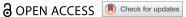


RESEARCH ARTICLE



Achievement Emotions of Medical Students: Do They Predict Self-regulated Learning and Burnout in an Online Learning Environment?

Zilu Wang and Binbin Zheng (D)

Faculty of Medicine, The University of Hong Kong, HKSAR, China

ABSTRACT

Background: Achievement emotions have been proven as important indicators of students' academic performance in traditional classrooms and beyond. In the online learning contexts, previous studies have indicated that achievement emotions would affect students' adoption of self-regulated learning strategies and further predict their learning outcomes. However, the pathway regarding how different positive and negative achievement emotions might affect students' burnout through self-regulated learning among medical students in online learning environments remains unclear. In this study, the aim is to investigate how achievement emotions and self-regulated learning predict burnout among medical students in online education.

Methods: This study involved 282 medical students who had attended online courses due to the sudden shift of learning mode caused by the COVID-19 pandemic in 2022. Confirmatory factor analysis was performed to examine the hypothesized factor structure, and structural equation modelling was conducted to test the hypothesized relationships among factors.

Results: The results of structural equation modelling revealed that medical students' self-efficacy positively predicted their enjoyment ($\beta = .57$) and online self-regulated learning (β = .54). Learning-related boredom inhibited students' adoption of online selfregulated learning strategies ($\beta = -.24$), and it was positively associated with their burnout (β = .54). Learning-related anxiety was a positive predictor of online selfregulated learning ($\beta = .38$).

Discussions: The results of this study suggest that achievement emotions experienced by medical students had a significant impact on their online self-regulated learning and burnout. Specifically, the experience of learning-related boredom was detrimental to the adoption of self-regulated learning strategies and increased the likelihood of burnout. However, learningrelated anxiety, despite being a negative achievement emotion, was positively associated with students' online self-regulated learning. These findings have important implications for online teaching and learning, particularly in the post-pandemic era.

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KEYWORDS

Achievement emotions; learning-related anxiety; learning-related boredom; self-regulation: medical student burnout

Introduction

The COVID-19 pandemic has accelerated the shift towards online teaching and learning in higher education [1]. The sudden change has brought numerous challenges to both teachers and students [2], such as limited experience with online platforms, and a lack of nonverbal communication, which may impede students' motivation and engagement in learning [3]. These difficulties exacerbated the negative achievement emotions experienced by students [4]. For example, learningrelated boredom during distance learning significantly increased due to the prolonged pandemic situation [5].

According to the control-value theory [6], achievement emotions include both positive emotions, such as enjoyment, and negative emotions, such as boredom and anxiety. Achievement emotions could be triggered by both social and cultural antecedents (e.g., learning environments), and individual antecedents (e.g., self-efficacy) [7,8]. On the other hand, achievement emotions have also been found to be essential determinants for students' academic achievements [9,10] and perceived learning experiences [10-13]. Studies conducted in online settings also concluded with similar findings [14].

To further examine how achievement emotions may influence learning outcomes and the mediating roles of other constructs, previous studies have looked into students' use of learning strategies. Positive achievement emotions, such as enjoyment, have been shown to increase the adoption of cognitive and metacognitive learning strategies [15]; while negative emotions, such as boredom, can impede the activation of relevant learning strategies [10,16]. Similar findings have been reported in online learning environments where students with higher levels of boredom tend to struggle with time management skills in completing online tasks [17]. However, studies have also yielded contradictory results

regarding the effect of negative achievement emotions. For example, frustration has been found to be a positive predictor of metacognition in online learning [18]. A more recent study also found learning-related anxiety positively predicted students' perceived knowledge improvements in online learning during the pandemic era. This was attributed to the heightened anxiety motivating students to study harder, with the fear of loss of academic year due to COVID-19 [4].

Regarding the relationship between achievement emotions and burnout [19], prior research has found that positive achievement emotions were negatively associated with burnout, whereas negative achievement emotions were positively correlated to burnout [20]. The high prevalence of burnout among medical students in both pre-clinical and clinical years has garnered attention from researchers, given its detrimental effect on students' personal and professional development [21]. However, the pathway through which specific positive and negative achievement emotions might affect medical students' burnout via mediating factors, such as the use of learning strategies, remains unclear. Therefore, the purpose of this study is to fill this research gap by investigating the structural relationships among self-efficacy, achievement emotions, online learning strategies, and burnout in online learning environments among medical students. Based on the literature, the proposed model is shown in Figure 1 where we hypothesized:

- H1. Self efficacy predicted students' achievement emotions, online self-regulated learning (SRL) and burnout.
- H1a. Self-efficacy positively predicted students' enjoyment.
- H1b. Self-efficacy negatively predicted anxiety and boredom.

- **H1c.** Self-efficacy positively predicted students' online SRL.
- **H1d.** Self-efficacy negatively predicted students' burnout.
- **H2.** Achievement emotions predicted students' online SRL.
- H2a. Enjoyment positively predicted students' online SRL.
- H2b. Boredom negatively predicted students' online SRL.

H2c.

Anxiety negatively predicted students' online SRL.

- H3. Negative achievement emotions positively predicted students' burnout.
- H3a. Anxiety positively predicted students' burnout.
- H3b. Boredom positively predicted students' burnout.
- H4. Students' online SRL negatively predicted students' burnout.

