

Examining the Interplay Between Self-Efficacy Beliefs, Emotions, Stress Mindset and Achievement in Different Assessments in University Mathematics

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There is currently little research that examines the interplay between various affective constructs, particularly within the context of mathematics assessment. This longitudinal study seeks to understand how student assessment-related affect changes across a university mathematics course and seeks to identify latent or explicit factors that play a role. We collected data on achievement emotions, self-efficacy, stress, and stress mindset across three time points, in addition to measures of academic performance, specifically on different forms of assessment. Without accounting for interactions, preliminary results considering the constructs individually demonstrate an increase in negative and decrease in positive affect. However, incorporating path analysis suggests that engagement on low-risk summative assessment has the potential to promote self-efficacy. As a consequence of this research, we hope to pinpoint suitable interventions that may have a positive influence on affect and achievement. The disentangling of these relationships will have practical implications for course design and assessment structure.

Keywords: assessment, affect, higher education

Social-cognitive theory (SCT) posits that personal affective factors, such as beliefs and emotions, have reciprocal relationships with learning behaviors and educational environments (Bandura, 1997). From this perspective, understanding assessment-related affect is critical to the design and delivery of assessments conducive to student achievement. Based on findings that different assessments elicit different affective responses (Riegel & Evans, 2021) and that frequent, low-risk assessment may enhance self-efficacy (Evans et al., 2020), we identified two broad research objectives: (1) To gain a deeper understanding of assessment-specific affective constructs, including why and how they change during a mathematics course, and (2) To gain a holistic view of the relationship between affect and assessment through examining students' assessment-related *affective field*, defined as, "the bundles of affective factors involved in particular situations in their intraplay" (Schindler & Bakker, 2020). This research particularly seeks to consider relationships between student assessment self-efficacy, emotions, and stress mindset in both an online quiz and final exam, amongst other measures, such as gender and achievement. We chose these affective variables as their relationships and interplay have been underexplored in the context of mathematics assessment. We hope to formulate generalizable implications for assessment practice.

Literature Review

Achievement Emotions in Assessment

Achievement emotions are emotions experienced by learners pertaining to achievement activities and outcomes (Pekrun, 2006). Positive emotions have generally been shown to correlate positively with engagement, attention, motivation, and performance, while negative emotions correlate negatively with these constructs (Mega et al., 2014; Peixoto et al., 2017; Pekrun et al., 2002; Reeve et al., 2014; Schukajlow & Rakoczy, 2016). Most research on achievement emotions with respect to assessment has focused on test-anxiety, with studies generally demonstrating a negative correlation between test-anxiety and achievement (e.g., Lang & Lang, 2010; Steinmayr, et al., 2016; Zeidner 2014). Little attention has been paid to other

emotions in this context. When considering online assessment, studies have generally indicated that students experience less stress and anxiety (Cassady & Gridley, 2005; Dermo, 2009; Engelbrecht & Harding, 2004; Stowell & Bennett, 2010), as well as more positive and fewer negative emotions (Daniels & Gierl, 2017; Riegel & Evans, 2021). In line with SCT, Pekrun (2000) argues that repeated experiences of emotion in recurring scenarios, such as assessment, can cause cognitive appraisals to be bypassed and lead to the emotion becoming habitualized. Research has shown there are reciprocal effects between emotions and achievement (Ahmed et al., 2013; Pekrun et al., 2017; Pekrun et al., 2019). More studies are needed to understand how emotions in assessment change and interact with other affective constructs over time.

Assessment Self-Efficacy

Self-efficacy is a construct in SCT defined as, "the beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3) and is a known predictor of achievement (Pajares & Graham, 1999; Zimmerman, 2000). Experiences of success support the development of self-efficacy while experiences of failure hinder it (Usher & Pajares, 2009), indicating that success or failure in one assessment may impact students' beliefs about future assessments. Few studies consider assessment-related self-efficacy, despite Bandura's (1997) proposal that self-efficacy measures must be both context and content specific. Since summative assessment is the foremost way tertiary institutions gauge students' progress (Iannone & Simpson, 2011), it is vital for research to understand and operationalize student assessment-related self-efficacy.

