ACHIEVEMENT GOALS AND EXTRANEOUS LOAD PREDICT GERMANE LOAD: THE MEDIATING EFFECTS OF ACHIEVEMENT EMOTIONS

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ABSTRACT

Purpose – Achievement emotions have been shown to mediate the association between achievement goals and learning performance, but no research to date has tested whether there is a similar process in predicting germane cognitive load. Based on the control-value theory of academic emotions (Pekrun, 2006), the present study tested a model to determine whether goal orientation and extraneous load were mediated by achievement emotions in predicting germane load.

Methodology – This survey study involved 487 voluntary university students ($N = 487$; 61% women; ages 17-23) who were enrolled in a statistics class and these study participants were selected using the cluster random sampling technique. They responded to three adapted scales which were translated into Bahasa Indonesia. The scales were, namely the Achievement Goal Questionnaire (AGQ), Achievement Emotions Questionnaire (AEQ), and Cognitive Load Questionnaire.

Data were collected 20 minutes before the statistics class ended and the data was then analyzed using bootstraped bias corrected (CI = 95%; N=5000) in Structural Equation Modelling (SEM).

Findings – The results of the structural equation modeling indicated that a mastery-approach goal was associated with higher germane load through higher enjoyment and lower anxiety, and a performance-avoidant goal was associated with lower germane load through higher anxiety. Moreover, extraneous load was negatively associated with germane load through enjoyment, but was positively associated with germane load through anxiety.

Significance – These findings have implications in educational settings: for most students with a mastery-approach goal, and enjoyable activities are helpful, as with those that increase cognitive performance in processing learning information. The present research is the first study to show that achievement goals are linked to the capacity to process learning-relevant information, in part due to the emotions the student experiences in the learning environment.

Keywords: Achievement goals, cognitive load, achievement emotions.

INTRODUCTION

Students' negative emotional experiences during learning were assumed to create cognitive load (Chen & Sun, 2012; Feldon et al., 2019; Lewis, 2019; Marchand & Guterez, 2012; Sunawan & Xiong, 2017), because emotions consumed cognitive resources (Awh et al., 2006), and working memory capacity became limited (King & Schaefer, 2011). From the perspective of cognitive load theory, learning is most effective when working memory resources are devoted to processing irrelevant vs. relevant information; both types of processing create cognitive load, but the first is counterproductive to learning and the second promotes learning. However, there are still unanswered questions about the impact of emotions on cognitive load such as, "Is the impact of achievement emotions on cognitive performance linear?" (Plass & Kaplan, 2016). Althaugh previous studies had shown that positive emotions predicted an increase in learning performance and negative emotions predicted a decrease in learning performance (Camacho-Morles et al., 2021; Pekrun et al., 2017). Pekrun (2006) in particular, warned that positive emotions

were not always adaptive, while negative emotions were not always less adaptive. Excessive positive emotions and excessive negative emotions could both potentially detract attention from learning, but low levels of emotion could facilitate learning. Low levels of positive emotion could help retain attention, and low levels of negative emotion, such as anxiety, could increase motivation. In addition, confusion as a negative achievement emotion could encourage further learning processes and the use of deep thinking strategies (D'Mello et al., 2014).

The current study, which was designed in part to clarify the impact of achievement emotions on germane load, was important to clarify the role of emotions in learning and competence development (Llorent et al., 2020). The present research was focused on enjoyment and anxiety because these emotions were the most frequent in learning (Dewaele et al., 2018).

In addition to understanding the effects of achievement emotions on cognitive load, it has also been important to identify contributors to these emotions. Achievement emotions might be stimulated by goal adoption (Linnenbrink, 2007). Studies on this topic have been relatively consistent in showing that a mastery achievement goal orientation was associated with positive emotions, such as enjoyment, whereas a performance-avoidance goal orientation was associated with negative emotion, such as anxiety (Pahljina-Reinic et al., 2017; Pekrun et al., 2009), and which was thought to decrease working memory performance (Linnenbrink et al., 1999).

