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A causal model of metacognitive awareness in integrated flipped learning among Iranian medical sciences students

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Abstract

Introduction:

Metacognitive awareness underpins self-regulated learning in medical education and may be shaped by how students manage motivation, cognition, and emotion in technology-supported designs such as integrated flipped learning. This study tested a hypothesised pathway model of factors associated with metacognitive awareness among medical sciences students.

Method

The study population comprised medical sciences students enrolled across affiliated campuses at Shiraz University of Medical Sciences (N = 1,432). Using cluster random sampling and a standard sample-size determination approach, 380 students were selected for analysis. Data were collected using standardised self-report instruments measuring metacognitive awareness, mindfulness, goal orientation, cognitive emotion regulation, metacognitive beliefs, academic self-efficacy, and need for cognition.

Results

Data were screened and summarised in SPSS; the hypothesised model was tested using path analysis in AMOS and evaluated using standard goodness-of-fit indices. The final model fit the data very well and indicated that metacognitive awareness was linked to metacognitive beliefs, need for cognition, and cognitive emotion regulation both directly and indirectly through academic self-efficacy, mindfulness, and goal orientation. The model explained a meaningful proportion of variance in metacognitive awareness and academic self-efficacy.

Conclusion

Overall, the findings point to practical levers in integrated flipped learning: strengthening academic self-efficacy, supporting adaptive emotion regulation, and cultivating students' engagement with effortful thinking, alongside metacognitive beliefs, may help develop metacognitive awareness in medical sciences education.

Introduction

Health sciences students (e.g., medicine, nursing, allied health) must learn under conditions that are cognitively demanding and time-pressured: they are expected to integrate foundational knowledge with clinical reasoning, manage uncertainty, and continuously recalibrate decisions using feedback. In such environments, success depends not only on "what students know," but also on how accurately they

monitor, regulate, and adapt their learning and reasoning processes that are central to self-regulated learning (SRL) and metacognition in medical education [1–4].

Metacognition is typically described as learners' awareness of their own cognition and their ability to regulate it (planning, monitoring, evaluating). It is tightly linked to safe clinical performance because diagnostic and management decisions can fail when students misjudge what they understand, rely on unfounded fluency, or persist with ineffective strategies. Therefore, medical education increasingly treats metacognitive development as a teachable and assessable competence rather than a byproduct of experience [2–5].

At the same time, many health sciences programs have expanded blended and flipped instructional designs, in which students are expected to prepare before class (often via digital resources) and then use class time for higher-order application. Evidence from health professions education suggests that flipped approaches can improve learning outcomes on average, but effects vary widely across contexts—especially when learners are not adequately supported in regulating pre-class learning and converting preparation into clinical-performance-relevant reasoning [6–10].

This variability is not surprising. SRL is not automatic; it depends on motivational beliefs, strategic knowledge, and the learner's capacity to manage attention and emotion under academic stress. For medical sciences students, these factors are not peripheral—they can determine whether flipped/blended learning becomes a high-yield pathway to deeper learning or a fragmented workload that increases stress and superficial study [1, 8, 11–13].

Accordingly, this article develops an explanatory approach for understanding why some health sciences students benefit more from integrated flipped/blended learning than others. Building on SRL and metacognition scholarship, it focuses on a set of theoretically grounded learner variables—achievement goals, mindfulness/attentional awareness, metacognitive beliefs, emotion regulation strategies, and need for cognition—as plausible drivers of metacognitive awareness and regulatory engagement in health sciences education [2, 11, 14, 15–21].

Literature review

Metacognition and SRL in medical education

A consistent theme in medical education research is that learners must become capable of reflecting on their thinking, detecting limitations, and adapting strategies in response to feedback and uncertainty. Reviews emphasize metacognitive reflection as a mechanism for more calibrated clinical judgment and for reducing errors rooted in overconfidence or shallow processing [2–4]. In parallel, SRL perspectives applied to medical education frame learning as cyclical: goal-setting and planning, strategic performance with monitoring, and self-evaluation leading to adaptive change. This framing is particularly relevant in clinical learning where performance is visible and feedback is frequent but unevenly used by students [1].

Instructional contexts: flipped/blended learning and the "regulation problem"

Flipped and blended formats require students to do substantial self-directed work before and between sessions, often through video-based or multimedia resources. Meta-analytic evidence in health professions education shows overall positive learning effects for flipped classrooms; however, recent syntheses in medical education also highlight heterogeneity and the importance of moderators (design quality, learner readiness, and support structures) [6,7]. A scoping review of medical students' SRL in blended environments similarly indicates that students' regulatory behaviors vary and that curricula often assume SRL capacity rather than deliberately cultivating it [8]. Beyond medical education, large-scale reviews suggest video can improve learning in higher education, but benefits depend on how learners engage with materials (e.g., active processing rather than passive watching) [9].

Why learner differences matter: motivation, cognition, attention, and emotion

SRL research consistently shows that motivational beliefs (e.g., task value, self-efficacy, goal orientations) influence whether students invest effortful strategies, persist under difficulty, and monitor their understanding realistically [11]. Achievement goal theory differentiates mastery- and performance-oriented goals (and approach/avoidance patterns), which are associated with different patterns of engagement and coping—issues that are highly salient in competitive, high-stakes medical programs [14]. At the same time, students often hold inaccurate beliefs about learning (e.g., confusing fluency with mastery), making them vulnerable to miscalibration—particularly when learning is self-paced and technology-mediated [12].

