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Emotions, Self-Regulated Learning, and Achievement in Mathematics: A Growth Curve Analysis

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The purpose of the current study was twofold: (a) to investigate the developmental trends of 4 academic emotions (anxiety, boredom, enjoyment, and pride) and (b) to examine whether changes in emotions are linked to the changes in students' self-regulatory strategies (shallow, deep, and meta-cognitive) and achievement in mathematics. Four hundred and ninety-five Grade 7 students completed measures assessing their emotions and self-regulatory strategies in mathematics 3 times across 3 terms in a school year. Students' achievement for each term was collected from school records. Growth curve analyses showed that students' enjoyment and pride in mathematics declined, whereas boredom increased over time. Anxiety remained relatively stable across the study period. The growth curve analyses also showed that changes in positive emotions were systematically associated with changes in self-regulated learning and achievement. Overall, the results suggest that in addition to the "will" and the "skill," students need the "thrill" to succeed in school.

Keywords: academic emotions, achievement, math, self-regulated learning

During the last 15 years, emotion has become an increasingly important topic within the field of educational psychology. In just less than a decade, four special issues (Efklides & Volet, 2005; Linnenbrink, 2006; Linnenbrink-Garcia & Pekrun, 2011; Schutz & Lanehart, 2002) and two edited volumes (Schutz & Pekrun, 2007; Schutz & Zembylas, 2009) on emotions in education have appeared. The impressive growth of research on emotion in education has been partially fueled by the claims that emotions are important predictors of students' self-regulation and achievement (Pekrun & Schutz, 2007). Although a growing number of empirical studies (e.g., Boekaerts, 2007; Linnenbrink, 2007; Pekrun, Goetz, Titz, & Perry, 2002) provide a general support for the purported significance of emotions, longitudinal studies are largely lacking. Consequently, little is known about the trajectories of students' academic emotions (Pekrun & Schutz, 2007). More important, little is known about how temporal changes in emotions influence the development of self-regulation and achievement (Schutz & Davis, 2000; Zeidner, Boekaerts & Pintrich, 2000). In this study, we address these issues. First, we examine the developmental trajectories of students' emotions (anxiety, boredom, enjoyment, and pride) in mathematics classrooms. Second, we explore whether changes in the emotions are associated with changes in self-regulated learning strategies and achievement in mathematics in a sample of early adolescents in a secondary school context. In what follows, we review the literature on the nature of academic emotions, their development, and their role in self-regulation and achievement.

Academic Emotions

Academic emotions are emotions that are tied directly to learning, instruction, and achievement in academic settings (Pekrun et al., 2002). Several important issues concerning the conceptualization of emotions need to be clarified here. One is the distinction among moods, emotions and affect. Whereas emotions are always about something, moods are objectless and diffuse (Morris, 1992). Affect is generally considered as a superordinate concept that includes both moods and emotions (Gross, 1998). Another critical issue pertains to classifications of emotions according to the dimensions of valence and activation. The valence dimension contrasts positive and negative emotions, while the activation dimension contrasts states of low activation and high activation (Pekrun, 2006). Based on such classifications, Pekrun (2006) distinguished four groups of academic emotions: positive activating emotions (e.g., enjoyment, pride), positive deactivating emotions (e.g., relief), negative activating emotions (e.g., anger, anxiety), and negative deactivating emotions (e.g., boredom, hopelessness). A final issue concerns the distinction between trait and state academic emotions Since Spielberger in his (1966) seminal work described anxiety as having two forms, trait and state, researchers have conceptualized emotions on state and trait levels. For instance, Pekrun (2006) made a distinction between trait-like academic emotions and state-like academic emotions. Trait-like academic emotions are typical emotional experiences that tend to be relatively stable. On the other hand, state-like emotions are momentary emotional experiences that follow a fluctuating course. In the current study, we focus on four trait-like academic emotions in mathematics: anxiety, boredom, enjoyment, and pride.

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Development of Academic Emotions

Although a growing body of theoretical literature exists on academic emotions, empirical evidence on the development of these emotions is largely lacking (Schutz & Pekrun, 2007). The existing theoretical accounts on the development of academic emotions typically emphasize the importance of cognitive appraisals in the development of emotions. Such models generally suggest that changes in cognitive appraisals of student–environment transactions are responsible for elicitation, maintenance, and alterations of academic emotions (Pekrun, 2006; Turner & Waugh, 2007). The theoretical literature also hypothesizes that cognitive appraisals vary across time and context as a function of personal goals, expectancies, and values (Lazarus, 1991; Pekrun, 2006; Turner & Waugh, 2007).

A growing body of the empirical literature lends support to the assumptions of the theoretical models. The literature generally shows that higher levels of mastery goals, self-concept, and task values are associated with higher levels of positive emotions and lower levels of negative emotions (e.g., Goetz, Pekrun, Hall, & Haag, 2006; Linnenbrink & Pintrich, 2002; Pekrun, Elliot, & Maier, 2006). Unfortunately, a large body of the empirical literature shows age-related declines in students' mastery goals, success expectancies, and task-values in different academic subjects; particularly, in mathematics (Linnenbrink & Fredricks, 2008; Wigfield, Eccles, Schiefele, Roeser, & Davis-Kean, 2006). Although the majority of this research has focused on long-term changes, several studies have found within-year declines in motivation (Meece & Miller, 2001; Nurmi & Aunula, 2005; Pajares & Graham, 1999). By analogy, it can be argued that there would be corresponding changes in students' emotions. Nevertheless, to date, longitudinal evidence on the development of students' emotions other than anxiety has been largely lacking (Pekrun & Schutz, 2007). In the academic settings, the two types of anxiety that are widely studied are test-anxiety and math anxiety (Hembree, 1990). The existing literature on the development of these types of anxiety generally shows mixed patterns. Whereas test anxiety literature generally shows an increase in students' test anxiety as they progress through primary and secondary schools (see Hembree, 1988; Wigfield & Eccles, 1989; Zeidner, 1998), the literature regarding math anxiety is rather mixed. For example, in a cross-sectional study, Wigfield and Meece (1988) found that Grade 9 students had higher mean levels of worry concerning math than Grade 6 students. On the other hand, in a longitudinal study of early adolescents across junior high transition, Wigfield and Eccles (1989) found a decrease in math anxiety from Grade 6 to Grade 7. Similarly, a study by Reuman, MacIver, Eccles, and Wigfield (1987) showed that students' worry about math decreased not only from sixth grade to seventh grade but also from the fall to the spring semester.