Methods

Context

This study was conducted in one medical school in Hong Kong and another medical school in southern mainland China. The study was approved by the Human Research Ethics Committee of the designated

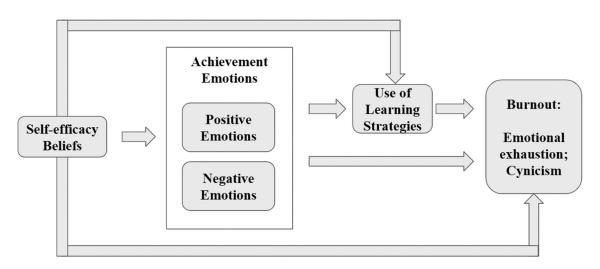


Figure 1. The hypothesized theoretical model of achievement emotions, online self-regulated learning and burnout.

university in Hong Kong (Ref No. EA220140). During the spring semester of 2022, the fifth wave of COVID-19 in Hong Kong and southern China necessitated a shift again from face-to-face teaching and learning to online mode. In response to this sudden shift, both faculties were required to offer fully online learning activities. Throughout the spring semester, all teaching and learning activities were conducted online in both medical schools. This involved synchronous delivery of problem-based learning and lectures via Zoom, as well as asynchronous delivery of e-learning modules through respective learning management systems.

Procedures

In late April of 2022, after three months of immersion in the online learning environment, an invitation to participate in an online survey was sent out to approximately 844 undergraduate and postgraduate medical students in both universities. The study received a total of 320 responses, resulting in a response rate of 38%. Among the respondents, 38 students only completed the demographic information section of the survey. As their demographics were similar to those of the other respondents, we considered this data to be missing at random (Scheffer, 2002). Thus, excluding the incomplete responses would not have an impact on the study

After excluding the incomplete data, this study included 282 respondents, of which 82 (29%) were undergraduates and 200 (71%) were postgraduate students. The undergraduate students were all from the MBBS program in the designated universities, while the postgraduate students had finished their MBBS degree and were primarily enrolled in the clinical oncology specialization.

Measurements

The survey included five instruments. Each item employed a 5-point, Likert-scale agreement response.

Self-efficacy

Motivational beliefs were measured using the 7-item self-efficacy subscale in Motivated Strategies for Learning Questionnaire (MSLQ) [22]. This instrument has been shown to be a valid measure in assessing medical students' motivational beliefs [23]. To suit the online learning context, minor adjustments were made to each item. For example, the original item 'I expect to do well in the class' was modified to 'I expect to do well in the online class')

Achievement emotions

Students' discrete achievement emotions were measured using three subscales: enjoyment, anxiety, and boredom Achievement **Emotions** Questionnaire - Shortened Version (AEQ-S) [24]. This shortened version has achieved satisfactory reliability and correlates substantially with the original AEQ, which has shown to be a valid measure and thus widely adopted in the education and psychology field [25]. The brevity of AEQ-S is beneficial in reducing the likelihood of participants dropping the survey [24].

Each subscale comprises four items that assess the specific emotions perceived by the students. A few items were revised to suit the online learning context. For example, the original item 'I get tense and nervous while studying' was modified to 'I get tense and nervous while studying online.'

Online self-regulated learning strategies

Students' online SRL were measured through six subscales adopted from the Online Self-regulated Learning Questionnaire (OSLQ) [26]. The six subscales are goal setting, environmental structuring, task strategies, time management, help seeking and self-evaluation, which comprise a total of 24 items. This instrument was specifically developed for online learning contexts, and it has been widely employed in assessing adult learners' online self-regulated learning [27,28].

Burnout

Students' burnout was measured using two 5-item subscales: emotional exhaustion and Cynicism from the Maslach Burnout Inventory - Student Survey (MBI-SS) [29]. The five-point scale ranges from 1 (Never), 2 (Sometimes), 3 (About half of the time), 4 (Mostly) to 5 (Always). To avoid redundancy with the items regarding participants' self-efficacy, the subscale of Academic Efficacy (AE) in MBI-SS was not adopted. In general, MBI-SS was designed for students across various disciplines and has been validated among medical students [30]. To ensure that the scale could be adapted to the online context, minor adjustments were made to some items. For example, the original item 'I feel used up at the end of the day at school' was modified to 'I feel used up at the end of the day after studying online'.)

Data analysis

Descriptive statistics of each variable were conducted. Pearson correlations between each variable were calculated after the reliability test. Confirmatory Factor Analysis (CFA) was performed to examine the hypothesized factor structure [31]. Finally, the Structural Equation Modelling (SEM) was conducted



to evaluate the hypothesized conceptual model (see Figure 1) [32]. The CFA and SEM were conducted in AMOS 28.0 using Maximum Likelihood Estimation as the estimation method, since the factors are categorical variables with five degrees [33].

The Model fit index was estimated using the primary first indices recommended by Hu and Bentler (1999) [34]. Four statistical indices regarding the degree of fitness would be reported: the chi-square goodness-offit (χ 2), the Root Mean Square Error of Approximation (RMSEA), the comparative fit index (CFI) and the Tucker-Lewis index (TFI). [35]. [36] For RMSEA, when the value is smaller than .08/.05, it would reflect an acceptable/good model fit. For TLI and CFA, a value > .95/.90 would exemplify good/acceptable model fit.

