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The Relationship between Cognitive Activation, Self-efficacy, Achievement Emotions and (Meta)cognitive Learning Strategies among Ugandan Biology Learners

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According to the control-value theory of achievement emotions, the influence of cognitive activation teaching strategies on students' effective use of Cognitive and Meta-Cognitive (CMC) learning strategies is mediated by control appraisals (e.g. self-efficacy) and achievement emotions (i.e. enjoyment and boredom). However, there is limited and contrasting empirical evidence to support this assertion despite claims of cross-cultural and domain consistency. The present study was aimed at examining the multiple mediational roles of self-efficacy and achievement emotions on the relationship between perceived cognitive activation during instruction and four CMC learning strategies among Ugandan biology students. Data were collected using anonymous questionnaires from 587 (50.6% females) tenth grade students with a mean age of 17 years (SD = 1.16) from 10 secondary schools in Uganda. We tested the mediation hypothesis in separate models with each CMC learning strategy. Indirect effects from cognitive activation through self-efficacy and/or enjoyment to CMC learning strategies were all significant confirming their mediational roles. There were significant ($p <$ 0.001) direct effects from cognitive activation to: self-efficacy ($\beta =$ 0.41), enjoyment ($\beta =$ 0.26) and cognitive learning strategies, i.e. rehearsal ($\beta =$ 0.30), organisation ($\beta =$ 0.30) and elaboration ($\beta =$ 0.33). Self-efficacy and enjoyment fully mediated the relationship between cognitive activation and metacognition. Except for self-efficacy, direct effects to or from boredom were not significant. Clearly, instructional strategies in biology that stimulate thought among learners are relevant for increasing effective use of any one of CMC learning strategies.

Keywords: *Cognitive activation; self-efficacy; achievement emotions; learning strategies; biology*

Introduction

Science instruction in Sub-Saharan Africa is in dire need of improvement. Owing to the limited resources and often inadequately trained teachers, instruction tends to be mostly teacher-centred. As a result, learning in these environments is often compromised with students reporting negative attitudes towards science domains and low achievement when compared with their peers in developed nations. According to the Control-Value Theory of Achievement Emotions (CVTAE), instructional strategies can foster the development of effective Cognitive and Meta-Cognitive (CMC) learning strategies among learners (Pekrun, 2006). Cognitive activation is a teaching strategy that involves providing learners with experiences that challenge their thought processes by allowing room for discourse, questioning, critical thinking and problem-solving (Baumert et al., 2010; Fauth, Decristan, Rieser, Klieme, & Büttner, 2014). Presenting cognitively challenging experiences to learners during instruction facilitates effective use of CMC learning strategies, i.e. rehearsal, organisation, elaboration and metacognition (Pekrun, 2006). Metacognition relates to the conscious knowledge and regulation of learning (Pintrich, Smith, Garcia, & McKeachie, 1991). Cognitive activation exerts it's influences on students' CMC learning strategies through its effects on learners' self-efficacy beliefs (i.e. learners' beliefs about their competencies in a given area) and achievement emotions (emotions experienced owing to involvement in teaching–learning activities or their outcomes, e.g. boredom and enjoyment). For example, if students are provided with opportunities to argue out and suggest strategies to combat climate change rather than being presented with suggestions directly, they will most likely feel more confident about their knowledge in the area and hence enjoy learning more about it. Such positive affective experiences enable students to invest their cognitive resources by using more effective CMC learning strategies. Effective use of CMC learning strategies results in higher achievement (Ahmed, van der Werf, Kuyper, & Minnaert, 2013; Liem, Lau, & Nie, 2008; Muwonge, Schiefele, Ssenyonga, & Kibedi, 2019). Cognitively activating instructional strategies are particularly beneficial for learners from low socio-economic backgrounds (Li, Liu, Zhang, & Liu, 2020).

There are several research findings that in part explain the relationships between cognitive activation teaching strategies, learners' perceived control, achievement emotions and CMC learning strategies as predicted by the CVTAE (e.g. Ahmed et al., 2013; Li et al., 2020; Obergriesser & Stoeger, 2020; You & Kang, 2014). However, no study could be traced that examined the multiple mediation model with self-efficacy, enjoyment and boredom as mediators in the biology domain. While it is reported that this relationship should be uniform across domains, a few studies conducted within biology report contrasting evidence when compared with those conducted in mathematics, especially regarding the relationship with the rehearsal strategy (Chatzistamatiou, Dermitzaki, Efklides, & Leondari, 2015). In addition, most of the partial evidence available has not been verified based on data from participants from low-income countries. Instruction in low-income countries often operates under conditions of low resources and with inadequately trained teachers and therefore tends to be more teacher-centred, promoting shallow learning strategies. In the next section, we discuss literature informing the study while also exposing the gaps leading to the present study.