It is important to distinguish the different causes of cognitive load. In the current study, the focus was on extraneous load and germane load. An extraneous cognitive load was caused by demands on the working memory having to process irrelevant information, and a germane load was due to demands on the working memory having to process relevant information (Sweller et al., 2011). Ideally, for learning, the extraneous load was low and the germane load was high, with working memory resources being used primarily to process learning-related information (Fraser et al., 2018). Building on these different lines of research, the present study explored a way to connect these three key results in the literature: that first, an achievement goal orientation was associated with achievement emotions; second, achievement emotions were associated with the germane cognitive load; and third, extraneous load was negatively associated with germane load. This study has made a unique contribution to the literature by testing

whether achievement goal orientation and extraneous load were directly associated with germane load, and the extent to which they were also indirectly associated with germane load through the effects of achievement emotions. These links were tested among college students in the learning context of a university statistics class.

LITERATURE REVIEW

Extraneous Load as a Predictor of Germane Load

Cognitive load theory (Sweller, 2010) has made predictions about the load on working memory while information was being processed during learning. Based on Miller's (1956) discovery that the working memory capacity was limited to 7 ± 2 items of information, cognitive load theory has provided guidance about developing effective educational activities that could optimize the working memory capacity for learning (Clark et al., 2006). Because the cognitive resource of working memory was limited, learning activities should allocate working memory resources to the optimal processing of information that was relevant for students' learning performance. Demands on the working memory—that is, the cognitive load—was the strongest predictor of students' learning performance (Clark et al., 2006). Paas, vanGog and Sweller (2010, p.116) defined cognitive load as "the learning of complex cognitive tasks, in which learners are often overwhelmed by the number of interactive information elements that need to be processed simultaneously before meaningful learning can commence." The level of cognitive load depended on the amount of element interactivity of information (Sweller, 2010). A larger amount of information usually had a more complex element interactivity and vice versa, and prior knowledge tended to reduce the complexity of element interactivity of information (Scheiter et al., 2009).

According to cognitive load theory, there were three types of demand on working memory. In other words, there were three types of cognitive load; these were called intrinsic, extraneous, and germane cognitive load (Sweller, 2010). Intrinsic cognitive load was due to the complexity of information that should be processed for optimal learning performance. Extraneous cognitive load was due to processing irrelevant information that interfered with learning. Germane cognitive load was due to efforts to process and create new information that was relevant for learning. In learning settings, for example, activities such as using social media during class created

extraneous load, which interfered with learning performance. Activities such as working on practice questions created a germane load, which was helpful for learning. Both the intrinsic and extraneous cognitive loads were additive because an increase in the extraneous load would lead to a decrease in the allocation of cognitive attention to the intrinsic load. Conversely, the low extraneous load prompts increased attention to information complexity. This study has focused on the extraneous load as a 'bad cognitive load' in order to explore its impact on learning.

Previous studies have found that the extraneous load negatively predicted the germane load (Gupta & Zheng, 2020; Lange et al., 2017). If the level of the extraneous load exceeded the capacity of the working memory, then the processing of learning-relevant information in the working memory will be decreased (Orru & Longo, 2019). By contrast, when there was less extraneous cognitive load, the working memory would be freed up to process learning-relevant information (Paas & van Merriënboer, 2020). In short, decreasing the extraneous cognitive load would increase the germane cognitive load. The germane load would be beneficial for optimal learning and information processing. However, anxiety could increase cognitive load (Dvorak-Bertsch et al., 2007; Lewis, 2019), suggesting the need for research on anxiety and other achievement emotions as predictors of the germane load.

Goal Orientation as Predictors of Achievement Emotions and the Germane Cognitive Load

In a learning context, an achievement goal might be what a student would have wanted to achieve in the future based on their current learning (Elliot & Fryer, 2008). The achievement goal orientation would provide the basis, rationale, and direction for a student's effort, motivation, use of learning strategies, germane load and academic achievement (Anderman et al., 2002; Costly & Lange, 2018; Lin, 2019; Lin & Wang, 2018; Trust & Hursh, 2008). Two achievement goal orientations (Elliot & McGregor, 2001) have received the most research attention. A mastery-approach goal (sometimes called a mastery goal) reflected a personal demand to learn by engaging with learning activities; a performance-avoidance goal reflected a demand from others to learn, to which the student has responded with avoidance. The connection between an achievement goal orientation and the cognitive load could be found from the results of experimental studies (Koorn, 2019; Wirth et al., 2009). Another study from Cook

et al. (2017) specifically found that mastery goals had a positive association with the germane load. Based on the findings of previous studies, this study will be looking into the impact of goal orientation on the germane load, both directly and indirectly through achievement emotions.

Achievement Emotions as Mediators

In the current study, achievement emotions were tested as mediators of two processes: first, the association between the extraneous load and the germane load, and second, the association between achievement goal orientation and the germane load. Regarding the first process, there has been little research on achievement emotions as mediators of the association between extraneous load and germane load.