Attention and emotion regulation are additional pressure points. Mindfulness-related constructs (present-moment attentional awareness) have been linked to improved psychological well-being and reduced reactivity, which may support sustained engagement and less avoidant coping during intensive study periods [16,17]. Metacognitive beliefs—beliefs about thinking itself (e.g., beliefs about worry, thought control, cognitive confidence)—are theorized to shape how individuals respond to intrusive thoughts and uncertainty; in academic settings, they can plausibly influence rumination, monitoring quality, and regulation choices under stress [18]. Likewise, cognitive emotion regulation strategies (e.g., reappraisal, catastrophizing, rumination) may help explain why some students maintain constructive monitoring and planning while others fall into maladaptive cycles during demanding coursework [19].

Finally, need for cognition reflects a tendency to enjoy and engage in effortful thinking. In medical sciences education—where deep processing and integration are essential—higher need for cognition may support more active engagement with pre-class materials, more hypothesis-driven reasoning, and stronger persistence in resolving conceptual uncertainty [20]. Together, these literatures motivate a learner-centered explanatory model: instructional design (integrated flipped/blended learning) creates the conditions for self-directed preparation, but learner differences in motivation, metacognitive beliefs, attention, and emotion regulation may determine whether those conditions translate into metacognitive awareness and effective SRL behaviors [1,2,11,6–10,18–20].

Theoretical Framework

This study is anchored in an SRL-metacognition perspective adapted to the realities of health sciences education. SRL is conceptualized as a cyclical process in which learners set goals, deploy strategies, monitor progress, and adapt based on feedback processes that are directly relevant to clinical learning and diagnostic reasoning training [1]. Within this frame, metacognition is treated as both (a) a structured form of awareness (knowledge of cognition) and (b) regulation of cognition (planning, monitoring, evaluation) [5]. These two components matter because medical students can fail in two different ways: they may lack accurate insight into what they do not know, or they may recognize gaps but fail to regulate behavior effectively under workload and stress [2–4].

Motivational mechanisms are specified using SRL motivation theory and achievement goal theory. Motivational beliefs are expected to influence whether students choose deeper strategies (e.g., elaboration, self-testing, error analysis) versus surface compliance behaviors [11]. Achievement goal orientations, especially approach/avoidance patterns, provide a theoretically grounded explanation for why some students use challenge as information (mastery-approach) while others respond to high-stakes contexts with threat management (performance-avoidance), which can undermine monitoring accuracy and adaptive strategy use [14].

The framework also integrates self-regulatory constraints that are especially salient in medical training: attentional control and emotion regulation. Mindfulness is incorporated as a disposition that may support attentional stability and reduced cognitive reactivity, which in turn can facilitate higher-quality monitoring and less avoidant coping during demanding learning periods [16,17]. Metacognitive beliefs (e.g., beliefs about the controllability/danger of thoughts and worry) are included as a higher-order cognitive layer shaping how learners interpret internal experiences (uncertainty, intrusive doubts) and how they select regulation strategies (e.g., productive monitoring vs. unproductive rumination) [18]. Emotion regulation strategies are included as proximal cognitive coping processes that may either preserve learning-oriented regulation (e.g., adaptive reappraisal) or derail it (e.g., catastrophizing, rumination) [19].

Finally, need for cognition is positioned as a trait-like driver of effortful engagement that can strengthen deep processing of pre-class resources and sustain reflective reasoning, particularly when flipped/blended learning places greater responsibility on the learner [20]. In a flipped/blended context where students often rely on video and self-paced preparation, the framework expects that learning gains are not merely a function of access to resources; rather, gains are produced when learners actively process content, test understanding, and regulate study behaviors—mechanisms supported by empirical syntheses on flipped learning, SRL in blended medical education, and video-based learning [6-10].

Based on this framework, the conceptual model will specify directional relationships among (1) motivational orientations, (2) mindfulness/attention, (3) metacognitive beliefs, (4) emotion regulation

strategies, and (5) need for cognition, as predictors of metacognitive awareness and SRL engagement within integrated flipped/blended learning for health sciences students [1,2,11,14,16–20].

Conceptual model and hypotheses

Building on self-regulated learning accounts of complex problem solving in health professions education, metacognitive awareness is treated here as the key *criterion* because it supports medical students' capacity to plan, monitor, and adjust learning and clinical reasoning under conditions of uncertainty and cognitive load [1]. Consistent with the metacognitive awareness construct, we focus on learners' awareness of cognition (knowledge of strategies, tasks, and self) and regulation of cognition (planning, monitoring, and evaluation) [3]. In the present model (see Figure 1), three proximal mechanisms are positioned as mediators: **goal orientation** (as a motivational lens shaping learning aims and effort investment) [22], **mindfulness** (as sustained, receptive attention and meta-awareness that can reduce autopilot responding and improve monitoring) [23], and **self-efficacy** (as beliefs about capability that influence persistence and strategic engagement) [11]. These mediators are hypothesized to transmit the effects of three **exogenous** learner dispositions—**need for cognition, cognitive emotion regulation**, and **metacognitive beliefs**—onto metacognitive awareness.

