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Enhancing academic resilience through motivation and strategy: evidence from Malaysian boarding schools using SDT

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ABSTRACT

This study investigates the relationship between student motivation and self-regulated learning strategies among Malaysian boarding school students, using self-determination theory (SDT) as its theoretical foundation. A total of 328 form four students from four northern Malaysian boarding schools participated. Using a validated version of the motivated strategies for learning questionnaire (MSLQ) and analyzed through second-order partial least squares structural equation modeling (PLS-SEM), results revealed a significant positive relationship between motivational beliefs, especially self-efficacy and intrinsic value, and self-regulated learning strategies. The study's novelty lies in validating a culturally adapted, second-order motivation model tailored to Malaysian boarding schools. Notably, the research isolates the mediating effect of intrinsic motivation on self-regulation within a high-pressure, collectivist setting, extending SDT's applicability. However, limitations lie in the use of a cross-sectional design and dependence on self-reported data, and regional focus. Future studies should adopt longitudinal designs, consider diverse school types, and integrate perspectives from teachers or parents to strengthen validity. Including objective academic performance metrics may offer deeper insight. This research affirms the relevance of SDT in Malaysia's education system and provides a validated framework linking motivation to strategic learning. The findings support evidence-based pedagogical strategies and align with sustainable development goal (SDG) 4 on quality education and goal 10 on reduced inequalities, promoting for fair and motivation-enhancing environments of learning.

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1. INTRODUCTION

The pursuit of quality education and the reduction of inequalities are foundational principles of the United Nations' sustainable development goals (SDGs), particularly SDG 4 and 10. Achieving these goals

depends not only on structural and policy-level reforms, but also on understanding student-level factors that shape academic success. Within this context, understanding the factors that influence academic achievement, particularly among secondary students, is critical. One such factor is student motivation, which plays a pivotal role in shaping learning strategies and academic outcomes. Self-determination theory (SDT) offers a strong and well-established foundation for theoretical analysis for examining how intrinsic and extrinsic motivation interact with learning strategies to influence student performance. This study explores the interplay between student motivation and learning strategies within Malaysian boarding schools, where unique challenges and opportunities significantly impact academic achievement.

In the Malaysian context, research shows that academic performance is shaped by a complex interplay of variables such as teacher support, parental involvement, community engagement, and the integration of technology. Utami [1] argues that parental involvement, such as assisting with homework or maintaining communication with school staff, has a straightforward positive influence on student achievement. The findings support the SDT framework by demonstrating how the psychological need for relatedness, one of SDT's core dimensions, can be fulfilled through family engagement.

Similarly, family and community support have been proved to be strong predictors of intrinsic motivation. Previous studies [2], [3] found that students who perceive higher levels of family support tend to show greater self-motivation and are oriented toward deep learning strategies, such as self-regulation and elaboration. Community-based programs, including mentorship initiatives and academic role models, further enhance students' motivation and learning outcomes [4]. These collaborative efforts not only foster academic achievement but also align with the broader goals of SDG 4 and 10 by reducing educational disparities and promoting inclusive learning environments.

Technological integration in education is another critical factor contributing to student engagement and success. In Malaysian boarding schools, the use of interactive learning platforms, digital collaboration tools, and online educational content has gained prominence. Several studies [5]–[7] show that such technologies, when appropriately implemented, cater to diverse learning preferences and enhance students' motivation and academic performance. These innovations support flexible, student-centered approaches and reinforce the SDGs' emphasis on equity and innovation in education.

Within this broader framework, student motivation remains a central driver of learning behaviors and academic performance. Grounded in SDT, this study differentiates between intrinsic and extrinsic motivation and examines how each relates to the selection and use of learning strategies. Students possessing intrinsic motivation exhibit a stronger inclination toward meaningful learning processes, such as elaboration, organization, and self-regulation [8]. These strategies have been associated with improved academic performance and deeper understanding of subject matter. In contrast, students with lower levels of motivation may rely on surface-level learning tactics or display academic disengagement.

Malaysian boarding schools offer a unique environment for exploring these dynamics. These institutions are characterized by structured routines, strong institutional culture, and limited parental presence. As a result, teachers, hostel wardens, and peers play significant roles in shaping students' academic and emotional development [9], [10]. Teacher behaviors, instructional methods, and classroom interaction styles can either enhance or hinder students' intrinsic motivation [2], [3], [8]. Interactive and differentiated teaching strategies that consider students' individual needs have been found to significantly influence their engagement and use of learning strategies.

Moreover, peer support and school-based mentorship contribute to the development of intrinsic and extrinsic incentives that affect students' academic trajectories. Consistent encouragement from instructors and classmates can boost self-efficacy and foster environments conducive to effective learning [2]. Conversely, students who lack such support often face motivational challenges that impede their academic growth.

In conclusion, the interplay between student motivation and learning strategies is a critical factor in academic achievement, particularly within the context of Malaysian boarding schools. By understanding the dynamics of intrinsic and extrinsic motivation, educators can create supportive environments that promote effective learning strategies and align with the goals of SDG 4 and 10. This study seeks to advance this understanding by examining the relationship between motivation and learning strategies in Malaysian boarding schools, with the ultimate goal of informing interventions that enhance academic achievement and reduce educational inequalities.

2. LITERATURE REVIEW

2.1. The theoretical aspect

Ryan and Deci SDT [11] suggests that learners are more intrinsically motivated and learn more effectively when their needs for autonomy, competence, and relatedness are met. When students feel autonomous, they are more likely to engage deeply with learning tasks, as they perceive them as personally meaningful [12]. Competence, or the belief in one's ability to succeed, encourages students to adopt

self-regulated learning strategies are critical for academic achievement [13]. Relatedness, or the sense of connection to teachers and peers, enhances motivation by creating a supportive learning environment [14]. SDT is particularly beneficial for students as it shifts the focus from extrinsic rewards, such as grades, to intrinsic motivation, which leads to more sustainable and meaningful engagement in learning [15]. For example, autonomy-supportive teaching practices, such as allowing students to choose their learning tasks, have been associated with improvements in academic performance and emotional well-being [12]. Additionally, competence-building feedback aids students in cultivating resilience, and a growth mindset, enabling them to tackle challenges effectively [16]. Collaborative learning environments, which foster relatedness, further enhance motivation by encouraging peer support and shared problem-solving [17]. By addressing these psychological needs, SDT supports the aims of SDG 4 and 10, which advocate for inclusive education and reduced disparities, promoting inclusive and equitable learning opportunities for all students [18]. Overall, SDT provides a comprehensive framework for educators to enhance student motivation, learning strategies, and academic achievement.

While Hofstede [19] and Tanase [20] pedagogical insights suggest that collectivist societies such as Malaysia may not prioritize autonomy in the same way as Western individualistic cultures, emphasizing conformity, respect, and relational harmony over personal choice, recent empirical studies challenge this assumption. Ryan and Deci [11] argue that autonomy is a universal psychological need, and emerging research in Malaysia supports this universality. For instance, a study by Gu *et al*. [21] found that perceived autonomy support significantly enhances interns' work engagement and reduces emotional exhaustion in Malaysian workplaces. Furthermore, in Malaysian higher education, autonomy-supportive teaching environments were shown to foster personal-best goal setting and agentic engagement [22]. Even in the entrepreneurial context, Malaysian students' intention to start businesses was strongly predicted by satisfying the three needs, autonomy (the sense of volition and self-direction in one's actions), competence (the feeling of mastery and effectiveness in interacting with one's environment), and relatedness (the sense of connection and belonging with others), as proposed in SDT [23]. These findings suggest that autonomy, although culturally expressed in relational ways, remains a central driver of well-being and motivation in Malaysia. This challenges the notion that autonomy is incompatible with collectivist values and reinforces SDT's cross-cultural relevance.