Stress Mindset

Crum et al. (2013) present a new construct of stress mindset, defined to be the extent of one's beliefs that stress has enhancing or debilitating consequences. The few existing studies in education indicate significant relationships with student affect and performance (Jenkins et al., 2021; Keech et al., 2018; Kilby & Sherman, 2016; Riegel et al., 2021). A further study by Crum et al. (2017) concluded that adopting an enhancing view of stress may be beneficial by altering how individuals respond in stressful scenarios over time. Research demonstrates that self-efficacy associates positively with positive emotions and negatively with negative emotions (Luo, et al., 2016; Pekrun et al., 2004; Pekrun, et al., 2011; Usher & Pajares, 2009). No studies have yet incorporated stress-mindset as a moderator for these relationships.

Methods

Setting and participants

The participants in this study were students enrolled in semester two of 2020 at a major New Zealand university in a second-year service mathematics course. The course featured frequent online quizzes to be completed any time between each lecture. These were designed to be low-risk through the use of multiple-choice questions, 30 minute completion windows, two attempts with instant feedback, and keeping best 27 out of 31 quizzes throughout the 12 weeks term. They amounted to 13 percent of the final grade. The course also had a test and a two-hour, invigilated, 50 percent final exam. After data cleaning, 277 of the 410 students enrolled at the start of the semester had consented to their data use and completed all three surveys. This study was approved by the University of Auckland Ethics Committee (approval number 024710).

Data collection and analysis

The research design is a repeated measures design with no control group. As part of the coursework, there were three ten-minute questionnaires administered online (via Qualtrics), each worth 0.1% of the final grade. During the twelve-week semester they were administered in week one (Q1: before any assessments), seven (Q2: after the mid-semester test), and eleven (Q3: before the final exam), and student achievement measures were collected throughout the semester. Participants were removed from the analysis if their responses demonstrated sufficient evidence of straight-lining or the survey was less than 50% completed. Missing data was inserted using EM-imputation. All analyses used version 27 of SPSS and its AMOS programme.

Measures

Achievement Emotions Questionnaire (AEQ). All three questionnaires included an adapted version of the test-related section of the AEQ (Pekrun et al., 2011), with statements pertaining to achievement emotions experienced before ($\chi^2/df = 2.09$, CFI = .92, RMSEA = .06, $n = 18$) and during an exam ($\chi^2/df = 2.72$, CFI = .90, RMSEA = .08, $n = 18$). Our adapted version consists of statements measuring anxiety, enjoyment, hope, and hopelessness on a Likert scale from 1 (*Strongly Disagree*) to 5 (*Strongly Agree*).

Measure of Assessment Self-Efficacy for Quiz (MASE-Q) and Exam (MASE-E). All three questionnaires included the newly developed MASE-Q ($\chi^2/df = 2.38$, CFI = .99, RMSEA = .07, $n = 7$) and MASE-E ($\chi^2/df = 1.47$, CFI = .99, RMSEA = .04, $n = 7$) (Riegel et al., 2022), designed to assess the participant's beliefs in their *comprehension and execution* and *emotional regulation* abilities while studying and during an assessment. Responses to statements were measured using a slider scale from 1 (*Cannot do at all*) to 100 (*Highly certain can do*). The participants were randomly presented with two assessment scenarios, a low-stakes online quiz and a high-stakes final exam to respond to the MASE-Q and MASE-E, respectively.

Stress and Stress Mindset Measure (SMM). To measure assessment stress, participants were asked "How stressful do you perceive this mathematics QUIZ/EXAM to be?" following each scenario. They responded on a nine-point scale from *Not stressful at all* to *Extremely stressful*. Using the scales developed by Crum et al. (2013), we included an adapted general version of the SMM in the first questionnaire ($\chi^2/df = 2.67$, CFI = .97, RMSEA = .08, $n = 7$) to obtain an overall measure of students' perception of stress. Additionally, an adapted SMM was designed to measure participant stress mindset in relation to the quiz (measured in Q2 and Q3) and exam scenarios (measured in Q1 and Q3). The scales consist of three stress-is-enhancing statements and four stress-is-debilitating statements. Participants responded on a five-point scale (*Strongly Disagree* to *Strongly Agree*).

Achievement. Student prior achievement was recorded as a self-reported prerequisite grade. We also collected performance results, which contributed to their final grade (quizzes, tutorial participation, assignments, test, and exam).

Demographic Information. We collected self-reported gender, ethnicity, and major.

Preliminary Results and Discussion

Several analyses have already been conducted using this data, including the validation of the MASE-Q and MASE-E (Riegel et al., 2022). Riegel et al. (2021) found stress mindset to be significant and achievement emotions dominant in predicting exam self-efficacy. As understanding the consequences of the pandemic became crucial, Riegel and Evans (2022) included new variables and found engagement with online quizzes, prior achievement, positive affect, and wellbeing were predictors of how students evaluated the impact to their learning.

