the positive profile stood out advantageously from both the anxious and the resigned profiles. This is evidenced by lower levels of negative emotions and higher levels of positive emotions. However, the positive profile is not the only one to differ advantageously from the two maladaptive profiles. Indeed, compared to both the anxious and the resigned profiles, the bored profile displayed a lower level of negative emotions, too.

Is the bored profile more adaptive than the positive profile?

While both the bored and the positive profiles are characterized by low levels of negative emotions (except for boredom), they differ regarding positive emotions. In contrast to students

with a positive profile, students with a bored profile experience markedly fewer positive emotions. Considering the beneficial effects of positive emotions on students' attention, motivation to learn, choice of learning strategies, self-regulation of learning, and their psychological and physical health (Ahmed et al. 2013; Peixoto et al. 2017; Pekrun 2006), the positive profile appears more adaptive than the bored profile.

Is the resigned profile more at risk than the anxious profile?

While students in both the anxious and the resigned profiles experienced negative achievement emotions, they differ regarding their frequency. The anxious profile reported experiencing more activating emotions (i.e., fear, nervousness, worry) than deactivating emotions (i.e., hopelessness, sadness, boredom), with the exception of shame, which was experienced at a similar frequency to the deactivating emotions. In contrast, students with a resigned profile very frequently experienced both activating and deactivating emotions and at a higher frequency than their peers with an anxious profile. Regarding positive emotions, while students with an anxious profile presented average levels of enjoyment and pride, the levels of students with a resigned profile for these were below average. As for hope, although the difference is not significant, the anxious profile displayed a positive centroid while the resigned profile presented a negative centroid. Taken together, these findings seem to indicate that students with an anxious profile are a little bit less at risk than their peers with a resigned profile.

But, do the conclusions drawn so far remain valid when problem-solving performance, perceived competence, and emotion regulation are taken into account?

Do these distinct subgroups differ regarding problem-solving performance, perceived competence, and emotion regulation strategies?

Is the positive profile still the most adaptive?

In line with our previous findings, students in the positive profile distinguished themselves from those in both the anxious and the resigned profiles by displaying higher problem-solving performance and more confidence in their problem-solving capabilities and by resorting much less frequently to maladaptive forms of emotion regulation, namely dysfunctional avoidance and negative self-talk. It is normal for students in the positive profile, who experience very few negative emotions, to resort less to adaptive forms of emotion regulation as well (i.e., emotion expression, brief attentional relaxation), compared to both the resigned and the anxious profiles. However, all three profiles make similar use of the help-seeking and the task utility self-persuasion strategies.

As regards the bored profile, a first observation is the absence of a significant difference in problem-solving performance between the two profiles. Students' unfamiliarity with non-routine problems may be a possible explanation. Several scholars have shown that the strategies used by students to solve the problems traditionally given in class prove to be ineffective in solving non-routine problems (Depaepe et al. 2015; Fagnant et al. 2003). Performance is thus not only a question of positive emotion but also a question of strategies. This point concurs with empirical studies based on CVT that have shown that the overall effects of emotions on academic achievement are mediated by a set of motivational and cognitive mechanisms that include cognitive and metacognitive strategies (Valiente et al.

2012). This finding regarding actual performance also applied to the subjective perception of one's competence. With respect to emotion regulation, since the bored profile displayed significantly higher levels of negative emotions than the positive profile, it was not surprising to note that the former resorted more to adaptive forms of emotion regulation (i.e., emotion expression, brief attentional relaxation). The exception is the task-utility self-persuasion strategy, for which a lower use was recorded among students with a bored profile. This suggests that in addition to ascribing no intrinsic value (enjoyment) to problem-solving tasks, students with a bored profile do not value their extrinsic value either. It is as if they were surfing over the tasks without really plunging in. They "routinely execute but do not get substantially involved with the tasks," to use the words of Nardi and Steward (2003, p. 346). These authors called it the "quiet disaffection" profile. Our findings indicated that this profile is more common in the sixth grade than in the fifth grade, suggesting that the higher we progress in school years, the more we meet bored students. This suggestion echoes the conclusions of studies that have investigated the origin of the automated and superficial behaviors of students. These studies showed that these behaviors are the product of a prolonged enculturation in a classroom culture where problem-solving tasks are stereotyped (demanding the routine application of simple arithmetical operations), unrealistic, and non-challenging (Depaepe et al. 2015). In addition, our findings revealed that students with a bored profile are more inclined to ruminate (engage in negative self-talk) than their peers with a positive profile. Besides, while the former have an average perception of competence, the latter displayed strong confidence in their capabilities. The substantial negative correlation between perceived competence and negative self-talk observed in our data may thus account for this difference. In this connection, studies have revealed that students who judge themselves to be ineffective are more prone to engage in ruminative thoughts (Johnston-Wilder et al. 2015; Thomsen 2006). This is probably because a negative perception of competence is mostly explained by repeated past failures (Artino 2012; Bandura 1997; Galand and Vanlede 2004), which activate negative thoughts and emotions that can, in turn, induce ruminative thoughts. Recall here that students with a bored profile reported an average perception of competence.

