British Journal of Educational Technology *Vol 45 No 1 2014* 171–185
doi:10.1111/j.1467-8535.2012.01382.x

Affective and motivational factors of learning in online mathematics courses

ChanMin Kim, Seung Won Park and Joe Cozart

ChanMin Kim, Ph.D., is Assistant Professor at The University of Georgia, Department of Educational Psychology and Instructional Technology. Seung Won Park is a Doctoral Candidate at The University of Georgia, Department of Educational Psychology and Instructional Technology. Joe Cozart, Ph.D., is Associate Director of Strategic Planning at the Georgia Department of Education. Address for correspondence: Dr ChanMin Kim, Educational Psychology and Instructional Technology, The University of Georgia, 217 Rivers Crossing, 850 College Station Road, Athens, GA 30602, USA. Email: chanmin@uga.edu

Abstract

We investigated what factors would be related to students' achievement in mathematics courses offered at a virtual high school. This was an attempt to understand *why* some succeed and some do not as well as to suggest what should be done to help with student success. Seventy-two students responded to a self-report survey on motivation (ie, self-efficacy, intrinsic value), mathematics achievement emotions (ie, anxiety, anger, shame, hopelessness, boredom, enjoyment, pride), and cognitive processes (ie, cognitive strategy use, self-regulation). A three-step hierarchical multivariate regression was employed to examine which of the factors predict student achievement. Results showed that motivation accounted for approximately 13% of the variance in student achievement and self-efficacy was the significant individual predictor of student achievement. However, when achievement emotions were added to the analysis, self-efficacy failed to predict student achievement and emotions accounted for 37% of the variance in student achievement. Cognitive strategy use and self-regulation did not explain any additional variance in the final scores. Findings are discussed and implications for future research and development are also suggested.

Mathematics is a core academic subject, not just for the domains of science, technology, engineering and mathematics but for nearly all students in nearly any domain (National Mathematics Advisory Panel [NMAP], 2008). It is important to develop the "means for reducing the mathematics achievement gaps that are prevalent in U.S. society" due to increased expectations in mathematics education (NMAP, 2008, p. xx). In response to national pressure to improve education in K-12 schools, many states have introduced new standards. Typically, these standards have raised the bar for mathematics in serious ways because of the ongoing struggle in the USA to demonstrate higher levels of mathematical proficiency on international assessments such as Trends in International Mathematics and Science Study (Martin, Mullis, Gonzalez & Chrostowski, 2004).

Learning mathematics *online* can be even more challenging for students due to a sense of isolation and a lack of social support in online learning environments (Erichsen & Bolliger, 2011; Muilenburg & Berge, 2005; Murphy & Rodríguez-Manzanares, 2008; Song, Singleton, Hill & Koh, 2004). Online education has shown phenomenal growth in its use and development (Watson, Murin, Vashaw, Gemin & Rapp, 2011). In the 2004–05 school year, there were 65% more K-12 public school students enrolled in online courses than there were in 2002–03 in the

Practitioner Notes

What is already known about this topic

- Motivation is important in students' learning and performance.
- Self-efficacy is a significant predictor for student motivation and learning.

What this paper adds

- Self-efficacy was not a predictor any more once achievement emotions were taken into account.
- Achievement emotions were useful in explaining student motivation and performance in online learning environments.
- The emotion of anger was the strongest individual predictor of student achievement. Lack of interpersonal interactions may have let adolescents' anger hinder their actions of studying without the opportunity of receiving social support from peers.
- The findings of this paper illustrate the interdependence of emotions, motivation and learning in a K-12 online learning setting.

Implications for practice and/or policy

- Unlike outcomes-oriented research that focuses on what knowledge is acquired or not, this study provides a basis that suggests diverse paths to promote student learning in online mathematics courses.

USA (Zandberg & Lewis, 2008). Over 1 million students took online courses in the 2007–08 school year, and it is estimated that 5 million students (ie, 10% of K-12 students) will take online courses in 5 years in the USA (Picciano & Seaman, 2007, 2009; Picciano, Seaman & Allen, 2010). The enrollment keeps rapidly increasing along with the growth of online virtual schools (Tucker, 2007). In the USA, all but one state has virtual schools according to a national investigation (Watson *et al*, 2011).

The *promise* that virtual schooling will equal or exceed the quality of education in face-to-face schools (Cavanaugh, 2001; Cavanaugh, Gillan, Kromrey, Hess & Blomeyer, 2004; Hughes, McLeod, Brown, Maeda & Choi, 2007) partly explains the widespread needs and expectations for virtual schooling (Hawkins, Barbour & Graham, 2012). Studies specifically on learning mathematics online also indicate that online courses are effective enough to become an alternative to face-to-face courses (Cavanaugh, Gillan, Bosnick & Hess, 2008; Hughes *et al*, 2007). Hughes and her colleagues (2007) found that students in algebra classes offered at virtual schools outperformed students in algebra classes offered at traditional schools in a content knowledge test. Learning gains were observed in online algebra learning classes regardless of the use of interactive technologies (Cavanaugh *et al*, 2008).

However, research findings are still inconsistent (Barbour, 2011; Hughes *et al*, 2007), and effectiveness comparison research does not necessarily provide much information of how to improve the design of online teaching and learning environments (Murphy, Rodríguez-Manzanares & Barbour, 2011). Over 10 years ago, Cavanaugh (2001) emphasized that online education can be as effective as face-to-face education "when implemented with the same care as effective face-to-face instruction" (p. 84). Exactly what *care* is needed remains unresolved. Recent research attempts to understand K-12 teachers' perspectives on online teaching as a way of examining what support (eg, professional development) could help improve virtual schooling (DiPietro, Ferdig, Black & Preston, 2008; Hawkins *et al*, 2012; Murphy *et al*, 2011). It would be also helpful

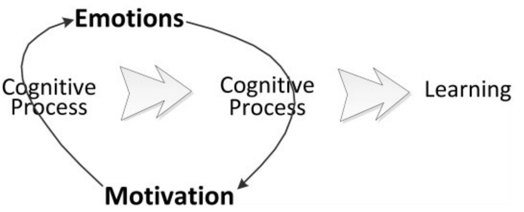

Figure 1: Role of motivation, emotions and cognitive processes in the process of learning

to know what support students need considering that the popularity of online learning does not guarantee student success (Barbour & Reeves, 2009; Cavanaugh, Barbour & Clark, 2009). Student readiness and retention can be challenging (Barbour & Reeves, 2009) and course dropout rates can be an issue (Kozma *et al*, 2000). In brief, there is a need to understand *why* some students succeed and some do not in order to suggest what should be done to improve student success in online mathematics learning.

