Asia-Pacific Edu Res (2016) 25(3):415–422
DOI 10.1007/s40299-015-0251-4

REGULAR ARTICLE

Beyond Math Anxiety: Positive Emotions Predict Mathematics Achievement, Self-Regulation, and Self-Efficacy

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Published online: 23 July 2015

Abstract Research on the affective dimensions of mathematics learning and achievement has tended to focus on negative emotions and on mathematics anxiety in particular, with much less work on positive emotions. Drawing from a positive education perspective, we aim to contribute to the growing literature on positive emotions and learning. We hypothesize that positive emotions are associated with learning and achievement in mathematics, even when mathematics anxiety is considered. Filipino students enrolled in a college trigonometry course completed the Academic Emotions Questionnaire-Mathematics and scales assessing their self-efficacy and self-regulation in trigonometry. Students' final grades for the course were recorded with their informed consent. Hierarchical regression analysis indicated that *enjoyment* and *pride* explained a significant amount of variance in the final grades, self-regulation, and self-efficacy, even after accounting for the variance explained by gender and anxiety. Although the results cannot be interpreted as indicating a causal relationship between positive emotions and achievement, the results indicate how positive emotions in mathematics learning can contribute to a more balanced picture of the role of affective states in mathematics learning.

Keywords Positive emotions · Enjoyment · Pride · Anxiety · Mathematics achievement · Self-efficacy · Self-regulation

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Introduction

It would not be an exaggeration to state that there has been an inordinate amount of attention on negative emotions as it relates to mathematics learning, particularly on the negative emotion of math anxiety. A quick search in Google Scholar using the search terms "math anxiety" and "mathematics anxiety" yields nearly 3000 publications (journal articles, book chapters, and books). The debilitating effect of mathematics anxiety on different facets of the mathematics learning process has been documented rather extensively (Ashcraft 2002; Tempel and Neumann 2014), more so than works on positive emotions in mathematics learning. Previously, there had been suspicion regarding the effect of positive emotions in learning; as Aspinwall (1998) noted, there was a sense that, if the primary goal in learning was to feel good, this goal would make students lazy thinkers who are unlikely to appreciate useful negative information or to respond to variations in the situation that might detract from feeling good. But since then, there have been proposals to draw on learners' positive emotions as resources for promoting better learning and academic adjustment (Terjesen et al. 2004). The call to focus on positive emotions derives not only from an attempt to regain a more balanced view of learners' emotional experiences in school (Seligman et al. 2009), but from an extensive body of theory and research that indicates how positive affective experience can drive even more positive affective, cognitive, and behavioral outcomes (Lyubomirsky et al. 2005). In this study, we demonstrate how positive emotions (enjoyment and pride) are associated with Filipino students' achievement in a college trigonometry course and also with the students' self-regulation and self-efficacy in the same course. We demonstrate that positive emotions predict these learning variables even after controlling for the influence of anxiety.

Emotions and Mathematics Learning

In recent years, education researchers have highlighted the role of affective factors in shaping differences in students' levels of learning motivations and achievement (Bernardo et al. 2014; Linnenbrink-Garcia and Pekrun 2011; Suarez-Alvarez et al. 2014; Tsai et al. 2015). A casual reading of the literature suggests that there had been a tendency for researchers to focus more on students' negative emotions. Research has shown how negative emotions adversely affect students' motivations and cognitive strategies (Frenzel et al. 2007; Pekrun et al. 2009; Villavicencio 2011). But more critically, negative emotions seem to dampen the effects of self-beliefs such as perceived control (Ruthig et al. 2008) and self-efficacy (Villavicencio and Bernardo 2013a) on achievement.

The effects of negative emotion have been extensively studied in mathematics, which is typically an emotionally intense subject for students due to its difficult nature (Kleine et al. 2005). In particular, much attention has been devoted to mathematics anxiety (Ashcraft 2002), understanding its antecedents (Tempel and Neumann 2014) and its consequences on learners' self-beliefs (Schnell et al. 2015), on motivational (Ashcraft and Moore 2009; Luo et al. 2014) and cognitive (Ganley and Vasilyeva 2014) processes involved in mathematical tasks. We do not attempt to comprehensively review the literature on mathematics anxiety in this report; instead, we call attention to the role of positive emotions in student learning.