Cognitive Activation and Learning Outcomes

Cognitive activation has been positively associated with students' self-efficacy (Li et al., 2020) and enjoyment (Cantley, Prendergast, & Schlindwein, 2017; Lazarides & Buchholz, 2019). Lazarides and Raufelder's (2020) study among mathematics German ninth and tenth graders found that only when learners received high cognitively activating instruction did their high perceived control result in more enjoyment of learning. Further, the relationship between cognitive activation and students' control appraisals may be moderated by their socio-economic backgrounds at both the student and classroom levels (Burge, Lenkeit, & Sizmur, 2015; Li et al., 2020). Hence, learners from low and middle socio-economic backgrounds are more likely to benefit from cognitively stimulating instruction than those from high socio-economic backgrounds. The negative effects of one's socio-economic background on their control appraisals in learning situations can be offset by providing appropriate teaching strategies that counter these effects to improve science achievement in low-income countries (Li et al., 2020).

The associations between learners' control appraisals and CMC learning strategy use have been supported by numerous studies (Ahmed et al., 2013; Chatzistamatiou et al., 2015; Muwonge, Ssenyonga, & Kwarikunda, 2018; Ng, Liu, & Wang, 2015) reporting that learners frequently adjust their CMC learning strategies to a task based on the perceived task demands. For example, challenging learning tasks are approached using the more effective deep CMC learning strategies while difficult tasks are approached with limited investment of cognitive effort, with use of less effective shallow learning approaches (i.e. rehearsal) and minimal use of the more effective deep learning approaches. The study by Muwonge et al. (2019) involving science and mathematics university teacher trainees ($n = 1081$) in Uganda found that their use of cognitive learning approaches like elaboration, organisation and critical thinking was significantly and positively correlated with their self-efficacy. The same trend was found for self-efficacy and meta-cognition among 649 teacher trainees (Muwonge, Schiefele, Ssenyonga, & Kibedi, 2017). These results were consistent with Chatzistamatiou et al.'s (2015) study among elementary mathematics students focusing on the use of memorisation, deep comprehension, metacognition and reflection strategies.

Learners' achievement emotions and their use of CMC learning strategies are related (Obergriesser & Stoeger, 2020; Pekrun, 2006). The associations between boredom and CMC learning strategies use are dependent on the type of learning strategy. For example, the meta-analysis by Tze, Daniels and Klassen (2016) found that, in general, high levels of boredom were associated with more use of shallow CMC learning strategies and less use of deep CMC learning strategies. This was consistent with Ahmed et al. (2013) and Pekrun, Goetz, Titz and Perry (2002), who noted significant negative associations between boredom and elaboration ($r = -0.26$) and boredom and meta-cognitive self-regulation ($r = -0.21$). However, other studies reveal contrasting evidence regarding the association between boredom and rehearsal, reporting either positive and/or insignificant associations (Muis et al., 2015; Pekrun et al., 2002; Pekrun, Goetz, Daniels, Stupnisky, & Perry, 2010; Perry, Hladkyj, Pekrun, & Pelletier, 2001). For example, consistent with Ahmed et al. (2013) and Pekrun et al. (2010), Pekrun et al. (2002) found no significant associations between boredom and rehearsal ($r = -0.06$). However, significant negative associations have been found between boredom and rehearsal (see study 1 in Muis et al., 2015). Insignificant associations between boredom and other learning strategies like critical thinking and metacognition are also evident in some other studies (see study 2 in Muis et al., 2015).

Unlike boredom, enjoyment seems to show a rather consistent relationship with CMC learning strategies. Obergriesser and Stoeger's (2020) findings indicate that enjoyment results in more effective CMC learning strategy use and over time these effects are reciprocal. In this 5-week longitudinal study, fourth graders ($n = 338$) were required to analyse texts from different science areas including those from biology. The noted effective use of text reduction learning strategies was due to enjoyment of the learning tasks while boredom was associated with the use of less effective text reduction strategies. Among elementary school learners, enjoyment of mathematics was positively correlated with the use of memorisation, reflection, metacognition and deep comprehension strategies (Chatzistamatiou et al., 2015). While there is substantial empirical support for the positive associations between enjoyment and deep CMC learning strategies, the evidence is mostly limited to the mathematics domain and studies conducted in developed nations. Also, there are contradictory findings showing either insignificant (Pekrun et al., 2002) or positive (Muis et al., 2015) associations between rehearsal and enjoyment. Most studies reported here were based on learners' interaction with mathematics content. In contrast, the study by Muis et al. was based on learners' interaction with qualitative information regarding climate change which is somewhat similar to the present study's focus on biology.

