ORIGINAL ARTICLE
Volume 15 Issue 4 2023
DOI: 10.21315/eimj2023.15.4.4
ARTICLE INFO
Received: 11-09-2022
Accepted: 19-03-2023
Online: 29-12-2023

Metacognitive Awareness and Its Relation to Students' Academic Achievement: Time to Ponder Its Implication in Delivery of Curriculum

Shahid Hassan[1], Sunil Pazhayanur Venkateswaran[2], Puneet Agarwal[1], Abdul Rasyid Sulaiman[3], Ismail Abdul Sattar Burud[1]

[1]*Department of Surgery, School of Medicine, International Medical University, Kuala Lumpur, MALAYSIA*

[2]*Department of Pathology, School of Medicine, International Medical University, Kuala Lumpur, MALAYSIA*

[3]*Department of Psychiatry, School of Medicine, International Medical University, Kuala Lumpur, MALAYSIA*

To cite this article: Hassan S, Venkateswaran SP, Agarwal P, Sulaiman AR, Burud IAS. Metacognitive awareness and its relation to students' academic achievement: time to ponder its implication in delivery of curriculum. Education in Medicine Journal. 2023;15(4):53–65. https://doi.org/10.21315/eimj2023.15.4.4

To link to this article: https://doi.org/10.21315/eimj2023.15.4.4

ABSTRACT

Metacognition skills enable learners to understand and monitor their cognitive processes. The categories described under metacognition are knowledge/regulation of cognition. Metacognitive skills are necessary in curriculum delivery. Students with metacognitive skills are expected to perform better and evidence recommends metacognition be taught in curriculum. The metacognition awareness inventory (MAI) score was collected for knowledge of cognitive factor (KCF) and regulation of cognitive factor (RCF). Knowledge monitoring accuracy (KMA) was also calculated as the difference between students' examination estimated score (SEES) versus actual knowledge on tests. Pearson's correlation coefficient was used to analyse MAI, academic achievement and SEES at the end of semester assessment (EOSA) written/clinical (EOSAW/EOSAC) test. A negative correlation was found between MAI and EOSAW (–0.029) and MAI and EOSAC (–0.187), while a high correlation between MAI and KCF (0.808) and MAI and RCF (0.920) was found ($p < 0.001$). The correlation between KCF and RCF was moderately high (0.559, $p < 0.001$). A negative correlation was also found between KMA and EOSAW (–0.392). The correlation of EOSA achievement scores and KCF and RCF was also negative at –0.002 and –0.100, respectively. A mixed insignificant ($p > 0.05$) correlation was noted among MAI, KMA and SEES for individual instruments. A poor correlation between metacognitive skills and achievement scores indicates students' unrealistic self-evaluation of cognition for knowledge and regulation.

Keywords: *Metacognition, Metacognition awareness, Medical students, Medical education, Self-regulation*

CORRESPONDING AUTHOR

Abdul Rasyid Sulaiman, School of Medicine, International Medical University, Jalan Jalil Perkasa 19, 57000 Kuala Lumpur, Malaysia

Email: abdul_rasyid@imu.edu.my

INTRODUCTION

In self-regulated learning (SRL) theory, metacognition refers to 'skills that enable learners to understand and monitor their cognitive process'. For successful learner reflection, feedback and awareness of their own learning process are essential to take control of one's learning. Reflective aspects of metacognition promote the self-efficiency of students' critical thinking and problem-solving skills. This awareness is referred to as metacognition and is of great importance in an educational context. The effects of self-efficacy beliefs on the cognitive process take a range of forms and much of human behaviour and setting of goals are influenced by self-appraisal capacity (1). Self-efficacy is a personal judgment of one's capabilities to perform a particular task successfully (2). For metacognitively aware students, the supervisor is a facilitator rather than a subject expert teacher and his job is to ensure analytic reasoning and problem-solving skills among the learners.

Metacognition is the ability to reflect upon, understand and control one's learning (3). Two categories of metacognition were described: knowledge of cognition and regulation of cognition (4–6). It can further be defined as what we know about our cognitive processes and how we use these processes to learn and remember (7). Our knowledge of cognition refers to what we know about how we learn, the procedures and strategies that are most effective for us and the conditions under which various cognitive activities are most effective (8). Planning involves setting out a cognitive task by identifying appropriate strategies and resources. Monitoring looks at progress through a cognitive task and our ability to determine our performance. Subsequently, evaluation involves looking at learning outcomes and matching those learning outcomes with the programme learning outcomes so that the regulation processes are effectively used (8).