Perhaps to balance what some perceive as an over-emphasis on negative emotions, advocates of positive education have suggested that positive emotions and other positive affective states have an important role in optimal school functioning (Seligman et al. 2009). These proposals draw from positive psychology research that document the causal role of positive affect in fostering success in variety of domains (see metaanalysis by Lyubomirsky et al. 2005). Much of the research points to how positive emotions promote important factors that lead to optimal performance, such as goal setting (Hom and Arbuckle 1988), self-efficacy (Baron 1990), and intrinsic task interest (Erez and Isen 2002).

Theories of positive psychology, like the broaden-and-build theory (Fredrickson 2001, 2003), argue that positive emotions trigger more expansive cognitive processing and actions, which in turn foster further positive affective experiences in a continuing spiral of positive thoughts and action. In particular, positive emotions engender thoughts and behaviors (e.g., perceiving higher task value, setting higher performance goals, self-regulatory behaviors, cognitive flexibility, and generativity) that promote building more psychological resource (e.g., self-efficacy, confidence, hope and optimism, and approach goals) for adapting to changes and challenges in one's environment (Fredrickson 2013; Lyubomirsky et al. 2005). In contrast, according to broaden-and-build theory, negative emotions trigger narrower cognitive and behavioral responses (e.g., rigid behavioral tendencies, less-flexible problem-solving and thinking processes, and avoidant goals). As such, advocates of positive education suggest that positive emotions mark optimal levels of function that have short- and long-term benefits (Fredrickson 2001) and that could be applied toward the short- and long-term goals of learners (Terjesen et al. 2004).

There is considerable evidence to support these arguments on the role of positive emotions in learning. Students who experience more positive emotions use more flexible and creative cognitive strategies (Isen and Reeve 2005) and metacognitive learning strategies (King and Areepattamannil 2014). Enjoyment and other positive emotions are also associated with greater interest in learning (Ainley and Ainley 2011) and stronger engagement in learning tasks (King et al. 2015). Specific to mathematics, positive emotions are associated with greater confidence and more effort in learning in the subject (Pinxten et al. 2014) and also with more enhanced benefits of high control (Ruthig et al. 2008) and of self-regulation (Villavicencio and Bernardo 2013b) on achievement. In one study, the positive emotion of confidence even predicts achievement better than anxiety (Stankov et al. 2012).

We note that there are other theories that account for the different roles of positive and negative emotions in student learning and achievement, most notably the control-value theory of academic emotions (Pekrun 2006). The cognitive-motivational model of control-value theory has some overlapping assumptions with broaden-and-build theory, but it does not emphasize positive emotions over negative emotions. Thus, in line with the general thrust of positive education, for the present study we draw mainly from the theoretical assumptions of broaden-and-build theory (Fredrickson 2001) and positive psychology theories of positive affective states (Lyubomirsky et al. 2005), but draw from other theories of academic emotions (i.e., Pekrun 2006), whenever appropriate.

The Current Study

In this study, we focus on how Filipino university students' experiences of enjoyment and pride in their trigonometry classes relate to their achievement in that class, and also to their self-efficacy and use of self-regulation in trigonometry. We focus on self-regulation and self-efficacy (in addition to achievement) because these two are exemplars of the cognitive-behavioral tendencies and positive

resources that are predicted to be engendered by positive emotions, according to broaden-and-build theory. Moreover, these two variables are known to interact to predict performance in mathematics (Gómez-Chacón et al. 2014).

Self-regulated learning refers to "self-generated thoughts, feelings, and actions that are planned and systematically adapted as needed to affect one's learning and motivation" (Schunk and Ertmer 2000, p. 631). Self-regulated learners are those who "set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment" (Pintrich 2000, p. 453). There is considerable evidence that supports the important role of self-regulation in achievement (Duckworth et al. 2015; King and Gaerlan 2014) and also some studies that show how emotions are related to self-regulation during learning (Spangler et al. 2002).

On the other hand, self-efficacy is an individual's evaluation that he or she has specific performance capabilities on a particular type of task (Bandura 1997). In the school contexts, self-efficacy refers to learners' judgments about their ability to complete learning tasks and is an important predictor of academic achievement (McIlroy et al. 2015; Tan and Tan 2014). The relationship between self-efficacy and achievement is mediated by motivation-related processes such as choosing more difficult tasks, expending greater effort, more persistence, and also by cognitive processes like problem-solving strategies and metacognitive processes similar to self-regulation (Schunk and Ertmer 2000).