The purpose of this study was to investigate what factors are related to students' achievement in mathematics courses offered at a virtual high school. Three kinds of factors were explored in this study: (1) motivational factors included self-efficacy and intrinsic value (Bandura, 1977, 1997, 2004; Eccles-Parsons *et al*, 1983; Pintrich & Schunk, 2002), (2) affective factors included mathematics achievement emotions (ie, boredom, anxiety, enjoyment, anger, shame, pride and hopelessness) (Pekrun, Goetz & Frenzel, 2007) and (3) cognitive process factors included cognitive strategy use and self-regulation (Pintrich & DeGroot, 1990; Zusho, Pintrich & Coppola, 2003).

Motivation, emotion and cognitive process

Learner motivation refers to desire to engage in a learning activity; achievement emotions refer to affective experiences in relation to an achievement activity or its outcome (Kim & Pekrun, in press). The role of motivation and emotions is crucial to learning (Astleitner, 2000; Carver & Scheier, 1990; Goetz, Pekrun, Hall & Haag, 2006; Op 't Eynde, de Corte, & Verschaffel, 2006; Pekrun, 1992; Pekrun, Goetz, Titz & Perry, 2002). For example, when students lack motivation, their learning process is rarely initiated (Bandura, 1986; Schunk, 1991). When students feel hopeless, their learning process is easily discontinued. To understand student learning, motivation and emotions should be studied also along with cognition (Ainley, 2006; Hannula, 2006; Meyer & Turner, 2006; Op 't Eynde & Turner, 2006; Op 't Eynde *et al*, 2006; Pekrun, 2006; Turner & Patrick, 2008). Online learning is no exception. In fact, motivation is often included in attempts to predict and understand student performance in K-12 online courses (eg, Roblyer, Davis, Mills, Marshall & Pape, 2008; C. Weiner, 2001); however, emotions are rarely considered in relation to motivation or cognition. Figure 1 illustrates the role of motivation, emotions and cognitive processes in learning as discussed in the following.

Motivation and emotions influence each other to lead to a certain action (or inaction) (Hannula, 2006; McLeod, 1988; Op 't Eynde & Turner, 2006; Op 't Eynde *et al*, 2006; Pekrun, 2006). Expectancy assessment is involved in this reciprocal process (Carver & Scheier, 1990). In other words, people's motivational and emotional responses occur based on (1) their perceived value of a certain action as well as (2) expectancy stemmed from their perceived control over the outcome of the action (Carver & Scheier, 1990; Eccles, 1983; Pekrun, 2006; B. Weiner, 1985). For example, Jenny has to retake a mathematics course that she failed last semester. Because the course is required for her high school graduation but it is not offered in the current semester at her school, she is enrolled in a course offered online at a virtual high school. The value of the course motivates Jenny to study hard; at the same time, her motivation can wither away and her anxiety level can be heightened unless she perceives control over the outcome. That is, her perception should be that her ability, not luck, would determine her success and her effort would equip her with sufficient ability for success. Typically, students' perceived task *value* and *self-efficacy* are considered important in determining their motivation to learn (Pintrich & Schunk, 2002). The emotions of *boredom, anxiety, enjoyment, anger, shame, pride, and hopelessness* are considered core achievement emotions that determine students' affective experiences (Goetz *et al*, 2006).

Motivation and emotions impact cognitive processes (Forgas, 2000; Gläser-Zikuda, Fuß, Laukenmann, Metz & Randler, 2005; Linnenbrink, 2006; Pekrun, 2006; Pekrun *et al*, 2002; Schwarz, 1990, 2000). In this study, cognitive processes include cognitive strategy use and self-regulation (Zusho *et al*, 2003). Cognitive strategies refer to rehearsal, elaboration, and organization and self-regulation refers to "planning, monitoring, and controlling" cognition (Zusho *et al*, 2003, p. 1084). For example, *the use of cognitive strategy* can be altered by emotions (Pekrun, 2006; Pekrun *et al*, 2002). Information is stored and retrieved differently depending on discrete emotions (Blaney, 1986; Bower, 1981; Levine & Pizarro, 2004). For instance, in the study of Holmberg and Holmes (1994), whether people were happy or unhappy about their marriage at present made their memory of early years of their marriage different. This implies that students' memory and recall of course materials can be different depending on their emotional experiences. Positive emotions (eg, enjoyment) tend to facilitate the flexible use of cognitive strategies and creativity whereas negative emotions (eg, anxiety) tend to lead to the rigid use of narrowly focused strategies (Isen, 2000; Levine & Pizarro, 2004). In addition, motivation and emotions influence *self-regulation* by facilitating or impeding self-monitoring processes (see Carver & Scheier, 1990 for review).

Much research on motivation, emotions and cognitive processes was conducted in face-to-face settings. However, students tend to sense disconnectedness in online learning environments due to a lack of interactions with their instructor and classmates (Hawkins *et al*, 2012; Song *et al*, 2004; C. Weiner, 2001). The lack of interactions between students and instructors as well as among students in both quantity and quality (Kozma *et al*, 2000) can impact students' motivation, emotions, and cognitive processes that typically involve social influence (Schunk, Pintrich & Meece, 2008). For example, self-efficacy, a critical factor of motivation as discussed earlier, is positively correlated with interactions within a community of inquiry (Shea & Bidjerano, 2010). Another recent study reports that students viewed their interactions with instructor as well as with peers as motivational (Borup, Graham & Davies, in press).

Researchers argue that such interactions are especially important in K-12 online courses with adolescents (DiPietro *et al*, 2008; Murphy & Rodríguez-Manzanares, 2008; Roblyer, Freeman, Stabler & Schneidmiller, 2007; C. Weiner, 2001). This emphasis may be because peer influence is essential in adolescents' coping with difficulties (Berndt & Perry, 1986; La Greca & Lopez, 1998). In understanding how motivation develops and changes, "the transactions among persons" are important (Turner & Patrick, 2008, p. 119). Interactions in online courses are also critical in forming students' emotional experience. Emotions are "socially constructed" although they are "personally enacted" (Schutz, Hong, Cross & Osbon, 2006, p. 344). Cognitive processes are impacted by online interactions as well; for instance, self-regulation was found to be positively correlated with social presence that was resulted from online interactions (Shea & Bidjerano, 2010). Besides, mathematics is learned *socially* throughout interactions with the instructor and classmates (Balacheff, 1990; Davydov & Kerr, 1995; Van Oers, 2006).