As suggested by Sideridis et al., (2014) [37], if each indicator demonstrates adequate reliability and normality, it would be sufficient to estimate models with three or more latent variables when the sample sizes are greater than 100. The current study had largely met these prerequisites and therefore be capable to adopt CFA and SEM to answer the research questions.

Results

Internal consistency of each instrument

The Cronbach's alpha (α) was calculated for all scales. The Cronbach's alphas for the 7 self-efficacy items and 24 online SRL items are .92 and .95 respectively. Within the AEQ-S, the Cronbach's alphas for the 4 items under each learning-related emotion (enjoyment, anxiety and boredom) are .74, .79 and .85 respectively. The burnout inventory was found to be highly reliable as well (10 items, $\alpha = .90$). The Cronbach's alphas of all the instruments adopted were above 0.7, indicating an acceptable internal consistency [38]. The skewness of all variables ranged from -1 to 1, and the kurtosis coefficients were all within -2 to 2, indicating that the data is normally distributed [39].

Descriptive statistics

The descriptive statistics of all the variables are displayed in Table 1. The mean scores for self-efficacy (M = 3.62, SD = .85) and online SRL (M = 3.52, SD)= .78) represented moderately high levels of beliefs in the respondents' learning capability and the active adoption of strategies used in online learning. The respondents reported occasional experiences of learning-related enjoyment (M = 3.64, SD = .75), but the levels of anxiety (M = 3.2, SD = .85) and boredom (M = 2.89. SD = .93) were also found to be considerable. The mean score of burnout (M = 2.63, SD = .79) indicates that the respondents experience this negative feeling almost half of the time during online learning.

Pearson correlation test was performed (see Table 2). Significant correlations were found between enjoyment and online SRL(r = .530,p < 0.001) as well as anxiety and online SRL (r = .232, p < 0.001). Burnout was positively correlated with anxiety (r = .430, p < 0.001) and boredom (r = .587, p < 0.001).

Measurement model

The CFA was performed to test the fitness of the six latent variables (self-efficacy, learning-related enjoyment, anxiety, boredom, online SRL and burnout). The results of maximum likelihood estimation showed acceptable local interdependence of the six latent variables, χ 2(309) = 585.293, p < .001, CFI = .94, TLI = .93, RMSEA = .056. The results of CFI, TLI and RMSEA fit the cut-off criteria suggested by Hu and Bentler (1999) [34], thereby indicating a reasonable factor structure for the hypothesized model. The details regarding the results of the measurement model are shown in Table 3.

Table 1. Descriptive statistics.

Variable	No. items	М	SD	α	Range	Skewness	Kurtosis
Self-efficacy	7	3.62	.85	.91	1–5	81	.82
Enjoyment	4	3.64	.75	.74	1–5	77	1.20
Anxiety	4	3.2	.85	.79	1–5	56	.07
Boredom	4	2.89	.93	.85	1–5	13	55
Online SRL	24	3.52	.78	.95	1–5	70	.61
Burnout	9	2.63	.79	.91	1–5	.66	.33

Table 2. Correlations among the study variables

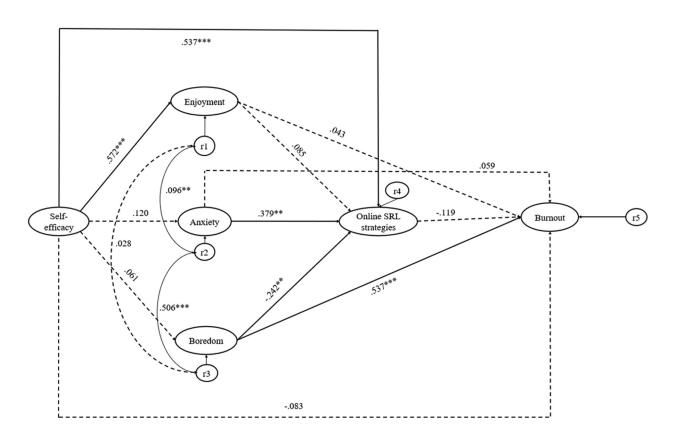
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Variable	1	2	3	4	5	6	7
1.Self-efficacy	-	.657***	.117*	.056	.638***	.561***	072
2.Enjoyment		-	.245***	.089	.530***	.481***	.003
3.Anxiety			-	.616***	.232***	.110	.430***
4.Boredom				-	.056	.057	.587***
5.Online SRL					-	.466**	069
6.Satisfaction						-	118*
7.Burnout							-

Note: *p<.05, **p<.01, ***p<.001.

Table 3. Results for the measurement model (N = 309).