Second, there has been only indirect evidence to suggest that achievement emotions mediated the association between achievement goals and the cognitive load. Previous research showed that achievement emotions mediated the association between achievement goal orientation and learning performance (Pekrun et al., 2009; Putwain, et al., 2013), but there have been no studies to date which have tested this process in relation to the germane cognitive load.

The Present Study

In the current study, college students in a statistics class agreed to provide feedback on their achievement goal orientation (mastery-approach or performance-avoidance), extraneous load, achievement emotions (enjoyment and anxiety), and germane load. The content of the class did not matter as much as the students' experiences in the class. Structural equation modeling was used to test the study's proposed model in which achievement goal orientation and extraneous load predicted germane load through the mediation of achievement emotions. Figure 1 shows the proposed conceptual model. The model was tested in the selected statistics class because this class had the largest enrollment.

Figure 1

The Proposed Conceptual Model
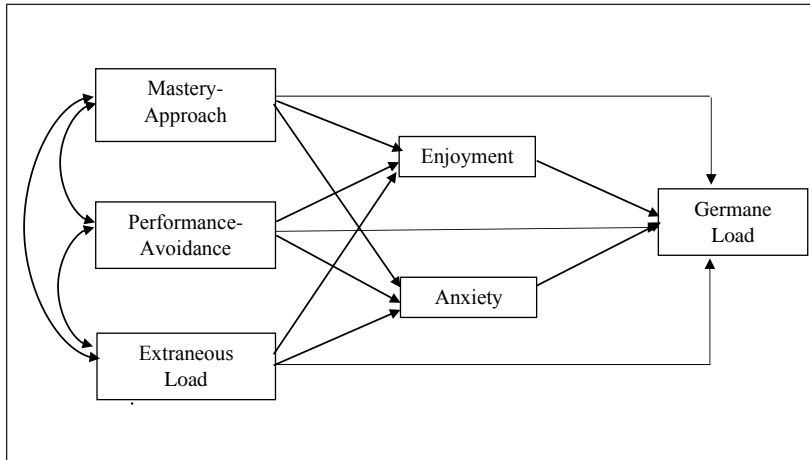
METHODOLOGY

Samples

The sample comprised 487 undergraduate students (191 men and 296 women) at a university in Semarang City, Indonesia. The target subjects were selected using the cluster random sampling technique in the university's statistics classes. Participants were aged between 17 to 23 years (M_{age} = 20.04, SD = 1.15). The questionnaires were administered twenty minutes before the Statistics class ended and the time given to answer the questionnaires was fifteen menutes. The respondents were willing to participate voluntarily because they had already given their consent by filling in a duly signed consent form.

Measurements

Data was collected using three scales, namely the Achievement Goal Questionnaire (AGQ), Achievement Emotions Questionnaire (AEQ), and Cognitive Load Questionnaire. The original versions of these scales were in English. In order to facilitate a better comprehension of the items in the questionnaires administered to the mainly Indonesian speaking student respondents, a back-translation procedure was applied to create versions of the questionnaires in Bahasa Indonesia.

Cognitive Load

Students' extraneous cognitive load and germane cognitive load were measured subjectively using the 8-item Cognitive Load Questionnaire (Leppink, Paas, Gog, Vleuten & Merrienboer, 2014). The scale has 4 items to assess extraneous load (e.g., "*The explanations and instructions in Statistics class were very unclear*") and 4 items to assess germane load (e.g., "*Statistics class really enhanced my understanding of the content that was covered*"). Each item was rated on a Likert scale ranging from 1 (not at all) to 5 (very much). The reliability test in the present study indicated that this scale had a good alpha coefficient of .90 for extraneous load and .89 for germane load (see Table 1).

Achievement Emotions

Students' emotions of enjoyment and anxiety during class were assessed using the 9-item Academic Emotions Questionnaire (AEQ) (Pekrun, Goetz, Titz, & Perry, 2002). Enjoyment was assessed using 4 items (e.g., "*I get excited about going to Statistics class*"), whereas students' anxiety was assessed using 5 items (e.g., "*I feel nervous in Statistics class*"). Each item was rated on a Likert scale ranging from 1 (not at all) to 5 (very much). The scales had adequate alpha reliability of .78 for both enjoyment and anxiety (see Table 1).