Need for cognition reflects a stable tendency to enjoy effortful thinking and to seek cognitively challenging activities [17]. In medical education, where learners routinely face ill-structured problems and competing information streams, NFC should increase students' willingness to invest cognitive effort in understanding, elaborating, and checking their thinking. Empirically, NFC has been linked to more adaptive learning engagement patterns and stronger mastery-oriented motivations, supporting a positive association between NFC and goal orientation (**H1a**) [24]. NFC has also been associated with greater use of explanatory processing and metacognitive activity during learning, indicating that cognitively engaged students are more likely to monitor and regulate comprehension and strategy use—directly supporting a positive path from NFC to metacognitive awareness (**H1d**) [25].

For the self-efficacy mechanism, NFC can plausibly foster efficacy beliefs via repeated experiences of successfully persisting through cognitively demanding tasks. This is consistent with evidence that NFC relates positively to self-efficacy and performance in academic and cognitively demanding contexts, supporting **H1b** (NFC → self-efficacy) [26,27]. The NFC → mindfulness link is theoretically defensible because mindfulness requires sustained attentional engagement and reduced distractibility—capacities that align with a preference for cognitive effort. However, the direct empirical base linking NFC and mindfulness is thinner than for the other H1 paths. As indirect support, NFC has been associated with cognitive capacity/efficiency under demand, and mindfulness research emphasizes attentional control and monitoring; together, these strands justify a directional hypothesis (**H1c**) that higher NFC will be associated with higher mindfulness, while acknowledging that this pathway is more exploratory and should be interpreted with appropriate caution [28].

Cognitive emotion regulation refers to the cognitive strategies learners use to manage achievement-related emotions (e.g., reappraisal, refocusing, rumination, catastrophizing) [19]. In medical students, achievement emotions and their regulation are not peripheral; they shape persistence, study behaviors, and self-regulated learning in online and blended settings, making CER theoretically relevant to both motivational and metacognitive outcomes [29]. Maladaptive CER strategies (e.g., rumination, catastrophizing) can consume working memory and attention, undermining monitoring accuracy, whereas adaptive strategies (e.g., positive reappraisal, planning) should preserve cognitive resources and promote strategic control. This supports a direct association from CER to metacognitive awareness (**H2d**), with the direction depending on the balance of adaptive vs. maladaptive strategies [19].

CER is also expected to operate through the mediators. First, by changing the emotional "cost" of challenge, CER can shape whether students approach tasks as opportunities for learning versus threats to competence, supporting a positive association between more adaptive CER and learning-oriented goal orientation (**H2a**) [29]. Second, CER strategies that reduce perseverative negative thinking should make present-moment attention more stable, supporting **H2b** (CER → mindfulness), consistent with evidence that mindfulness measures relate meaningfully to cognitive emotion regulation patterns [30]. Third, effective regulation of learning-related emotions is closely tied to efficacy beliefs in medical students; structural models in medical education show that motivational beliefs and learning-related emotions are intertwined with metacognitive learning strategies and performance, supporting **H2c** (CER → self-efficacy) as a plausible pathway feeding forward into metacognitive awareness [31,32].

Metacognitive beliefs capture beliefs about thinking itself (e.g., beliefs about uncontrollability/danger of thoughts, the usefulness of worry, and the need to control cognition) [18]. In demanding medical curricula, dysfunctional metacognitive beliefs can amplify repetitive negative thinking and attentional capture by threat-related cognitions, which should interfere with monitoring and regulation of cognition. Empirical work links emotion dysregulation and repetitive negative thinking to metacognitive beliefs, supporting a direct detrimental relationship between dysfunctional metacognitive beliefs and metacognitive awareness (**H3d**, negative) [33].

The mediator pathways are also theoretically and empirically grounded. First, metacognitive beliefs shape how learners interpret errors and uncertainty; beliefs that thoughts are dangerous or uncontrollable can promote avoidance- or performance-focused striving rather than learning-focused striving, implying **H3a** (MCB → goal orientation) [18,33]. Second, metacognitive models of mindfulness argue that mindfulness is meaningfully related to metacognitive processes and (in part) reflects a different stance toward internal experiences; empirical findings show systematic associations between mindfulness constructs and metacognitive belief patterns, supporting **H3b** (MCB → mindfulness) [23,34]. Third, dysfunctional metacognitive beliefs can reduce perceived capability to control cognition under pressure, undermining confidence to deploy strategies effectively; thus **H3c** (MCB → self-efficacy) is expected, with the direction again depending on whether beliefs facilitate or impair perceived cognitive control [11,18].

Self-efficacy is expected to predict metacognitive awareness because students who believe they can succeed are more likely to invest effort in planning, monitoring, and adjusting strategies instead of disengaging [11]. In medical students, evidence from structural models indicates that academic self-efficacy is positively related to metacognitive learning strategies and academic performance, supporting **H4b** (self-efficacy → metacognitive awareness) [31]. Self-efficacy is also expected to support mindfulness (**H4a**) because confident learners tend to show less threat-driven attentional narrowing and greater capacity to stay engaged with present-task demands; recent evidence directly links mindfulness and general self-efficacy in students, supporting the plausibility of this pathway [35].