		Standardized			
Latent variable	Item	Factor Loading Estimate (FLE)	SE		
Self-efficacy	MSLQ_1	.827***	-		
	MSLQ_2	.746***	.07		
	MSLQ_3	.727***	.06		
	MSLQ_4	.828***	.06		
	MSLQ_5	.782***	.07		
	MSLQ_6	.808***	.06		
	MSLQ_7	.854***	.06		
Enjoyment	AEQS_1	.636***	-		
	AEQS_2	.668***	.12		
	AEQS_3	.682***	.13		
	AEQS_4	.594***	.12		
Anxiety	AEQS_5	.681***	-		
	AEQS_6	.693***	.10		
	AEQS_7	.700***	.10		
	AEQS_8	.689***	.10		
Boredom	AEQS_9	.807***	-		
	AEQS_10	.770***	.07		
	AEQS_11	.713***	.07		
	AEQS_12	.783***	.07		
Online SRL	Goal setting	.880***	-		
	Environment structuring	.855***	.05		
	Task strategies	.784***	.06		
	Time management	.871***	.05		
	Help seeking	.809***	.05		
	Self-evaluation	.824***	.05		
Burnout	Emotional exhaustion	.890***	-		
	Cynicism	.920***	.06		

Note: ***p<.001.



*p<0.05; **p<0.01; ***p<0.001

Figure 2. The results of SEM.

Structural model

SEM was performed to test the structural relationships among self-efficacy, achievement emotions, online SRL, and burnout. The results of SEM were presented in Figure 2. The hypothesized model demonstrated good model fit: χ^2 (1251, N = 282) = 2037.37, p < 0.001; CFI = .91; TLI = .90, RMSEA = .047, with the 90% confidence interval [.044, .051].

Self-efficacy had a direct and positive effect on learning-related enjoyment ($\beta = .58$, p < .001), but it did not predict anxiety (β =.120, p > .05) and boredom (β=.061, p > .05). In addition, self-efficacy had a direct and positive effect on online SRL ($\beta = .54$, p < .001). While the coefficient was negative, self-efficacy did not have a direct and significantly negative effect on burnout (β =-.083, p > .05).

Regarding the relationship between achievement emotions and online SRL, learning-related enjoyment did not significantly and positively predict students' online SRL (β =.085, p > .05). Learning-related boredom, while not correlating with online SRL (shown in Table 2), negatively predicted online SRL ($\beta = -.24$, p <.01), but learning-related anxiety, as a negative learning-related emotion, led to a positive impact on online SRL ($\beta = .38, p < .01$).

Regarding the relationship between native achievement emotions and burnout, while boredom had a direct and positive effect on burnout ($\beta = .54$, p <.001), anxiety did not have a significantly positive effect on it (β =.059, p > .05).

Lastly, online SRL did not significantly and negatively predict burnout (β =-.119, p > .05).

Discussion

This study provides a structural model that investigates the relationships among medical students' selfefficacy, achievement emotions, online SRL, and burnout in online learning. The major findings of this study indicate that learning-related boredom negatively predicted online SRL and positively predicted students' burnout, which supported out H2b & H3b. Interestingly, learning-related anxiety, as a negative achievement emotion, positively predicted students' adoption of online SRL strategies. This finding rejected our hypothesis H2c.

Boredom as a negative predictor of online SRL

The negative impact of boredom on students' online SRL has confirmed what the control-value theory suggests [6-8,40]. Learning-related boredom, as a deactivating emotion, has inhibited the adoption of online SRL strategies among medical students. This result is also consistent with previous findings

indicating boredom as a negative predictor of educational involvement and emotional autonomy [41,42]. High levels of boredom might result in attention problems and irrelevant thinking in both traditional classrooms and online settings [3,43]. Therefore, it would be unlikely for students to activate effective cognitive resources while learning. This finding could enrich the literature regarding the critical effects of boredom on students' SRL in the online settings among medical students [4,44].

The findings of this study have implications for improving the instructional design of the online courses. Educators could apply certain tools and strategies to reduce students' boredom, increase their attention and enjoyment in the online courses [45]. For example, game-based learning has been proven to be able to facilitate students' engagement and decrease the degree of boredom experienced by the students. Thus, teachers could consider adopting appropriate online games in teaching, so as to motivate and foster enjoyment in online learning environments [46]. Moreover, educators could state the relatedness of the learning contents to the realworld situation. This would be meaningful to students' values regarding the importance of learning and prevent students from depersonalization and derealization. In addition, the careful use of different technologies in online courses would also contribute to students' engagement in class [47]. According to the Cognitive Load Theory [48], sometimes students would be overloaded due to the varieties of new technologies introduced, which might result in learners' disengagement and burnout. Hence, the instructional designers are suggested to select only those appropriate media for online interaction and knowledge transfer. These strategies would be effective in decreasing boredom and enhancing engagement among online learners.

Boredom as a positive predictor of burnout

While previous studies have examined the effect of either positive or negative achievement emotions as one latent variable on students' burnout [49], less is known about the effects of each discrete emotion on students' burnout. The result of this study may go beyond previous reports by showing the linkage between each discrete emotion and medical students' burnout.

Our results are consistent with one previous study suggesting a positive association between boredom and burnout [50]. It could be explained by the common negative impacts led by learning-related boredom [51]. Boredom is usually followed by anguish, doldrums and languor [52]. These feelings are similar to emotional exhaustion and cynicism, which are the two major components of burnout. Meanwhile,

learners who feel bored while learning might lose their interests quickly and thus leading to avoidance behaviours [53]. Therefore, boredom is regarded as a negative indicator of students' learning engagement. Leiter and Maslach (2017) indicated engagement and burnout are two relative constructs which are relatively adversely associated with each other 54]. Hence, while boredom disengages students from learning, the increased level of lethargy and anguish would trigger the sense of burnout at the same time.