Acievement Goal Orientation

The Achievement Goals Questionnaire (AGQ) (Elliot & McGregor, 2001) was used in this study to assess two kinds of student goal orientation during class, namely mastery-approach goal orientation (3 items, e.g., "*I want to learn as much as possible from Statistics class*") and performance-avoidance goal orientation (3 items, e.g., "*I just want to avoid doing poorly in Statistics class.*"). Each item is rated using a 7-point Likert scale ranging from 1 (not at all the case) to 7 (completely the case). Results ot reliability tests showed that the good alpha coefficients were .73 for mastery-approach goal orientation and .81 for performance-avoidance goal orientation (see Table 1).

Data Analysis

Data analysis was conducted to examine the role of enjoyment and anxiety as mediators in the associations between goal orientation and the germane load, and between the extraneous load and the germane load. Product moment correlation was used to explore possible

relationships among the variables. Structural equation modeling was used to test the hypothesized model. The fitness of the model was assessed based on several goodness-of-fit-indexes, namely χ2 test, ratio of χ2 to degrees of freedom (χ2 / df), the Comparative Fit Index (CFI) and the Root Mean Square Error of Approximation (RMSEA) (Cheung & Rensvold, 2002; Milfont & Fisher, 2010). The SEM literature has suggested that model fit is excellent when χ2/df ≤ 3, CFI ≥ .95, TLI ≥ .95, and RMSEA ≤ .05. Mediation effects were tested using the bias-corrected bootstrapping technique with 5000 iterations (Preacher & Hayes, 2008). The mediation effects were estimated by using point estimates and 95 percent confidence intervals. Product moment correlations were calculated using SPSS version 21 software, while SEM and the bias-corrected bootstrapping analysis were performed using AMOS version 21.

RESULTS

The proposed model has examined achievement goals and the extraneous load as predictors of the germane load, and achievement emotions as mediators of these associations. The intercorrelation matrix presented in Table 1 provides preliminary evidence in support of the proposed model. All expected correlations were significant and in the expected direction, with some x exceptions of correlation between mastery approach and germane load (r = .23, p < .01), between anxiety and germane load (r = .02, p > .05), and between anxiety and germane load (r = .05, p > .05).

Table 1

The Intercorrelation between the Matrix, Means and Standard Deviations of All the Study Variables

	1	2	3	4	5	6
1. Mastery approach	(.73)					
2. Performance avoidance	.17*	(.81)				
3. Enjoyment	.33*	-.05	(.78)			
4. Anxiety	.02	.40*	-.28*	(.78)		
5. Extraneous load	-.03	.19*	-.28*	.37*	(.90)	

(continued)

	1	2	3	4	5	6
6. Germane load	.23*	.02	.44*	.05	.17*	(.89)
M	4.22	3.79	3.76	2.78	2.73	3.77
SD	0.62	0.84	0.65	0.78	0.87	0.54

Note. $N = 487$. Internal consistency (α) is shown in parentheses. * $p < .01$

The results of the structural equation modeling showed that the proposed model had an acceptable fit to the data, χ^2 (212) = 353.55, $p < .01$, χ^2/df = 1.67, CFI = .97, RMSEA = .04. Figure 2 shows the associations among variables as β. All predictors explained the variance of the germane load was at 41 percent. The following sections will highlight the direct and indirect effects that were of interest in this study.

Figure 2

Structural Equation Modeling Results Showing the Direct and Indirect Predictors of Germane Load
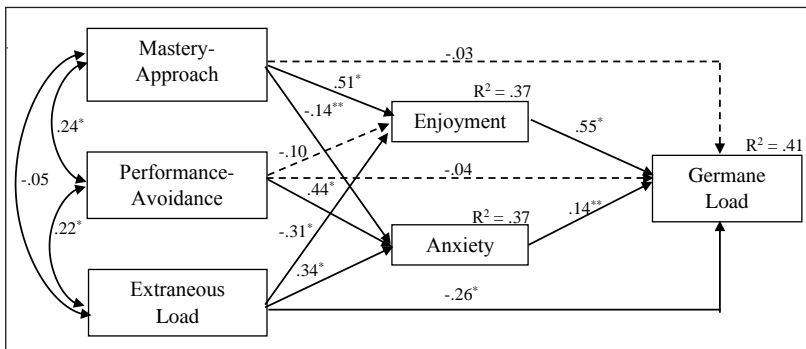
Note. Associations between variables are shown as β. The model showed good fit to the data, χ^2 (212) = 353.55, $p < .01$, χ^2/df = 1.67, CFI = .97, RMSEA = .04 *$p < .01$ **$p < .05$