Few studies have examined longitudinal changes in the other academic emotions such as boredom, enjoyment, and pride. For boredom, a cross-sectional study found that eighth graders reported higher rates of schoolwork-related boredom than fifth graders, suggesting an increasing trend (Larson & Richards, 1991). For enjoyment, one recent longitudinal study showed that students' reported levels of enjoyment of mathematics decreased from seventh grade to eighth grade (Frenzel, Goetz, Lüdtke, Pekrun, & Sutton, 2009). Indeed, research into achievement motivation has clearly demonstrated that *students' intrinsic motivation*, which is mostly defined as enjoyment of learning, decreases overtime, particularly during junior high school years (Wigfield et al., 2006). The literature on the changes in the emotion of pride in academic settings is relatively the least developed. Although their focus was not age differences in pride, Goetz, Cronjaeger, Frenzel, Lüdtke, and Hall's (2010) data showed that there is no significant differences in pride in mathematics achievement between Grade 8 and Grade 11. Except for the sporadic evidence just summarized, the literature on the development of academic emotions is very limited—and this is particularly so in mathematics.

Emotions and Self-Regulated Learning

As has been noted, one of the purported adaptive functions of emotions is self-regulation. From cognitive accounts it appears that emotions necessitate regulation or maintenance of person-–environment transactions with respect to events or objects of personal significance to the individual (Lazarus, 1991; Scherer, 2001). Although a number of researchers have discussed the role of emotions in self-regulated learning, there are limited theoretical explications of how emotions influence self-regulation of cognition. The existing theoretical accounts generally emphasize the importance of emotions in motivating adaptive use of information-processing strategies. For instance, Boekaerts' (2007) dual-processing model of self-regulation describes self-regulation as a goal-directed, dynamic, and interactive process. The model assigns an important role to cognitive appraisals that denote whether the tasks are congruent or incongruent with the students' learning goals and aspirations. A match between personal goals and learning tasks produces positive emotions and cognitions, which in turn lead them to pursue a learning pathway that is characterized by adaptive use of cognitive and motivational strategies that ensure competence. However, a mismatch between personal goals and the learning tasks produces negative cognitions and emotions that prompt students to take the well-being pathway characterized by avoidance of learning tasks in protection of self-image. Boekaerts argued that the constellations of positive affect and positive self-appraisal lead to exertion of effort, which subsequently is assumed to lead to performance.

In her multidimensional model of affect, Linnenbrink (2007) described the role of affect in students' behavioral and cognitive engagement. Linnenbrink's model proposes that affect signals approach or avoidance of a particular goal, which, in turn, depends on personal goal orientations. Whereas approaching a mastery goal is likely to elicit positive affect, approaching a performance goal tends to elicit negative affect. The affective experiences, in turn, are hypothesized to enhance adaptive behavioral (persistence and effort) and cognitive (meta-cognitive and elaborative-strategy) engagements that have implications for self-regulation and performance.

Pekrun's (2006) control–value theory of achievement emotions proposes that emotions are elicited via cognitive appraisals of control over activities or outcomes that are personally significant. Students' perceived control of learning activities or learning outcomes as implied by, for instance, self-efficacy and subjective importance of these activities or outcomes are important predictors of their emotions. With regard to self-regulated learning, the theory generally postulates that whereas positive activating emo-

tions such as enjoyment and pride enhance the use of elaborative organizational and meta-cognitive strategies, positive deactivating emotions such as relief undermine the use of such strategies. The theory further proposes that negative activating emotions such as anxiety enhance the use of superficial learning strategies and undermine the use of deep and meta-cognitive strategies. For negative deactivating emotions such as boredom, the theory postulates that they undermine the use of any learning strategy.

Two lines of evidence lend support to the theoretical explications of the role of emotions in self-regulation of learning. First, experimental social–psychology research on the effects of mood or affect on information processing suggests that negative emotions may preempt cognitive resources that are required for any encoding of information involving elaboration, organization, comprehension, and decision making (Ellis & Ashbrook, 1988). On the other hand, positive affective experiences have been shown to enable individuals to categorize items and situations more creatively and flexibly, to elaborate on the material at hand, and to organize the material flexibly (see Isen, 2004). In general, the evidence shows that positive emotions can prompt elaborative processing, cognitive organization, and problem solving (see Isen, 2004).

Second, both experimental and descriptive research in educational psychology shows that emotions can facilitate or hinder self-regulation of cognition. For instance, test anxiety literature shows that students with high test anxiety can have difficulty encoding information. Test anxiety is also shown to be negatively linked to information-processing strategies such as elaboration and organization. Research also shows that test-anxious students tend to rely on superficial processing strategies (see Zeidner, 1998, for a review). Some studies on affect generally demonstrate the importance of pleasant affect in self-regulation of learning. For example, in a series of quasi-experimental studies by Pintrich, Linnenbrink and colleagues (all discussed in Linnenbrink, 2007), students' negative affect was unrelated to elaborative and meta-cognitive strategies, whereas their positive affect was either positively related or unrelated to their reported strategies. Recent research into the role of specific emotions (other than anxiety) in the self-regulation of learning also demonstrates the importance of discrete emotions. For instance, in a sample of university students, Pekrun et al. (2002) found positive emotions (enjoyment, hope, and pride) to be related positively to elaboration, organization, meta-cognition, and critical thinking, but the relations between these strategies and the negative emotions (anger, anxiety, boredom, and hopelessness) were weaker and inconsistent.

Emotions and Achievement

Relatively limited research has been conducted on the influence of emotions on achievement, with the exception of test anxiety (Pekrun, 2006). For test anxiety, reviews of research have shown that high levels of test anxiety are associated with lower levels of academic performance at both primary and postsecondary levels (see Hembree, 1988; Wigfield & Eccles, 1989; Zeidner, 1998, 2007). Available research shows that math anxiety is negatively related to performance. More specifically, two meta-analytic studies by Hembree (1990) and Ma (1999) have shown that math anxiety has an overall negative relationship with math achievement. There is one important difference between the two reviews. Whereas in Hembree's review only 12% of the studies reviewed were conducted on primary and secondary school students, Ma's review considered primary studies that were conducted on K–12 students only. Irrespective of the population in the primary studies, the two reviews show that math anxiety is inversely related with mathematics achievement. One important finding of the two reviews is that the strength of the association between math anxiety and math achievement appears to increase with age.

Although other emotions are studied less frequently than anxiety, as noted by Pekrun (2006), the available evidence generally shows that achievement is positively linked with positive emotions but negatively linked with negative emotions. Studies on boredom consistently report negative correlations between boredom and academic performance (Daniels et al., 2009; Goetz, Frenzel, Pekrun, Hall, & Lüdtke, 2007; Pekrun, Goetz, Daniels, Stupnisky & Perry, 2010; Pekrun, Elliot & Maier, 2009). For enjoyment and pride, several studies have reported significant positive correlations between these emotions and academic performance as indexed by classroom tests or grade point average (Frenzel, Thrash, Pekrun, & Goetz, 2007; Goetz et al., 2007; Pekrun et al., 2002).