Anxiety as a positive predictor of online SRL

The positive predictive effect of learning-related anxiety on students' adoption of online SRL rejected our hypothesis in the study. The result is contradictory to what most studies have suggested that negative emotions might disengage students from SRL [10]. In our study, students reported an average of moderate level of anxiety (M = 3.20). It is consistent with previous research suggesting low or moderate anxiety could be positively correlated with academic achievement [55], as well as another study suggesting the positive effect of learning-related anxiety on students' perceived knowledge improvements through proper effort regulation in online learning during the COVID-19 [4].

Learning-related anxiety was defined as an activating achievement emotion with medium level of control to the learning environment [6]. Students with high levels of anxiety during learning might exaggerate the importance of the learning situation and attempt to enhance the sense of control towards study [56]. Hence, the strong values of learning perceived by students with high levels of learning anxiety might set higher goals for themselves. While controlled at a moderate level, learning-related anxiety could drive learners to devote more effort and resources to avoid failures. Therefore, it is reasonable for learners to both adopt and adapt certain learning strategies more actively and evaluate their learning performance more frequently. This explanation is also in accord with the previous findings which proposed negative activating emotions (i.e., frustration) could lead to positive effects on learners' metacognition [18]. In addition, they further suggested that what are considered negative emotions do not necessarily always lead to negative outcomes and vice versa [6–8], we should always consider those emotion constructs as dynamic elements working in particular contexts.

Additionally, the characteristics of medical students would also relate to the previous explanation regarding the positive predictive effects of anxiety on online SRL. Medical students are considered as highly competitive and self-regulated learners [57]. Hence, learning-related anxiety experienced by medical students is always considered relatively high, due to the excessive academic loads and the difficulties implied in the knowledge [58]. In the current distant education, while changes in teaching mode interrupted their learning pace and plans, it is likely that they will devote more resources to regulate themselves in order to react to the uncertainty embedded in the learning environment [59]. For medical students in senior years as well as graduate medical students, their self-regulated skills have been trained through previous practice. Therefore, they might be more familiar with how to adjust themselves in response to the unavoidable anxiety and stress embedded in their learning activities. In addition, cultural influence should also be considered when looking into emotions experienced by medical trainees [60]. Asian students in general exhibited higher anxiety and self-doubt, for example than European students, despite their high academic achievement [61,62]. It is explained that the collectivist-oriented culture and family dynamics such as pressure to excel in academics contribute to Asian students' overall high anxiety. As a result, Asian students can be more tolerant of higher anxiety (tougher), thus would not affect their SRL or academic achievement [63]. This could probably also explain why in our study anxiety does not have a positive effect on burnout. Future studies could explore more cultural differences when examining the relationships between emotions and burnout.

Finally, while medical students' adoption of online SRL strategies is negatively correlated to their burnout, it cannot predict the occurrence of burnout in the final structural model. This result could be explained by the investigation conducted by Mheidly et al., which indicated the mediating role of coping strategies on the relationship between learning strategies and burnout [64]. Although medical school stressors are one of the major antecedents of students' burnout, there are many approaches that could buffer the negative effects of the stress from the learning environment. Despite the effective adoption of learning strategies, students could also activate relevant coping strategies, such as maintaining supportive relationships with peers, expressive distressing emotions and actively seeking help when needed, in order to reduce the level of burnout [65]. Future research could further examine the protective factors of burnout in different learning environments and contexts.

It should also be mentioned that this study is not without limitations. Firstly, the participants of the studies were from a convenience sample, which might result in selection bias. Students who completed the questionnaire in this survey might be more interested in the issues that were investigated in this study, and thus they might be more sensitive to their emotions than those who did not participate in the study.

In addition, this study examined these variables using aptitude scale by collecting survey data. It is possible that some subjects might fail to assess themselves accurately, or they might give some more socially acceptable answers. Future studies could adopt multidimensional data to examine those psychological constructs, such as using eye tracking data or microanalysis interview to examine students' SRL [66,67], or using EEG, ECG to measure students' emotional state while learning [68].

Conclusions

Our study confirmed that learning-related boredom inhibited students' online SRL [6,8] and increased the degree of burnout experienced by them. However, in contrast to previous literature suggesting a negative effect of anxiety on learning [9,61], we found that learning-related anxiety was in fact, positively associated with the adoption of online SRL strategies. This could be explained by medical students' intention of enhancing their control of the learning environment, in response to the uncertainties embedded in the online learning. The results emphasized the importance of managing medical students' burnout by reducing boredom-related learning experience in the online courses, while also exploring the positive effects of a moderate level of learning-related anxiety by providing relevant support, such as effort regulation.

Disclosure statement

No potential conflict of interest was reported by the authors.

Ethics approval

This study had been approved by the Human Research Ethics Committee (HREC) at the University of Hong Kong.