In brief, motivation, emotions and cognitive processes are influenced by interactions with their instructor and classmates; it would be interesting to see how motivation, emotion and cognition interplay in online K-12 mathematics learning environments where student–student and student–teacher interactions tend to be minimal (Hawkins *et al*, 2012; Kozma *et al*, 2000; C. Weiner, 2001). However, these three processes have rarely been studied together to understand learning processes in online courses. In an empirical study, teachers in high school online courses acknowledged that limited interactions could create students' negative emotions such as fear and anxiety and diminish the opportunity to prompt students' motivation (Murphy & Rodríguez-Manzanares, 2008); however, students' motivational and emotional experiences were not systematically investigated.

Research questions

To understand what factors are related to students' achievement in mathematics courses offered at a virtual high school, we investigated the relationships between motivation, mathematics achievement emotions, cognitive process and academic achievement of students. The following research questions were addressed:

1. How do motivational factors (ie, self-efficacy and intrinsic value) predict student achievement in online mathematics courses?
2. How do affective factors (ie, mathematics achievement emotions; boredom, anxiety, enjoyment, anger, shame, pride, and hopelessness) predict student achievement in online mathematics courses?
3. How do cognitive process factors (ie, cognitive strategy use and self-regulation) predict student achievement in online mathematics courses?
4. How are students' motivation, mathematics achievement emotions and cognitive processes related to each other in online mathematics courses?

Methods

Participants

Participants were 72 students enrolled in online mathematics courses offered at a virtual high school in the southeastern USA. The typical course completion rate with satisfactory grades is approximately 75%, not including students who dropped out of the courses. The average age of the participants was 16.7 years; 61.1% were female ($n = 44$). Sixty-five point three per cent of the participants were Caucasian ($n = 47$), 11.1% were Black/African American ($n = 8$), 11.1% were Asian American ($n = 8$), 8.3% were Hispanic/Latino ($n = 6$) and 4.2% were multiracial ($n = 3$).

Data collection

Motivation

Self-efficacy and intrinsic value were measured using the motivational beliefs section of the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich & DeGroot, 1990) that consists of 22 items related to self-efficacy, intrinsic value and test anxiety. However, four items related to test anxiety were excluded since test anxiety pertains to achievement emotions of this study. Students responded to each item using a 7-point Likert scale ranging from 1 (*Not at all true of me*) to 7 (*Very true of me*). Reliability of scores on the various subscales that make up the motivational beliefs section of the MSLQ has been reported with a Cronbach's alpha value ranging from 0.62 to 0.93 (Pintrich, Smith, Garcia & McKeachie, 1991) and validity of scores has also been assessed and verified in a variety of school settings (eg, Wolters & Pintrich, 1998). Scale reliabilities in this study ranged from 0.85 to 0.90 (see Table 1).

Achievement emotions

The achievement emotions of boredom, anxiety, enjoyment, anger, shame, pride and hopelessness were measured using the Achievement Emotion Questionnaire in Mathematics (AEQ-M) (Pekrun *et al*, 2007). The AEQ-M is a multidimensional self-report instrument that is designed to assess students' emotions experienced in mathematics learning contexts. The AEQ-M measures emotions that are linked to learning and achievement activities and their outcomes. It contains 60 items measuring seven discrete emotions relating to mathematics: boredom, anxiety, enjoy-

Table 1: Scale reliability (Cronbach's alpha)

Factors	*Scales*	*Sample items*	*Cronbach's alpha*
Motivation	Self-efficacy	I'm certain I can understand the ideas taught in this course.	.90
	Intrinsic value	I like what I am learning in this class.	.85
Mathematics achievement emotions	Boredom	My math homework bores me to death.	.83
	Anxiety	I start sweating because I am worried I cannot complete my assignments in time.	.93
	Enjoyment	I enjoy my math class.	.67
	Anger	My math homework makes me angry.	.81
	Shame	When I don't understand something in my math homework, I don't want to tell anybody.	.81
	Pride	I think I can be proud of my knowledge in mathematics.	.70
	Hopelessness	During the math test, I feel hopeless.	.90
Cognitive process	Cognitive strategy	I use what I have learned from old homework assignments and the textbook to do new assignments.	.84
	Self-regulation	I ask myself questions to make sure I know the material I have been studying.	.59

ment, anger, shame, pride and hopelessness. For this study, some items have been reworded to align better with the asynchronous online course environment where students review and study course materials in a course website. For example, the item "I am so angry during my math class that I would like to leave" has been revised to "I am so angry during my math class that I would like to log out of the course website." Students responded to each item using a 5-point Likert scale ranging from 1 (*Strongly disagree*) to 5 (*Strongly agree*). Reliability of scores on the various subscales that make up the AEQ-M has been assessed at 0.84 to 0.92 (Pekrun *et al*, 2007) and validity of test scores has also been assessed and verified in a variety of school settings (eg, Frenzel, Thrash, Pekrun & Goetz, 2007; Pekrun *et al*, 2004). Scale reliabilities in this study ranged from 0.67 to 0.90 (see Table 1).

Cognitive processes

Cognitive strategy use and self-regulation were measured using the self-regulated learning strategies section of MSLQ (Pintrich & DeGroot, 1990) that consists of 22 items related to cognitive strategy use and self-regulation. Items have been adapted to reflect the participants of this study who were in online mathematics courses. For example, the item "I outline the chapters in my book to help me study" has been revised to "I outline the information in online course materials to help me study." Reliability for the various sub-measures that make up the self-regulated learning strategies section of the MSLQ has been assessed at 0.52 to 0.80 (Pintrich *et al*, 1991) and validity of the measure has also been assessed and verified (eg, Wolters & Pintrich, 1998) in a variety of school settings. Scale reliabilities in this study ranged from 0.59 to 0.84 (see Table 1).

Achievement

Achievement was measured using students' final grade scores. The possible range of the final score was 0–100. Integrity in student grades is emphasized in the virtual school to make the grade a more true indicator of achievement than would be found in a school with less robust policies. For example, the virtual school policies dictate that the grade represent the level of content standard mastery; there are no easy bonus points for turning in a parent signed syllabus or anything like that where the bonus is detached from content standards. The state board rule for virtual learning requires schools to transcribe the grade assigned so that students know that they have to meet the course expectations.

Procedure

Participants were recruited in the first week of the courses. In the second week of the semester, those who agreed to participate in our study received an email with a link to a webpage that presented surveys with demographic questions and questions to measure their (1) motivation (ie, self-efficacy and intrinsic value), (2) achievement emotions (ie, boredom, anxiety, enjoyment, anger, shame, pride and hopelessness) and (3) cognitive processes (ie, cognitive strategy use, self-regulation). Participants' final grade scores were collected after the semester ended.