We now seek to use the longitudinal data to understand how different affective constructs interact and individually change over time for students, as well as investigate students' affective fields in assessment. To address the first part of this goal we ran repeated measures ANOVAs and *t*-tests, which largely suggested a significant increase in negative and decrease in positive affect across the semester (Table 1). This raises interesting questions around 'trait' affect, which we hope to unpack, but also fails to illuminate why these constructs change. To investigate further, we employed path analysis. We first examined the unexplored construct of assessment self-efficacy, incorporating the effects between and within assessment and self-efficacy.

Table 1. Repeated measures ANOVAs and *t*-tests for affective variables.

	Range	1	2	3	<i>df</i>	<i>F</i>	η^2	<i>t</i>	<i>d</i>
		Mean (<i>SD</i>)	Mean (<i>SD</i>)	Mean (<i>SD</i>)					
<u>Self-Efficacy</u>									
Quiz (CE)	(0,100)	71.81 (15.42)	68.33 (18.22)	66.23 (19.43)	1.87	18.28**	.06	-	-
Quiz (ER)	(0,100)	69.56 (18.95)	65.81(20.42)	64.77 (20.00)	1.83	11.00**	.04	-	-
Exam (CE)	(0,100)	66.69 (15.98)	63.46 (18.31)	59.14 (18.84)	1.98	38.02**	.12	-	-
Exam (ER)	(0,100)	65.09 (18.44)	62.27 (20.32)	58.63 (20.04)	1.92	20.87**	.07	-	-
<u>Emotions (Before)</u>									
Anxiety	(1,5)	3.37 (0.75)	3.41 (0.78)	3.43 (0.76)	1.95	1.40	.01	-	-
Enjoyment	(1,5)	2.93 (0.74)	2.92 (0.77)	2.82 (0.77)	1.92	4.51*	.02	-	-
Hope	(1,5)	3.30 (0.65)	3.17 (0.70)	3.07 (0.71)	1.96	19.3**	.07	-	-
Hopelessness	(1,5)	2.36 (0.78)	2.62 (0.87)	2.78 (0.85)	1.99	47.62**	.15	-	-
<u>Emotions (During)</u>									
Anxiety	(1,5)	2.89 (0.90)	3.02 (0.89)	3.15 (0.88)	1.97	18.75**	.06	-	-
Enjoyment	(1,5)	2.97 (0.73)	2.91 (0.79)	2.87 (0.76)	1.99	3.11*	.01	-	-
Hope	(1,5)	3.28 (0.67)	3.14 (0.75)	3.09 (0.76)	1.96	12.41**	.04	-	-
Hopelessness	(1,5)	2.39 (0.67)	2.59 (0.80)	2.80 (0.88)	1.98	53.10**	.16	-	-
<u>Stress</u>									
Exam	(1,9)	6.48 (1.70)	-	6.87 (1.58)	-	-	-	-3.69**	.22
Quiz	(1,9)	-	5.02 (2.08)	4.94 (2.02)	-	-	-	0.63	.04
<u>Stress Mindset</u>									
Exam (Debilitating)	(1,5)	3.10 (0.68)	-	3.19 (0.70)	-	-	-	-1.96*	.12
Exam (Enhancing)	(1,5)	3.12 (0.79)	-	3.02 (0.76)	-	-	-	1.96*	.12
Quiz (Debilitating)	(1,5)	-	2.95 (0.76)	2.98 (0.74)	-	-	-	-0.59	.04
Quiz (Enhancing)	(1,5)	-	3.18 (0.81)	3.14 (0.76)	-	-	-	0.81	.05

*Note. ** $p < .001$, * $< .05$; CE = comprehension and execution, ER = emotional regulation.

Acceptable models are presented in Figure 1. Anticipated reciprocal effects between exam self-efficacy with a similarly high-stakes test are seen. However, quiz *comprehension and execution* self-efficacy does not demonstrate a reciprocal relationship with quiz achievement following the test. Moreover, for quiz *emotional regulation* self-efficacy, there is no reciprocal relationship with performance. These findings may suggest that the relationship between self-efficacy and performance is weaker in low-risk assessments, which elicit less of an emotional response, and the effects are overwhelmed by the affective influence of a high-stakes assessment.