The Present Study

In the current study, we sought to contribute to the growing knowledge base describing emotions and their consequences in academic learning context by addressing two important gaps in the literature. First, we analyzed trajectories of four academic emotions—anxiety, boredom, enjoyment and pride—among a sample of young adolescents in a critical transition year. On the basis of the extant literature, we expected that there would be an overall decline in positive emotions but an increase in negative emotions. Second, we examined the systematic associations between the academic emotions and self-regulated learning strategies and achievement over time. Regarding this second purpose, we addressed two issues. First, we examined whether students' baseline emotions (i.e., initial levels) are associated with their baseline self-regulated learning and achievement. Second, we examined whether the changes in emotions are associated with the changes in self-regulated learning and achievement. Although cross-sectional and laboratory-based social psychological research has shown that emotions influence information-processing strategies, little empirical evidence exists on how emotions affect such strategies in academic contexts over time. Based on the literature on emotions and information-processing strategies reviewed, we expected that the changes in positive emotions would be positively associated with the changes in self-regulated learning strategies and achievement but that negative emotions would have negative associations.

Method

Participants and Procedure

The current study is part of a short-term longitudinal research project examining changes in motivation, emotions, and self-regulated learning of 522 students in Grade 7 over a school year in two secondary schools located in two middle-income suburban communities in the Netherlands. Twenty-seven students who did not provide complete data for at least two occasions were excluded from the analyses. The final sample was 495 students (mean age 5

12.8 years) from 21 classrooms (average class size = 23). Fifty-one percent of the participants were girls. Informed written consent was obtained from parents or guardians. Surveys were administered to the participants in their classrooms. Participants were reminded of confidentiality and of their freedom to discontinue participation at any time. The participants provided data at three occasions—fall (Time 1 [T1]), winter (T2), and spring (T3)—approximately 3.5 months apart.

Measures

Academic emotions. Four students' emotions (anxiety, boredom, enjoyment, and pride) in mathematics were assessed using an adapted version of Academic Emotions Questionnaire–Mathematics (Frenzel et al., 2007; Pekrun, Goetz, & Frenzel, 2005). Students responded to 31 items assessing their level of anxiety, boredom, enjoyment, and pride when attending math classes, when studying math, and when taking math tests or examinations. The scales were Anxiety (eight items; e.g., "I am scared of taking math tests"), Boredom (six items; e.g., "I get bored of studying math"), Enjoyment of Math (eight items; e.g., "I feel happy doing my math homework"), and Pride (nine items; e.g., "I'm proud of my performance in math"). Participants responded on a scale ranging from 1 (*not at all*) to 5 (*very much*), and the scores were averaged to form the emotion indexes. Principal component factor analyses with varimax rotation on the 31 items at the three measurement occasions resulted in four factors explaining 54%, 56% and 58% of variance at T1, T2, and T3, respectively. The Cronbach's alpha reliabilities across the three waves (Waves 1–3) were .83, .86, and .85 (enjoyment); .87, .85, and .86 (pride); .84, .88, and .87 (boredom); and 80, .84, and .84 (anxiety).

Self-regulated learning strategies. Two components of self-regulated learning—the use of cognitive and meta-cognitive strategies—were assessed using items adapted from the learning strategy subsection of the latest version of Motivated Strategies for Learning Questionnaire (MSLQ; Wolters, Pintrich, & Karabenick, 2005). The cognitive strategy subscale assesses rehearsal, elaborative, and organizational strategies. Wolters et al. (2005) recommended the use of one general cognitive strategy rather than the three separate strategies of rehearsal, elaboration, and organization for young adolescents typical of the current sample. To ascertain if this was the case in the current sample, we subjected the 26 items from T1 measurement to a principal component factor analysis with varimax rotation. The results of the analysis did not reveal a clear two-factor structure as was suggested by the authors. Inspection of the factor loadings showed that seven items had either lower loading on a theoretical factor or cross-loaded or wrongly loaded on another factor. In all of these cases, the items were deleted. Factor analysis on the remaining 19 items resulted in three factors, explaining 64% of the variance. The first factor included items measuring rehearsal. The second factor included items measuring elaboration and organization strategies. The third factor included items measuring meta-cognitive strategies such as planning, monitoring, and evaluation. The three factors were labeled *shallow strategy* (α = .69, .74, .75), *deep strategy* (α = .78, .86, .87), and *meta-cognitive strategy* (α = 85, .89, .91) in that order. Principal component factor analyses on the 19 items at the later measurement occasions resulted in the same three factors explaining 67% and 68% of variance at T2 and T3, respectively.

Mathematics achievement. We collected the participants' math grades for the three trimesters of the 2007–2008 academic year from the school record office. The Dutch grading scale ranges from 1 (*poor*) to 10 (*outstanding*). Grades of 5.5 and above are passing grades.

Prior academic achievement. students' scores on a national test at the end of. ementary school were taken as indicators of students' prior academic achievement. Their scores on this test ranged from 513 to 550 (M = 538, SD = 6.60). The possible range is between 501 and 550. We mean-centered the scores to aid interpretation.

Data Analytic Strategy

To estimate the general developmental trends for students' emotions and the impact of the emotions on the development of self-regulated learning and achievement, we used multilevel modeling (Singer & Willet, 2003; Snijders & Bosker, 1999). Specifically, we tested a two-level multilevel model of longitudinal change. The Level-1 model (within-student model) describes each student's change trajectory with growth curve parameters (i.e., the *intercept* representing the student's initial status and the *slope* representing the student's rate of linear growth). The Level-2 model (between-student model) describes individual differences in these growth curve parameters. To partition the within-student variability and between-student variability in the four academic emotions, we estimated four unconditional means models (with no predictors). To examine the general trend of the development of the academic emotions, we estimated four unconditional growth curve models (with no substantive predictors except time, see Singer & Willet, 2003). These initial models were used to determine whether there was systematic mean-level change and individual variability in the emotions. We also estimated four unconditional models for self-regulated learning and achievement: three for the components of self-regulated learning (shallow, deep, and meta-cognitive strategies) and one for achievement. The self-regulated learning and achievement unconditional growth models were used as baseline models against which later explanatory models were compared to see if the addition of emotions could explain some of the intraindividual variation in initial status or rates of change. To rule out the interpretation that prior cognitive ability might have influenced the development of self-regulated learning and achievement, we controlled for students' prior academic achievement in the conditional models. All variables were centered at T1. Model fit was assessed using likelihood-ratio test based on the deviance statistic (Snijders & Bosker, 1999). All our analyses were conducted using MLwiN 2.23 software (Rasbash, Browne, Healy, Cameron, & Charlton, 2011) and maximum-likelihood estimation. The basic equations comprising the multilevel growth models in the current study are as follows:

For the unconditional models:

$$Y_{ij} = \gamma_{00} + \gamma_{10}(\text{Time}_{ij}) + \zeta_{0j} + \zeta_{1j}(\text{Time}_{ij}) + \varepsilon_{ij},$$

where Y_{ij} represents a focal outcome variable (e.g., achievement), γ_{00} and γ_{10} are, respectively, average initial status and average rate of change. The symbols ζ_0, ζ_1, and ε represent, respectively,

residual variance in initial status, residual variance in rate of change, and within-person residual variance.