Thus, we hypothesize that positive emotions would be associated with students' self-efficacy, use of self-regulation, and achievement. We focus on two positive emotions, enjoyment and pride, which are two of the basic positive emotions typically reported by students (Pekrun 2006). The two emotions are different in terms of their object focus. Enjoyment is focused on the activity, which means that students experience the positive emotion with reference to their learning tasks. In contrast, pride is focused on the outcome; students experience pride because their performance in some learning tasks meets their standards or expectations (Pekrun 2006). In concrete terms, for example, students *enjoy* their class activities and lessons in trigonometry; enjoyment will show its influence on the students' motivations, engagement, and cognitive strategies while engaging these learning tasks (e.g., self-efficacy and self-regulation), which should have a positive influence on learning achievement. On the other hand, students feel *pride* when they obtain good scores on their trigonometry quizzes and assignments, which could also have positive associations with motivation and creative problem solving. But pride may also have some negative side effects when excessive pride expresses itself mainly in the glory of achievement, which may result in neglect of the further pursuit in their learning tasks (Pekrun and Perry 2014). Thus, although both positive emotions are expected to be positively associated with learning (Frenzel et al. 2007), we should understand that the pathways to achievement might involve slightly different psychological processes.

We aim to show that positive emotions can incrementally predict variations in achievement, self-regulation, and self-efficacy, over and above the variation explained by anxiety in mathematics, which, as we have briefly summarized earlier, is also related to these learning processes and outcomes. Doing so would strengthen the claim that positive emotions are important predictors of these learning processes. Finally, we also include gender in the analysis because there has been extensive research on gender differences in achievement in mathematics (Halpern et al. 2007), and some have linked this gender difference to mathematics anxiety—female students are more anxious about mathematics than their male counterparts (Erturan and Jansen 2015). There are also studies that suggest that female students have lower self-efficacy in mathematics (Else-Quest et al. 2010).

In summary, we study the relationship between Filipino university students' experiences of enjoyment and pride in their trigonometry classes using hierarchical regression analyses, where gender and anxiety are included in the more basic models, prior to testing the model that includes the relationship between the two positive emotions and three learning variables: final grades in the class, self-regulation, and self-efficacy. We hypothesize that, in all three learning variables, enjoyment and pride would explain a significant amount of variance, even after accounting for the variance explained by gender and anxiety.

Method

Procedure and Participants

Prior to data collection, permission was sought from the chair of the mathematics department of a large state university in the Central Luzon region, who later endorsed the request to the various trigonometry instructors. With the consent of the instructors, the questionnaires were administered to their classes during a two-week period after the midterm; the data-gathering activity lasted about 15 min.

For each of the 31 large classes, a preset number of students were randomly selected to participate in the study. However, only participants who gave their informed consent (which included consent to allow the researchers to record their final grade in the course) prior to the date of the data-gathering activity were included in the study. As

some participants were below the age of consent, these participants were requested to obtain consent from their parent/guardian if they agreed to participate. The final participants were 1345 engineering students (906 male, 439 female), all Filipinos, with an age range of 15–25 years ($M = 16.49$, SD = 1.66).

Measures

All the measures used in the study were in English, as English is the medium of instruction in the trigonometry classes, and all assessment procedures in the class (quizzes, exams) were also administered in English.

Academic Emotions

The emotion measures were obtained from the Academic Emotions Questionnaire-Math (AEQ-M, Frenzel et al. 2007). Positive emotions include 10 items about enjoyment of learning (e.g., "*I enjoy trigonometry so much that I was strongly motivated to participate*") and 6 items of pride (e.g., "*I am proud of how well I have done in trigonometry class.*"). On the other hand, academic anxiety consists of 16 items (e.g., "*When taking the trigonometry test, I worry I will get a bad grade.*") The instructions clarified that items refer only to their trigonometry class and do not refer to their emotions related to their trigonometry teachers. Participants were told that there were no right and wrong answers and that responses would be treated with confidentiality. Participants responded using a scale from 1 (*strongly disagree*) to 5 (*strongly agree*).

Self-Efficacy for Trigonometry Learning

The self-efficacy for learning scale of the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al. 1991) was used. The scale had eight items (e.g., *"I'm certain I can understand the most difficult lessons presented in trigonometry."*), which were answered on a scale from 1 (*not at all true of me*) to 5 (*very true of me*).