Mindfulness is hypothesized to enhance metacognitive awareness (**H5a**) because mindful attention increases the likelihood that learners notice comprehension breakdowns, emotional interference, and strategy inefficiency early enough to intervene. This is consistent with a metacognitive perspective on mindfulness and empirical work positioning mindfulness as related to metacognitive constructs [23]. Mindfulness is also expected to influence goal orientation (**H5b**) by reducing stress-reactive performance concerns and supporting a development/mastery focus; empirical evidence shows mindfulness is positively associated with development goal orientation in achievement contexts [36].

Finally, goal orientation is expected to predict metacognitive awareness (**H6**). When medical students adopt learning-oriented goals, they are more likely to engage in monitoring, self-testing, and strategy adjustment because these behaviors are instrumental for improvement rather than merely for impression management [22]. Empirically, longitudinal evidence indicates that learning goal orientation relates to metacognitive awareness and that metacognitive awareness can function in motivational–regulatory processes, reinforcing the expected positive association in demanding training contexts [37].

Methods

Research design and setting

This study used an applied, cross-sectional, descriptive–correlational design to test a hypothesised causal structure among cognitive–motivational variables and metacognitive awareness in medical sciences students. The proposed relations were examined using path analysis (structural equation modelling logic), estimating direct and indirect effects among observed composite scores. Data were collected during virtual delivery of the General English course in the 2020–2021 academic year (1399–1400 in the Iranian calendar).

Integrated flipped learning context

The General English course was delivered in an online/technology-supported format during the 2020–2021 using LMS: Adobe Connect. The course followed an integrated flipped learning structure in which core content was first studied before live sessions through short instructor-prepared materials (recorded mini-lectures, slides) and brief pre-class tasks (preparatory questions). Synchronous sessions were then

used primarily for active learning (discussion, problem-solving). After the live sessions, students completed follow-up activities (practice tasks, assignments) to consolidate learning. This design intentionally integrated pre-class preparation with in-session application and post-session consolidation, consistent with an integrated flipped approach.

Participants

The statistical population comprised medical sciences students enrolled in the General English course. The required sample size was determined using the Krejcie and Morgan table, and 380 students were selected for analysis. Participants were recruited using a multistage random cluster sampling approach: eligible General English classes were treated as clusters, and students were randomly selected from class lists proportional to the predetermined sample size [38].

Research instruments

All measures were administered as a single online questionnaire package. Higher scores indicate higher levels of the measured construct unless otherwise stated.

Metacognitive awareness. Metacognitive awareness was assessed using the Metacognitive Awareness questionnaire developed by Mokhtari and Reichard (2002). The scale includes 30 items rated on a 5-point Likert format. In this study, internal consistency was acceptable (Cronbach's α = 0.83). [39, 40]

Mindfulness was measured using the Freiburg Mindfulness Inventory—Short Form (FMI-SF) developed by Walach (2001) and validated in Iran by Gasemi Jobaneh et al. (2015). The instrument has 14 items rated on a 5-point Likert scale from 1 (rarely) to 5 (always). In this study, reliability was excellent (α = 0.94). Evidence for construct/content validity has been reported in prior Persian validation work; here we relied on the validated Persian version and evaluated internal consistency [41, 42].

Goal orientation was assessed using the Goal Orientation questionnaire attributed to Bouffard (1998) and adapted/validated in Iran by Dehghani, Najvani, and Zarepour (2016). In the administered questionnaire package, the goal orientation block comprised 13 items (items 63–76 in the full survey). Items were rated on a 5-point Likert format (1 to 5), with higher total scores indicating stronger goal orientation. Internal consistency in the current study was acceptable (α = 0.75). Validity evidence is taken from the prior Iranian validation study; in this study we focused on reliability (α) [43, 44].

Cognitive emotion regulation. Cognitive emotion regulation was measured using the short Persian version of the Cognitive Emotion Regulation Questionnaire (CERQ-short) by Garnefski (2002), validated in Iran by Hassani (2011). The short form contains 18 items rated on a 5-point Likert scale from 1 (almost never) to 5 (almost always), capturing cognitive strategies used after negative events. In the present dataset, reliability was good (α = 0.88). Prior studies report acceptable construct validity for the

Persian short form; the current study emphasised internal consistency and use of a validated Persian version [19, 45].

Metacognitive beliefs. Metacognitive beliefs were assessed using the Metacognitions Questionnaire (MCQ) by Wells (1997), normed/validated in Iran by Shirin-zadeh (2005). The study used a 27-item version rated on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Higher scores indicate stronger dysfunctional metacognitive beliefs. Reliability in this study was acceptable (α = 0.81). Construct validity evidence is based on prior validation studies; internal consistency was assessed in the current data [46, 47].

Self-efficacy. Self-efficacy was measured with the short form of the Self-efficacy questionnaire developed by Sherer and Maddux (1996) and validated in Iran by Barati (2010). The instrument contains 17 items rated on a 5-point Likert scale from 1 (never) to 5 (always). Higher total scores indicate higher perceived self-efficacy. Reliability in the present study was excellent (α = 0.91). Prior studies provide validity evidence; in this study, internal consistency was evaluated [40].