For the conditional models:

$$Y_{ij} = \gamma_{00} + \gamma_{10}(\text{Time})_{ij} + \gamma_{01}(\text{BLAnxiety})_j + \gamma_{02}(\text{BLBoredom})_j + \gamma_{03}(\text{BLEnjoyment})_j + \gamma_{04}(\text{BLPride})_j + \gamma_{05}(\text{TVAnxiety} \times \text{Time})_{ij} + \gamma_{06}(\text{TVBoredom} \times \text{Time})_{ij} + \gamma_{07}(\text{TVEnjoyment} \times \text{Time})_{ij} + \gamma_{08}(\text{TVPride} \times \text{Time})_{ij} + z_{0j} + z_{1j}(\text{Time})_{ij} + \varepsilon_{ij},$$

where BL = base line (T1 measurement) and TV = time varying (deviations from the baseline; T1 score is subtracted from the scores at subsequent measurement occasions; for a similar approach, see Shim, Ryan, & Anderson, 2008; see Figure 1).

Results

Descriptive statistics are presented in Table 1. Inspection of the means across the three measurement occasions reveals that there appear to be a general decline in the mean levels of positive emotions (i.e., enjoyment and pride) and cognitive self-regulatory strategies overtime. While for boredom, the trend is one of increase, anxiety does not seem to show a clear pattern. Pearson product-moment correlations among the study variables are presented in Table 2.

Changes in Emotions Over Time

As mentioned earlier, to describe and partition the variation in students' emotions, we specified four unconditional means models. In addition, we specified four unconditional growth models to estimate the general trend of the development of the emotions. The results of the unconditional models for the emotions are presented in Table 3. The variance components of the unconditional means models show that the within-student variation in emotions is on average about 1.5 times larger than the variation in emotions between students (63% for anxiety, 55% for boredom, 57% for enjoyment, and 57% for pride).[1] Adding a linear slope to the Level-1 models (unconditional growth model) reduces the unexplained variances on average by about 20%, indicating that a substantial percentage of within-student variation is associated with a student-specific linear time trend.

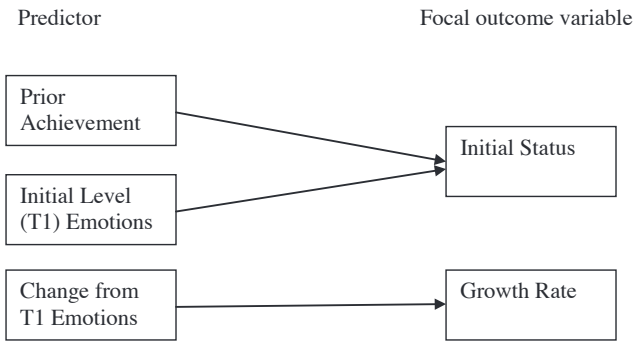

Figure 1. Graphic model representation of the conditional models. Focal outcome variables are: shallow strategy, deep strategy, meta-cognitive strategy, and achievement. T1 = Time 1.

The coefficients presented in Table 3 summarize a number of relevant findings with respect to the development of the four emotions. The table shows that the growth rate for anxiety is nonsignificant, indicating that anxiety appears to be relatively stable across the study period. Nevertheless, the variance in the anxiety growth rate is significant, suggesting that there are individual differences in the rate of growth. The mean growth rate for boredom was positive and significant, reflecting that the linear increase in students' reported levels of boredom across the time period of the current study. More specifically, given the standard deviation of 0.78 at T1, this indicates that students' boredom increased by 0.25 standard deviation units during the study period. Further, the variances in the initial levels of anxiety and boredom were significant, revealing that some students had higher initial levels of anxiety and boredom than others had. Although the variance in the growth rate was not significant, the covariance between the initial levels of and the changes in boredom was significant, indicating that students with higher initial levels of boredom showed a faster rate of increase than those with lower initial levels.

For enjoyment and pride, the picture is rather different. The growth rate estimates for enjoyment and pride were negative and statistically significant, indicating that both enjoyment and pride decreased linearly across the study period. Students' enjoyment of math decreased at the rate of 0.28 *SD* units per trimester since the initial trimester. Similarly, students' pride in math decreased at 0.20 *SD* units per trimester during the study span. The variance of the initial levels of both enjoyment and pride were statistically significant, reflecting meaningful individual variability in initial levels of these emotions. Such individual variability was seen in the growth rate for enjoyment but not for that of pride. Further, the results showed that there was a significant negative association between initial levels and rates of change in enjoyment, indicating that students with lower initial enjoyment show a faster rate decline than individuals with higher initial enjoyment.

Relationships Between Changes in Emotions and Changes in Self-Regulation Strategies and Achievement

In the conditional models, we examined whether and to what extent the emotions predicted the trajectories of self-regulatory strategies and achievement. More specifically, we sought to examine whether initial levels of emotions predicted initial levels of self-regulatory strategies and achievement as well as whether temporal changes in emotions predicted temporal changes in the strategies and achievement. Because we did not estimate the unconditional growth curve models for self-regulated learning strategies and achievement against which we could compare the effects

[1] The percentages were calculated by dividing the within-student variance of the focal outcome variable by the total variance (i.e., within-student variance plus between-student variance; for example, the within-student variance for anxiety is .25, and between student variance is .15). Thus, the percentage of within-student variance is .25 divided by .40 (.25 + .15) = .625, or, 62.5% ($\varepsilon_{ij}/\varepsilon_{ij} + z_{0j}$).