Overall, previous studies present partial and, in some cases, inconsistent findings of the relationships between the study variables. While the CVTAE proposes that the relationships between the study variables are independent of the domain and cultural context, this has not been adequately tested beyond the commonly studied mathematics domain and particularly in developing nations with students from low socio-economic backgrounds.

The Present Study

This study was aimed at examining the mediation effects of self-efficacy and achievement emotions on the relationship between perceived cognitive activation during instruction and learners' CMC learning strategies. Based on the CVTAE (see illustration in Figure 1), we hypothesised that both self-efficacy and achievement emotions played multiple mediational roles in the studied relationship (Pekrun, 2006). According to the CVTAE, the teaching–learning environment and students' emotional and behavioural learning outcomes are inter-correlated with reciprocal causal relationships. Achievement emotions directly affect learning effort. The pattern of achievement emotions experienced in achievement situations is influenced by one's control (i.e. self-efficacy) and value appraisals in addition to their unique innate temperament. These appraisals develop according to how individuals interpret

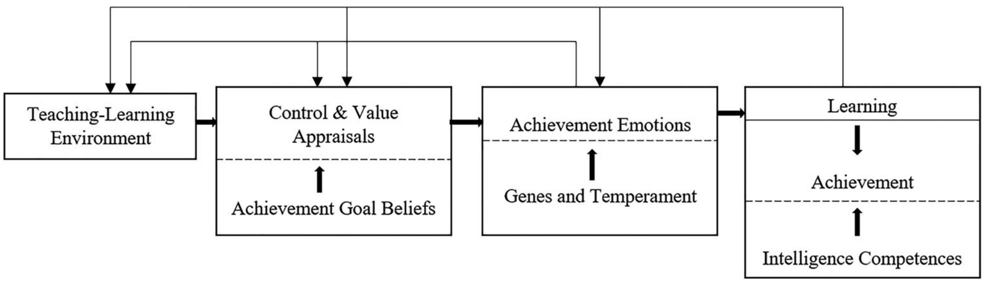

Figure 1. The CVTAE mediation model. Note: adapted from Pekrun's (2006) model

events in their learning environment related to their control over the learning task, the value of engaging in achievement activities and their achievement goals. This study focuses on how the cognitive activation teaching strategies' effects on students' learning strategies are mediated by self-efficacy and achievement emotions. Understanding how cognitive activation shapes learner outcomes is essential for designing effective instruction by informing teachers and teacher trainers.

Methods

Study Design and Procedures

The study employed a cross-sectional survey. Ethical approval was sought from the Mbarara University of Science and Technology Ethics Review Board (MUST-REC) in Uganda and the Research Unit, University of Rwanda—College of Education. The first author then contacted the administrators of the selected schools to communicate relevant information about the study, collect student information to guide sample selection and schedule data collection sessions with students. Data collection was conducted with the help of two trained research assistants. The selected students were informed of all relevant information about the study and their ethical rights. They were allowed to ask questions that were answered by the study team. Data were collected during class hours.

Participants

We collected data from 587 tenth grade secondary school students from 10 schools (including single-sex, mixed-sex, boarding, day and combined day and boarding schools) from one district in Uganda. These students are in their third year of secondary school schooling, which lasts 6 years. We used proportionate random sampling (based on class size, gender and school type, i.e. single-sex schools and mixed-sex schools) to ensure a representative sample. Of these, 50.1% were from mixed-sex schools and the rest from single-sex schools; 48.9% were males and 50.6% were female. Their age ranged between 14 and 22 years (mean = 16.99; standard deviation = 1.16).

Instruments

We collected data using anonymous self-administered questionnaires consisting of five sections. The first section elicited learners' demographic variables. The next four sections consisted of scales measuring perceived cognitive activation, self-efficacy, achievement emotions and CMC learning strategies. The items were adapted to refer to the domain of biology and several grammatical changes were made to ease understanding.