Results

A three-step hierarchical multivariate regression was computed to explore the relation between student achievement and the motivation, emotion and cognitive process variables. The motivation variables (ie, self-efficacy, intrinsic value) were entered in the first step of these analyses, the achievement emotion variables (ie, boredom, anxiety, enjoyment, anger, shame, pride and hopelessness) were entered in the second step, and the cognitive process variables (ie, cognitive strategy use, self-regulation) were entered in the last step. This analysis strategy was selected because (1) achievement emotions are often viewed as a result of motivation despite the bidirectional influence between the two and (2) both influence students' use of cognitive strategies and their self-regulation (eg, Carver & Scheier, 1990; Op t'Eynde *et al*, 2006; Pekrun, 2006; Pekrun *et al*, 2002). Table 2 presents means, standard deviations and correlations of the variables in the study.

Pearson correlations indicate that final scores were correlated significantly with self-efficacy but not with cognitive strategy use and self-regulation. The correlational results also indicate that final scores were related significantly to all mathematics achievement emotions but boredom. Students with a higher final score tended to report the lower levels of anxiety ($r = -0.33$, $p < 0.01$), anger ($r = -0.51$, $p < 0.01$), shame ($r = -0.37$, $p < 0.01$) and hopelessness ($r = -0.44$, $p < 0.01$) but the higher levels of enjoyment ($r = 0.41$, $p < 0.01$) and pride ($r = 0.30$, $p < 0.01$).

The correlations between the motivational variables and the achievement emotions were significant. Students with a higher self-efficacy tended to report the lower levels of boredom ($r = -0.45$, $p < 0.01$), anxiety ($r = -0.49$, $p < 0.01$), anger ($r = -0.61$, $p < 0.01$), shame ($r = -0.46$, $p < 0.01$) and hopelessness ($r = -0.63$, $p < 0.01$) but the higher levels of enjoyment ($r = 0.58$, $p < 0.01$) and pride ($r = 0.52$, $p < 0.01$). Students who perceived a higher intrinsic value tended to report the lower levels of boredom ($r = -0.67$, $p < 0.01$), anxiety ($r = -0.24$, $p < 0.05$), anger ($r = -0.49$, $p < 0.01$) and shame ($r = -0.27$, $p < 0.05$), hopelessness ($r = -0.46$, $p < 0.01$) but the higher levels of enjoyment ($r = 0.64$, $p < 0.01$) and pride ($r = 0.66$, $p < 0.01$).

The correlations between motivation and cognitive processes were significant. Students with a higher self-efficacy tended to report the higher levels of cognitive strategy use ($r = 0.43$, $p < 0.01$) and self-regulation ($r = 0.57$, $p < 0.01$). Students with a higher perception of intrinsic value tended to report the higher levels of cognitive strategy use ($r = 0.61$, $p < 0.01$) and self-regulation ($r = 0.73$, $p < 0.01$).

With regard to correlations between emotions and cognitive processes, students with the lower levels of boredom ($r = -0.39$, $p < 0.01$) but with the higher levels of enjoyment ($r = 0.34$, $p < 0.01$) and pride ($r = 0.23$, $p < 0.05$) tended to report a higher level of cognitive strategy use. Students with the lower levels of boredom ($r = -0.57$, $p < 0.01$), anger ($r = -0.44$, $p < 0.01$), shame ($r = -0.31$, $p < 0.01$) and hopelessness ($r = -0.44$, $p < 0.01$) but with the higher levels of enjoyment ($r = 0.56$, $p < 0.01$) and pride ($r = 0.56$, $p < 0.01$) tended to report a higher level of self-regulation.

Table 2: Means, standard deviations, zero-order correlations and reliabilities for the study variables (n = 72)

	M	SD	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1. Self-Efficacy[a]	45.79	9.65	—											
2. Intrinsic value[b]	46.47	9.22	0.74**	—										
3. Cognitive Strategy[c]	66.43	12.34	0.43**	0.61**	—									
4. Self-Regulation[d]	42.00	7.26	0.57**	0.73**	0.57**	—								
5. Boredom[e]	8.95	3.66	−0.45**	−0.67**	−0.39**	−0.57**	—							
6. Anxiety[f]	31.94	12.94	−0.49**	−0.24*	0.01	−0.21	0.28*	—						
7. Enjoyment[g]	17.01	4.52	0.58**	0.64**	0.34**	0.56**	−0.74**	−0.42**	—					
8. Anger[h]	12.45	5.48	−0.61**	−0.49**	−0.09	−0.44**	0.63**	0.61**	−0.62**	—				
9. Shame[i]	11.48	5.57	−0.46**	−0.27*	−0.05	−0.31**	0.27*	0.74**	−0.40**	0.64**	—			
10. Pride[j]	13.87	3.73	0.52**	0.66**	0.23*	0.56**	−0.61**	−0.27*	0.64**	−0.57**	−0.47**	—		
11. Hopelessness[k]	16.66	7.93	−0.63**	−0.46**	−0.15	−0.44**	0.44**	0.84**	−0.58**	0.74**	0.78**	−0.44**	—	
12. Final[l]	81.88	13.44	0.35**	0.19	−0.04	0.12	−0.19	−0.33**	0.41**	−0.51**	−0.37**	0.30**	−0.44**	—

Notes:
[a]Possible range of Self-Efficacy score: 9–63.
[b]Possible range of Intrinsic Value score: 9–63.
[c]Possible range of Cognitive Strategy score: 13–91.
[d]Possible range of Self-Regulation score: 9–63.
[e]Possible range of Boredom score: 3–15.
[f]Possible range of Anxiety score: 11–55.
[g]Possible range of Enjoyment score: 6–30.
[h]Possible range of Anger score: 5–25.
[I]Possible range of Shame score: 5–25.
[j]Possible range of Pride score: 4–20.
[k]Possible range of Hopelessness: 6–30.
[l]Possible range of Final: 0–100.
$^{**}p < 0.01$; $^{*}p < 0.05$.

Table 3: Summary of multiple regression analysis for variables predicting achievement (n = 72)

Variable	*B*	*SE*	*β*
Step1			
Self-efficacy	0.63	0.23	0.45**
Intrinsic value	–0.21	0.24	–0.14
Step 2			
Self-efficacy	0.055	0.25	0.04
Intrinsic value	–0.20	0.30	–0.14
Boredom	1.59	0.69	0.43*
Anxiety	0.207	0.21	0.20
Enjoyment	1.14	0.52	0.38*
Anger	–1.37	0.46	–0.56**
Shame	0.122	0.46	0.05
Pride	0.181	0.60	0.05
Hopelessness	–0.36	0.42	–0.21
Step 3			
Self-efficacy	0.08	0.26	0.06
Intrinsic value	–0.05	0.34	–0.04
Boredom	1.46	0.70	0.40*
Anxiety	0.27	0.21	0.26
Enjoyment	1.18	0.52	0.40*
Anger	–1.3	0.48	–0.53**
Shame	0.05	0.47	0.02
Pride	0.19	0.63	0.05
Hopelessness	–0.47	0.43	–0.27
Cognitive strategy	–0.01	0.16	–0.01
Self-regulation	–0.37	0.30	–0.20

Note: $R^2 = 0.13$ ($p < 0.01$) for Step 1; $\Delta R^2 = 0.24$ ($p < 0.01$) for Step 2; $\Delta R^2 = 0.01$ for Step 3.
*$p < 0.05$; **$p < 0.01$.