Need for cognition. Need for cognition was measured using the short form of the Need for Cognition scale developed by Cacioppo (1982) and normed in Iran by Taherpour, Zamani, and Mohseni (2005). The scale includes 18 items rated on a 5-point Likert scale from 1 (never) to 5 (always). Reliability in this study was acceptable (α = 0.76). Validity evidence comes from the prior Persian norming work; internal consistency was assessed in this dataset [17].

Implementation procedures

After obtaining a list of eligible students enrolled in General English, selected students received the study link within the virtual learning context. Before completing the questionnaire, participants received a brief explanation of the study aims and instructions. Electronic informed consent was obtained from all participants prior to data collection. Participants reviewed an online information sheet and indicated consent (e.g., by selecting “I agree”) before accessing the questionnaire. Participation was voluntary, and respondents could discontinue at any time without penalty. Participation was voluntary and anonymous. The study protocol was reviewed and approved by the Research Ethics Committees of Payame Noor University (Approval ID: IR.PNU.REC.1400.005; approval date: 13 April 2021). The study was conducted in accordance with the principles of the Declaration of Helsinki and its later amendments.

Data analysis

Data were screened using descriptive statistics (mean, standard deviation) and distributional indices (skewness, kurtosis). Given acceptable univariate normality (approximately within ± 2 for skewness/kurtosis), hypothesis testing proceeded using path analysis to estimate direct and indirect effects in the hypothesised model. Descriptive and correlational analyses were conducted in IBM SPSS

Statistics, and path analysis was conducted in IBM SPSS Amos. Statistical significance was evaluated at conventional alpha levels ($p < 0.05$).

Results

Participants and preliminary screening

Analyses in this section focus on the medical sciences student group (n = 380). We first report descriptive indices (means/SDs, skewness, kurtosis) to check univariate distributional assumptions and then present bivariate correlations before testing the full path model.

Table 1. Descriptive statistics indices of the research variables

Variables	Mean	Standard deviation	Skewness	Kurtosis
Metacognitive beliefs	73.56	13.51	0.13	-0.92
Cognitive emotion regulation	53.37	10.02	0.22	0.15
Need for cognition	35.86	7.59	0.95	1.88
Self-efficacy	71.46	9.01	-1.07	1.73
Mindfulness	36.52	5.02	0.31	-0.32
Goal orientation	49.09	6.65	-0.35	0.16
Metacognitive awareness	63.54	6.94	-0.93	0.67

As shown in **Table 1**, the highest mean score was observed for **metacognitive beliefs** (M = 73.56, SD = 13.51), followed by **self-efficacy** (M = 71.46, SD = 9.01). The lowest mean score was for **need for cognition** (M = 35.86, SD = 7.59), while **mindfulness** (M = 36.52, SD = 5.02) and **metacognitive awareness** (M = 63.54, SD = 6.94) fell in the mid-range. In terms of variability, **metacognitive beliefs** showed the largest dispersion (SD = 13.51), whereas **mindfulness** showed the smallest dispersion (SD = 5.02), indicating comparatively more homogeneous responses on mindfulness.

Skewness and kurtosis values suggested **acceptable univariate normality** for all study variables. Skewness ranged from **−1.07** (self-efficacy) to **0.95** (need for cognition), and kurtosis ranged from **−0.92** (metacognitive beliefs) to **1.88** (need for cognition). Overall, these distributional indices indicate no serious departures from normality, supporting the use of parametric correlation estimates and model testing based on path analysis assumptions.

Table 2. Correlation matrix of the research variables

Variables	1	2	3	4	5	6	7
Metacognitive beliefs	1						
Cognitive emotion regulation	0.042	1					
Need for cognition	0.216**	0.230**	1				
Self-efficacy	0.433**	0.242**	0.357**	1			
Mindfulness	0.249**	0.245**	0.285**	0.349**	1		
Goal orientation	0.343**	0.223**	0.359**	0.346**	0.247**	1	
Metacognitive awareness	0.304**	0.256**	0.326**	0.364**	0.379**	0.335**	1

**P < 0.01

As shown in Table 2, the correlation matrix indicated that study variables were positively and significantly related to one another at p < 0.01, supporting the expected direction of associations prior to the path analysis. The only exception was the association between metacognitive beliefs and cognitive emotion regulation, which was small and non-significant (*r* = 0.042).

Regarding the criterion variable, metacognitive awareness was significantly and positively correlated with mindfulness (*r* = 0.379), self-efficacy (*r* = 0.364), goal orientation (*r* = 0.335), need for cognition (*r* = 0.326), metacognitive beliefs (*r* = 0.304), and cognitive emotion regulation (*r* = 0.256) (all p < 0.01). Among intercorrelations of key predictors/mediators, the strongest association was observed between metacognitive beliefs and self-efficacy (*r* = 0.433, p < 0.01), and the mediators were also positively interrelated (e.g., self-efficacy with mindfulness and goal orientation).