2.2. Research problem

Despite growing interest in the factors influencing student academic performance, there remains a critical gap in understanding the interplay and connection between motivational beliefs and self-regulated learning strategies within the unique context of Malaysian boarding schools. These institutions, which serve as key drivers of secondary education for high-performing students, operate in highly structured and collectivist environments where students often experience reduced parental involvement and increased academic pressure [4], [19], [24]. While previous studies have proven the positive impact of learning motivation in general educational settings [9], [13], [25], their applicability to boarding school contexts, where environmental, cultural, and psychosocial factors differ significantly, remains underexplored.

Malaysian boarding school students are frequently expected to demonstrate high levels of autonomy and academic self-discipline, yet they face challenges in developing effective learning strategies without direct familial support [6], [26], [27]. Furthermore, existing literature tends to examine either motivation or learning strategy usage in isolation, with limited research integrating both constructs in a single structural model tailored to the Malaysian context [17], [18], [28]. This fragmentation limits educators' ability to design holistic interventions that address both psychological and behavioral aspects of learning. Moreover, while SDT has been widely validated in Western contexts [11], [12], its application in collectivist societies such as Malaysia remains inconsistent due to differences in how autonomy and motivation are perceived culturally [19], [20]. Several studies [19], [20] suggest that motivational constructs may manifest differently across cultural contexts, calling for localized validation of Western-derived frameworks.

There is also a methodological gap in present literature. Many previous studies have relied on outdated or non-validated instruments or employed statistical methods that do not sufficiently account for the multidimensional essence of learning strategies and motivation [29]–[31]. In contrast, this study addresses these issues by employing a validated version of the motivated strategies for learning questionnaire (MSLQ) within a second-order partial least squares structural equation modeling (PLS-SEM) framework, thereby offering a more nuanced and contextually grounded analysis. Therefore, this study is necessary to fill the empirical and contextual gaps in understanding how motivational beliefs influence the adoption of self-regulated learning strategies among Malaysian boarding school students. It also seeks to refine existing theoretical frameworks by adapting them to a collectivist educational setting and using robust analytical techniques to uphold validity and reliability. In doing so, the study contributes both to academic theory and to the practical development of targeted educational interventions aligned with national and global goals, including the pursuit of quality education and the reduction of educational inequalities.

2.3. Objective of the study

The research objective (RO1) of the study is to examine the relationship between students' motivational beliefs and their use of self-regulated learning strategies in Malaysian boarding schools. This objective aims to uncover how key motivational elements, particularly self-efficacy and intrinsic value, influence students' ability to organize and self-regulate their learning. Understanding this relationship enables educators to design effective interventions that foster both student motivation and strategic academic behaviors. Thus, the hypothesis (H01) was formulated as: there is no significant relationship between student motivation and learning strategies. This null hypothesis provides the basis for empirical testing through SEM. If rejected, it supports theoretical claims from SDT and provides evidence that integrating motivational components into classroom practice can meaningfully enhance students' self-regulated learning capacities. Ultimately, this study contributes to efforts aligned with SDG 4 (quality education) and SDG 10 (reduced inequalities) by informing policies and pedagogies that promote inclusive, student-centered, and effective learning environments.

3. METHOD

3.1. Research design

This research used a quantitative correlational design to explore the link between student motivation and learning strategies. This study primarily sought to explore how motivational components, such as test anxiety, self-efficacy, and intrinsic value correlate with students' use of cognitive strategies and self-regulation. Data were acquired by using self-reported questionnaires and examined through PLS-SEM to evaluate the strength and significance of these relationships. The PLS-SEM model was specified by defining latent constructs representing motivation and learning strategies, with multiple observed indicators for each construct. Model validity and reliability were assessed through assessments of convergent validity via average variance extracted (AVE), discriminant validity through the Fornell-Larcker criterion, and internal consistency reliability using Cronbach's alpha and composite reliability (CR). This study evaluated model fit using the standardized root mean square residual (SRMR) and normed fit index (NFI), ensuring acceptable levels according to established thresholds. Hypothesized relationships between motivational components and learning strategies were tested, with null hypotheses formulated for each path. Expected effect sizes were informed by previous literature. To address potential confounding effects, age and gender were included as control variables in the analysis. These detailed specifications ensure rigorous and transparent analysis of the complex relationships studied.

3.2. Population and sampling

The population consisted of 1,200 form four students (equivalent to grade 10) from 11 boarding schools in Kelantan and Kedah. Referring to the sample size table of Krejcie and Morgan [28], a minimum of 291 respondents was required for this population size. Initially, using stratified sampling technique, a total of 348 students were targeted, accounting for a 20% buffer to accommodate potential non-responses or incomplete data. After the data cleaning process, which involved removing incomplete or inconsistent responses, a final valid sample of 328 students was retained, exceeding the minimum threshold and ensuring sufficient statistical power for subsequent analysis.

3.3. Respondents

The study involved 328 form four students (156 females and 172 males), aged 16, from four boarding schools in northern Malaysia. These students were selected to represent the population of form four students in boarding schools in the region. The sample included a varied group of students, with 48% male and 52% female participants. The respondents' demographic characteristics are displayed in Table 1, including gender and other relevant background information, summarized using frequency and percentage.

Table 1. Overview of respondents (n=328)

Category	Parameter	Frequency	Percentage (%)
Gender	Male	172	52
	Female	156	48
Education	Form 4	328	100

3.4. Instrument

The MSLQ was used to measure students' motivational beliefs and self-regulated learning strategies [32]. The MSLQ consists of 56 self-report items on a 7-point Likert scale (1=not at all true of me to 7=very true of me) and is divided into two main sections: motivational beliefs and self-regulated learning strategies. Factor analysis was conducted to validate the scale's construction.

In terms of reliability, the internal consistency (Cronbach's alpha) of the 15 subscales ranges from 0.62 to 0.93. For example, self-efficacy for learning and performance (α=0.93), task value (α=0.90), and metacognitive self-regulation (α=0.79) demonstrated strong reliability. Regarding validity, confirmatory factor analysis (CFA) supported the construct validity of both the six motivational and nine learning strategy factors. Predictive validity was confirmed through significant correlations with academic achievement, with average correlations ranging from r=0.21 to 0.39 for key subscales such as self-efficacy, task value, and elaboration strategy.

3.5. Data collection and analysis procedure

The study was approved under the grant number INTI-FELA-01-04-2024, following a thorough review of the research questionnaire and methodologies employed. Following this, permission was sought from the relevant Ministry and the principals of the four selected schools. Data were collected over a three-week period, with each session conducted after school hours in classrooms to avoid academic disruption. The paper-based questionnaires were administered in person by the researchers and teachers appointed by the schools. Each session began with a standardized briefing that explained objectives of the study, the voluntary nature of participation, and the assurance of anonymity and confidentiality for students. No personal identifiers were collected, and all data were anonymized during analysis. Participation was strictly voluntary. The average completion time was 25–30 minutes. After all questionnaires were collected manually, the data were analyzed using SPSS version 27 and SmartPLS 4.0. The study employed PLS-SEM, as it is particularly effective for analyzing complex research models involving small sample sizes and non-normally distributed data. This approach also addresses the limitations of traditional covariance-based SEM techniques, making it appropriate for exploratory investigations [29], [33].