Perceived cognitive activation was measured using five items ($\alpha = 0.72$) adapted from a tool developed by Fauth et al. (2014). The items were rated on a four-point Likert scale from 1 (*Strongly disagree*) to 4 (*Strongly agree*). A sample item stated that: 'Our biology teacher gives us tasks I like to think about'. Self-efficacy was measured using five items ($\alpha = 0.87$) adapted from the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991). The items were rated on a seven-point Likert scale ranging from 1 (*Not at all true of me*) to 7 (*Very true for me*). A sample item stated that:

'I believe I will receive an excellent mark in biology'. Learning-related enjoyment and boredom were measured using items adapted from the Achievement Emotions Questionnaire (Pekrun, Goetz, & Perry, 2005). The boredom subscale comprised of five items with internal reliability $\alpha = 0.91$. A sample item stated that: 'Biology material bores me to death'. The enjoyment subscale comprised of 5 items with internal reliability $\alpha = 0.86$. A sample item stated that: 'I look forward to studying biology'. All items on both subscales were rated on a five-point Likert scale from 1 (*Strongly disagree*) to 5 (*Strongly agree*). CMC learning strategies were measured using items adapted from the MSLQ (Pintrich et al., 1991) including four subscales: rehearsal (four items, $\alpha = 0.72$), organisation (four items, $\alpha = 0.74$), elaboration (six items, $\alpha = 0.78$) and metacognitive self-regulation (seven items, $\alpha = 0.81$). Sample items for rehearsal, organisation, elaboration and metacognition included: 'I memorise keywords to remind me of important concepts in this class', 'I make simple charts, diagrams, or tables to help me organise course material', 'When reading for this class, I pull together information from different sources, such as lessons, readings, and discussions' and 'When reading for this course, I make up questions to help focus my reading'.

Data Analysis Strategy

All preliminary analyses were conducted in SPSS version 25. To examine the mediational hypothesis, several steps were followed: (1) data screening; (2) measurement model analysis; (3) structural model analysis; and (4) determination of indirect effects. Data screening was conducted in SPSS version 25 and the rest of the steps were conducted in Mplus 7.4. The data were first screened to ensure their suitability for Structural Equation Modeling (SEM) by assessing univariate and multivariate normality, the missing value pattern (using Little's Missing Completely at Random test), the presence of outliers and multicollinearity (Kline, 2011). Univariate non-normality and therefore likely multivariate non-normality was confirmed, necessitating the use of a more robust estimator, Maximum Likelihood Estimation with Robust Standard Errors during SEM. The default Full Information Maximum Likelihood estimator was retained during SEM owing to the presence of some missing values. However, the percentage of these missing values was small (2% or less) and the missingness was random ($\chi^2 = 25690.337$, d.f. = 27357, $p = 1.00$). No outliers and multicollinearity were detected.

Confirmatory factor analysis was then performed to evaluate the effectiveness of the proposed measurement model to be used in structural model analysis. Four measurement models corresponding to four structural models were tested. All measurement models had four similar factors (i.e. perceived cognitive activation, self-efficacy, boredom and enjoyment; each with five items loading on it) and one of the CMC learning strategies (i.e. rehearsal, elaboration, organisation or metacognition with 4, 6, 4 and 7 items loading on each factor, respectively). The extent of fit of both measurement and structural models to the data was determined using multiple fit indices and the χ^2 statistics. The model was deemed to adequately fit the data if the χ^2(d.f.) < 5, the Comparative Fit Index (CFI) and Tucker–Lewis Index (TLI) were ≥ 0.90 and the Root Mean Square Error of Approximation (RMSEA) and the Standardised Root Mean Residual (SRMR) were ≤ 0.10 (Hu & Bentler, 1999).

Results

Preliminary Results

Descriptive statistics and Pearson correlations between the study variables are shown in Table 1. Correlations between each pair of the study variables (i.e. perceived cognitive activation, self-efficacy, enjoyment, boredom, rehearsal, elaboration, organisation and metacognition) were significant ($p < 0.001$). Perceived cognitive activation was negatively correlated with boredom and positively correlated with all other variables. Boredom was also negatively correlated with all other variables. Self-efficacy was positively correlated with enjoyment and all CMC learning strategies.

Analysis of the Measurement Models

We tested four measurement models each with one of CMC learning strategies (i.e. rehearsal, elaboration, organisation or metacognition) as latent variables and all of the other four latent variables of

Table 1. Means, standard deviations and Pearson correlation coefficients among the study variables

Variable	Mean (SD)	Correlation coefficients						
		1	2	3	4	5	6	7
1. Cognitive activation	2.83 (0.61)	—						
2. Self-efficacy	5.57 (1.23)	0.34**	—					
3. Enjoyment	3.87 (0.90)	0.41**	0.66**	—				
4. Boredom	2.03 (1.06)	−0.26**	−0.52**	−0.60**	—			
5. Rehearsal	5.23 (1.23)	0.39**	0.47**	0.50**	−0.29**	—		
6. Elaboration	5.29 (1.13)	0.47**	0.53**	0.58**	−0.38**	0.65**	—	
7. Organisation	5.23 (1.31)	0.40**	0.37**	0.46**	−0.26**	0.60**	0.62**	—
8. Metacognition	5.12 (1.18)	0.48**	0.51**	0.59**	−0.34**	0.59**	0.70**	0.66**