Direct Effects

Table 3. Estimates of direct effect coefficients

Variables	β	t	P value
Direct effects of metacognitive beliefs on:			
Self-efficacy	0.34	7.35	0.01
Mindfulness	0.12	2.32	0.05
Goal orientation	0.28	6.00	0.01
Metacognitive awareness	0.12	2.41	0.05
Direct effects of cognitive emotion regulation on:			
Self-efficacy	0.15	3.42	0.01
Mindfulness	0.16	3.18	0.01
Goal orientation	0.15	3.22	0.01
Metacognitive awareness	0.11	2.38	0.05
Direct effects of need for cognition on:			
Self-efficacy	0.20	4.34	0.01
Mindfulness	0.15	2.95	0.01
Goal orientation	0.26	5.52	0.01
Metacognitive awareness	0.12	2.47	0.05
Direct effects of self-efficacy on:			
Mindfulness	0.21	2.73	0.01
Direct effects of goal orientation on:			
Metacognitive awareness	0.12	2.49	0.05

Table 3 presents the direct effects from the path model. All hypothesised direct paths were statistically significant ($p \leq 0.05$), supporting the proposed structure linking the exogenous variables to the mediators and (for selected paths) to metacognitive awareness.

Metacognitive beliefs had significant direct effects on self-efficacy ($\beta = 0.34$, $p = 0.01$), goal orientation ($\beta = 0.28$, $p = 0.01$), mindfulness ($\beta = 0.12$, $p = 0.05$), and metacognitive awareness ($\beta = 0.12$, $p = 0.05$). The strongest pathway in this block was from metacognitive beliefs to self-efficacy.

Cognitive emotion regulation showed significant direct effects on mindfulness ($\beta = 0.16$, $p = 0.01$), self-efficacy ($\beta = 0.15$, $p = 0.01$), goal orientation ($\beta = 0.15$, $p = 0.01$), and metacognitive awareness ($\beta = 0.11$, $p = 0.05$). This suggests emotion-regulation strategies contributed both to motivational/attentional mediators and, to a smaller extent, directly to metacognitive awareness.

Need for cognition had significant direct effects on goal orientation (β = 0.26, p = 0.01), self-efficacy (β = 0.20, p = 0.01), mindfulness (β = 0.15, p = 0.01), and metacognitive awareness (β = 0.12, p = 0.05). The strongest association was with goal orientation.

Finally, direct effects were also observed among mediators: self-efficacy positively predicted mindfulness (β = 0.21, p = 0.01), and goal orientation positively predicted metacognitive awareness (β = 0.12, p = 0.05), consistent with the proposed mediational chains.

Indirect Effects

Table 4. Estimates of indirect effect coefficients

Variables	β	t	P value
Indirect effects of metacognitive beliefs on:			
Self-efficacy	0.03	2.30	0.05
Mindfulness	0.08	3.41	0.01
Metacognitive awareness	0.12	4.50	0.01
Indirect effects of cognitive emotion regulation on:			
Self-efficacy	0.02	2.30	0.05
Mindfulness	0.04	2.68	0.01
Metacognitive awareness	0.08	4.12	0.01
Indirect effects of need for cognition on:			
Self-efficacy	0.03	2.27	0.05
Mindfulness	0.05	3.02	0.01
Metacognitive awareness	0.10	4.45	0.01
Indirect effects of goal orientation on:			
Metacognitive awareness	0.02	1.93	0.055
Indirect effects of self-efficacy on:			
Metacognitive awareness	0.04	2.83	0.01

Table 4 reports statistically significant indirect effects for the three exogenous variables through the mediating structure.

Metacognitive beliefs showed indirect effects on self-efficacy (β = 0.03, p = 0.05), mindfulness (β = 0.08, p = 0.01), and metacognitive awareness (β = 0.12, p = 0.01), indicating that part of their influence on the outcome operated through the mediators.

Cognitive emotion regulation also demonstrated indirect effects on self-efficacy (β = 0.02, p = 0.05), mindfulness (β = 0.04, p = 0.01), and metacognitive awareness (β = 0.08, p = 0.01).

Need for cognition had indirect effects on self-efficacy (β = 0.03, p = 0.05), mindfulness (β = 0.05, p = 0.01), and metacognitive awareness (β = 0.10, p = 0.01), suggesting its association with metacognitive awareness was partly transmitted through stronger self-efficacy and mindfulness.

In addition, self-efficacy had a significant indirect effect on metacognitive awareness (β = 0.04, p = 0.01). By contrast, the indirect effect of goal orientation on metacognitive awareness was small (β = 0.02) and did not reach a conventional significance threshold (t = 1.93).

The model explained meaningful variance in key variables. Specifically, predictors jointly explained 30% of the variance in academic self-efficacy (R^2 = 0.30), 18% in mindfulness (R^2 = 0.18), and 22% in goal orientation (R^2 = 0.22). The full model accounted for 27% of the variance in metacognitive awareness (R^2 = 0.27).

Model Fit Evaluation

Table 5. Model goodness-of-fit indices

Variables	Indices
Chi-square to degrees of freedom ratio (χ^2/df)	0.64
Comparative Fit Index (CFI)	0.99
Goodness-of-Fit Index (GFI)	0.98
Adjusted Goodness-of-Fit Index (AGFI)	0.99
Root Mean Square Error of Approximation (RMSEA)	0.009

Table 5 indicates that the hypothesised path model fit the data extremely well in the medical sciences sample. The chi-square to degrees of freedom ratio was low (χ^2/df = 0.64). Incremental and absolute fit indices were at recommended levels (CFI = 0.99, GFI = 0.98, AGFI = 0.99), and RMSEA was very small (RMSEA = 0.009), indicating a close fit to the population covariance matrix.