ORCID

Binbin Zheng http://orcid.org/0000-0001-6160-0104

References

- [1] Ruthberg J, Quereshy H, Ahmadmehrabi S, et al. A multimodal multi-institutional solution to remote medical student education for otolaryngology during COVID-19. Otolaryngology-Head And Neck Surgery. 2020;163(4):707-709. doi: 10.1177/0194599820933599
- [2] Zis P, Artemiadis A, Bargiotas P, et al. Medical studies during the COVID-19 pandemic: the impact of digital learning on medical students' burnout and mental health. Int J Environ Res Public Health. 2021;18(18 (1):349. doi: 10.3390/ijerph18010349.
- [3] Khalil R, Mansour AE, Fadda WA, et al. The sudden transition to synchronized online learning during the COVID-19 pandemic in Saudi Arabia: a qualitative

- study exploring medical students' perspectives. BMC Med Educ. 2020;20(1):1-10. doi: 10.1186/s12909-020-02208-z.
- [4] Tzafilkou K, Perifanou M, Economides AA. Negative emotions, cognitive load, acceptance, self-perceived learning outcome in emergency remote education during COVID-19. Educ Inf Technol. 2021;26 (6):7497–7521. doi: 10.1007/s10639-021-10604-1.
- [5] Baltà-Salvador R, Olmedo-Torre N, Peña M, et al. Academic and emotional effects of online learning during the COVID-19 pandemic on engineering students. Educ Inf Technol. 2021;26(6):7407-7434. doi: 10.1007/s10639-021-10593-1.
- [6] Pekrun R. The control-value theory of achievement emotions: assumptions, corollaries, and implications for educational research and practice. Educ Psychol Rev. 2006;18 (4):315-341. doi: 10.1007/s10648-006-9029-9.
- [7] Pekrun R, Elliot AJ, Maier MA. Achievement goals and achievement emotions: testing a model of their joint relations with academic performance. J Educ Psychol. 2009;101(1):115. 2009. doi: 10.1037/a0013383
- [8] Pekrun R, Perry RP. Control-value theory of achievement emotions. In: Pekrun R, Linnenbrink-Garcia L, editors. International handbook of emotions in education. Routledge; 2014. pp. 120-141.
- [9] Artino AR Jr, Holmboe ES, Durning SJ. Can achievement emotions be used to better understand motivation, learning, and performance in medical education? Med Teach. 2012;34(3):240-244. doi: 10.3109/ 0142159X.2012.643265.
- [10] Ahmed W, Van der Werf G, Kuyper H, et al. Emotions, self-regulated learning, and achievement in mathematics: a growth curve analysis. J Educ Psychol. 2013;105(1):150. doi: 10.1037/a0030160
- [11] Lazarides R, Buchholz J. Student-perceived teaching quality: how is it related to different achievement emotions in mathematics classrooms? Learn Instr. 2019;61:45-59. doi: 10.1016/j.learninstruc.2019.01.001
- [12] Liu XX, Gong SY, Zhang HP, et al. Perceived teacher support and creative self-efficacy: the mediating roles of autonomous motivation and achievement emotions in Chinese junior high school students. Thinking Skills And Creat. 2021;39:100752. doi: 10.1016/j.tsc. 2020.100752
- [13] Tempelaar DT, Niculescu A, Rienties B, et al. How achievement emotions impact students' decisions for online learning, and what precedes those emotions. Internet Higher Educ. 2012;15(3):161-169. doi: 10. 1016/j.iheduc.2011.10.003
- [14] Dettmers S, Trautwein U, Lüdtke O, et al. Students' emotions during homework in mathematics: testing a theoretical model of antecedents and achievement outcomes. Contemp Educ Psychol. 2021;36(1):25-35. doi: 10.1016/j.cedpsych.2010.10.001.
- [15] King RB, Areepattamannil S. What students feel in school influences the strategies they use for learning: academic emotions and cognitive/meta-cognitive strategies. J Pac Rim Psychol. 2014;8(1):18-27. doi: 10.1017/prp.2014.3.
- [16] Obergriesser S, Stoeger H. Students' emotions of enjoyment and boredom and their use of cognitive learning strategies-How do they affect one another? Learn Instr. 2020;66:101285. doi: 10.1016/j.learnin struc.2019.101285
- [17] Ding Y, Zhao T. Emotions, engagement, and selfperceived achievement in a small private online