Knowledge of cognition is the reflective aspect of learning: what students know about themselves, strategies and conditions under which strategies are most useful. Knowledge of cognition is further distinguished into three domains of declarative, procedural and conditional knowledge, together considered as the building blocks of conceptual knowledge. Declarative knowledge is about self and strategies, procedural knowledge is about how to use strategies and conditional knowledge is about where and why to use strategies. Regulation of cognition is the control aspect of learning: the way students plan and implement their strategies, as well as monitor and evaluate their learning. Regulation of cognition, like knowledge of cognition, is also broadly sub-grouped into planning, monitoring and evaluation aspects (9, 10). A strong correlation between knowledge and the regulation of cognition factors suggests that knowledge and regulation complement each other to help students become self-regulated learners to achieve competency.

In curriculum delivery with student-centred learning, the onus of accountability is on the students, and it is imperative to teach metacognitive skills in the classroom. The process can start with the metacognitive awareness inventory score in different domains of cognition to discuss the purpose and importance of a strategy taught in a classroom setting. Once the strategy is set for any given condition, the same strategy can be generalised to a new situation, taking the knowledge of the cognitive domain from declarative to procedural and to another level of conditional knowledge. Students can learn from this discussion to know their status of regulation of cognition in terms of planning, mentoring and evaluation to improve their management of information and skills to become competent learners.

Metacognition in teaching and learning supports the acquisition, comprehension, retention and application of what is learned. Good metacognitive skills support students in taking responsibility for their own learning to develop scientific concepts appropriately. The literature supports the idea that metacognitively aware learners set learning strategies more effectively and perform better than unaware learners (11, 12). It allows individuals to plan, monitor and evaluate their learning to improve their performance. There are two components of metacognition: knowledge and the regulation of cognition.

Cognition is often used synonymously with metacognition; the two differ in the sense that cognitive skills are about performing a task, whereas metacognitive skills are about understanding how it is performed. Successful adult learners employ a range of metacognitive skills from knowledge of cognition to regulation of cognition. Knowledge of cognition includes declarative, procedural and conditional knowledge as building blocks of a conceptual map. Regulation of cognition corresponds to knowledge about the way students plan to implement strategies, monitor to correct comprehension errors and evaluate the progress of their learning. A strong correlation between these factors is likely to help students become self-regulated learners. However, studies suggest strong correlations between achievement scores and regulation of cognition but not between achievement scores and knowledge of cognition (13).

Metacognition is a long-lasting developmental process that can be used at the right time and in the right place to promote students' academic achievement. Researchers have emphasised the importance of metacognition skills in students' learning (14). It is highly important that students control their attention, motivation, learning environment and progress in training. Researchers have also shown that metacognition skills increase with age and that its different elements have different frames (15–17). Students in the current study were exposed to a series of activities to enable them to ultimately develop their own strategies and were provided with a framework to become aware of metacognition and its importance in the learning process. Developing and practicing metacognition skills prior to one's engagement in learning experiences enhances the outcome of learning.

Students with well-developed metacognitive skills are expected to perform better than those without metacognition being involved in learning and teaching. Evidence can be provided by studying the correlation coefficient values of metacognition awareness inventory (MAI) scores with those of individual assessment tools and broad-based assessment achievement scores. Metacognition is measured as a metacognition awareness score as well as metacognitive knowledge and metacognitive regulation factors. To measure these scores, some researchers use self-administered inventories and correlate them to students' performance as their academic achievement score (3, 18). Other researchers have measured metacognitive skills as knowledge monitoring accuracy (KMA) ability as calibration performance at local or global judgment levels. The measurement of local judgment is determined at the item level as the difference between the actual score of items (questions) on each test and the estimated score and how well a student performed on that item. Global judgment is determined after the entire test is completed and KMA is determined as the accumulative difference between actual score and how well the students think they have performed in that test. Local KMA is thought to be a measure of ongoing metacognitive regulation during testing and global KMA is a measure of cumulative metacognitive regulation (19).

Metacognition skills play a pivotal role in a student-centred approach in which students are empowered to regulate their self-learning. How effectively this approach is implemented to achieve its outcome in many centres where it is practiced is not clear. However, students' engagement in teaching and the promotion of self-assessment and self-sufficient approaches improve learning and knowledge retention