Discussion

In this medical sciences student sample, the proposed model suggests that metacognitive awareness is meaningfully embedded in the realities of health professions education, where learners must continuously plan, monitor, and evaluate their thinking while working under time pressure, high cognitive load, and uncertainty in clinical problem solving. Such environments demand not only domain knowledge but also the ability to regulate attention, emotion, and effort to maintain diagnostic accuracy and safe decision making. Evidence from medical education scholarship consistently frames self-regulated learning in clinical contexts as a dynamic interaction between learner agency and workplace demands (e.g., supervision, patient care, limited time), highlighting why metacognitive monitoring is especially consequential for medical trainees [48–50].

The positive paths from need for cognition to the mediators (and its direct association with metacognitive awareness) are theoretically coherent in medical training. Medical curricula require sustained engagement with complex cases, repeated retrieval and integration of biomedical knowledge, and iterative hypothesis testing—tasks that naturally reward students who enjoy effortful thinking. Consistent with this logic, evidence in health professions contexts links need for cognition with how clinicians tolerate ambiguity and uncertainty and how they experience stress under demanding cognitive conditions, supporting the interpretation that cognitively engaged learners are more likely to invest in reflective monitoring of their reasoning and learning strategies [51].

The observed role of goal orientation as a mediator is also consistent with how motivation operates in evaluation-rich medical training environments. In clinical learning, goal orientations can shape whether students approach workplace learning as mastery-focused improvement (seeking feedback, deliberate practice) versus performance-focused impression management, a distinction that becomes salient when assessment is frequent, social, and high stakes. Empirical work in clerkship settings documents meaningful differences in goal orientations across clinical training structures, and mixed-methods evidence connects students' feedback-seeking behaviors to goal orientation patterns—together supporting goal orientation as a plausible mechanism through which broader learner dispositions translate into metacognitive engagement [52, 53].

The findings supporting self-efficacy as a regulatory driver fit well with medical education contexts in which learners repeatedly face threshold tasks (e.g., procedural skills, early clinical reasoning, OSCE-type performance). In such settings, confidence judgments influence whether learners initiate action, persist after setbacks, and deploy strategies actively rather than disengaging. Structural modeling research in medical students indicates that academic self-efficacy relates to metacognitive strategy use and achievement-related processes, and recent evidence suggests that students' engagement with reflection can meaningfully connect to clinical-skill self-efficacy (positively or negatively depending on how reflection is experienced) [31, 54].

The contribution of mindfulness is also interpretable through medical training demands: mindfulness may help students stabilize attention under pressure and reduce reactivity to stressors, thereby improving the "signal" available for metacognitive monitoring (e.g., noticing uncertainty, detecting

strategy mismatch, and adjusting effort). A recent systematic review and meta-analysis indicates that mindfulness interventions can reduce stress in medical students, which is educationally relevant because reduced distress and better attentional stability can indirectly support reflective monitoring and learning regulation in demanding curricula [55].

The positive effects involving emotion regulation align strongly with what is known about emotionally challenging experiences in medical education. Medical students report memorable incidents that elicit intense negative emotions and use diverse emotion regulation strategies—sometimes adaptive, sometimes avoidant or ineffective—which can shape how much cognitive capacity remains available for monitoring and control during learning. Recent work with medical students also shows that achievement emotions in online learning relate to self-regulated learning and burnout, reinforcing the idea that emotion-related processes are not peripheral but structurally intertwined with regulatory learning behaviors in contemporary medical education. Emotionally challenging workplace experiences may also influence professional identity formation, making it even more important to understand how emotional demands interface with learning regulation and metacognitive functioning [29, 56, 57].

Finally, the associations involving metacognitive beliefs can be understood through the broader claim—well established in clinical reasoning scholarship—that making thinking visible (monitoring, evaluating, and adjusting reasoning) is central to diagnostic performance. Work in Medical Education Online, for example, explicitly maps metacognitive and regulatory dimensions of diagnostic problem solving, reinforcing the view that beliefs about thinking and cognitive control can plausibly shape how actively learners monitor and manage their reasoning while solving clinical problems. Related educational work argues that clinical reasoning can be strengthened when educators make learners' thinking processes explicit and coach metacognitive reflection in authentic tasks, which supports the educational relevance of pathways that culminate in metacognitive awareness [21, 58].

Implications for medical education practice

Taken together, these findings suggest that strengthening metacognitive awareness in medical sciences students is likely to require multi-component educational design rather than isolated training. In practical terms, curricula may benefit from (a) structured opportunities for metacognitive reflection embedded in clinical learning, (b) feedback and coaching practices that explicitly target self-monitoring and strategy selection, and (c) learning environments that normalize uncertainty and support adaptive emotion regulation during evaluation-rich activities (e.g., OSCE preparation, simulation debriefing, workplace-based assessment). This is consistent with evidence that self-regulated learning in clinical environments is shaped by contextual and social factors such as supervision and feedback practices [48–50].

This interpretation does not depend on institutional comparisons; it follows directly from what makes medical sciences education distinctive: learning is deeply tied to workplace participation, performance assessment, and high-stakes reasoning under uncertainty, conditions known to intensify the need for regulation of cognition, motivation, and emotion. The strong model fit is therefore not merely statistical;

it is educationally meaningful because it maps onto mechanisms through which medical trainees learn and perform in complex environments where failures of monitoring and regulation can have academic and clinical consequences [49, 51].