- course. J Comput Assist Learn. 2020;36(4):449-457. doi: 10.1111/jcal.12410.
- [18] Artino AR Jr, Jones KD II. Exploring the complex relations between achievement emotions and self-regulated learning behaviors in online learning. Internet Higher Educ. 2012;15(3):170-175. doi: 10. 1016/j.iheduc.2012.01.006.
- [19] Fares J, Al Tabosh H, Saadeddin Z, et al. Stress, burnout and coping strategies in preclinical medical students. North Am J Med Sci. 2016;8(2):75. doi: 10. 4103/1947-2714.177299.
- [20] Burr J, Beck Dallaghan GL. The relationship of emotions and burnout to medical students' academic performance. Teach Learn Med. 2019;31(5):479-486. doi: 10.1080/10401334.2019.1613237.
- [21] Dimitriu MC, Pantea-Stoian A, Smaranda AC, et al. Burnout syndrome in Romanian medical residents in time of the COVID-19 pandemic. Med Hypotheses. 2020;144:109972. doi: 10.1016/j.mehy.2020.109972
- [22] Pintrich PR, Smith DA, Garcia T, et al. A Manual for the Use of the Motivated Strategies for Learning Questionnaire (MSLQ). National Center for Research to Improve Postsecondary Teaching and Learning,
- [23] Soemantri D, Mccoll G, Dodds A. Measuring medical students' reflection on their learning: modification and validation of the motivated strategies for learning questionnaire (MSLQ). BMC Med Educ. 2018;18 (1):1-10. doi: 10.1186/s12909-018-1384-y.
- [24] Bieleke M, Gogol K, Goetz T, et al. The AEQ-S: a short version of the achievement emotions questionnaire. Contemp Educ Psychol. 2021;65:101940. doi: 10.1016/j.cedpsych.2020.101940
- [25] Hayat AA, Shateri K, Amini M, et al. Relationships between academic self-efficacy, learning-related emotions, and metacognitive learning strategies with academic performance in medical students: a structural equation model. BMC Med Educ. 2020;20(1):1-11. doi: 10.1186/s12909-020-01995-9.
- [26] Barnard L, Lan WY, To YM, et al. Measuring self-regulation in online and blended learning environments. Internet Higher Educ. 2009;12(1):1-6. doi: 10.1016/j.iheduc.2008.10.005
- [27] Zalli MMM, Nordin H, Hashim RA. Online self-regulated learning strategies in MOOCs: a measurement model. Int J Emerg Technol Learn. 2020;15(8):255. doi: 10.3991/ijet.v15i08.12401.
- [28] Lin F, Lim L, Ho YY, et al. Validating and applying an adapted OSLQ to examine adult learners' online selfregulation. High Educ Res Dev. 2023;1-16. doi: 10. 1080/07294360.2023.2183938
- [29] Maslach C, Jackson SE, Leiter MP. Maslach Burnout Inventory. In: Third edition. Zalaquett CP, Wood RJ, editors. Evaluating stress: A book of resources. Scarecrow Education; 1997. p.191-218.
- [30] Shi Y, Gugiu PC, Crowe RP, et al. A Rasch analysis validation of the Maslach burnout inventory-student survey with preclinical medical students. Teach Learn Med. 2019;31(2):154-169. doi: 10.1080/10401334. 2018.1523010.
- [31] Brown TA. Confirmatory factor analysis for applied research (2nd ed.). New York, NY: Guilford publications; 2015.
- [32] Barrett P. Structural equation modelling: adjudging model fit. Pers Individ Dif. 2007;42(5):815-824. doi: 10.1016/j.paid.2006.09.018.

- [33] Rhemtulla M, Brosseau-Liard PÉ, Savalei V. When can categorical variables be treated as continuous? A comparison of robust continuous and categorical estimation methods under suboptimal conditions. Psychol Methods. 2012;17(3):354. doi: 10. 1037/a0029315.
- [34] Hu LT, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Struct Equ Modeling: A Multidisciplinary J. 1999;6(1):1-55. doi: 10.1080/ 10705519909540118.
- [35] Hair JF Jr, Sarstedt M, Hopkins L, et al. Partial least squares structural equation modeling (PLS-SEM): an emerging tool in business research. Eur Bus Rev. 2014;26(2):106–121. doi: 10.1108/EBR-10-2013-0128.
- [36] Marsh HW, Balla JR, McDonald RP. Goodness-of-fit indexes in confirmatory factor analysis: the effect of sample size. Psychol Bull. 1998;103(3):391. doi: 10. 1037/0033-2909.103.3.391.
- [37] Sideridis G, Simos P, Papanicolaou A, et al. Using structural equation modeling to assess functional connectivity in the brain: power and sample size considerations. Educ Psychol Meas. (5):733-758. doi: 10.1177/0013164414525397.
- [38] Gliem JA, Gliem RR. Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales. Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education, Columbus, OH; 2003. p. 82-88.
- [39] Mardia KV. Applications of some measures of multivariate skewness and kurtosis in testing normality and robustness studies. Sankhyā: The Indian J Of Stat, Series B. 1974;36:115-128.
- [40] Pekrun R, Goetz T, Daniels LM, et al. Boredom in achievement settings: exploring control-value antecedents and performance outcomes of a neglected emotion. J Educ Psychol. 2010;102(3):531. doi: 10.1037/
- [41] Mann S, Robinson A. Boredom in the lecture theatre: an investigation into the contributors, moderators and outcomes of boredom amongst university students. Br Educ Res J. 2009;35(2):243-258. doi: 10.1080/ 01411920802042911.
- [42] Sharp JG, Sharp JC, Young E. Academic boredom, engagement and the achievement of undergraduate students at university: a review and synthesis of relevant literature. Res Pap Educ. 2009;35(2):144-184. doi: 10.1080/02671522.2018.1536891.
- [43] Cho MH, Heron ML. Self-regulated learning: the role of motivation, emotion, and use of learning strategies in students' learning experiences in a self-paced online mathematics course. Distance Educ. 2015;36(1):80-99. doi: 10.1080/01587919.2015.1019963.
- [44] Parker PC, Perry RP, Hamm JM, et al. A motivation perspective on achievement appraisals, emotions, and performance in an online learning environment. Int J Educ Res. 2021;108:101772. doi: 10.1016/j.ijer. 2021.101772
- [45] Plass JL, Homer BD, MacNamara A, et al. Emotional design for digital games for learning: the effect of expression, color, shape, and dimensionality on the affective quality of game characters. Learn Instr. 2020;70:101194. doi: 10.1016/j.learninstruc.2019.01.005
- [46] Sabourin JL, Lester JC. Affect and engagement in Game-BasedLearning environments. IEEE Trans Affect Comput. 2013;5(1):45-56. doi: 10.1109/ T-AFFC.2013.27.