Direct Effects of Achievement Goals and Extraneous Load on Germane Load

As expected, there was a significant, negative direct association between extraneous load and germane load ($\beta = -.26$, $p < .01$). This was because when students reported a high extraneous load

(indicating a higher allocation of cognitive resources to processing irrelevant information) they also tended to report a lower germane load (indicating a lower allocation of cognitive resources to processing relevant information). However, neither of the achievement goals was directly associated with germane load. Instead, mastery goal orientation and performance-avoidance orientation appeared to be associated with germane load only through the mediating effects of achievement emotions.

The Mediating Effect of Achievement Emotions

Evidence of mediation depends on three components. First, the predictors (achievement goals and the extraneous load) should be correlated with the mediators (achievement emotions). In the current model, this was true for all predictors. Second, the mediators should be correlated with the outcome variable (the germane load). In this case, both achievement emotions were correlated with germane load. Finally, the indirect link between the predictors and the outcome variable should explain more variance than the direct links. This last component was tested using bootstrapping with 5000 iterations to produce a bias-corrected estimate of each mediator effect, using a confidence interval of CI = 95%. The mediation effects by which achievement goal orientations were associated with the germane load by way of achievement emotions are as presented in Table 2.

Table 2

The Mediation Effects of Academic Emotions

Mediator	Estimation	SE	Bias-corrected 95%		p
			LL	UL	
MAp ➔ Enj ➔ GL	.26	.06	.17	.39	<.01
MAp ➔ Anx ➔ GL	-.02	.01	-.05	-.00	<.05
PAv ➔ Anx ➔ GL	.04	.02	.01	.09	<.05
EL ➔ Anx ➔ GL	.03	.01	.01	.06	<.01
EL ➔ Enj ➔ GL	-.11	.02	-.16	-.07	<.01

Note. N = 487. MAp = Mastery-approach goal orientation; PAv = Performance-avoidance goal orientation; Enj = Enjoyment; Anx = Anxiety; EL = Extraneous load; GL = Germane load

Both enjoyment and anxiety had significant mediating effects on the processes of interest. First, the association between mastery goal orientation and germane load was significantly mediated by the

higher enjoyment and lower anxiety. More specifically, the evidence has suggested that students who reported a higher mastery goal orientation also tended to experience more enjoyment and lower anxiety, and in turn, a higher germane load. Second, the association between performance-avoidant achievement orientation and germane load was significantly mediated by higher anxiety. This was because students who reported a higher performance-avoidant goal orientation also tended to experierence more anxiety, and in turn, a lower germane load.

DISCUSSION

The current study has examined students' achievement emotions as mediators of the process by which students' achievement goal orientation and extraneous load have predicted the germane cognitive load in a university course. Results of the structural equation modeling carried out showed that both higher enjoyment and lower anxiety mediated the association between a mastery-goal achievement orientation and the higher germane load, and higher anxiety mediated the association beween performance-avoidance and the lower germane load. The findings seemed to suggest that motivation in the form of achievement goal orientation did not directly impact the working memory performance. Instead, achievement goal orientation could predict the germane load to the extent that it produced both positive and negative emotions. These results thus, confirmed the importance of achievement emotions during the learning process, and this could have implications for the design of learning materials and activities.

Previous studies have documented certain aspects of the conceptual model tested in the current research. First, an achievement goal orientation has been shown to be correlated with achievement emotions (Pekrun et al., 2009). Second, achievement emotions have been shown to be correlated with the cognitive load (Chen & Chang, 2009; Fraser & McLaughlin, 2018; Sugiyo et al., 2018; Vytal, et al., 2012). Third, achievement emotions played a mediating role between motivation and cognitive performance (Pekrun et al., 2009; Simonton & Garn, 2020). The current study has contributed to the literature in the field by examining a process that connected these two lines of research. More specifically, achievement emotions were tested as mediators of the association between achievement goal orientation and germane load. The results supported this conceptual model, as well as the cognitive affective theory of learning with media (CATLM;

Moreno, 2006), which has stated that motivation and positive effects supported the working memory performance.