Taken together, our findings underscore that the positive profile is academically more adaptive not only in terms of achievement emotions but also in terms of preventing ruminative thinking and supporting task-utility enhancement. Unfortunately, this profile is less common in grade 6 than in grade 5.

What about the other three profiles?

Regarding actual and perceived problem-solving performance, findings stressed the absence of difference between the three profiles. Let us note, however, that the centroids for the resigned profile are systematically (and sometimes notably) below the centroids of the anxious and bored profiles. With respect to emotion regulation, although these three profiles resort heavily and with a similar frequency to brief attentional relaxation, emotion expression, and dysfunctional avoidance strategies, students with a bored profile display a lower use of the task-utility self-persuasion strategy than the other two profiles. On this matter, studies have shown that ascribing value to the task is strongly correlated with positive emotions, self-regulated behaviors, and math performance (Ahmed et al. 2010; Peixoto et al. 2017; Pekrun 2006). Further, the resigned profile displayed a higher use of the negative self-talk strategy than the other two profiles. In this respect, studies have shown that the more intense, frequent, and lasting the negative emotions, the more likely the individual will have his/her attention drawn

away from the task at hand and will engage in ruminative thoughts (Thomsen 2006). Nonetheless, the cross-sectional design of the present study implies considering both directions of the relationship. Studies have also shown that focusing repetitively on one's negative emotions, together with their causes and consequences, increases and prolongs negative emotions (Nolen-Hoeksema 2000; Rusting and Nolen-Hoeksema 1998), which also support our findings. Based on the association between rumination and deficits in executive capacity, cognitive flexibility, task-switching, concentration, attention, memory, motivation, problem-solving, and beyond learning, to negative mental health effects (Haeffel 2010; Thomsen 2006), it seems that students with a resigned profile are more at risk than their peers with an anxious or a bored profile.

Another distinction between those three profiles concerns the students' grade level and gender. The anxious profile is mainly composed of fifth grade girls, the resigned profile includes more sixth grade girls, and the bored profile comprises mostly sixth grade boys. In line with studies that have shown a decline in motivation, engagement, and positive emotional experience during the school years (Jacobs, Lanza, Osgood, Eccles and Wigfield 2002), we hypothesize that, in the sixth grade, some anxious girls switch to the resigned profile while some positive boys switch to the bored profile. But, this is only speculation, as we did not use a longitudinal design.

The highly negative feelings of students with a resigned profile also seem to indicate that the heavy use of the negative self-talk strategy cannot be compensated for by the use of more adaptive forms of emotion regulation. This assumption is supported by the strong correlation observed between negative self-talk and negative emotions. Taken together, these findings concur that the resigned profile is the most at risk.

Do these distinct subgroups differ regarding gender?

The gender distinction refines the previous depiction of how emotional, motivational, and cognitive characteristics combine within upper elementary students in the context of problem-solving tasks. Findings revealed a substantially larger proportion of girls with a resigned profile, a larger proportion of girls with an anxious profile, a slightly larger proportion of boys with a positive profile, and a markedly larger proportion of boys with a bored profile. This is consistent with previous studies conducted with elementary students showing that girls experience significantly more negative emotions and fewer positive emotions in mathematics and rate their competence in mathematics lower compared to boys (Frenzel et al. 2007; Jacobs et al. 2002; Lichtenfeld et al. 2012; Stipek and Gralinski 1991). According to previous research, these gender differences may be the product of two dangerous stereotypes: that girls have weaker mathematical ability than boys and that mathematics falls within the male domain (Ambady et al. 2001; Frenzel et al. 2007). However, this is not the only possible explanation for these gender differences. Another area of research has shown that girls, whether they do poorly or well in school, were more prone to internal distress than boys (Martin 2004; Pomerantz et al. 2002). To make sense of these gender differences, future research is warranted that replicates the present study in other academic domains.

Future perspective and limitations

The person-centered approach of the present study is relatively rare in motivation and emotion research (Hayenga and Corpus 2010) and therefore calls for replication and