Note: ***p* < 0.001. Cases deleted pairwise.

perceived cognitive activation, self-efficacy, boredom and enjoyment. All measurement models adequately fitted the data (see Table 2) as they meet the set criteria of χ^2(d.f.) < 5, RMSEA < 0.06, CFI/TLI ≥ 0.90 and SRMR < 0.08 recommended by Hu and Bentler (1999). All factor loadings were statistically significant at $p < 0.001$ and ranged between 0.446 and 0.858. Hence, the indicators were deemed appropriate for measuring the variables of interest (Byrne, 2010).

Analysis of the Structural Models

Based on the CVTAE, we tested four similar structural models each with five latent variables obtained from CFA. The number of latent variables in each model was limited to five to reduce model complexity and therefore the possibility of error in determining model fit. For each structural model, cognitive activation was the independent variable, self-efficacy was the proximal mediator, boredom and enjoyment were the distal mediators, and the relevant CMC learning strategy was the dependent variable. Models 1–3 (shown in Figure 2) and 4 (shown in Figure 3) have as the dependent variable rehearsal, elaboration, organisation and metacognition, respectively.

Unlike models 1–3, model 4 (see Figure 3) indicated best fit when direct paths from cognitive activation to both the distal mediators (i.e. boredom and enjoyment) and the dependent variable (i.e. metacognition) were removed.

The four models explained 49.7, 59.6, 43.5 and 53.2% of the variances in rehearsal, elaboration, organisation and metacognition, respectively. On average, each model explained approximately 18.2, 63.3 and 39.3% of the variances in self-efficacy, enjoyment and boredom, respectively. Further, in all models the direct path coefficients from boredom to the respective CMC learning strategies were not statistically significant, i.e. rehearsal (β = 0.12, SE = 0.065, p > 0.05), organisation

Table 2. Fit statistics and indices for the measurement and structural models tested

	χ^2	d.f.	χ^2(d.f.)	RMSEA[CI]	CFI	TLI	SRMR
Model with:				*Measurement models*			
1. Rehearsal	515.038	242	2.13	0.044 [0.039–0.049]	0.94	0.94	0.04
2. Elaboration	609.292	289	2.11	0.043 [0.039–0.048]	0.94	0.93	0.04
3. Organisation	478.189	242	1.98	0.041 [0.035–0.046]	0.95	0.94	0.04
4. Metacognition	574.757	314	1.83	0.038 [0.033–0.042]	0.95	0.95	0.04
				Structural models			
1. Rehearsal	568.162	243	2.33	0.048 [0.043–0.053]	0.93	0.92	0.05
2. Elaboration	662.421	290	2.28	0.047 [0.044–0.053]	0.93	0.92	0.05
3. Organisation	531.373	243	2.19	0.045 [0.044–0.053]	0.94	0.93	0.05
4. Metacognition	705.756	319	2.21	0.045 [0.041–0.050]	0.93	0.92	0.06

Note: RMSEA, root mean square error of approximation; CI, confidence interval; CFI, comparative fit index; TLI, Tucker–Lewis index; SRMR, standardised root mean residual.