Generally, we see simultaneous effects between different forms of assessment self-efficacy, suggesting performance in one assessment may indirectly influence self-efficacy in another. In the first half of semester, exam self-efficacy more strongly predicts quiz self-efficacy. However, in the second half of the semester (after the mid-semester test) quiz self-efficacy is a stronger

predictor of exam self-efficacy. This in part indicates that repeated experiences on low-risk assessments can influence the efficacy of students going into an exam, though high-stakes assessments during the semester can overwhelm these effects. The quizzes were designed so participating students were likely to receive full marks, meaning performance on quizzes largely reflects student engagement. Thus, it is plausible to suggest that through incorporating the intervention of regular quizzes, educators can indirectly promote exam self-efficacy and achievement. To further support this hypothesis, we intend to conduct a cross-lagged panel analysis so to determine directions of influence between the types of assessment self-efficacies.

Questions

We have presented some of the results of our preliminary analyses and seek to discuss with the attendees of RUME the following questions:

- We can perform similar path analyses to the ones presented here for other variables collected to look at affective relationships with achievement, but how might we retain the interplay between affective variables with our limited sample size?
- Certain affective constructs (e.g., beliefs) are considered slow to change. How can we use our data to provide insight into our understanding of “trait” or “global” affect?

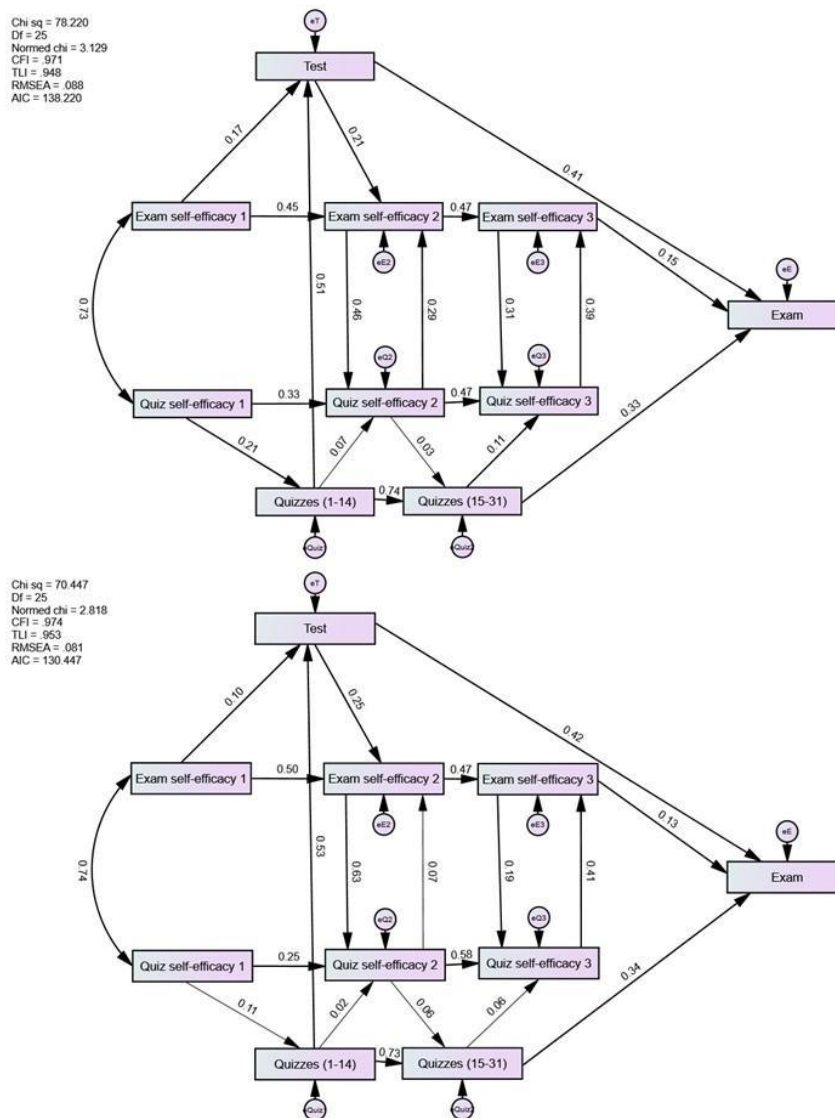


Figure 1. Path analyses of comprehension and execution (top) and emotional regulation (bottom) self-efficacy.

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