extension in future work. *First*, the four clusters revealed are a function of the emotional variables examined. As a consequence, it is likely that the addition or deletion of certain cluster variables would nuance the clusters obtained. Along the same line of thought, the variables we used in clustering might be refined by the addition of achievement goals, not only because they have been shown to have a significant impact on students' motivation, emotions, and academic achievement but also because they seem to be a key difference between the four profiles (Daniels et al. 2008; Kaplan and Maehr 2002; Pekrun et al. 2009). Such a study would deepen our understanding of the characteristics of each profile. On the basis of the extant literature on achievement goals and the present results, we speculate that the bored profile would probably be low on both mastery and performance goals and that the positive profile would show the highest mastery goals. Conversely, the anxious and the resigned profiles would presumably display high levels of performance goals and low levels of mastery goals. *Second*, although there is some evidence that students show different patterns of emotions across content areas (Ben-Eliyahu and Linnenbrink-Garcia 2013; Goetz et al. 2010), future research might investigate if the four emotional profiles found in the present study are a function of academic subdomains (e.g., problem-solving) and academic domains (e.g., mathematics) or if they are defined at the academic level and, consequently, are more general and stable. As academic emotions have been shown to be domain-specific and even task-specific, we would expect that students' emotional profiles change across academic content. However, the bored profile is pretty close to the "quiet disaffection" profile depicted by Nardi and Steward (2003) and to disengagement profiles (Ferguson et al. 2005) observed at a more general level. *Third*, and along the same line of thought, it might be interesting to move beyond problem-solving performance to identify correlates that may further differentiate the clusters, such as behavioral engagement, dropout intentions, self-protective behavior, and emotional well-being (Alivernini and Lucidi 2011; Hayenga and Corpus 2010). This will make it possible to characterize the risky profiles more precisely and, thereby, to improve both prevention and treatment interventions. *Fourth*, our findings suggest a possible shift of a number of students between the fifth grade and sixth grade from the anxious profile to the resigned profile as well as from the positive profile to the bored profile, which we hypothesized as resulting from prolonged enculturation in a class culture promoting non-challenging, meaningless, and procedural tasks. Therefore, another fruitful direction would be to replicate the present study adopting a developmental perspective. In support of this hypothesis, as mentioned previously, research on motivation and academic emotions has suggested a motivational and emotional decline as students move through the school years (Ahmed et al. 2013; Jacobs et al. 2002; Sorić et al. 2013). At the same time, studies on goal achievement and intrinsic/extrinsic motivation have pointed out different patterns of adaptiveness depending on age (Deci et al. 1999; Midgley et al. 2001). These divergent findings evidence the need to look at the evolution during schooling of the four profiles identified, particularly at key points such as the transition from primary school to secondary school. *Finally*, several methodological limitations are also worth noting. First, while the effect sizes are small for several variables, let us keep in mind that as we controlled for strong background variables, all additional variance explained in the dependent variables can be viewed as meaningful. Second, the low Cronbach's alpha values suggest the use of a more aggregated measure of problem-solving performance in future studies. Third, the confidentiality of self-report responses was not fully respected, as the first author checked students' responses at the end of the assessment in order to minimize the amount of missing data.

Practical implications

The early identification of profiles could be useful in preventing task disengagement and failure. Such a person-centered approach sheds light on students' specific differences in their emotional and motivational relationship to mathematical problem-solving tasks. This information is valuable in designing tailor-made interventions that fit the specific needs of students according to their profiles. In this connection, among the various emotion regulation techniques that have emerged in recent years, school-based interventions designed to help students reduce their anxiety highlight the benefits of relaxation techniques (Cheek et al. 2002; Segool et al. 2013) and mindfulness training (Burke 2010; Napoli et al. 2005). Considering these results, it appears that students with an anxious profile might benefit from relaxation and mindfulness interventions. Further, drawing on the bidirectional relationships between academic emotions and motivation mentioned in the introduction, scholars have recommended acting on both fronts simultaneously to reach the learner's emotions more effectively (Dweck 1992; Kim and Hodges 2012; Peixoto et al. 2017; Pekrun 2006). Thus, students with a resigned profile, as the most at-risk profile, might need a more forceful intervention that targets both their negative academic emotions and their perceived low competence. Their negative emotions might be managed through the development of a combination of behavioral (e.g., relaxation and mindfulness training) and cognitive (e.g., positive reappraisal) emotion regulation strategies (Hanin & Van Nieuwenhoven, 2018a; Segool et al. 2013; Sorić et al. 2013). As for their perception of competence, scholars have recommended, among other strategies, helping students to set clear, proximal, and attainable goals and to regularly evaluate their progress towards meeting them; emphasizing the close relationship between success, effort, and the use of adaptive strategies; providing honest, encouraging, and constructive feedback; and providing opportunities for mastery experiences (Artino 2012; Maddux 2002; Schunk 2003). Students with a bored profile might need to be offered more challenging tasks, but tasks within their proximal area of development so as not to induce a feeling of uncontrollability that could weaken their perceived competence. The bored profile also draws attention to the need to give students an active role in their knowledge and skills construction and to confront them with realistic and authentic tasks so that they perceive the sense and utility of academic tasks. These practices might be implemented both within the whole class and from an individualized perspective.

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Current themes of research:

Self-efficacy belief, emotional competencies, and heuristic and self-regulation strategies in upper elementary students in the context of mathematical problem-solving.

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Most relevant publications in the field of Psychology of Education:

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