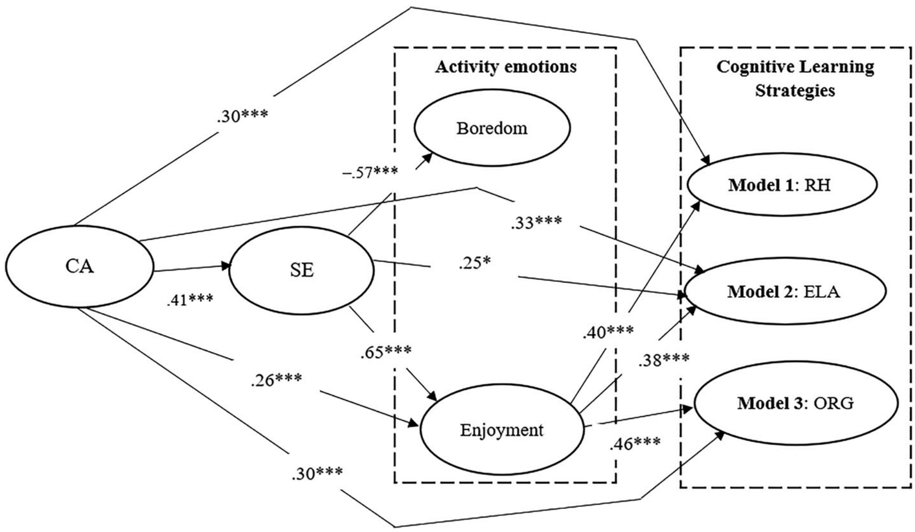

Figure 2. Direct path coefficients for structural models 1–3 with dependent variables rehearsal, elaboration and organisation. CA, Cognitive Activation. SE, Self-Efficacy. RH, Rehearsal. ELA, Elaboration. ORG, Organisation. Note: Only significant direct paths are shown. ***$p < 0.001$, *$p < 0.05$

($\beta = 0.09$, SE = 0.075, $p > 0.05$), elaboration ($\beta = 0.08$, SE = 0.057, $p > 0.05$) and metacognition ($\beta = 0.11$, SE = 0.057, $p > 0.05$). For the models 1–3, there were statistically significant positive path coefficients from cognitive activation to self-efficacy ($\beta = 0.41$, SE = 0.056), cognitive activation to enjoyment ($\beta = 0.26$, SE = 0.059), self-efficacy to enjoyment ($\beta = 0.65$, SE = 0.044) and enjoyment to either one of cognitive learning strategies, i.e. rehearsal ($\beta = 0.40$, SE = 0.112), elaboration ($\beta = 0.38$, SE = 0.092) and organisation ($\beta = 0.46$, SE = 0.087) at $p < 0.001$. Also, there were statistically significant positive direct path coefficients for cognitive activation to either one of cognitive learning strategies, i.e. rehearsal ($\beta = 0.30$, SE = 0.068, $p < 0.001$), elaboration ($\beta = 0.33$, SE = 0.062, $p < 0.001$) and organisation ($\beta = 0.30$, SE = 0.059, $p < 0.001$). However, there were no statistically significant direct path coefficients from cognitive activation to boredom for all three models ($\beta = 0.12$, SE = 0.063, $p > 0.05$). There was a statistically significant direct path coefficient from self-efficacy to elaboration ($\beta = 0.25$, SE = 0.093, $p < 0.05$) and not to either organisation ($\beta = 0.05$, SE = 0.085, $p > 0.05$) or rehearsal ($\beta = 0.20$, SE = 0.105, $p > 0.05$).

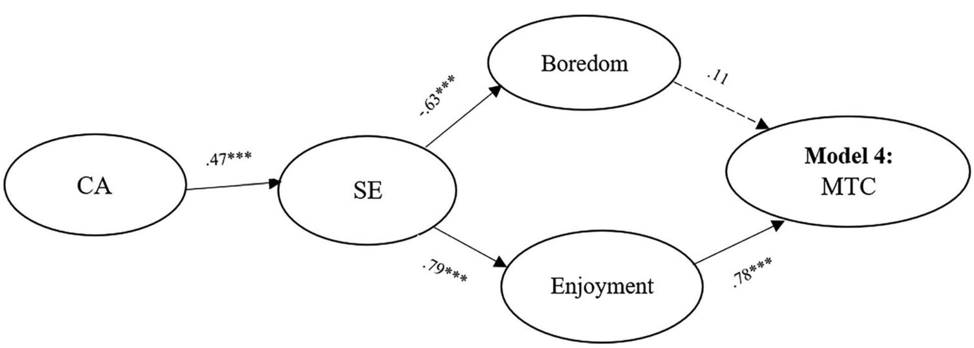

Figure 3. Direct path coefficients for the structural model 4 with metacognition as the dependent variable. CA, Cognitive Activation. SE, Self-efficacy. MTC, Metacognition. Note: the direct path indicated by the dashed line indicates a non-significant effect. ***$p < 0.001$

Table 3. Standardised statistics for indirect effects with bootstrap confidence intervals