As illustrated in Table 3, results from the first step of multiple regression analysis show that self-efficacy and intrinsic value accounted for approximately 13% of the variance in students' final scores, $F(2, 69) = 5.241$, $p < 0.01$. Self-efficacy ($\beta = 0.45$, $p < 0.01$) was the significant individual predictor of the final scores. Results from the second step analysis indicate that the achievement emotion variables increase the amount of variance explained by all of the predictors in the equation to approximately 37%, $\Delta F(7, 62) = 3.449$, $p < 0.01$. In this analysis, self-efficacy failed to individually predict the final scores ($\beta = 0.04$, $p = 0.83$). Among the achievement emotion variables, boredom ($\beta = 0.43$, $p < 0.05$), enjoyment ($\beta = 0.38$, $p < 0.05$) and anger ($\beta = -0.56$, $p < 0.01$) were the significant individual predictors of the final scores. Finally, the third step analysis revealed that cognitive strategy use and self-regulation did not explain any additional variance in the final scores, $\Delta F(2, 60) = 0.858$, $p = 0.42$. Cognitive strategy use ($\beta = -0.01$, $p = 0.91$) and self-regulation ($\beta = -0.20$, $p = 0.22$) failed to individually predict the final scores. Consistent with the second step analysis, boredom, enjoyment and anger remained the significant individual predictors of the final scores.

Discussion

We investigated the relationships between motivation, emotions, cognitive process and achievement of students in order to understand *why* some succeed and some do not in mathematics courses offered at a virtual high school. Findings, limitations and implications are discussed in the following.

Findings

First, motivation accounted for approximately 13% of the variance in student achievement and self-efficacy was the significant individual predictor of student achievement. However, when achievement emotions were added to the analysis, we found (1) the proportion of the variance in student achievement explained by the predictors increased to 37% and (2) self-efficacy failed to individually predict student achievement. This finding is interesting for the following reasons. Research has shown that self-efficacy is a significant predictor for student learning and performance (Bandura, 1986; Roblyer *et al*, 2008; Schunk, 1991; Schunk *et al*, 2008). However, in this study, self-efficacy was not a predictor any more once we took into account achievement emotions. This finding suggests that the effect of self-efficacy may be moderated by emotional experiences. This may be the case for online learning where students' interactions with their instructor and classmates tend to be lacking (Erichsen & Bolliger, 2011; Hawkins *et al*, 2012; Muilenburg & Berge, 2005; Song *et al*, 2004; C. Weiner, 2001). Our finding also suggests that the study of emotions can provide "an empowering source of information about how to influence motivational patterns" (Ford, 1992, p. 145). In addition, the study finding illustrates the interdependence of emotions, motivation and learning (Ainley, 2006; Hannula, 2006; Meyer & Turner, 2006; Op 't Eynde & Turner, 2006; Op 't Eynde *et al*, 2006; Pekrun, 2006; Turner & Patrick, 2008).

Second, among the achievement emotions, boredom, enjoyment and anger were significant individual predictors of student achievement. Anger was the strongest individual predictor of student achievement. It may have made anger a prominent emotion that the students were signed up for the course against their will often because the local school did not offer the course or had a scheduling issue, as mentioned earlier in the paper. Considering that the participants' mean age was about 16, this finding may be related to the uniqueness of adolescence (eg, La Greca & Lopez, 1998). Adolescents' relationships with peers become as or sometimes more important than relationships with parents (Berten, 2008) and play a supportive, social role in coping with difficulties (Berndt & Perry, 1986; La Greca & Lopez, 1998). However, the characteristics of the online math learning environments the participants were in did not allow them to interact with their peers as they would do in face-to-face classrooms despite the importance of such interactions highlighted in the literature on K-12 online education (DiPietro *et al*, 2008; Murphy & Rodríguez-Manzanares, 2008; Roblyer *et al*, 2007). A lack of interpersonal interactions may have let their anger hinder their actions of studying without the opportunity of receiving social support from peers. In fact, different emotions lead to different actions (or inactions) (Frijda, Kuipers & Schure, 1989; Plutchik, 1980; Roseman, Wiest & Swartz, 1994). For example, the emotion of anger can induce the action of ignorance or withdrawal and the emotion of enjoyment can induce the action of staying focused on task. Action tendencies resulted from discrete emotions should be studied further, especially in online learning environments where social interactions are not as present as in face-to-face environments. Further research should incorporate a multi-method approach, which includes such data collection methods as interviews and online activity observations.

Third, both self-efficacy and intrinsic value were significantly correlated with all the emotions examined. This finding supports the notion of the reciprocal relationship between motivation and emotions (Hannula, 2006; McLeod, 1988; Op 't Eynde & Turner, 2006; Op 't Eynde *et al*, 2006; Pekrun, 2006) in online learning environments (Kim & Hodges, 2012). Considering the view of motivation as part of emotions (eg, Op 't Eynde *et al*, 2006) as well as the view of emotion as part of motivation (eg, Ford, 1992; Hannula, 2006), it is practically not easy to separate motivation and emotions from each other (Ainley, 2006). This finding also suggests that an integrative consideration of both constructs is needed to improve online learning (Kim, 2012; Kim & Hodges, 2012).

Last, cognitive strategy use and self-regulation did not explain any additional variance in student achievement. Cognitive processes may have been helpful in explaining student achievement if we further examined the specific processes of rehearsal, organization, elaboration, planning and monitoring throughout the semester. Nonetheless, cognitive strategy use was significantly correlated with intrinsic value, self-efficacy, boredom, enjoyment and pride. Self-regulation was significantly correlated with intrinsic value, self-efficacy, boredom, enjoyment, anger, shame and hopelessness. Although these findings do not suggest cause and effect relationships, they are consistent with the previous research showing that people's cognitive processes can be different according to their motivation and emotions (Forgas, 2000; Gläser-Zikuda *et al*, 2005; Linnenbrink, 2006; Pekrun, 2006; Pekrun *et al*, 2002; Schwarz, 1990, 2000).