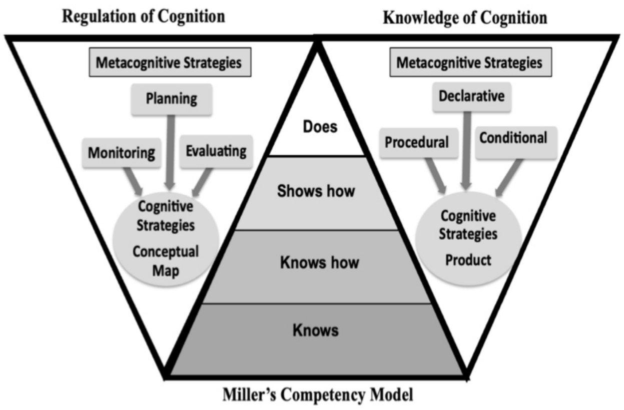

Figure 1: Metacognition as knowledge of cognition and regulation of cognition aligned with Miller's competency model.
Source: Adapted from Corbetta et al. (20)

among the learners. This concept adds a new dimension to Miller's model of competency-based learning and this very concept brings metacognition into learning (Figure 1). Changes in curriculum design to acquire competency require students to develop metacognitive skills for critical judgments with analytic reasoning and independent problem solving. For good learning practice, metacognitive skills are necessary to understand the learning process and to accomplish successful curriculum delivery. The role of metacognitive skills in relation to academic achievement is discussed in keeping with the implications of future curriculum practice.

The specific objective of this study was to create awareness and measure metacognition skills in terms of MAI scores and to examine their impact on students' achievement scores in the clinical phase of the Bachelor of Medicine and Bachelor of Surgery (MBBS) programme at the International Medical University.

METHODOLOGY

This was a quantitative experimental (randomised control) cohort study to investigate the students' metacognition scores and their impact on the assessment scores before and after metacognitive intervention among the students of the MBBS programme at a private medical institution. Students as subjects for the current study were surveyed twice after duly provided with a student information sheet and written consent form for their informed decisions. The data were collected from 84 students in years three and four of the clinical phase. However, two students did not complete the inventory and were excluded from the study.

A randomised sample of the students was assigned to the control and study groups, respectively. The sample size for the current study was calculated using the sample size for Pearson's correlation table. In keeping with the commonly reported correlation coefficient range from 0.23 to 0.73, as suggested in the literature, $r = 0.3$ was decided for this study as the acceptable correlation coefficient towards the minimal side of the range at the 95% confidence level, with the alpha set at 0.05 (two tailed) and the power of study ($1-\beta$) set at 0.8. The sample size was ultimately calculated as 84 subjects. A computer-selected random number method to generate a sequence that did not have any pattern was used to allocate the students' participation in the control and study groups. Forty-two students were allocated to the control and study groups, respectively. All those who consented to participate were included in the study.

The MAI, designed by Schraw and Dennison, is a widely used and established inventory (3). The MAI was used in the present study to determine awareness of metacognitive skills among preclinical students in a private medical school in Malaysia. The MAI is a frequently used self-report instrument to measure metacognition. The MAI was developed specifically to address the two theoretical components (or dimensions) of metacognition: knowledge of cognition (17 items) and regulation of cognition (35 items). A dichotomous version of 'yes' or 'no' of the MAI was used in the current study. The score was collected to measure students' metacognitive skills (total MAI score) transferred to a numeric score from the categorical data collected as yes = 1 and no = 0. The first data collection was done at semester six (year three) and second at semester seven (year four) of their training. As it was in the same language (English), the MAI was administered and no changes in items and the scoring rubric were made and the revalidation of a published questionnaire was not undertaken. Another survey on students' examination estimated score (SEES) on their performance in examinations was collected using online feedback as to what score (percentage) they expected to achieve in their respective written and clinical examinations. The feedback proforma named SEES was provided as a hard copy to complete immediately upon leaving the examination hall after their respective assessments of written and clinical tests on different dates.

Using an established theory (4–6), Schraw and Dennison (1994) created these two subscales from a larger pool of items they developed to measure the subcomponents theorised to constitute each, with the knowledge dimension including items addressing declarative, procedural and conditional knowledge, and the regulation dimension including items addressing planning, information management strategies, monitoring, debugging strategies and evaluation (3).

The MAI score was collected as a reflection of students' metacognitive skills in terms of declarative, procedural and conditional knowledge, as well as planning, monitoring and evaluation. The purpose of this study was to examine the relationship between metacognitive skills of years three and four students recorded as MAI scores and broad-based measurement of academic achievement as end of semester assessment (EOSA) scores. Another purpose of the MAI score was to collect baseline data to follow the students' progressive learning curve through the clinical years of semester seven of the MBBS programme in the International Medical University.

Another purpose of this study was exploratory in nature, to determine the metacognitive skills in terms of the statistical relationship between metacognitive skills as knowledge of cognitive factor (KCF) represented with 17 items and regulation of cognitive factor (RCF) represented with 35 items. KCF was further divided into three categories: declarative knowledge with eight items, procedural knowledge with four items and conditional knowledge with five items. RCF, on the other hand, was further divided into five categories in the original MAI; the authors accounted for RCF for the three categories of planning, monitoring and evaluation only. Thus, we considered 37 items for KCF and RCF out of a total of 52 items for the MAI. KMA was also calculated as the difference between students' estimated vs. actual knowledge on tests. The MAI score was analysed using the Pearson correlation coefficient with academic achievement in the EOSA for different assessment instruments of written tests (One Best Answer [OBA] and Extended Matching Question [EMQ]) and clinical tests (Objective Structured Clinical Examination [OSCE]).