3.6. Pilot test

A pilot study was employed with a sample size of 30 students from a boarding school in Negeri Sembilan, who were not part of the main study. The pilot test sought to detect potential issues in the research instruments and to verify their reliability. The internal consistency of the scales was evaluated using Cronbach's alpha coefficient, confirming their dependability for the main study [30]. Additionally, the Malay translation of the MSLQ was validated by two language experts from a local university in Selangor, Malaysia, to ensure linguistic accuracy and cultural relevance. During the translation of the MSLQ, cultural adaptation was carefully considered to ensure both linguistic accuracy and contextual relevance for Malaysian students. Phrases implying individualism, such as "working independently," were rephrased to preserve meaning while respecting collectivist cultural norms. This process aimed to enhance clarity, maintain conceptual equivalence, and ensure the translated version retained its reliability and validity within the Malaysian cultural and educational context.

Table 2 shows that the pilot test demonstrated satisfactory internal consistency across all measured constructs, with Cronbach's alpha coefficients ranging from 0.74 (the lowest) to 0.89 (the highest), for both motivational beliefs (including self-efficacy, test anxiety, and intrinsic value) and self-regulated learning strategies (including self-regulation and cognitive strategy use), indicating that the instruments were reliable measures for assessing students' motivation and learning strategies.

Table 2. Cronbach's alpha of the pilot study

Variables	Dimensions	Cronbach's alpha
Motivational beliefs	Self-efficacy	0.89
	Test anxiety	0.75
	Intrinsic value	0.87
Self-regulated learning strategies	Cognitive strategy use	0.83
	Self-regulation	0.74

4. RESULTS

4.1. Assessing the measurement model

To evaluate a reflective measurement model in PLS-SEM, it is essential to report metrics related to reliability and validity. These include internal consistency (Cronbach's alpha and CR), convergent validity (AVE and indicator loadings), and discriminant validity (evaluated through cross-loadings, Fornell-Larcker, and heterotrait-monotrait (HTMT) criteria) [33]. As shown in Table 3, to assess the convergent validity of the measurement model of this study, the factor loading or indicator's reliability, the CR, and the AVE threshold points proposed by Hair *et al.* [30] are used, which pointed out that the factor loading of the indicator must be

attained at 0.708, the AVE of the construct must be 0.50, and the reliability of the construct must be 0.70, the cross-loading should be less than 0.10 [34].

Table 3. Measurement model analysis using PLS-SEM

Assessment	Level of acceptance
Indicator reliability/factor loadings	Indicator loading of 0.708 or higher is recommended
Internal consistency	CR>0.7
Convergent validity	AVE>0.50
Discriminant validity	Cross-loading <0.10

4.1.1. Investigating the measurement model for internal consistency reliability and convergent validity

Figure 1 shows the initial measurement model of the study consisting of exogenous and endogenous variables. The outcomes of the measurement model analysis are displayed in Figure 1 and Table 3. Table 4 shows the results of the initial measurement model analysis. All the indicators of outer loadings for cognitive motivational beliefs self-efficacy (CMBSE), cognitive motivational beliefs intrinsic value (CMBIV), cognitive motivational beliefs test anxiety (CMBMB), cognitive self-regulated learning strategies cognitive strategy use (CSLCSU), and cognitive self-regulated learning strategies self-regulation (CSLSSR) constructs are between -0.678 (lowest) and 0.936 (highest). Values of eight indicators are less than 0.4, which are CMBMB1_R (-0.678), CMBMB2_R (-0.746), CMBMB3_R (0.054), CMBMB4_R (-0.392), CSLCSU3_R (0.078), CSLSSR2_R (-0.216), CSLSSR6_R (-0.085), CSLSSR7_R (-0.326), according to Hair *et al.* [30], an indicator with an outer loading less than 0.40 should generally be removed from the model, as it indicates a weak relationship between the indicator and the latent construct. There were 15 indicators like CMBIV1 (0.551), CMBIV2 (0.686), CMBIV5 (0.695), CMBSE8 (0.64), CSLCSU4 (0.646), CSLCSU5 (0.692), CSLCSU6 (0.677), CSLCSU7 (0.508), CSLCSU8 (0.682), CSLCSU9 (0.66), CSLCSU12 (0.595), CSLSSR1 (0.669), CSLSSR3 (0.593), CSLSSR8 (0.427), CSLSSR9 (0.557), according to Hair *et al.* [30], an indicator with an outer loading between 0.40 and 0.708 affected the AVE of the construct, which does not meet the threshold of the AVE of 0.50, must be deleted. From the table, CSLCSU has an AVE of 0.435 and CSLSSR is of 0.279, which is below the threshold of 0.5, indicating poor convergent validity.

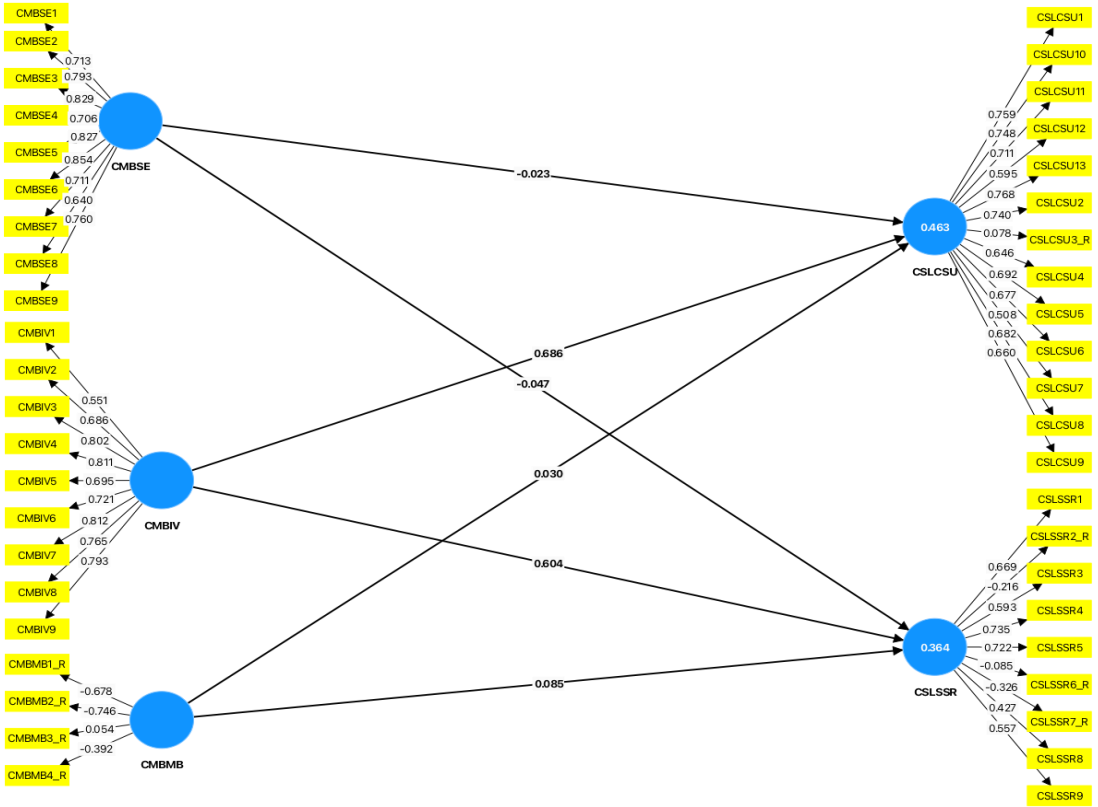

Figure 1. Initial measurement model of the study

Table 4. Convergent validity and reliability of initial measurement model of the study