Limitations

There are several limitations in this study that suggest several directions for future research. First, the number of participants was small. The generalizability of the study findings should be limited. Second, differences among participants other than in motivation, emotions and cognitive processes were not investigated. Other preexisting differences among participants such as prior knowledge may have contributed to their achievement. A study with a larger number of participants would allow us to run a path analysis such as structural equation modeling, which would lead to further examination of direct and indirect relationships among motivation, emotions, cognitive processes as well as other possible variables. Last, changes in participants' motivation, emotions and cognitive processes were not examined. A study with multi-time measurements would be helpful in understanding dynamics among students' motivation, emotions and cognitive processes throughout the semester. The virtual school is currently installing analytics in their learning management system, which will allow us to see student achievement changes over time.

Implications

Unlike outcomes-oriented research that focuses on what knowledge is acquired or not, our study provides a basis that suggests diverse paths to promote student learning in online mathematics courses. For example, if students' emotional experiences are improved (eg, increased enjoyment, decreased anxiety), motivation, cognitive processes and achievement could be enhanced. Emotion regulation can be taught to improve emotional experiences (eg, Kim & Hodges, 2012). Technologies such as relational agents, affect-aware tutors and virtual change agents (Campbell & Green, 2009; Kim, 2012; Woolf *et al*, 2009) can be implemented to facilitate constructive emotions for online learning. Also, if interactions between students and instructors as well as among students are promoted, enhanced social presence can improve students' motivation, emotions, cognitive processes and math learning.

Methods of highlighting intrinsic value of learning tasks should be studied further for online mathematics learning contexts. For instance, autonomy-supportive environments can be designed to encourage students' interest (Ryan & Deci, 2000) and mastery goal orientations can be also emphasized to help students perceive value of tasks beyond instrumentality (Ames, 1992; Covington, 2000). This would help with not only student motivation but also emotions. Also, individual differences should be taken into considerations when designing online learning environments. This is because students react to the same situation differently due to memory of prior experiences, task difficulty, goal specificity and vicarious experience, and so forth (Carver & Scheier, 1990; Locke & Latham, 2000; Pekrun, 2006; B. Weiner, 1985). Technological advances make it possible to realize these needs, for example, through adaptive systems (eg, Papanikolaou, Grigoriadou, Kornilakis & Magoulas, 2003; Park & Lee, 1996). In addition, teaching about cognitive strategy use and self-regulation would be also helpful in promoting student success in online mathematics courses.

References

Ainley, M. (2006). Connecting with learning: motivation, affect and cognition in interest processes. *Educational Psychology Review*, *18*, 4, 391–405.

Ames, C. (1992). Classrooms: goals, structures, and student motivation. *Journal of Educational Psychology*, *84*, 3, 261–271.

Astleitner, H. (2000). Designing emotionally sound instruction: the FEASP-approach. *Instructional Science*, *28*, 3, 169–198.

Balacheff, N. (1990). Towards a problematique for research on mathematics teaching. *Journal for Research in Mathematics Education*, *21*, 4, 258–272.

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, *84*, 191–215.

Bandura, A. (1986). *Social foundations of thought and action: a social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1997). *Self-efficacy: the exercise of control*. New York: Freeman.

Bandura, A. (2004). Health promotion by social cognitive means. *Health Education & Behavior*, *31*, 143–164.

Barbour, M. K. (2011). The promise and the reality: exploring virtual schooling in rural jurisdictions. *Education in Rural Australia*, *21*, 1, 1–20.

Barbour, M. K. & Reeves, T. C. (2009). The reality of virtual schools: a review of the literature. *Computers and Education*, *52*, 2, 402–416.

Berndt, T. J. & Perry, T. B. (1986). Children's perceptions of friendships as supportive relationships. *Developmental Psychology*, *23*, 583–592.

Berten, H. (2008). Peer influences on risk behavior: a network study of social influence among adolescents in Flemish secondary schools. Paper presented at the annual meeting of the American Sociological Association Annual Meeting, Boston, MA. Retrieved March 10, 2012, from http://citation.allacademic.com/meta/p_mla_apa_research_citation/2/3/9/7/8/pages239786/p239786-1.php

Blaney, P. H. (1986). Affect and memory: a review. *Psychological Bulletin*, *99*, 2, 229–246.

Borup, J., Graham, C. R. & Davies, R. (in press). The nature of adolescent learner interaction in a virtual high school setting. *Journal of Computer Assisted Learning*. doi:10.1111/j.1365-2729.2012.00479.x.

Bower, G. H. (1981). Mood and memory. *American Psychologist*, *36*, 2, 129–148.

Campbell, R. H. & Green, G. M. (2009). *Relational Agents and StructurANTion theory: moving towards a model for automated system integration*. Proceedings of UK Academy for Information Systems Conference.

Carver, D. S. & Scheier, M. F. (1990). Origins and functions of positive and negative affect: a control-process view. *Psychological Review*, *97*, 1, 19–35.

Cavanaugh, C. (2001). The effectiveness of interactive distance education technologies in K-12 learning: a meta-analysis. *International Journal of Educational Telecommunications*, *7*, 1, 73–88.

Cavanaugh, C., Barbour, M. K. & Clark, T. (2009). Research and practice in K-12 online learning: a review of literature. *International Review of Research in Open and Distance Learning*, *10*, 1, 1–22. Retrieved June 8, 2012 from http://www.irrodl.org/index.php/irrodl/article/view/607

Cavanaugh, C., Gillan, K., Bosnick, J. & Hess, M. (2008). Effectiveness of online Algebra learning: implications for teacher preparation. *Journal of Educational Computing Research*, *38*, 1, 67–95.

Cavanaugh, C., Gillan, K., Kromrey, J., Hess, M. & Blomeyer, R. (2004). *The effects of distance education on K-12 student outcomes: a meta-analysis*. Naperville, IL: Learning Point Associates. Retrieved June 8, 2012 from http://www.eric.ed.gov/PDFS/ED489533.pdf

Covington, M. C. (2000). Goal theory, motivation, and school achievement: an integrative review. *Annual Review of Psychology*, *51*, 171–200.

Davydov, V. & Kerr, S. T. (1995). The influence of L. S. Vygotsky on education theory, research, and practice. *Educational Researcher*, *24*, 3, 12–21.

DiPietro, M., Ferdig, R. E., Black, E. W. & Preston, M. (2008). Best practices in teaching K-12 online: lessons learned from Michigan Virtual School teachers. *Journal of Interactive Online Learning*, *7*, 1. Retrieved June 8, 2012 from http://www.ncolr.org/jiol/issues/PDF/7.1.2.pdf

Eccles, J. S. (1983). Expectancies, values, and academic behavior. In J. T. Spencer (Ed.), *Achievement and achievement motivation* (pp. 75–146). San Francisco: W. H. Freeman.