Model pathway	Standardised β	SE	95% CI Lower	95% CI Upper
Model 1				
CGA–SE–ENJ–RH	0.107**	0.034	0.057	0.172
CGA–ENJ–RH	0.105**	0.037	0.055	0.180
CGA–SE–ENJ	0.268***	0.040	0.205	0.339
CGA–SE–BD	−0.233**	0.040	−0.307	−0.172
Total indirect	0.212**	0.062	0.118	0.322
Model 2				
CGA–SE–ENJ –ELA	0.103**	0.029	0.061	0.160
CGA–SE–ELA	0.104*	0.042	0.041	0.180
CGA–ENJ–ELA	0.100**	0.031	0.057	0.164
CGA–SE–ENJ	0.268***	0.041	0.204	0.338
CGA–SE–BD	−0.233***	0.041	−0.307	−0.172
Total indirect	0.307***	0.044	0.241	0.385
Model 3				
CGA–SE–ENJ–ORG	0.124***	0.032	0.078	0.186
CGA–ENJ–ORG	0.121***	0.034	0.075	0.189
CGA–SE–ENJ	0.269***	0.041	0.205	0.339
CGA–SE–BD	−0.233***	0.041	−0.307	−0.172
Total indirect	0.245***	0.052	0.168	0.340
Model 4				
CGA–SE–ENJ–MC	0.289***	0.047	0.216	0.371
CGA–SE–ENJ	0.371***	0.051	0.286	0.455
CGA–SE–BD	−0.294***	0.043	−0.367	−0.223
Total indirect	0.289***	0.047	0.216	0.371

Note: CI, confidence interval; CGA, cognitive activation; SE, self-efficacy; ENJ, enjoyment; BD, boredom; RH, rehearsal; ELA, elaboration; ORG, organisation; MC, metacognition. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

For model 4, all path coefficients were significant ($p < 0.001$) except for the path from boredom to metacognition ($\beta = 0.11$, SE = 0.057). The path coefficients from cognitive activation to self-efficacy ($\beta = 0.47$, SE = 0.055), self-efficacy to enjoyment ($\beta = 0.79$, SE = 0.029) and enjoyment to metacognition ($\beta = 0.78$, SE = 0.046) were positive while that from self-efficacy to boredom ($\beta = 0.63$, SE = 0.041) was negative.

Mediation Analysis

To confirm the mediation hypothesis, we tested the significance of the indirect effects through enjoyment and self-efficacy using the bootstrap method with 10,000 bootstrap samples. Only those indirect pathways that contained all significant direct path coefficients were tested. All indirect effects tested were significant at either $p < 0.05$ or $p < 0.001$, as illustrated in Table 3. Further, the 95% confidence intervals for all the indirect effects (specific and total indirect effects) tested did not contain zero, confirming the mediational effects of self-efficacy and enjoyment on the relationship between perceived teacher cognitive activation and students' use of CMC learning strategies.

Discussion

The present study was aimed at examining the relationship between perceived cognitive activation, learner academic self-efficacy, achievement emotions (i.e. boredom and enjoyment) and CMC learning strategies (i.e. rehearsal, elaboration, organisation, meta-cognition) in biology as predicted by Pekrun's (2006) CVTAE model. We tested the extent to which self-efficacy and achievement emotions mediated the effects of perceived cognitive activation on CMC learning strategy usage.

As shown in Figure 2, the presence of direct paths from cognitive activation to some CMC learning strategies in addition to indirect paths through self-efficacy and/or boredom or enjoyment confirms partial mediation effects. Further, as shown in Figure 3, the absence of a direct path from cognitive activation to metacognition confirms full multiple mediation effects.

The study confirmed the mediational hypothesis proposed by Pekrun's (2006) CVTAE model. Control appraisals and achievement emotions mediated the effects of perceived cognitive activation on CMC learning strategies usage. As discussed earlier, these mediational results were partly supported by empirical evidence from the literature (Ekatushabe, Kwarikunda, Muwonge, Ssenyonga, & Schiefele, 2021; Li et al., 2020; Liem et al., 2008; Obergriesser & Stoeger, 2020; Putwain, Schmitz, Wood, & Pekrun, 2021; You & Kang, 2014). Often, these studies do not examine the multiple mediating roles of both cognitive appraisals and achievement emotions when examining the influence of instruction on students' learning. Self-efficacy and enjoyment partially mediated the relationship between cognitive activation and rehearsal, elaboration and organisation. The effects of cognitive activation on learners' levels of meta-cognition were fully mediated by self-efficacy and enjoyment. The confirmed mediation hypothesis provides further support for the growing literature concerning the influence of instructional characteristics on students' affective (in this study self-efficacy, boredom and enjoyment) and cognitive (i.e. CMC learning strategies and achievement) outcomes. Further, self-efficacy fully mediated the effects of cognitive activation on boredom somewhat similar to Wang et al.'s (2018) study in which the effects of instruction on boredom were fully mediated by cognitive appraisals. Students who reported receiving highly cognitively stimulating learning experiences were more likely to report high perceived ability in biology and subsequently low levels of learning-related boredom. Contrary to Lazarides and Buchholz's (2019) study among German ninth-grade mathematics students, in this study, there were no statistically significant directs effects from cognitive activation to boredom. Such differences could be attributed to the domain under investigation and/or several contextual differences (i.e. class sizes, more passive teaching strategies and limited teaching–learning resources) that might moderate the effects of cognitive activation on learners' levels of boredom.