- [47] Skulmowski A, Xu KM. Understanding cognitive load in digital and online learning: a new perspective on extraneous cognitive load. Educ Psychol Rev. 2021;34 (1):1-26. doi:10.1007/s10648-021-09624-7.
- [48] Plass JL, Moreno R, Brünken R, Eds. Cognitive load theory. 2010.
- [49] de la Fuente J, Lahortiga-Ramos F, Laspra-Solís C, et al. A structural equation model of achievement emotions, coping strategies and engagement-burnout in undergraduate students: a possible underlying mechanism in facets of perfectionism. Int J Environ Res Public Health. 2020;17(6):2106. doi:10.3390/ ijerph17062106
- [50] Sousa T, Neves P. Two tales of rumination and burnout: examining the effects of boredom and overload. Appl Psychol. 2021;70(3):1018–1044. doi: 10.1111/apps.12257.
- [51] Tze V, Daniels LM, Klassen RM. Evaluating the relationship between boredom and academic outcomes: a meta-analysis. Educ Psychol Rev. 2016;28(1):119-144. doi:10.1007/s10648-015-9301-y.
- [52] Raffaelli Q, Mills C, Christoff K. The knowns and unknowns of boredom: a review of the literature. Exp Brain Res. 2018;236(9):2451-2462. doi: 10.1007/s00221-017-4922-7.
- [53] Sulea C, Van Beek I, Sarbescu P, et al. Engagement, boredom, and burnout among students: basic need satisfaction matters more than personality traits. Learn Individual Differences. 2015;42:132-138. doi: 10.1016/j.lindif.2015.08.018
- [54] Maslach C, Leiter MP Understanding burnout: New models. In: Cooper CL Quick JC, editors. The handbook of stress and health: A guide to research and practice. Wiley Blackwell; 2017. pp. 36-56.
- [55] Shibli N, Nawaz N, Ameen N, et al. The effects of anxiety on achievement and performance: a college study. Int J Sci Res Publ. 2015;5(6):1-2.
- [56] Cowden P. Communication and conflict: anxiety and learning. Res In High Educ J. 2001;9:1.
- [57] Haight SJ, Chibnall JT, Schindler DL, et al. Associations of medical student personality and health/wellness characteristics with their medical school performance across the curriculum. Acad Med. 2012;87(4):476-485. doi: 10. 1097/ACM.0b013e318248e9d0
- [58] Hope V, Henderson M. Medical student depression, anxiety and distress outside North America:

- a systematic review. Med Educ. 2014;48(10):963-979. doi: 10.1111/medu.12512.
- Zapata-Cuervo N, Montes-Guerra MI, Shin HH, et al. Students' psychological perceptions toward online learning engagement and outcomes during the COVID-19 pandemic: a comparative analysis of students in three different Countries. J Hosp Tour Educ. 2022;1-15. doi: 10.1080/10963758.2021.1907195
- [60] Artino AR Jr, Naismith LM. 'But how do you really feel?' Measuring emotions in medical education research. Med Educ. 2015;49(2):140-142. doi: 10. 1111/medu.12642.
- [61] Lee S, Juon HS, Martinez G, et al. Model minority at risk: expressed needs of mental health by Asian American young adults. J Community Health. 2009;34(2):144-152. doi: 10.1007/s10900-008-9137-1.
- [62] Stankov L. Unforgiving Confucian culture: a breeding ground for high academic achievement, test anxiety and self-doubt? Learn Individual Differences. 2010;20 (6):555–563. doi: 10.1016/j.lindif.2010.05.003.
- [63] Mheidly N, Fares MY, Fares J. Coping with stress and burnout associated with telecommunication and online learning. Front Public Health. 2020;8:672. doi: 10.3389/fpubh.2020.574969
- [64] Ellis RJ, Nicolas JD, Cheung E, et al. Comprehensive characterization of the general surgery residency learning environment and the association with resident burnout. Ann Surg. 2021;274(1):6-11. doi: 10. 1097/SLA.0000000000004796.
- [65] Susac AN, Bubic A, Kaponja J, et al. Eye movements reveal students'strategies in simple equation solving. Int J of Sci and Math Educ. 2014;12(3):555-577. doi: 10.1007/s10763-014-9514-4.
- [66] Gandomkar R, Yazdani K, Fata L, et al. Using multiple self-regulated learning measures to understand medical students' biomedical science learning. Med Educ. 54(8):727-737. doi: 10.1111/medu.14079
- [67] Bandara D, Song S, Hirshfield L, et al. A more complete picture of emotion using electrocardiogram and electrodermal activity to complement cognitive data. In International Conference on Augmented Cognition. Springer, Cham. 2016: 287-298.
- [68] Camacho-Morles J, Slemp GR, Pekrun R, et al. Activity achievement emotions and academic performance: a meta-analysis. Educ Psychol Rev. 2021;33 (3):1051-1095. doi: 10.1007/s10648-020-09585-3