Eccles-Parsons, J., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L. *et al* (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motivation* (pp. 75–146). San Francisco: Freeman.

Erichsen, E. A. & Bolliger, D. U. (2011). Towards understanding international graduate student isolation in traditional and online environments. *Educational Technology Research and Development*, *59*, 3, 309–326.

Ford, M. E. (1992). *Motivating humans: goals, emotions, and personal agency beliefs*. Newbury Park, CA: Sage.

Forgas, J. P. (2000). Affect and information processing strategies: an interactive relationship. In J. P. Forgas (Ed.), *Feeling and thinking: the role of affect in social cognition* (pp. 253–280). Paris: Cambridge University Press.

Frenzel, A. C., Thrash, T. M., Pekrun, R. & Goetz, T. (2007). Achievement emotions in Germany and China: a cross-cultural validation of the Academic Emotions Questionnaire–Mathematics. *Journal of Cross-Cultural Psychology*, *38*, 302–309.

Frijda, N. H., Kuipers, P. & Schure, E. (1989). Relations among emotion, appraisal, and emotional action readiness. *Journal of Personality and Social Psychology*, *57*, 2, 212–228.

Gläser-Zikuda, M., Fuß, S., Laukenmann, M., Metz, K. & Randler, C. (2005). Promoting students' emotions and achievement: instructional design and evaluation of the ECOLE-approach. *Learning and Instruction*, *15*, 5, 481–449.

Goetz, T., Pekrun, R., Hall, N. & Haag, L. (2006). Academic emotions from a social-cognitive perspective: antecedents and domain specificity of students' affect in the context of Latin instruction. *British Journal of Educational Psychology*, *76*, 2, 289–308.

Hawkins, A., Barbour, M. K. & Graham, C. R. (2012). "Everybody is their own island": teacher disconnection in a virtual school. *International Review of Research in Open and Distance Learning*, *13*, 2, 123–144.

Hannula, M. S. (2006). Motivation in mathematics: goals reflected in emotions. *Educational Studies in Mathematics*, *63*, 2, 165–178.

Holmberg, D. & Holmes, J. G. (1994). Reconstruction of relationship memories: a mental models approach. In N. Schwarz & S. Sudman (Eds), *Autobiographical memory and the validity of retrospective reports* (pp. 267–288). New York: Springer-Verlag.

Hughes, J. E., McLeod, S., Brown, R., Maeda, Y. & Choi, J. (2007). Academic achievement and perceptions of the learning environment in virtual and traditional secondary mathematics classrooms. *American Journal of Distance Education*, *21*, 4, 199–214.

Isen, A. M. (2000). Positive affect and decision making. In M. Lewis & J. Haviland-Jones (Eds), *Handbook of emotions* (2nd ed.). (pp. 417–435). New York: Guilford.

Kim, C. (2012). The role of affective and motivational factors in designing personalized learning environments. *Educational Technology Research & Development*, *60*, 4, 563–584.

Kim, C. & Hodges, C. B. (2012). Effects of an emotion control treatment on academic emotions, motivation and achievement in an online mathematics course. *Instructional Science*, *40*, 1, 173–192.

Kim, C. & Pekrun, R. (in press). Emotions and motivation in learning and performance. In J. M. Spector, M. D. Merrill, J. Elen & M. J. Bishop (Eds), *The handbook of research for educational communications and technology* (4th ed.). New York, NY: Springer.

Kozma, B., Zucker, A., Espinoza, C., McGhee, R., Yarnall, L., Zalles, D. *et al* (2000). The online course experience: evaluation of the virtual high school's third year of implementation, 1999–2000. Retrieved June 8, 2012 from http://www.govhs.org/Images/SRIEvals/$file/SRIAnnualReport2000.pdf

La Greca, A. M. & Lopez, N. (1998). Social anxiety among adolescents: linkages with peer relations and friendships. *Journal of Abnormal Child Psychology*, *26*, 2, 83–94.

Levine, L. J. & Pizarro, D. A. (2004). Emotion and memory research: a grumpy overview. *Social Cognition*, *22*, 5, 530–554.

Linnenbrink, E. A. (2006). Emotion research in education: theoretical and methodological perspectives on the integration of affect, motivation, and cognition. *Educational Psychology Review*, *18*, 4, 307–314.

Locke, E. A. & Latham, G. P. (2000). Building a practically useful theory of goal setting and task motivation. *American Psychologist*, *57*, 9, 705–717.

Martin, M. O., Mullis, I. V. S., Gonzalez, E. J. & Chrostowski, S. J. (2004). *TIMSS 2003 international science report: findings from IEA's Trends in International Mathematics and Science Study at the fourth and eighth grades*. Chestnut Hill, MA: TIMSS & PIRLS Study Center, Lynch School of Education, Boston College.

McLeod, D. B. (1988). Affective issues in mathematical problem solving: some theoretical considerations. *Journal for Research in Mathematics Education*, *19*, 2, 134–141.

Meyer, D. K. & Turner, J. C. (2006). Re-conceptualizing emotion and motivation to learn in classroom contexts. *Educational Psychology Review*, *18*, 4, 377–390.

Muilenburg, L. Y. & Berge, Z. L. (2005). Student barriers to online learning: a factor analytic study. *Distance Education*, *26*, 1, 29–48.

Murphy, E. & Rodríguez-Manzanares, M. (2008). Revisiting Transactional Distance Theory in a context of web-based high-school distance education. *Journal of Distance Education*, *22*, 2, 1–14.