Construct	Indicator	Outer loadings (0.708)	Cronbach's alpha (0.70)	CR (rho-a) (0.70)	CR (rho-c) (0.70)	AVE (0.50)	Convergent validity and reliability- Yes or No?
CMBIV	CMBIV1	0.551	0.896	0.904	0.916	0.55	Yes
	CMBIV2	0.686					
	CMBIV3	0.802					
	CMBIV4	0.811					
	CMBIV5	0.695					
	CMBIV6	0.721					
	CMBIV7	0.812					
	CMBIV8	0.765					
	CMBIV9	0.793					
CMBMB	CMBMB1_R	-0.678	0.868	-0.998	0.523	0.293	No
	CMBMB2_R	-0.746					
	CMBMB3_R	0.054					
	CMBMB4_R	-0.392					
CMBSE	CMBSE1	0.713	0.912	0.936	0.925	0.581	Yes
	CMBSE2	0.793					
	CMBSE3	0.829					
	CMBSE4	0.706					
	CMBSE5	0.827					
	CMBSE6	0.854					
	CMBSE7	0.711					
	CMBSE8	0.64					
	CMBSE9	0.76					
CSLCSU	CSLCSU1	0.759	0.883	0.905	0.903	0.435	No
	CSLCSU2	0.74					
	CSLCSU3_R	0.078					
	CSLCSU4	0.646					
	CSLCSU5	0.692					
	CSLCSU6	0.677					
	CSLCSU7	0.508					
	CSLCSU8	0.682					
	CSLCSU9	0.66					
	CSLCSU10	0.748					
	CSLCSU11	0.711					
	CSLCSU12	0.595					
	CSLCSU13	0.768					
CSLSSR	CSLSSR1	0.669	0.631	0.713	0.593	0.279	No
	CSLSSR2_R	-0.216					
	CSLSSR3	0.593					
	CSLSSR4	0.735					
	CSLSSR5	0.722					
	CSLSSR6_R	-0.085					
	CSLSSR7_R	-0.326					
	CSLSSR8	0.427					
	CSLSSR9	0.557					

Therefore, 19 indicators as CMBMB1_R, CMBMB2_R, CMBMB3_R, CMBMB4_R; CSLCSU3_R, CSLCSU4, CSLCSU5, CSLCSU6, CSLCSU7, CSLCSU8, CSLCSU9, CSLCSU12; CSLSSR1, CSLSSR2_R, CSLSSR3, CSLSSR6_R, CSLSSR7_R, CSLSSR8, and CSLSSR9 were deleted. The results of reanalyzing the measurement model after deleting the indicators are shown in Table 5. Results of the measurement model, as in Table 5, after deleting CMBMB1_R, CMBMB2_R, CMBMB3_R, CMBMB4_R; CSLCSU3_R, CSLCSU4, CSLCSU5, CSLCSU6, CSLCSU7, CSLCSU8, CSLCSU9, CSLCSU12; CSLSSR1, CSLSSR2_R, CSLSSR3, CSLSSR6_R, CSLSSR7_R, CSLSSR8, and CSLSSR9. Values of indicators like CMBIV1, CMBIV2, CMBIV5, and CMBSE8 are between 0.4-0.708, if the AVE is greater than 0.5, it indicates that the latent variable meets the standard for convergent validity [30]. In this case, there is no need to delete the measurement items, even if its outer loading is between 0.4 and 0.708, as the overall convergent validity is still acceptable. Therefore, these indicators remain valid.

Table 6 shows the discriminant validity assessment using cross-loading of the measurement model after deleting CMBMB1_R, CMBMB2_R, CMBMB3_R, CMBMB4_R; CSLCSU3_R, CSLCSU4, CSLCSU5, CSLCSU6, CSLCSU7, CSLCSU8, CSLCSU9, CSLCSU12; CSLSSR1, CSLSSR2_R, CSLSSR3, CSLSSR6_R, CSLSSR7_R, CSLSSR8, and CSLSSR9. Discriminant validity is questionable when an item's loading on its assigned construct is not at least 0.1 greater than its loadings on other constructs. In the decision of deleting CMBIV1, the difference between its loading on CMBIV (0.552) and its cross-loading on CMBSE (0.485) is only 0.067, suggesting insufficient discriminant validity.

Table 5. Convergent validity and reliability of the measurement model after deleting 19 indicators

Construct	Indicator	Outer loadings (0.708)	Cronbach's alpha (0.70)	CR (rho-a) (0.70)	CR (rho-c) (0.70)	AVE (0.50)	Convergent validity and reliability-Yes or No?
CMBIV	CMBIV1	0.552	0.896	0.905	0.916	0.55	Yes
	CMBIV2	0.685					
	CMBIV3	0.801					
	CMBIV4	0.811					
	CMBIV5	0.693					
	CMBIV6	0.721					
	CMBIV7	0.813					
	CMBIV8	0.762					
	CMBIV9	0.795					
CMBSE	CMBSE1	0.716	0.912	0.935	0.925	0.581	Yes
	CMBSE2	0.795					
	CMBSE3	0.828					
	CMBSE4	0.706					
	CMBSE5	0.828					
	CMBSE6	0.855					
	CMBSE7	0.708					
	CMBSE8	0.635					
	CMBSE9	0.759					
CSLCSU	CSLCSU1	0.827	0.851	0.858	0.893	0.627	Yes
	CSLCSU10	0.809					
	CSLCSU11	0.723					
	CSLCSU13	0.817					
	CSLCSU2	0.777					
CSLSSR	CSLSSR4	0.832	0.635	0.644	0.845	0.731	Yes
	CSLSSR5	0.878					

Table 6. Discriminant validity assessment using cross-loading of the measurement model after deleting 19 indicators

Indicator	CMBIV	CMBSE	CSLCSU	CSLSSR
CMBIV1	0.552	0.485	0.338	0.198
CMBIV2	0.685	0.37	0.455	0.295
CMBIV3	0.801	0.486	0.533	0.384
CMBIV4	0.811	0.483	0.534	0.403
CMBIV5	0.693	0.432	0.405	0.408
CMBIV6	0.721	0.395	0.488	0.45
CMBIV7	0.813	0.392	0.541	0.408
CMBIV8	0.762	0.457	0.487	0.372
CMBIV9	0.795	0.42	0.57	0.391
CMBSE1	0.326	0.716	0.226	0.124
CMBSE2	0.522	0.795	0.388	0.202
CMBSE3	0.474	0.828	0.343	0.197
CMBSE4	0.368	0.706	0.22	0.138
CMBSE5	0.515	0.828	0.375	0.289
CMBSE6	0.449	0.855	0.324	0.175
CMBSE7	0.318	0.708	0.165	0.055
CMBSE8	0.269	0.635	0.124	0.049
CMBSE9	0.536	0.759	0.348	0.221
CSLCSU1	0.577	0.405	0.827	0.421
CSLCSU10	0.574	0.395	0.809	0.427
CSLCSU11	0.44	0.2	0.723	0.41
CSLCSU13	0.48	0.217	0.817	0.443
CSLCSU2	0.516	0.321	0.777	0.471
CSLSSR4	0.395	0.171	0.404	0.832
CSLSSR5	0.464	0.234	0.525	0.878

Therefore, 20 indicators including the CMBMB1_R, CMBMB2_R, CMBMB3_R, CMBMB4_R; CSLCSU3_R, CSLCSU4, CSLCSU5, CSLCSU6, CSLCSU7, CSLCSU8, CSLCSU9, CSLCSU12; CSLSSR1, CSLSSR2_R, CSLSSR3, CSLSSR6_R, CSLSSR7_R, CSLSSR8, CSLSSR9, and CMBIV1 were deleted, as shown in Table 7. The results of reanalyzing the measurement model after deleting the above indicators are shown in Figure 2 and Table 8. Table 8 highlights the findings of the internal consistency reliability test and the convergent validity test. The Cronbach's alpha value and CR value for all instruments are between 0.701 to 0.904, surpass the value 0.700 for internal consistency reliability [29]. As for convergent validity test, the value of AVE must exceed 0.500 (AVE>0.5) as suggested. Based on the findings, all constructs have achieved the AVE standard (AVE>0.5) with outer loadings value of 0.600 and above [35].