Table 1
Descriptive Statistics for the Study Variables

Variable	Time 1			Time 2			Time 3		
	M	*SD*	a	*M*	*SD*	a	*M*	*SD*	a
Anxiety	2.00	0.55	.80	2.03	0.57	.84	2.06	0.64	.84
Boredom	2.19	0.78	.84	2.46	0.92	.88	2.64	0.96	.87
Enjoyment	2.36	0.76	.83	2.12	0.72	.86	1.98	0.74	.85
Pride	2.92	0.74	.87	2.74	0.80	.85	2.63	0.79	.86
Shallow	2.85	0.87	.68	2.68	0.93	.74	2.67	0.93	.75
Deep	2.97	1.08	.88	2.84	0.95	.90	2.73	0.89	.87
Meta-cognitive	3.11	0.81	.85	3.02	0.84	.89	2.92	0.89	.90
Achievement	7.13	1.15	—	6.84	1.18	—	6.65	1.20	—

Note. Shallow 5 shallow strategy; deep 5 deep strategy; meta-cognitive 5 meta-cognitive strategy.

of adding emotions as explanatory variables, we first estimated these models.

Analyses of the growth trajectories for self-regulatory strategies revealed a general declining trend (see Table 4). The results in Table 4 show that students' reported use of shallow strategy declined over the course of the current study as indicated by the negative and significant estimate for the growth rate parameter. Inspection of the mean across the three measurement occasions shows that students' shallow strategy decreased from 2.83 to 2.68 and remained almost the same at T3. Deep and meta-cognitive strategy showed a steady decline over the course of the current study as indicated by negative and significant growth rate parameters. For instance, the table shows that the average student began the study with a deep strategy score of 2.98 (on a 5-point scale) and lost an average of 0.12 *SD* units per measurement occasion. Similarly, the average student began with 3.10 scores of meta-cognitive strategy and lost an average score of 0.11 *SD* units during the study period. Furthermore, there were positive and significant variances in initial levels and rates of change in deep and meta-cognitive strategies, indicating meaningful individual variability in the average initial and change scores of individuals on the strategies overtime. More specifically, the significant variances in the initial levels show individual differences in initial levels of the strategies such that some students start higher than others do. The significant variances in rates of change indicate that some students declined at a faster rate than others did over the same period of time.

In addition, the covariance between initial levels and rates of change in deep strategy was negative and significant, indicating that students with a lower initial deep strategy showed a faster rate decline than individuals with a higher initial deep strategy. Finally, our analysis revealed that students' achievement decreased significantly;

Table 2
Intercorrelations Among Study Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. Anxiety T1	—																							
2. Anxiety T2	.56	—																						
3. Anxiety T3	.39	.53	—																					
4. Boredom T1	.18	.16	.17	—																				
5. Boredom T2	.07	.14	.13	.52	—																			
6. Boredom T3	.11	.11	.22	.49	.60	—																		
7. Enjoyment T1	2.12	2.12	2.17	2.51	2.29	2.30	—																	
8. Enjoyment T2	2.07	.02	2.06	2.37	2.42	2.38	.56	—																
9. Enjoyment T3	2.05	.03	.13	2.30	2.27	2.31	.46	.63	—															
10. Pride T1	.26	.11	.02	2.26	2.17	2.10	.45	.31	.23	—														
11. Pride T2	.17	.25	.11	2.20	2.26	2.17	.28	.49	.40	.56	—													
12. Pride T3	.16	.19	.27	2.15	2.16	2.14	.23	.35	.51	.47	.56	—												
13. Shallow T1	.03	.06	2.03	2.22	2.20	2.19	.30	.27	.20	.25	.28	.23	—											
14. Shallow T2	.05	.18	.06	.17	2.23	2.20	.20	.33	.18	.20	.32	.18	.37	—										
15. Shallow T3	.01	.10	.15	2.16	2.24	2.24	.17	.28	.36	.14	.25	.33	.32	.32	—									
16. Deep T1	.04	.06	.07	.07	2.08	2.03	.29	.21	.10	.29	.25	.14	.33	.20	.20	—								
17. Deep T2	2.08	2.09	2.09	2.22	2.17	2.16	.32	.31	.27	.18	.25	.18	.21	.26	.16	.26	—							
18. Deep T3	2.11	2.04	.06	2.17	2.15	2.15	.27	.34	.35	.12	.23	.35	.16	.20	.37	.22	.22	—						
19. Meta-cognitive T1	2.08	2.12	2.03	2.22	2.14	2.14	.33	.23	.20	.24	.20	.19	.30	.21	.20	.32	.27	.33	—					
20. Meta-cognitive T2	2.09	2.09	2.07	2.23	2.18	2.18	.28	.34	.25	.15	.29	.15	.26	.33	.15	.22	.33	.38	.36	—				
21. Meta-cognitive T3	2.16	2.16	2.11	2.26	2.20	2.20	.29	.35	.36	.16	.24	.27	.22	.23	.32	.20	.31	.53	.26	.34	—			
22. Achievement T1	2.31	2.27	2.13	2.24	2.06	2.06	.21	.12	.13	2.06	.04	2.02	.14	.10	.12	.17	.29	.33	.36	.20	.29	—		
23. Achievement T2	2.25	2.30	2.18	2.26	2.16	2.16	.24	.17	.18	.00	.05	.01	.11	.10	.06	.16	.31	.39	.35	.35	.33	.71	—	
24. Achievement T3	2.20	2.23	2.19	2.25	2.26	2.26	.22	.18	.22	.04	.10	.14	.20	.20	.15	.16	.25	.35	.30	.30	.31	.54	.63	—

Note. T1 5 Time 1; shallow 5 shallow strategy; deep 5 deep strategy; meta-cognitive 5 meta-cognitive strategy.
| .09| # *r* , |.12|, *p* , .05; *r* 5 $ |.12|, *p* , .01.

Table 3
General Trend of Changes in Emotions

Variable	Anxiety		Boredom		Enjoyment		Pride	
	$Model_0$	$Model_1$	$Model_0$	$Model_1$	$Model_0$	$Model_1$	$Model_0$	$Model_1$
Fixed effects								
Mean initial status	2.11	2.10	2.50	2.29	2.21	2.42	2.80	2.93
Mean growth rate		0.02		0.21^{pp}		2 0.21^{pp}		2 0.16^{pp}
Random effects								
Within-student	0.25^{pp}	0.21^{pp}	0.51^{pp}	0.44^{pp}	0.39^{pp}	0.27^{pp}	0.42^{pp}	0.37^{pp}
Initial status	0.15^{pp}	0.15^{pp}	0.42^{pp}	0.32^{pp}	0.30^{pp}	0.40^{pp}	0.31^{pp}	0.30^{pp}
Growth rate		0.03^{p}		0.02		0.07^{p}		0.03
Covariance		2 0.01		0.05^{p}		2 0.07^{p}		2 0.00
Deviance	2,648.44	2,630.13	3,839.31	3,726.24	3,407.23	3,265.92	3,511.53	3,443.82

^{p}p , .05. ^{pp}p , .01.

more specifically, their achievement decreased by 0.21 *SD* units for every trimester in our study. Overall, about 45% of the variance in achievement was found to be within students and 24% of this variance was explained by the linear time trend (see Table 4).