Self-Regulation in Trigonometry Learning

The self-regulation scale of the MSLQ (Pintrich et al. 1991) was used. It had 12 items (e.g., *"When I become confused about something I'm reading in trigonometry, I go back and try to figure it out."*), which were answered using the same scale as above.

Mathematics Achievement

Achievement was measured using the students' final grades in trigonometry provided by course instructors at the end of the semester. The grades were computed by combining various assessments: problem exercises, quizzes, assignments, and midterm and final exams. The highest grade possible was 100 and the lowest grade given was 65; the passing grade was 75.

Results

Table 1 shows the descriptive statistics for the final grades and scores for self-regulation, self-efficacy, and the three academic emotions in trigonometry. To test the hypothesis that positive emotions predict positive processes and outcomes in learning mathematics beyond the variance explained by anxiety, three hierarchical multiple regression analyses were conducted. Each of the three dependent variables (self-efficacy, self-regulation, and final grades) was regressed first on gender in Model 1. Anxiety was then added for Model 2, and then the two positive emotions were added for Model 3. The results of these regression analyses are summarized in Table 2.

Although not related to our main hypothesis, we note that gender was not significantly related to achievement, but was related to self-efficacy in trigonometry learning (male students were higher). As expected, anxiety was negatively associated with all three dependent variables. But most important to our hypotheses, the addition of the positive emotions explained a significant portion of the variance in all three dependent variables, over and above the variance explained by anxiety. The additional variance in final grades explained by positive emotions was only around 3 %, but this was a significant increase. Interestingly, enjoyment and pride were associated with the final grades in different ways, with enjoyment positively predicting grades and pride negatively so. The pattern of results was similar for self-regulation and self-efficacy, with positive emotions explaining an additional 30 % of the variance in the two dependent variables. Unlike with final grades, the two positive emotions were both positively associated with self-regulation and self-efficacy.

Discussion

The results of our study indicate that, aside from mathematics anxiety, there is some incremental value in looking at positive emotions that students experience in mathematics. Even after accounting for influence of anxiety, the results show that students' experiences of enjoyment and pride explain an additional amount of variance in the students' final grade, self-efficacy, and self-regulation in the trigonometry class. Both enjoyment and pride had positive associations with both self-efficacy and self-regulation.

Table 1 Descriptive Statistics

	Cronbach α	*M*	SD	Correlations (*r*)				
				(2)	(3)	(4)	(5)	(6)
(1) Anxiety	.86	2.51	.65	−.49**	.38**	.51**	−.27**	−.44**
(2) Enjoyment	.83	3.55	.68		.81**	.74**	.60**	.36**
(3) Pride	.86	3.60	.83			.71**	.57**	.23**
(4) Self-efficacy	.89	3.28	.73				.60**	.35**
(5) Self-regulation	.81	3.51	.55					.21**
(6) Final grade	–	78.94	6.23					

** $p < .0001$

Table 2 Summary of regression analyses

	Final grades			Self-regulation			Self-efficacy		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Gender	.04	−.03	−.04	.02	−.02	−.03	.18*	.10*	.09*
Anxiety		−.45**	−.36**		−.27**	.03		−.49**	−.19*
Enjoyment			.29**			.43**			.35**
Pride			−.13*			.24**			.36**
R^2	.00	.20	.23	.00	.07	.39	.03	.27	.62
F	2.19	166.28**	99.92**	<1.0	51.15**	210.36**	44.87**	244.44**	550.24**
df	1,1343	1,1342	1,1340	1,1343	1,1342	1,1340	1,1343	1,1342	1,1340
ΔR^2		.20	.03		.07	.32		.24	.36
ΔF		329.84**	27.09**		101.55**	343.47**		429.69**	627.73**
df		1,1342	1,1340		1,1342	1,1340		1,1342	1,1340

* $p < .05$, ** $p < .0001$

Consistent with the assumptions of broaden-and-build theory, the experience of positive emotions fosters cognitive-behavioral processes (self-regulation) and psychological resources (self-efficacy) that are important components of optimal performance. In theory, these positive consequences of positive emotions should spiral up into further positive emotions and outcomes. However, if we look at the associations with final grade, that is not consistently so.