After deleting the CMBMB1_R, CMBMB2_R, CMBMB3_R, CMBMB4_R; CSLCSU3_R, CSLCSU4, CSLCSU5, CSLCSU6, CSLCSU7, CSLCSU8, CSLCSU9, CSLCSU12; CSLSSR1, CSLSSR2_R, CSLSSR3, CSLSSR6_R, CSLSSR7_R, CSLSSR8, CSLSSR9, and CMBIV1, the model was reanalyzed, and according to Table 6, all indicators have outer loading values that are between 0.635, the lowest, and 0.876, the highest, and all AVE is more than 0.5, Hair *et al.* [30] mention that outer loadings above 0.6 and AVE values greater than 0.5 generally indicate that the measurement model is reliable and valid, and therefore, item deletion is typically unnecessary if these criteria are met. Meanwhile, all the values of Cronbach's alpha, CR (rho-a), and CR (rho-c) are above the threshold point of 0.70, and the values of the AVE of all constructs meet the threshold point of 0.50. Since the values of the outer loadings of all indicators, the values of Cronbach's alpha and CR are above 0.70, and the values of the AVE for all constructs are above 0.50, it can be concluded that the convergent validity of the measurement model is valid. Then, the analysis proceeds to assess the discriminant validity of the measurement model.

Table 7. 20 indicators were deleted

Construct	Indicator	Outer loading	Deletion rationale
CMBMB	CMBMB1_R	-0.678	Loading <0.40→weak indicator
CMBMB	CMBMB2_R	-0.746	Loading <0.40→weak indicator
CMBMB	CMBMB3_R	0.054	Loading <0.40→weak indicator
CMBMB	CMBMB4_R	-0.392	Loading <0.40→weak indicator
CSLCSU	CSLCSU3_R	0.078	Loading <0.40→weak indicator
CSLSSR	CSLSSR2_R	-0.216	Loading <0.40→weak indicator
CSLSSR	CSLSSR6_R	-0.085	Loading <0.40→weak indicator
CSLSSR	CSLSSR7_R	-0.326	Loading <0.40→weak indicator
CMBIV	CMBIV1	0.551	AVE<0.50→contributed to low AVE
CMBIV	CMBIV2	0.686	AVE<0.50→contributed to low AVE
CMBIV	CMBIV5	0.695	AVE<0.50→contributed to low AVE
CMBSE	CMBSE8	0.64	AVE<0.50→contributed to low AVE
CSLCSU	CSLCSU4	0.646	AVE=0.435→below threshold of 0.50
CSLCSU	CSLCSU5	0.692	AVE=0.435→below threshold of 0.50
CSLCSU	CSLCSU6	0.677	AVE=0.435→below threshold of 0.50
CSLCSU	CSLCSU7	0.508	AVE=0.435→below threshold of 0.50
CSLCSU	CSLCSU8	0.682	AVE=0.435→below threshold of 0.50
CSLCSU	CSLCSU9	0.66	AVE=0.435→below threshold of 0.50
CSLCSU	CSLCSU12	0.595	AVE=0.435→below threshold of 0.50
CSLSSR	CSLSSR1	0.669	AVE=0.279→below threshold of 0.50
CSLSSR	CSLSSR3	0.593	AVE=0.279→below threshold of 0.50
CSLSSR	CSLSSR8	0.427	AVE=0.279→below threshold of 0.50
CSLSSR	CSLSSR9	0.557	AVE=0.279→below threshold of 0.50

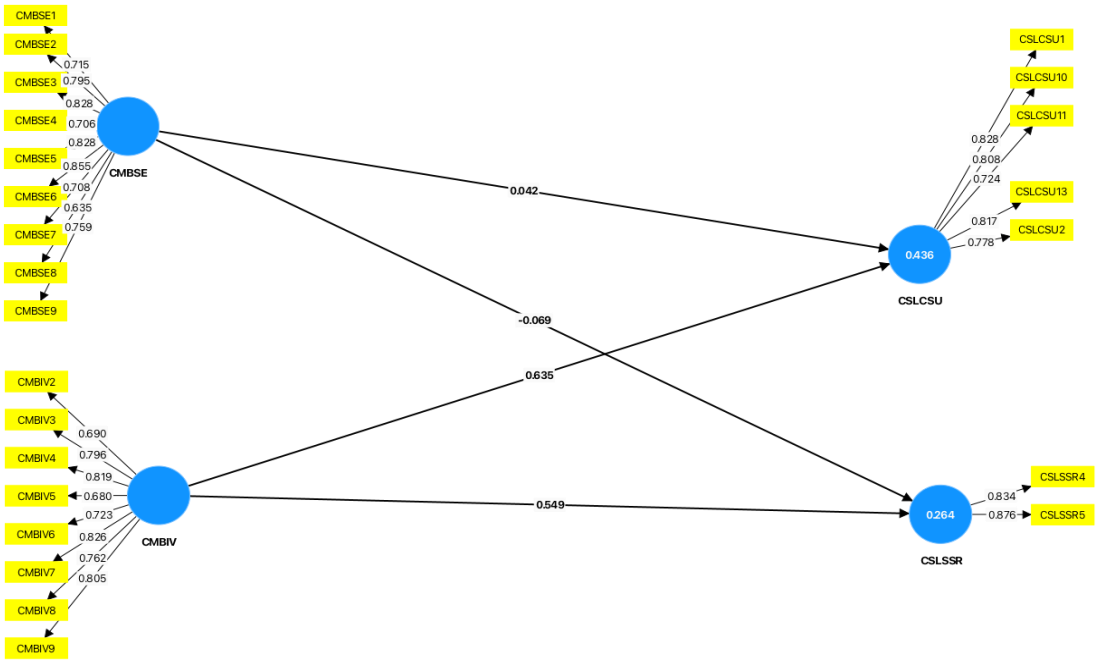

Figure 2. Measurement model of the study after deleting 20 indicators

Table 8. Convergent validity and reliability of the measurement model after deleting 20 indicators