To attain our second objective, we fitted a series of models by adding baseline emotions and time-varying emotions to the unconditional growth models of self-regulated learning strategies and achievement, controlling for prior academic achievement. We had two purposes: first, we wanted to examine how students' initial levels of emotions predicted their initial levels of strategies and achievement. Second, and more important, we were interested in investigating whether the changes in emotions would predict the changes in the strategies and achievement overtime. To accomplish this, we added time-invariant baseline emotions scores and time-varying emotions to the previously specified models, controlling for prior achievement.

The results of our analyses are presented in Table 5. In general, comparing the conditional models with the unconditional growth curve models across the outcomes yields statistically significant likelihood-ratio statistics suggesting that these models were statistically a better fit than their respective earlier models (see chi-square values in Table 5). The results of the conditional models in general suggest that emotions are functionally important for students' self-regulation and performance. The role of emotions in strategy use varied as a function of the type of strategy. In the shallow strategy model, initial levels of boredom, enjoyment, and pride significantly predicted initial levels of shallow strategy use in the expected directions. Changes in these emotions also significantly predicted the changes in shallow strategy use. Both initial levels of and changes in anxiety were not significantly associated with shallow strategy. Overall, the model explained 33% of variance in initial levels. In the deep strategy model, initial levels of enjoyment and pride significantly predicted initial levels of deep strategy use. Similarly, changes in enjoyment and pride predicted changes in deep strategy use. The model explained 30% of variance in initial status and 66% of variance in growth rate in deep strategy use. In the meta-cognitive strategy model, initial levels of the four emotions predicted initial levels of meta-cognitive strategy use. With regard to multivariate changes, both changes in enjoyment and pride significantly predicted changes in meta-cognitive strategy use. The model explained 23% and 25% of variance in initial status and in rate of change, respectively, in meta-cognitive strategy use.

With regard to the associations between emotions and achievement, the results appear to be more consistent. Initial levels of anxiety, boredom, enjoyment, and pride consistently predicted initial levels of achievement. Here the direction of effects is worth noting; while initial levels of anxiety and boredom negatively predicted initial level of achievement, the initial level of enjoyment had a positive effect. However, the initial level of pride had a

Table 4
General Trend of Changes in Self-Regulated Learning Strategies and Achievement

Variable	Shallow		Deep		Meta-Cognitive		Achievement	
	$Model_0$	$Model_1$	$Model_0$	$Model_1$	$Model_0$	$Model_1$	$Model_0$	$Model_1$
Fixed effects								
Mean initial status	2.83	2.93	2.86	2.98	3.10	3.19	6.94	7.19
Mean growth rate		2 0.10^{pp}		2 0.12^{pp}		2 0.10^{pp}		2 0.25^{pp}
Random effects								
Within-student	0.65^{pp}	0.64^{pp}	0.83^{pp}	0.75^{pp}	0.60^{pp}	0.52^{pp}	0.67^{pp}	0.51^{pp}
Initial status	0.28^{pp}	0.27^{pp}	0.21^{pp}	0.46^{pp}	0.24^{pp}	0.30^{pp}	0.83^{pp}	0.95^{pp}
Growth rate		0.01		0.06^{p}		0.08^{p}		0.10^{pp}
Covariance		0.01		2 0.15^{pp}		2 0.05		2 0.08^{p}
Deviance	4,007.93	3,993.00	4,221.85	4,185.61	3,862.76	3,837.96	4,402.51	4,289.40

^{p}p , .05. ^{pp}p , .01.

Table 5
Multilevel Growth Estimates of the Effects of Emotions on Self-Regulated Learning Strategies and Achievement

	Shallow		Deep		Meta-cognitive		Achievement	
Variable	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Fixed effects								
Mean initial status	2.10		1.87		2.67		8.30	
Prior achievement	0.00	[2 .00, .00]	0.01	[2 .00, .01]	0.01	[2 .00, .03]	0.03^{pp}	[.01, .06]
Anxiety	0.10	[2 .04, .24]	2 0.08	[2 .13, .02]	2 0.11^{p}	[2 .21, 2 .01]	2 0.37^{pp}	[2 .51, 2 .25]
Boredom	2 0.13^{pp}	[2 .21, 2 .05]	2 0.03	[2 .12, .05]	2 0.10^{p}	[2 .19, 2 .02]	2 0.27^{pp}	[2 .38, 2 .19]
Enjoyment	0.18^{pp}	[.10, .28]	0.35^{pp}	[.27, .43]	0.27^{pp}	[.19, .35]	0.20^{pp}	[.13, .27]
Pride	0.19^{p}	[.11, .29]	0.16^{pp}	[.08, .25]	0.11^{p}	[.03, .19]	2 0.19^{pp}	[2 .32, 2 .10]
Mean growth rate	2 0.01		2 0.02		2 0.03		2 0.19	
Anxiety	0.05	[2 .11, .01]	2 0.01	[2 .07, .05]	2 0.01	[2 .02, .09]	2 0.09^{pp}	[2 .15, 2 .03]
Boredom	2 0.06^{p}	[2 .10, 2 .03]	0.01	[.05, 2 .01]	0.00	[2 .04, .05]	2 0.06^{pp}	[2 .11, 2 .03]
Enjoyment	0.10^{pp}	[.06, .14]	0.13^{pp}	[.06, .21]	0.11^{pp}	[.06, .17]	0.04^{p}	[.01, .09]
Pride	0.13^{pp}	[.09, .18]	0.12^{pp}	[.05, .19]	0.06^{pp}	[.02, .11]	0.08^{pp}	[.05, .14]
Random effects								
Within-student	0.61^{pp}	[.56, .66]	0.75^{pp}	[.68, .87]	0.51^{pp}	[.46, .58]	0.50^{pp}	[.44, 56]
Initial status	0.18^{pp}	[.32, .23]	0.32^{pp}	[.18, .46]	0.23^{pp}	[.11, .31]	0.80^{pp}	[.69, .95]
Growth rate	—	—	0.02	[2 .06, .08]	0.06^{p}	[.02, .13]	0.08^{p}	[.02, .18]
Deviance	3,829.74		3,995.95		3,699.92		4,160.88	
Chi-square	163.26		189.66		138.04		128.52	

Note. Interindividual variance in rate of change in shallow strategy was zero. CI 5 confidence interval.
^{p}p , .05. ^{pp}p , .01.

negative effect on the initial level of achievement. Changes in anxiety and boredom predicted changes in achievement negatively, but changes in enjoyment and pride predicted changes in achievement positively. Overall, the model explained 16% and 21% of the variances in initial levels and rates of change in achievement, respectively.