The effects of the motivational and emotional impacts on germane load that were documented in the present study can be understood in light of the position taken in the study by Valiente, Swanson and Eisinberg (2012) that motivation and emotion would enhance or inhibit the working memory. For example, anxiety has been found to reduce working memory performance (Meisner & Bogner, 2012). However, in the present study, anxiety showed a small but significant association with germane load, although the association was much lower than the link between enjoyment and germane load. This finding has suggested the possibility that anxious individuals used compensatory mechanisms to offset the negative effects of anxiety on performance (Eysenk et al., 2007), for example through increased effort or adjustments in cognitive processes. This finding has also confirmed Pekrun's (2006) view that not all negative emotions adversely affected cognitive performance. Moreover, the findings of this study have also confirmed that positive emotions have evolved to expand and consolidate the use of cognitive resources so that the germane load could be more optimal (Howthorne et al., 2019; Plass & Kalyuga, 2019).

The present findings also seemed to suggest that achievement emotions were more proximal predictors of the working memory performance than motivation was. In line with other studies (Pekrun et al., 2009; Putwain et al., 2013) this research has found that achievement emotions mediated the correlation between motivation and cognitive load. More specifically, enjoyment positively mediated the association between a mastery-approach goal orientation and germane load, whereas anxiety negatively mediated this association. These findings suggest that the adoption of a performance-avoidance goal orientation could stimulate anxiety about failure, which might then encourage the use of compensatory mechanisms to process learning information (Eysenk, et al., 2007). However, the adoption of a mastery-approach goal orientation would encourage the optimal use of cognitive resources to process the learning information; the student would feel less anxious and would be able to process the learning-relevant information (Lin, 2018; Lin & Wang, 2019).

In the present study it was found that the extraneous load directly and negatively predicted the germane load; the association was also mediated by achievement emotions. This result corroborated the

findings in a previous study by Lange and Costly (2017), who found that in addition to the direct association, the higher anxiety and lower enjoyment both mediated the negative effect of extraneous load on germane load. These findings have suggested that when the learning process presented irrelevant learning information, anxiety about the risk of failure in the future would encourage the use of cognitive resources to select and process information that was relevant to the learning objectives.

Overall, the findings of this study have suggested the importance of adaptive achievement goals (particularly, a mastery approach goal) for students, and efforts to minimize irrelevant information during the learning process (Leppink, 2017; Plass & Kalyuga, 2019). Cognitive load theory would suggest the importance of learning materials and methods that could help students to develop a mastery-approach goal orientation so that they would enjoy the learning process and, in turn, would optimally use cognitive resources to process learning information. In addition, when students realized that their learning was not relevant to achieving learning goals, they could be helped to re-focus their efforts on achieving learning goals.

Implications, Limitations and Future Research

The results obtained in this study have implications for teachers who want to design instructional activities for optimizing the germane load of their students. Promoting the mastery-approach as a goal for students and creating enjoyable activities are the two inputs which will help increase cognitive performance in processing learning information. It will also to improve the germane load of students who have a performance-avoidant goal orientation. Students in this study with a performance-avoidant goal orientation did not necessarily have a lower germane load. This was perhaps because, as teachers have always known, students would have more than one reason for avoiding performance. However, germane load was decreased to the extent that the performance-avoidant goal orientation increased students' anxiety. That is, the germane load was lower when students with the performance-avoidant goal orientation also experienced anxiety. This observation suggests that helping students change from a performance-avoidant goal to a mastery goal may be easiest when teachers promote enjoyable learning activities and enhance students' mastery.

There are three key limitations in the present study. Firstly, although the study model was conceptualized in terms of causal relationships,

the data collected was cross-sectional and the analyses were correlational in nature. Experimental and longitudinal data would have been helpful to establish causality in future studies. Secondly, the conceptual model used in the present studyfocused on only two achievement goal orientations and only two achievement emotions. A larger model could elucidate more complex associations among the variables in relation to germane load. For example, Pahljina-Reinic and Kolic-Vehovec (2017) explained that multiple goal orientations (mastery/performance-approach goal orientation) had the most adaptive effect on motivation, achievement emotions and learning performance. Future research will be invaluable if it involves multiple goal orientations in predicting achievement emotions, as well as the cognitive load. Finally, self-rating scales were applied to assess students' emotions and cognitive load in this study, increasing the possibility of shared method bias. More objective measures, such as teacher ratings and observational ratings, could be helpful in future research on the predictors of the germane load.

CONFLICT OF INTEREST

The authors report no conflict of interest, as the current study was conducted solely for the purposes of their own research program.

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