Murphy, E., Rodríguez-Manzanares, M. A. & Barbour, M. (2011). Asynchronous and synchronous online teaching: perspectives of Canadian high school distance education teachers. *British Journal of Educational Technology*, *42*, 4, 583–591. doi: 10.1111/j.1467-8535.2010.01112.x.
National Mathematics Advisory Panel (NMAP) (2008). *Foundations for success: the final report of the National Mathematics Advisory Panel*. Washington, DC: U.S. Department of Education.
Op 't Eynde, P. & Turner, J. E. (2006). Focusing on the complexity of emotion issues in academic learning: a dynamical component systems approach. *Educational Psychology Review*, *18*, 4, 361–376.
Op 't Eynde, P., de Corte, E. & Verschaffel, L. (2006). "Accepting emotional complexity": a socio-constructivist perspective on the role of emotions in the mathematics classroom. *Educational Studies in Mathematics*, *63*, 2, 193–207.
Papanikolaou, K. A., Grigoriadou, M., Kornilakis, H. & Magoulas, G. D. (2003). Personalizing the interaction in a web-based educational hypermedia system: the case of INSPIRE. *User Modeling and User-Adapted Interaction*, *13*, 3, 213–267.
Park, O. & Lee, J. (1996). Adaptive instructional systems. In D. Jonassen (Ed.), *Handbook of research on educational communications and technology* (2nd ed.). (pp. 651–684). Maway, NJ: Lawrence Erlbaum Associates, Publishers.
Pekrun, R. (1992). The impact of emotions on learning and achievement: towards a theory of cognitive/motivational mediators. *Applied Psychology*, *41*, 4, 359–376.
Pekrun, R. (2006). The control-value theory of achievement emotions: assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review*, *18*, 4, 315–341.
Pekrun, R., Goetz, T. & Frenzel, A. C. (2007). Perceived learning environment and students' emotional experiences: a multilevel analysis of mathematics classrooms. *Learning and Instruction*, *17*, 5, 478–493.
Pekrun, R., Goetz, T., Perry, R. P., Kramer, K., Hochstadt, M. & Molfenter, S. (2004). Beyond test anxiety: development and validation of the Test Emotions Questionnaire (TEQ). *Anxiety, Stress, and Coping*, *17*, 287–316.
Pekrun, R., Goetz, T., Titz, W. & Perry, R. P. (2002). Academic emotions in students' self-regulated learning and achievement: a program of qualitative and quantitative research. *Educational Psychologist*, *37*, 2, 91–105.
Picciano, A. G. & Seaman, J. (2007). *K-12 online learning: a survey of school district administrators*. Needham, MA: The Sloan Consortium.
Picciano, A. G. & Seaman, J. (2009). *K-12 online learning: a 2008 follow up of the survey of U.S. school district administrators*. Needham, MA: The Sloan Consortium.
Picciano, A. G., Seaman, J. & Allen, I. E. (2010). Educational transformation through online learning: to be or not to be. *Journal of Asynchronous Learning Networks*, *14*, 4, 17–35.
Pintrich, P. R. & Schunk, D. H. (2002). *Motivation in education: theory, research, and applications* (2nd ed.). Upper Saddle River, NJ: Merrill Prentice Hall.
Pintrich, P. R., Smith, D., Garcia, T. & McKeachie, W. (1991). *A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ)*. Ann Arbor, MI: The University of Michigan.
Pintrich, R. R. & DeGroot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, *82*, 33–40.
Plutchik, R. (1980). *Emotion: a psychoevolutionary synthesis*. New York: Harper & Row.
Roblyer, M. D., Davis, L., Mills, S., Marshall, J. & Pape, L. (2008). Toward practical procedures for predicting and promoting success in virtual school students. *The American Journal of Distance Education*, *22*, 2, 90–109.
Roblyer, M. D., Freeman, J., Stabler, M. & Schneidmiller, J. (2007). *External evaluation of the Alabama ACCESS initiative: PHASE 3 report*. Eugene, OR: International Society for Technology in Education. Retrieved June 8, 2012 from http://accessdl.state.al.us/2006Evaluation.pdf
Roseman, I. J., Wiest, C. & Swartz, T. S. (1994). Phenomenology, behaviors, and goals differentiate discrete emotions. *Journal of Personality and Social Psychology*, *67*, 2, 206–221.
Ryan, R. M. & Deci, E. L. (2000). Intrinsic and extrinsic motivations: classic definitions and new directions. *Contemporary Educational Psychology*, *25*, 54–67.
Schunk, D. H. (1991). Self-efficacy and academic motivation. *Educational Psychologist*, *26*, 207–231.
Schunk, D. H., Pintrich, P. R. & Meece, J. L. (2008). *Motivation in education. Theory, research, and applications* (3rd ed.). Upper Saddle River, NJ: Pearson Education Inc.
Schutz, P. A., Hong, J. Y., Cross, D. I. & Osbon, J. N. (2006). Reflections on investigating emotion in educational activity settings. *Educational Psychology Review*, *18*, 4, 343–360.
Schwarz, N. (2000). Emotion, cognition, and decision making. *Cognition and Emotion*, *14*, 4, 433–440.

Schwarz, N. (1990). Feelings as information: informational and motivational functions of affective states. In E. T. Higgins & R. M. Sorrentino (Eds), *Handbook of motivation and cognition: foundations of social behavior* Vol. 2 (pp. 527–561). New York: Guilford.
Shea, P. & Bidjerano, T. (2010). Learning presence: towards a theory of self-efficacy, self-regulation, and the development of a communities of inquiry in online and blended learning environments. *Computers & Education*, *55*, 1721–1731.
Song, L., Singleton, E. S., Hill, J. R. & Koh, M. H. (2004). Improving online learning: student perceptions of useful and challenging characteristics. *Internet and Higher Education*, *7*, 59–70.
Tucker, B. (2007). *Laboratories of reform: virtual high schools and innovation in public education*. Washington, DC: Education Sector Reports.
Turner, J. C. & Patrick, H. (2008). How does motivation develop and why does it change? Reframing motivation research. *Educational Psychologist*, *43*, 3, 119–131.
Van Oers, B. (2006). An activity theory approach to the formation of mathematical cognition: developing topics through predication in a mathematical community. In J. Maasz & W. Schloeglmann (Eds), *New mathematics education research and practice* (pp. 113–179). Rotterdam, The Netherlands: Sense Publishers B.V.
Watson, J., Murin, A., Vashaw, L., Gemin, B. & Rapp, C. (2011). *Keeping pace with K-12 online learning: an annual review of state-level policy and practice*. Retrieved June 8, 2012 from http://gsehd.gwu.edu/documents/gsehd/resources/gwuohs-onlineresources/reports/evergreeneducationgroup_keepingpacek12online-2011.pdf
Weiner, B. (1985). An attributional theory of achievement motivation and emotion. *Psychological Review*, *92*, 4, 548–573.
Weiner, C. (2001). *A new alternative: adolescent students study in cyberspace*. Unpublished Doctoral Dissertation: Capella University.
Wolters, C. A. & Pintrich, P. R. (1998). Contextual differences in student motivation and self-regulated learning in mathematics, English, and social studies classrooms. *Instructional Science*, *26*, 27–47.
Woolf, B., Burleson, W., Arroyo, I., Dragon, T., Cooper, D. & Picard, R. W. (2009). Affect-aware tutors: recognising and responding to student affect. *International Journal of Learning Technology*, *4*, 3/4, 129–164.
Zandberg, I. & Lewis, L. (2008). *Technology-based distance education courses for public elementary and secondary school students: 2002–03 and 2004–05*. Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.
Zusho, A., Pintrich, P. R. & Coppola, B. (2003). Skill and will: the role of motivation and cognition in the learning of college chemistry. *International Journal of Science Education*, *25*, 1081–1094.