To recapitulate, the analyses showed that whereas boredom increases, enjoyment and pride decline over the course of the study. Overall, in three quarters of the estimates, the initial levels of the emotions predicted the initial levels of the strategies. The analyses also showed that the changes in the two positive emotions were consistently associated with the changes in the strategies. In the achievement growth model, a very consistent pattern emerged with all the estimated coefficients being significant.

Discussion

The fundamental premise underlying research on emotions in education is that the development of academic emotions has an important implication for sustained self-regulated learning and achievement. Nevertheless, this basic assertion underlying the contemporary research on the role of emotions in education remains relatively unexamined. In addition, only little is known about developmental changes in academic emotions. In the current study, we sought to fill this gap in the literature by (a) investigating the trajectories of academic emotions from beginning to the end of a school year and (b) by examining the associations between changes in academic emotions and changes in self-regulated learning strategies (shallow, deep, and meta-cognitive strategies) and achievement in mathematics among early adolescents in a critical transition year. With regard to the first aim, we expected a declining trend for positive emotions but an increasing trend for negative emotions. With regard to the second purpose, we expected positive emotions to predict self-regulatory strategies and achievement positively, and for negative emotions, we expected negative associations. The findings of the current study provide important insights into the developmental changes in academic emotions and the implications of these changes for self-regulation and achievement.

The expected increase in negative emotions was confirmed for boredom but not for anxiety. Although the growth rate coefficient for anxiety was positive, it was not statistically significant. Overall, contrary to previous studies that reported either mixed findings on math anxiety (see Wigfield & Meece, 1989; Wigfield & Eccles, 1989) or an increasing trend for test anxiety (see Hembree, 1988; Zeidner, 1998) , we found in the current study that anxiety appears to be relatively stable across the study period. One important difference between previous research on anxiety and the current study is that of the temporal unit used. While most of the previous studies used year-to-year changes or age differences in anxiety for studying developmental patterns, the current study employed a within-year design. Such a design might have masked visibility of possible changes. However, research into achievement motivation has generally shown that with-in-year changes are more pronounced than between-year changes (see Eccles, 2005).

Consistent with our expectation, boredom showed a steady increase over the study period. Larson and Richards (1991) found that adolescents experience higher levels of boredom in school related activities than preadolescents suggesting an increasing trend during this particular developmental stage. According to Csikszentmihalyi (1997), if an individual's perceived capability is greater than the situational challenge, boredom is likely to occur. Conversely, if perceived capability is lower than situational demands, anxiety is experienced. Such a theoretical proposition suggests that when boredom increases, anxiety may decline. In the current study, although boredom increased overtime, anxiety remained relatively stable.

Contrary to the increasing trend for boredom and consistent with our expectations, the trend for enjoyment and pride was one of decline. The decline in these two positive emotions parallels the decline in related constructs such as interest (liking of learning) and self-esteem for this particular age group (e.g., Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002). Yet specific studies on the development of positive academic emotions are currently unavailable, and comparison of any sort is impossible. One possible reason for declining enjoyment and pride may have to do with decreasing competence and value appraisals. Theoretical models of emotions in education (e.g., Boekaerts, 2007; Pekrun, 2006; Linnenbrink & Pintrich, 2002) have posited goals, competence beliefs, and values as important antecedents of emotions in academic settings. Cross-sectional studies have also shown that competence- and value-related beliefs are indeed associated with such emotions (Boekaerts, 2007; Frenzel et al., 2007; Goetz, Frenzel, Pekrun, & Hall, 2006). On the other hand, developmental research on competence- and value-related beliefs has consistently shown a declining trend (e.g., Jacobs et al., 2002). Thus, the declining trend for positive emotions found in the current study may have to do with the consistently documented downward spiral in early adolescents' motivation (van der Werf, Opdenakker, & Kuyper, 2008; Wigfield et al., 2006).

Turning now to the implications of changes in emotions, we found that the changes in emotions were systematically related to changes in self-regulated learning strategies and achievement. The findings of this study show that the associations between emotions and the components of self-regulated learning vary depending on valence and activation of the discrete emotions. For instance, anxiety and boredom had differential associations with cognitive and meta-cognitive processing strategies. According to predictions based on control-value theory (Pekrun, 2000, 2006), higher levels of anxiety would be associated with lower levels of reported use of deep and meta-cognitive strategies but higher levels of shallow strategy. The theory predicts that higher levels of boredom would be associated with lower levels of shallow, deep, and meta-cognitive strategies. In the current study, only the inclining rate of boredom was associated with the declining rate of shallow strategy. Indeed, neither of the changes in anxiety or boredom was significantly associated with the changes in either deep or meta-cognitive strategies, although the effects were in the expected direction. Consistent with previous cross-sectional studies on the relationship between negative emotions and higher level cognitive strategies (Minnaert, 1999; Pekrun et al., 2002), initial levels of anxiety and boredom were negatively associated with initial levels of meta-cognitive strategies. According to the resource allocation model (Ellis & Ashbrook, 1988), because negative emotions preempt processing capacity, they incapacitate effortful information processing such as the use of elaborative and meta-cognitive strategies. Although the current study was not designed to test such an assumption, the negative associations between the negative emotions and the deep and meta-cognitive components of self-regulated learning suggest that this may be the case. Nevertheless, the current findings also warn that the associations between emotions and information-processing strategies might depend on both the nature of discrete emotion and the type of information-processing strategy under consideration (see Linnenbrink, 2007).

Consistent with research reporting negative effects of anxiety and boredom on cognitive performance (e.g., Ashcraft, 2002; Pekrun et al., 2010; Zeidner, 1998), changes in both boredom and anxiety were associated with the changes in mathematics achievement. In one of the earliest studies on the longitudinal associations between anxiety and achievement, Hill and Sarason (1966) found significant and increasing associations between test anxiety and achievement. On the other hand, test anxiety did not affect concurrent or later achievement in a longitudinal study by Fincham, Hokoda, and Sanders (1989). In a cross-sectional study, Pintrich and de Groot (1990) found that test anxiety was significantly associated with academic performance but not with either cognitive or meta-cognitive strategies. These authors argued that anxiety may influence the retrieval of information rather than information processing (encoding). In the current study, the initial levels of both anxiety and boredom were significantly associated with initial levels of achievement. Taken together, the results of the current study regarding the effects of anxiety and boredom on achievement are consistent with a number of recent studies that documented negative associations between these emotions and performance (e.g., Daniels et al., 2009; Pekrun et al., 2009; 2010).