Construct	Indicator	Outer loadings (0.708)	Cronbach's alpha (0.70)	CR (rho-a) (0.70)	CR (rho-c) (0.70)	AVE (0.50)	Convergent validity and reliability- Yes or No?
CMBIV	CMBIV2	0.69	0.897	0.901	0.918	0.585	Yes
	CMBIV3	0.796					
	CMBIV4	0.819					
	CMBIV5	0.68					
	CMBIV6	0.723					
	CMBIV7	0.826					
	CMBIV8	0.762					
	CMBIV9	0.805					
CMBSE	CMBSE1	0.715	0.912	0.935	0.925	0.581	Yes
	CMBSE2	0.795					
	CMBSE3	0.828					
	CMBSE4	0.706					
	CMBSE5	0.828					
	CMBSE6	0.855					
	CMBSE7	0.708					
	CMBSE8	0.635					
	CMBSE9	0.759					
CSLCSU	CSLCSU1	0.828	0.851	0.858	0.893	0.627	Yes
	CSLCSU10	0.808					
	CSLCSU11	0.724					
	CSLCSU13	0.817					
	CSLCSU2	0.778					
CSLSSR	CSLSSR4	0.834	0.635	0.642	0.845	0.732	Yes
	CSLSSR5	0.876					

4.1.2. Assessing discriminant validity of the measurement model

To assess the discriminant validity of the measurement model, this study employs the Fornell-Larcker criterion, cross-loadings, and the HTMT criterion. While Hair *et al.* [30] and Henseler *et al.* [36] emphasized the superiority of the HTMT approach in rigorously detecting construct differences, the Fornell-Larcker and cross-loading methods are also included to accommodate differing statistical perspectives. Based on the Fornell-Larcker assessment, Table 9 shows that the square roots of the AVE values exceed the corresponding inter-construct correlations, indicating satisfactory discriminant validity as per Fornell and Larcker [37].

Table 9. Discriminant validity assessment using cross-loading of the measurement model after deleting 20 indicators

Indicator	CMBIV	CMBSE	CSLCSU	CSLSSR
CMBIV2	0.69*	0.37	0.455	0.295
CMBIV3	0.796*	0.486	0.533	0.384
CMBIV4	0.819*	0.483	0.534	0.403
CMBIV5	0.68*	0.432	0.405	0.407
CMBIV6	0.723*	0.395	0.488	0.45
CMBIV7	0.826*	0.392	0.541	0.407
CMBIV8	0.762*	0.457	0.487	0.373
CMBIV9	0.805*	0.42	0.57	0.391
CMBSE1	0.314	0.715*	0.226	0.124
CMBSE2	0.511	0.795*	0.387	0.202
CMBSE3	0.467	0.828*	0.342	0.197
CMBSE4	0.357	0.706*	0.22	0.138
CMBSE5	0.497	0.828*	0.375	0.289
CMBSE6	0.433	0.855*	0.324	0.175
CMBSE7	0.3	0.708*	0.164	0.055
CMBSE8	0.248	0.635*	0.124	0.048
CMBSE9	0.517	0.759*	0.347	0.221
CSLCSU1	0.576	0.405	0.828*	0.421
CSLCSU10	0.566	0.395	0.808*	0.427
CSLCSU11	0.445	0.2	0.724*	0.41
CSLCSU13	0.483	0.217	0.817*	0.443
CSLCSU2	0.519	0.321	0.778*	0.471
CSLSSR4	0.403	0.171	0.404	0.834*
CSLSSR5	0.466	0.234	0.525	0.876*

*The square roots of the AVE values exceed the corresponding inter-construct correlations

In addition, cross-loadings are examined to further evaluate discriminant validity, as presented in Table 10. According to previous studies [30], [38], an indicator must load more strongly on its designated construct than on any other to demonstrate adequate discriminant validity. In this study, all indicators exhibit higher loadings on their constructs respectively compared to their loadings on other constructs, thereby supporting discriminant validity through the cross-loading criterion.

Furthermore, the HTMT ratio of correlations is employed to assess discriminant validity, as seen in Table 11. Henseler *et al.* [36] proposed HTMT as a more robust and reliable method compared to traditional techniques, arguing that it is more sensitive in detecting a lack of discriminant validity. HTMT value below 0.90 (or more conservatively, 0.85) indicates that discriminant validity is established between constructs. The result shows that all HTMT values fall well below the threshold (0.85), providing further evidence of satisfactory discriminant validity.

To evaluate potential multicollinearity among indicators, the variance inflation factor (VIF) was assessed, as shown in Table 12. VIF measures the extent of collinearity between one predictor and the others in a model. According to Hair *et al.* [30], VIF values below 5 indicate that multicollinearity is not a concern, while more conservative thresholds suggest a cut-off of 3.3 [39]. Since all VIF values are well below the threshold of 5, confirming the absence of multicollinearity issues among the indicators in the measurement model.

Table 10. Discriminant validity assessment using Fornell-Larcker criterion of the measurement model after deleting 20 indicators

Construct	CMBIV	CMBSE	CSLCSU	CSLSSR
CMBIV	0.765*			
CMBSE	0.562	0.762*		
CSLCSU	0.659	0.399	0.792*	
CSLSSR	0.51	0.239	0.547	0.855*

*The square roots of the AVE of the constructs, and the rest are the values of the correlations between the constructs.

Table 11. Assessing discriminant validity of the measurement model using HTMT criterion of the measurement model after deleting 20 indicators

Construct	CMBIV	CMBSE	CSLCSU	CSLSSR
CMBIV				
CMBSE	0.585			
CSLCSU	0.747	0.402		
CSLSSR	0.673	0.275	0.741	

Table 12. VIF of the measurement model indicators after deleting 20 indicators

Indicator	VIF
CMBIV2	1.729
CMBIV3	2.335
CMBIV4	2.452
CMBIV5	1.663
CMBIV6	1.831
CMBIV7	2.6
CMBIV8	2.134
CMBIV9	2.353
CMBSE1	2.014
CMBSE2	2.317
CMBSE3	2.821
CMBSE4	2.047
CMBSE5	2.807
CMBSE6	3.088
CMBSE7	2.89
CMBSE8	2.538
CMBSE9	1.97
CSLCSU1	2.174
CSLCSU10	1.984
CSLCSU11	1.606
CSLCSU13	2.097
CSLCSU2	1.936
CSLSSR4	1.275
CSLSSR5	1.275

4.2. Assessment of structural model

With the measurement model demonstrating satisfactory reliability, convergent validity, and discriminant validity through the Fornell-Larcker criterion, cross-loadings, HTMT ratios, and acceptable VIF values, the model meets the essential prerequisites for proceeding to the structural model analysis [30]. The results of the assessment of the second-order model are shown in Table 13 and Figure 3. Table 14 shows that the values of outer loadings of sub-constructs of student motivation and learning strategies, namely CMBIV, CMBSE, CSLCSU, and CSLSSR, are between 0.804 (the lowest) and 0.944 (the highest). Meanwhile, all values for Cronbach's alpha, CR rho-a, and rho-c exceed 0.70, indicating that they meet the established threshold. Hair *et al.* [30] mentioned that if the construct meets the CR (rho-a) value above 0.70 and the AVE is higher than 0.50, the respective construct is convergently valid. Therefore, it can be concluded that the measurement models of CMBIV, CMBSE, CSLCSU, and CSLSSR are convergently valid. Due to all constructs being convergently valid, the study proceeds to assess the discriminant validity of the measurement model. The following stage is assessing the discriminant validity of the second-order model. Like the first-order model discriminant validity assessment, this study uses all the criteria, such as Fornell-Larcker, cross-loading, and HTMT.