Conclusion

This study tested a hypothesised pathway model in medical sciences students and found that metacognitive awareness can be meaningfully explained through a combined set of cognitive–motivational and regulatory factors operating via goal orientation, mindfulness, and self-efficacy. The model demonstrated excellent fit to the data and accounted for a substantial proportion of variance in metacognitive awareness, indicating that students' metacognitive awareness is not an isolated trait but is closely connected to how they regulate emotions, engage in effortful thinking, and evaluate their own cognitive processes in demanding learning conditions.

Overall, the findings support the view that strengthening metacognitive awareness in medical sciences education is likely to require attention to both upstream dispositions (need for cognition, cognitive emotion regulation, metacognitive beliefs) and the proximal mechanisms that translate these into metacognitive functioning (goal orientation, mindfulness, self-efficacy). Because the design was cross-sectional and relied on self-report measures, future work should replicate the model in other medical sciences cohorts and use longitudinal or intervention designs to clarify directionality and strengthen causal inference.

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Declarations

Ethics approval and consent to participate

This study involving human participants was reviewed and approved by the Research Ethics Committees of Payame Noor University (Approval ID: IR.PNU.REC.1400.005; approval date: 13 April 2021). The study was conducted in accordance with the principles of the Declaration of Helsinki and its later amendments. Electronic informed consent was obtained from all participants before data collection. Participants reviewed an online information sheet and indicated their consent electronically before accessing the questionnaire. Participation was voluntary and anonymous, and participants could discontinue at any time without penalty.

Consent for publication

Not applicable. This manuscript does not contain any individual person's identifiable data, images, or videos.

Clinical trial number

Not applicable. This study was not a clinical trial.

Availability of data and materials

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

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

M.H.S. contributed to the study conception, supervision, and critical revision of the manuscript. M.H.A.H. contributed to conceptualisation, literature review, drafting, and revision of the manuscript. F.R. contributed to methodology, data interpretation, and critical revision of the manuscript. All authors read and approved the final manuscript.

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Figures

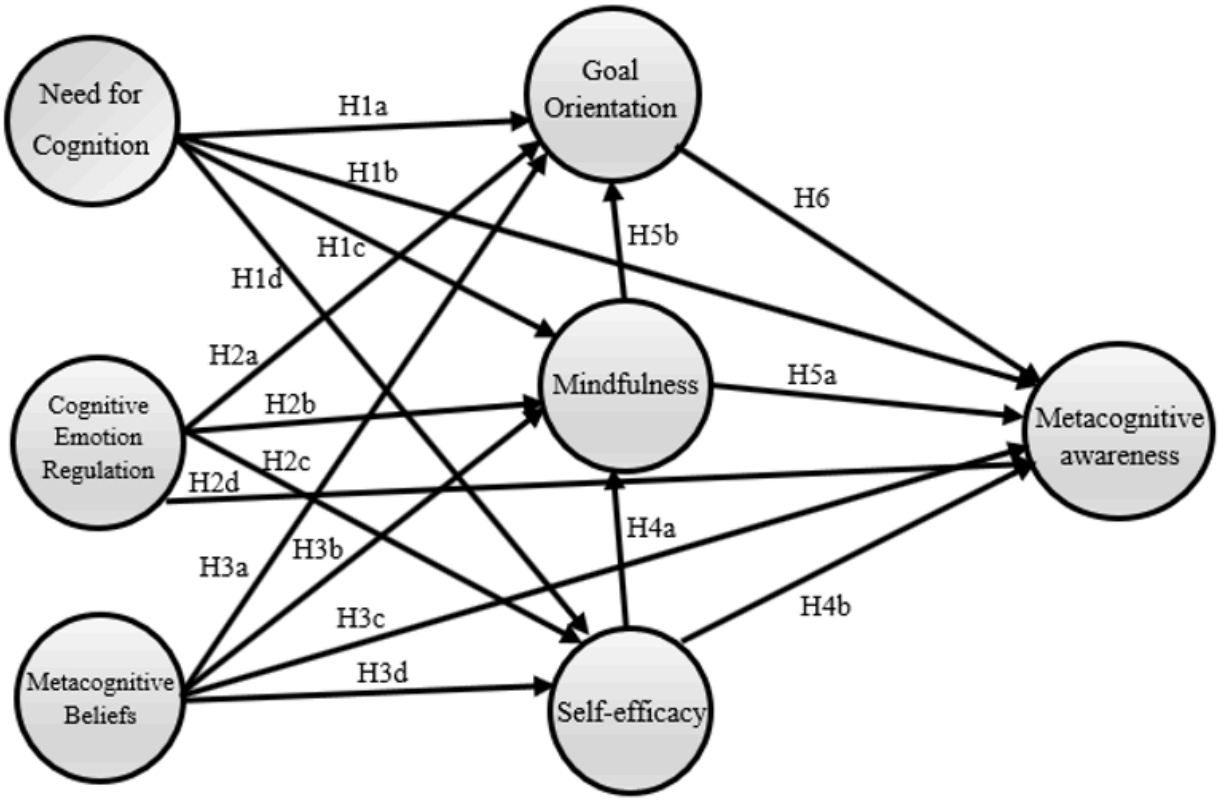


Figure 1

Conceptual visualization of the model.