In contrast, the two positive emotions (enjoyment and pride) were positively associated with self-regulated learning strategies as well as with achievement in a very consistent manner. In general, the findings of the current study support the theoretical propositions that positive emotions are associated with flexible information processing (Fredrickson, 2001; Pekrun, 2006). The feeling of enjoyment may result from an evaluation of a situation that has produced or has the potential to produce a positive outcome (Lazarus, 1991). In this case, enjoyment may serve as source of feedback about the self-regulatory process. Numerous social psychological studies have found that when individuals are in a positive affective state, they tend be more adept at elaborating, organizing, and categorizing incoming information than those in a negative or neutral state (see Isen, 2004, for a review). The current findings also showed that changes in enjoyment were consistently associated with the changes in the three components of self-regulated learning. In addition, changes in enjoyment were systematically related to changes in students' achievement, which requires constellation of motivation and effortful processing of information. Moreover, the initial levels of enjoyment were systematically associated with the initial levels of the strategies and achievement, corroborating previous cross-sectional work (e.g., Frenzel et al., 2007; Pekrun et al., 2002).

The role of pride in self-regulated learning and achievement appears to show a similar pattern to that of enjoyment. The changes in pride were positively associated with the changes in the self-regulatory strategies; that is, the steeper the rate of decline in pride for a student, the steeper the rate of decline in the strategies. In addition, initial levels of pride were positively associated with initial levels of the self-regulatory strategies. These findings are consistent with the assumptions that positive emotions positively influence the nature and scope of information-processing style (Fredrickson, 2001; Pekrun, 2006). With regard to the actual achievement, we found that students' initially reported pride was negatively related to their initial achievement, which appears to contradict the assumption that positive emotions have a broadening and building effect (Fredrickson, 2001). Nevertheless, we also found that the changes in pride were significantly and positively associated with the changes in achievement. These apparently contrasting findings can be explained by looking at the nature of

pride. Tracy and Robins (2007) distinguished between two types of pride experience: *authentic pride* and *hubristic pride*. Authentic pride results from attributing one's performance to one's effort or ability in a particular domain. On the other hand, hubristic pride comes from attributing success to one's general self (e.g., "I am generally smart"). Although there is no ground to suggest that our participants' report of pride at the beginning of the year was hubris, we can defy the assumption that it is authentic. A possible reason why participants' reports may be inaccurate is that the students might have evaluated their potential performance in math on the basis of their elementary school experience. Thus, they might have had an inflated self-esteem that could have influenced their sense of pride. This generality bias might dissipate as the students become more realistic in their self-evaluation. Realistic self-evaluations in turn lead to expression and experience of an authentic pride, which is likely to influence students' achievement via increased perseverance (Williams & DeSteno, 2008). The same may hold true for the declining pride experience. Students' report of higher pride at the beginning of the study period might have resulted from their unrealistic perceptions about their confidence and success in mathematics.

An interesting issue worth discussing is that of the general pattern of the effects of positive and negative emotions. Overall, the significant relationships between positive emotions and self-regulated learning and achievement constituted over three quarters of the total significant associations. This is an interesting finding, given the fact that most of the previous research in education has focused on the effect of negative emotions, particularly anxiety. We found more positive associations of positive emotions with the outcome variables than negative associations of negative emotions with these variables. There are two possible interpretations of these findings. First, these results suggest that positive emotions do indeed broaden students' thought–action repertoire, as suggested by Fredrickson (2001), and provide evidence for trait-like effects of positive emotions in addition to the momentary effects found in previous studies. Second, although previous studies have shown the negative effects of negative emotions on information-processing strategies and performance, in the current study, their effects were weak and mostly nonsignificant, once positive emotions were taken into account. Such results imply that positive emotions are perhaps "undoing" the effects of negative emotions (see Fredrickson, 2001).

There are several limitations of this study. First, our study is limited to the domain of mathematics, and generalization to other school subjects such as languages is difficult if not impossible. Nevertheless, given the recent findings that emotions are domain specific (Goetz et al., 2006), our focus on mathematics is legitimate. Future research should examine the developmental patterns in emotions and their functional roles in other school subjects.

Second, the inclusion of just three time points tends to limit the functional form of growth that can be studied. Future research should use additional time points to model complex form of growth. More time points increase the power to detect effects more accurately (Singer & Willet, 2003). Yet it should be noted that the three time points used in the current study are meaningful time points in the lives of our participants. A related limitation is that we used three schools terms within a year. Thus, we were not able to capture year-to-year changes in the nature and function of academic emotions. Future research on year-to-year development of the nature and function of academic emotions in mathematics is sorely needed. Third, although we used grades as indicators of achievement to model growth, grades may lack common metric over time. In future research, standardized tests may be used to model the longitudinal associations between emotions and achievement. Fourth, although our study controlled only for prior achievement, motivational variables such as self-concept and perceived value could influence both the developmental changes as well as the developmental functions of academic emotions. This could be a fruitful area for future research. Finally, although our longitudinal data have enabled us to model associations of variables over time, a definitive causal conclusion about the relationship is impossible. Nevertheless, our study was based on models of emotions in education that hypothesize such causality. Obviously, future research is needed to discern such causality.

Despite these limitations, the present findings contribute to our understanding of academic emotions during a critical transition year. First, the study is one of the first to document patterns of change in academic emotions over a specified period of time among sample of young adolescents on a transition. One of the most widely studied emotions in education is anxiety. Surprisingly, longitudinal research on the development of test anxiety is very limited (Zeidner, 2007). Hence, there have been calls for ontological development of academic emotions (Pekrun & Schutz, 2007; Zeidner, 2007); we believe that we have attempted to answer such calls. Second and more important, the bulk of empirical research in the past has focused on motivational factors that influence students' self-regulated learning and achievement (See Schunk & Zimmerman, 2008; Wigfield et al., 2006). Results of the current study highlight the importance of attending to students' emotions to optimize their self-regulated learning and achievement and provide evidence on the role of emotions in self-regulation that Zeidner et al. (2000) wondered about a decade ago. With regard to practical implications, the results suggest that interventions that aim at cultivating positive emotions can enhance students' self-regulated learning and performance. In conclusion, the results of the current study provide compelling evidence for the importance of emotions in self-regulated learning and achievement of students in mathematics. Overall, the findings of the current study suggest that in addition to the "will" and the "skill" (see Pintrich & de Groot, 1990), students need to have the "thrill" to succeed in school.

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