Table 13. Structural model analysis using PLS–SEM

Assessment	Level of acceptance	Literature support
Lateral collinearity	VIF<5.0	[30]
Path coefficient	P-value <0.05, t-value >1.645 (one-tailed), t-value >1.96 (two-tailed)	[30]
R^2	0.26 – substantial, 0.13 – moderate, 0.02 – weak	[40]
f^2	0.35 – substantial, 0.13 – medium, 0.02 – small	[40]
Q^2	A value greater than 0 indicates predictive relevance for endogenous constructs	[30]

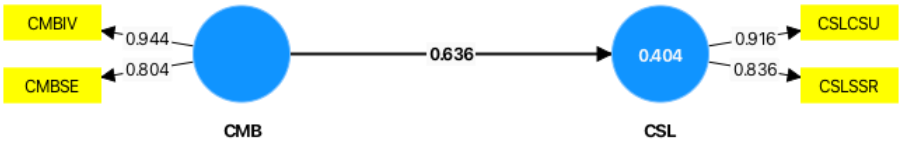

Figure 3. The structural model of the study

Table 14. Convergent validity of the constructs of the second-order model

Construct	Indicator	Outer loadings (0.708)	Cronbach's alpha (0.70)	CR (rho-a) (0.70)	CR (rho-c) (0.70)	AVE (0.50)	Convergent validity and reliability- Yes or No?
CMB	CMBIV	0.944	0.719	0.895	0.868	0.768	Yes
	CMBSE	0.804					
CSL	CSLCSU	0.916	0.707	0.755	0.87	0.77	Yes
	CSLSSR	0.836					

Tables 15 to 17 show the discriminant validity of the second order of the CMB-CSL measurement model using the Fornell-Larcker criterion, cross-loadings, and the HTMT criterion. Table 12 shows that the values of AVE are higher than the correlations between the constructs. Fornell and Larcker [37] mentioned that if the value of AVE square roots is higher than the value of correlation between construct, then the issue of discriminant validity in the measurement model is non-exist. Table 14 shows that the cross-loading value between the indicator and other constructs is no value greater than 0.1. Chin [34] argued that if there is a cross-loading value less than 0.1, it means no issue of discriminant validity. Table 15 shows that the highest value of the ratio correlations of the HTMT criterion is 0.815, which is less than 0.850. According to Kline [27], if the ratio correlation of the HTMT criterion is less than 0.850, it can be concluded that the constructs are discriminating valid. Apart from the criteria, when the model was assessed based on the inner VIF, as in Table 16. All the VIF values were below the threshold points of 5.11 mentioned that when the VIF value is under 5, as seen in Table 18, it suggests the absence of collinearity in the measurement model [30].

Table 15. Discriminant validity assessment using Fornell-Larcker criterion

Construct	CMB	CSL
CMB	0.876	
CSL	0.636	0.877

Table 16. Discriminant validity assessment using cross-loadings

Construct	CMB	CSL
CMBIV	0.944	0.675
CMBSE	0.804	0.376
CSLCSU	0.633	0.916
CSLSSR	0.463	0.836

Table 17. Discriminant validity assessment using HTMT criterion

Construct	CMB	CSL
CMB		
CSL	0.815	

Table 18. VIF – inner model

Construct	VIF
CMB->CSL	1.000

Based on the results in Tables 15 to 18, this study is now ready to proceed with testing the hypotheses. In testing the hypothesis, standard beta, t-value, and p-value will be used to reject or support the study's hypotheses. To do so, this study analyzes the data using bootstrapping of 10,000 subsamples [30].

4.3. Results of bootstrapping analysis

$H_0$1 states that CMB is not a significant predictor of CSL, as seen in Figure 4 and Table 19. The value of path coefficient (std. beta), t-statistics, and p-value are utilized to test this hypothesis. Table 20 shows that the model's path coefficient (std. beta) of CMB→CSL is 0.636, R2=0.404, t=10.382, inner VIF=1.000, p=<.001. This means that the CMB is a significant predictor for CSL. The R^2 value is 0.404, meaning the CMB contributes to a CSL variance of approximately 40.4%. According to Cohen [41], the contribution is substantial if the R^2 is more than 0.26. This study also found that the f^2 is 0.679, which means that the effect size of the CMB on CSL is substantial. Cohen [41] claims that the effect size is substantial if the f^2 is greater than 0.35. Therefore, this study rejects the $H_0$1, which states that CMB is not a significant predictor of CSL.

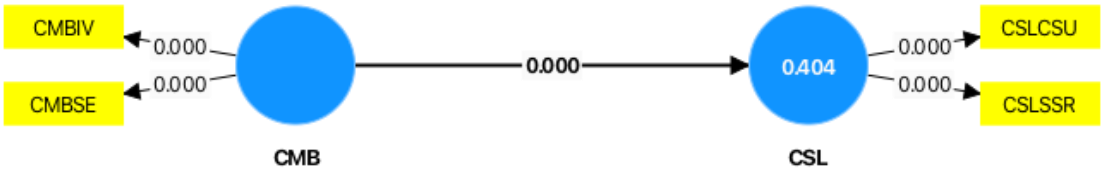

Figure 4. The path coefficients (Std. Beta) and t-value of the structural model

Table 19. $H_0$1 testing results

H_0	R	Std Beta	Std Dev	t-value	R^2	f^2	Inner VIF	p-value	Decision
$H_0$1	CMB→CSL	0.636	0.035	18.382	0.404	0.679	1.000	<0.001	Rejected

Table 20. The total effect of the CMB-CSL

Coeff.	t-value	p-value
0.636	18.382	<0.001

Based on the findings, student motivation (β=0.631, Coeff.=0.636, t-value=18.382, p<0.05) significantly influences learning strategies (Table 17). Therefore, $H_0$1 is rejected. This means that there is a significant relationship between student motivation (CMB) and learning strategies (CSL) among Malaysian boarding school students. With the revelations of hypotheses testing, the research questions are answered, and simultaneously, the study's objectives are achieved.

5. DISCUSSION

5.1. H01: the influence of motivational beliefs on self-regulated learning strategies

The rejection of H01, which confirms a significant relationship between motivational beliefs and self-regulated learning strategies, underscores the critical need for educators to implement interventions that not only build students' self-regulation skills but also intentionally cultivate their motivational beliefs. This holistic approach is consistent with SDT, which asserts that intrinsic motivation and self-regulated behaviors emerge when learners' basic psychological needs are satisfied, which are autonomy, competence, and relatedness. By fostering these needs, educators can create learning environments that promote intrinsic motivation and facilitate the adoption of effective learning strategies, ultimately enhancing academic performance. This study provides robust evidence that motivational beliefs are strong predictors of self-regulated learning strategies among Malaysian boarding school students. These results align with prior studies that emphasize the positive impact of motivation on students' use of cognitive and metacognitive strategies, which in turn lead to improved academic achievement [9], [13], [25]. In particular, students with higher self-efficacy and intrinsic value scores demonstrated more frequent engagement with self-regulated learning behaviors, reinforcing the assertion that motivational beliefs are foundational to independent academic engagement [8], [14], [42]. This further validates the relevance of SDT in educational contexts where nurturing internal psychological drivers is essential for student success [11], [12], [15].