Mediational effects of enjoyment and boredom were different. Boredom played no mediational role from cognitive activation to the CMC learning strategies. Direct effects from cognitive activation to boredom and from boredom to the CMC learning strategies were not significant. Hence, the learners' levels of boredom did not predispose them to a particular CMC learning strategy. While these findings contrast with the CVTAE assumptions, they were partially supported by prior studies by You and Kang (2014) and Obergriesser and Stoeger (2020). In You and Kang's (2014) study among Korean students ($n = 426$), boredom did not mediate the relationship between perceived control and CMC learning strategies but enjoyment did. In Obergriesser and Stoeger's (2020) study, intra-individual boredom did not predict the usage of effective text reduction strategies. The behaviour of boredom in the tested model could be explained by the frequently teacher-centred teaching–learning environment in Ugandan schools that makes experiences of boredom inevitable. Hence, it is possible that, over time, learners eventually adopt coping strategies that buffer the effects of boredom on learning.

As was expected and supported by literature, enjoyment positively predicted all three deep learning strategies, i.e. elaboration, organisation and meta-cognition (Ahmed et al., 2013; Obergriesser & Stoeger, 2020; Pekrun et al., 2010; You & Kang, 2014). However, the positive association between enjoyment and rehearsal was inconsistent with some literature (Pekrun et al., 2010), implying that students who reported greater enjoyment of biology were more likely to use rehearsal strategies in addition to deeper strategies in their learning than those who reported lower enjoyment. Whether this controversy was due to the nature of the domain (that tends to be more qualitative in nature) or the nature of teaching–learning environment in Uganda (that often encourages shallow learning by focusing on memorisation rather than reasoning) remains to be understood with possibly cross-cultural and cross-domain comparisons. Nonetheless, it did present unique findings on the importance of enjoyment for supporting even the use of shallow strategies like rehearsal in the domain of biology. The findings that cognitive activation is directly and indirectly associated with learners' CMC learning strategies adds to the scarce literature in the area and further illustrates the critical role of instruction that targets stimulation.

Limitations and Recommendations

There are limitations to the interpretation of these results. First, we based our analysis on data collected exclusively from student reports. However, self-reports are known to be subject to response biases, especially social desirability, that might skew the data towards more positive responses. Also, teacher behaviours illustrating cognitive activation were reported by the students with no validation using teacher self-reports or teacher observation. Future studies should consider collecting data from multiple sources including observations and teacher reports. Second, unlike most previous mediation studies that used data collected over time, the present study used data collected only once which cannot be used to verify causal relationships. We recommend that future studies consider an experimental and/or longitudinal study design. Third, several other important dimensions of instruction (i.e. structuredness, clarity, autonomy support, value induction, task demands) and prior achievement were not included in this model, although they have also demonstrated significant relationships with learners' CMC learning strategies and achievement emotions (Ahmed et al., 2010; Lazaridesa & Buchholz, 2019; Wang et al., 2017). Inclusion of these dimensions would provide valuable information to better design instruction that improves learners' abilities to effectively use learning strategies. Lastly, the focus on only boredom and enjoyment may have left out valuable information regarding the role of other emotions like hope and pride.

Conclusions

The present study provided substantial support for CVTAE assumptions using a less commonly studied population of students from a low-income country. As predicted, self-efficacy and enjoyment mediated the relationship between perceived cognitive activation and use of CMC learning strategies. Consistent with previous research, there was a significant negative direct effect from self-efficacy to boredom. On the other hand, direct effects from enjoyment to any one of the CMC learning strategies were all significant. We also found self-efficacy to directly predict enjoyment and only elaboration among all other CMC learning strategies. The significant direct effects from cognitive activation to rehearsal, elaboration and organisation indicated partial mediation effects of self-efficacy and enjoyment. However, there were no significant direct effects from boredom to any one of the CMC learning strategies. The positive effect between enjoyment and rehearsal was also uncommon. More studies need to be conducted to ascertain whether the observed controversies are domain and/or culture specific. Our study therefore adds to the growing cross-cultural literature to validate the effect of instruction on students' cognitive, affective and behavioural achievement outcomes across several science domains. For disadvantaged class environments like those in low-income countries, the study findings provide suggestions for teachers to improve instruction through cognitive activation (in addition to other reported teaching strategies like autonomy support, improved structure and clarity, and improved learning conditions) to encourage the development of effective emotions and CMC learning skills among learners.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Disclosure statement

No potential conflict of interest was reported by the authors.

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