Enjoyment and pride predict the final grades in opposite ways. The positive relationship between achievement and enjoyment is consistent with much of the previous literature (Frenzel et al. 2007; Pekrun and Perry 2014) and with the broaden-and-build assumption that the positive effect of enjoyment would be sustained and spiraled onward leading to high levels of performance until the completion of the class. On the other hand, the negative association between pride and final grade is consistent with observations that, in cases when high levels of pride become associated with basking in the glory of achievement (Pekrun and Perry 2014), the student might not focus as much resources to further academic pursuit and lead to declines in performance. Thus, instead of building on and broadening the cognitive and affective resources for further achievement, it seems that the students who reported high levels of pride may have rested on their laurels, so to speak.

The simple implication of these findings is that teachers should value these positive emotions when their students experience them and, whenever possible, create opportunities wherein these emotions can be experienced and sustained. In the context of mathematics classes for example, creating learning activities that are enjoyable to the students is likely to make the students believe that they can engage and manage the learning tasks and also to engender more cognitive flexibility and self-regulation while doing the task. As suggested by broaden-and-build theory (Fredrickson 2001, 2003), the creation of these positive resources further enhances the positive emotional experiences, and, if this is sustained, the students can achieve optimal outcomes at the end of the learning cycle.

It is also important to affirm student achievements, so they can experience pride in the mathematics classroom. The experience of pride is also associated with positive

self-beliefs and self-regulatory processes that are known to be important components of successful learning (Duckworth et al. 2015; McIlroy et al. 2015). But teachers should ensure that feelings of pride are associated with cognitive and motivational processes that lead to successful outcome that is the object of pride and guard against having pride be associated with personal aggrandizement. As indicated in our results, it is possible that pride might result in losing focus on furthering academic pursuits and lead to lower academic outcomes.

Interestingly, in many Asian cultures, pride is not always seen as a positive emotion, as it may also be associated with arrogance and self-satisfaction. In this regard, it may be interesting to inquire into the cultural meanings associated with these positive emotions. Researcher also suggests that there are cultural differences in the level of arousal associated with ideal positive affect, with Asians preferring low-arousal positive affective states compared to their western counterparts, who prefer higher-arousal positive emotions (Tsai 2007). This might have an implication for what types of activities are considered "enjoyable" by students from different cultures. Or perhaps other positive emotions like curiosity, awe, amusement, or interest are more important in the experience of various Asian students that may be more relevant to understanding Asian students' learning and achievement in mathematics and other domains.

A more in-depth cultural analysis of the role of positive emotions was beyond the limited scope of our study and would need to be addressed in future research. And there are other important limitations that we should note. One limitation relates to the use of self-reports to examine students' emotions, and self-reports are not the most reliable measure of emotions; previous studies have raised issues regarding how Filipino students conceptualize academic emotions (Bernardo et al. 2009). But we should note that the AEQ-M has been established as a reliable and valid measure of academic emotions in different cultures (Frenzel et al. 2007; Pekrun et al. 2002). We also measured emotions only at one point in the class, which may not be ideal given that emotions are likely to be fluid and changing in the course of the study. Future research should consider using multiple longitudinal measures of these emotions. We should also note that there is a possibility that the negative relationship between pride and performance may indicate a negative or net suppression effect (Cohen and Cohen 1975), as we observe that the three variables (enjoyment, pride, and grade) are actually positively correlated with each other. If this is actually a net effect, then the pride is actually suppressing the error variance in enjoyment and not actually explaining the variance in performance. The best way to rule out the net suppression effect is by using experimental and/or longitudinal designs, which would allow more direct test of the negative relationship between pride and academic performance of students.

Notwithstanding these limitations, our study still achieves its modest goal, which is to show how positive emotions can incrementally predict learning process variables and outcomes over and above the variance explained by anxiety. We noted that there has been so much focus on the negative emotion of anxiety, and our results show that focusing on positive affective states can also be as informative, consistent with the premises of positive education (Terjesen et al. 2004) that apply principles of positive psychology (Seligman and Csikszentmihalyi 2000) and particularly the arguments related to how positive emotions broaden people's cognitive resources (Fredrickson 2001). We hope that our results that highlight the important role of positive emotions in trigonometry learning can call further attention of researchers and educational professionals to the important role of positive affective experiences in learning and schools.

Acknowledgements This research was supported by a Faculty Development Grant and a Dissertation Grant awarded to the first author by the Commission on Higher Education, Philippines. Preparation of this manuscript was supported in part by a grant to the second author from the Research Development and Administration Office of the University of Macau (Project Reference No.: SRG014-FSH13-ABIB).

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