In addition, the present study resonates with a broader literature base emphasizing the roles of peer collaboration, teacher support, and community involvement in fostering both motivation and learning [2], [4], [17]. The boarding school context, when structured supportively, provides students with emotional and social resources that enhance their motivation, which in turn leads to greater use of self-regulation strategies. Digital technologies also contribute to this dynamic by supporting personalized and student-centered learning pathways that align with SDT's emphasis on autonomy and competence [5]–[7]. The integration of digital tools, collaborative learning, and differentiated instruction [2], [8] presents practical strategies for enhancing both motivation and strategic learning behavior. Nonetheless, the literature is not without dissenting views. Several scholars urge caution in generalizing the relationship between motivation and self-regulated learning. For instance, Pintrich [25] and Wentzel [43] observe that student responses to motivational interventions can vary significantly based on personal, cultural, and contextual factors. Hofstede [19] emphasizes that in collectivist societies like Malaysia, students may interpret autonomy differently, potentially moderating the relationship between motivation and learning behavior. Tanase [20] further highlights that systemic and cultural misalignments between instructional approaches and student expectations can diminish the efficacy of motivational interventions. Methodologically, the cross-sectional design of this study restricts causal inference [44], while self-reported data may pose the risk of common method bias [30], [31].

Despite these limitations, the study presents several novel contributions that address gaps in the existing literature. Notably, it employs a validated version of the MSLQ within a second-order SEM-PLS model specifically adapted to the Malaysian boarding school context. Unlike earlier models, this approach isolates and confirms the influence of self-efficacy and intrinsic value, while discarding test anxiety due to inadequate psychometric strength, providing clearer grasp of the ways in which motivation drives strategic learning. The rigorous validation process, including the deletion of 19 weak items to meet AVE and loading criteria, and the application of HTMT, VIF, and cross-loadings, significantly strengthens the credibility and generalizability of the model [29], [30], [37]. Practically, the study sheds light on how motivation can be fostered in structured residential environments where parental involvement is limited. It emphasizes that intrinsic motivational factors should be prioritized in instructional design, particularly within Malaysian boarding schools. Concrete recommendations emerging from the findings include implementing autonomy-supportive teaching, promoting collaborative learning structures, and integrating personalized digital tools.

These recommendations align with the goals of SDG 4 (quality education) and SDG 10 (reduced inequalities) by equipping all students, regardless of background, with the psychological and strategic resources necessary for academic resilience and lifelong success. This aligns with prior research advocating for inclusive, context-responsive learning environments. For instance, Ramachandaran *et al.* [45] identified personalized and collaborative educational strategies, including mentorship, networking, and leadership development programs, as essential for empowering marginalized groups, especially women, through education in Malaysia. Furthermore, Vasudevan *et al.* [46] underscored the role of sustainable and transformational leadership in cultivating autonomy-supportive organizational cultures that enhance motivation and performance. These findings resonate with current efforts to implement autonomy-supportive pedagogy and personalized strategies in schools. For example, Wider [47] found that metacognitive monitoring and regulation significantly predicted the development of physics problem-solving skills among secondary school students, with notable gender differences in performance despite similar metacognitive levels. Finally, stakeholder engagement, particularly involving students, teachers, and families, is essential for sustaining collaborative learning models in tech-enhanced environments [46]. These combined insights

reinforce the present study's assertion that integrating contextually grounded instructional design with self-determination principles can guide effective educational reforms for Malaysian boarding schools.

5.2. Limitations of the study

5.2.1. Cross-sectional design

The cross-sectional nature of the study limits the establishment of causal links between motivational beliefs and self-regulated learning strategies. While significant correlations exist, the precise direction of these relationships cannot be confirmed. A longitudinal or experimental approach would be more appropriate to examine changes in motivation and learning behavior over time.

5.2.2. Self-reported data and potential bias

The data, obtained through self-reported questionnaires, may be prone to social desirability bias and common method variance. Students may have overestimated their motivational levels or learning behaviors to align with perceived academic expectations, potentially inflating observed correlations.

5.2.3. Limited generalizability

Participants were exclusively selected from four boarding schools in northern Malaysia, which may not reflect the diversity of student experiences across other regions or educational settings (e.g., urban day schools, rural public schools, and vocational institutions). As such, caution should be exercised in generalizing the findings beyond the specific cultural and institutional context studied.

5.2.4. Conceptual narrowing due to indicator deletion

Although test anxiety was initially included due to its theoretical relevance in motivational constructs, its exclusion was necessary based on poor psychometric indicators (e.g., low outer loadings, AVE<0.5). Additionally, in Malaysian collectivist boarding schools, academic pressure may be normalized and expressed differently than in Western contexts, making traditional test anxiety constructs less culturally resonant [19], [20]. To ensure robust measurement validity, 20 indicators were removed during the measurement model refinement process. While this improved statistical quality, it may have led to a narrower conceptual representation of key constructs, particularly the removal of all indicators under the test anxiety subscale. Given the academic pressure often experienced in Malaysian boarding schools, this dimension might have offered valuable insights into students' motivational challenges. The absence of this perspective suggests a need for future development of culturally adapted instruments that can capture context-specific expressions of anxiety without compromising model integrity.

5.3. Future research recommendations

5.3.1. Adopt longitudinal or experimental designs

It is recommended that future studies employ longitudinal or quasi-experimental designs to measure how motivational beliefs and self-regulated learning strategies develop over time. Such designs would allow researchers to explore causal pathways and the sustainability of motivational interventions across academic semesters or grade levels.

5.3.2. Incorporate multiple data sources

To minimize biases inherent in self-reported measures, future research should triangulate data by incorporating teacher assessments, peer feedback, academic records, or observational methods. This would provide a more holistic and objective understanding of students' motivation and learning behaviors.

5.3.3. Expand to diverse educational settings and populations

Further research should investigate similar constructs across different educational contexts, such as public day schools, rural institutions, vocational colleges, and international schools. Comparing motivational dynamics across these varied settings would enhance the generalizability of findings and identify culturally or contextually specific factors influencing student engagement.

5.4. Practical implications for policy and practice

The validated second-order model provides a practical framework that can guide educational policy and school-level interventions. Specifically, it enables policymakers and school leaders to identify motivation gaps using quantifiable indicators. This model may be integrated into teacher training programs to promote autonomy-supportive and competence-enhancing instructional practices, particularly in boarding school environments where student self-regulation is critical. Additionally, the framework supports Malaysia's National Education Blueprint by aligning with national goals for inclusive and student-centered learning.

It also contributes to global efforts under SDG 4 focusing on quality education, and SDG 10 targeting reduced inequalities, offering a context-sensitive approach to educational reform.

6. CONCLUSION

This study makes a novel contribution by validating a culturally adapted, second-order motivational model using SEM-PLS in the context of Malaysian boarding schools. Unlike previous studies, it isolates and confirms the influence of self-efficacy and intrinsic value on self-regulated learning while deliberately excluding test anxiety based on psychometric limitations. The model refinement process through rigorous indicator validation, AVE adjustments, and discriminant validity testing adds empirical robustness.

Importantly, the resulting model offers a replicable diagnostic framework applicable to other collectivist educational contexts in Southeast Asia. It bridges theoretical constructs from SDT with practical interventions, supporting scalable implementation in curriculum design, teacher training, and national education strategy. The study thus contributes both conceptually and practically to the ongoing global discourse on inclusive and equitable education.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

ETHICAL APPROVAL

The ethical approval was granted by the Research Management Center Committee at INTI International University, which also serves as the institution's ethics committee. The study was approved under the grant number INTI-FELA-01-04-2024.

DATA AVAILABILITY

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

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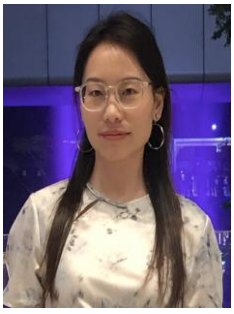

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