Data collection was done by administering the MAI and SEES twice, once during year three (semester six) and secondly during year four (semester seven) of the programme. Both were self-administered to the students. However, an intervention followed, and the data were collected in semester six. The metacognition interventional strategy for the study group only during the early phase of semester seven was carried out, comprising plenaries and in-depth discussions for students to develop insight into what metacognition concerns and how it may help students enhance their learning skills for longer retention. The plenaries comprised of lectures on different aspects from definition to usability in learning were sent out for their asynchronous study, followed by discussion in a flipped classroom session.

The MAI and KCF scores were analysed using the Pearson correlation coefficient with academic achievement scores in EOSA before and after the intervention, based on the exclusive interventional strategy in metacognition for the study group. The MAI score was also compared with metacognitive skills such as KCF and RCF using the Pearson correlation coefficient.

RESULTS

For the 84 respondents, the mean (+/– standard deviation [SD]) MAI score was 39.07 (6.68). The mean (SD) scores for KCF, RCF and KMA were 11.52 (2.92), 27.41 (4.95), and 24.13 (14.24), respectively (Table 1). A poor correlation was observed between MAI and KMA (0.134, p = 0.223); however, a highly significant correlation between MAI and KFC (0.808, p = <0.001) and MAI and RFC (0.920, p = <0.001), respectively, was found. The trend continued to be a poor correlation between KMA and KCF (0.178 [0.106]) and between KMA and RCF (0.109 [0.323]); however, the correlation was positive (Table 2).

A negative correlation between MAI and EOSA written (EOSAW) and clinical (EOSAC) was –0.029 (796) and –0.187 (0.088), respectively. A similarly negative correlation between MAI and SEES total (SEST) was –0.006 (0.958). A positive but poor correlation between MAI and SEES in written exam (SESW) was 0.007 (952). However, the SEES for clinical exam (SESC) remained negative (–0.033 [0.765]) (Table 3).

A similar poor correlation between MAI and individual assessment tools was observed for OBA (–0.063 [0.571]), EMQ (0.003 [0.987]) and OSCE (–0.187 [0.088]) (Table 4).

A negative correlation persisted between KMA and EOSAW and EOSAC scores of –0.099 (0.369) and –0.044 (0.689), respectively (see Table 3). The correlation between SEES for the EOSAW test was positive (0.007 [0.952]) and negative for the EOSAC test (–0.033 [0.765]). A similarly negative correlation between KMA and individual assessment tools of OBA, EMQ and OSCE was 0.092 (0.403), 0.089 (0.418) and –0.044 (0.689), respectively, in all three individual assessment tools (Table 4). The trend continued to be negative for SEES and all three individual instruments of OBA (–0.165 [0.134]), EMQ (–0.242 [0.027]) and OSCE (–0.024 [9.831]) (Table 4).

A positive, though poor, correlation was found between the KCF and EOSW tests (0.037 [0.736]). However, the correlation between the KCF and EOSC tests remained negative (–0.117 [0.290]). On the other hand, the correlations between the RCF and EOSW (–0.060 [0.590]) and EOSC (–0.189 [0.085]) tests were negative (Table 3). Looking at the KCF and individual tests, the scores were poor, however, it was positive for OBA (0.023 [0.835]) and EMQ (0.043 [0.698]), and negative for OSCE (–0.021 [0.849]). For RCF, correlations between OBA (–0.099 [0.370]) and EMQ (–0.019 [0.864]) remained negative as an overall trend. The same trend was further observed with a positive, but a poor correlation between KCF and SEES OBA (0.060 [0.588]) and negative for SEES EMQ (–0.021 [0.849]) and SEES OSCE (–0.055 [0.618]) (Table 4).

Table 1: Descriptive statistics (mean and SD) of MAI, KMA, KCF and RCF score

Variable	Mean	SD
MAI total score	39.07	6.68
KMA total score (written and clinical)	24.13	14.24
KCF	11.92	2.92
RCF	27.41	4.95

Table 2: Correlation between MAI, KMA, KFC and RCF scores (N = 84)

Variable	MAI score (*p*)	KMA score (*p*)	KCF (*p*)	RCF (*p*)
MAI	1	0.134 (0.223)	0.808 (<0.001)	0.920 (<0.001)
KMA	0.134 (0.223)	1	0.178 (0.106)	0.109 (0.323)
KCF	0.808 (<0.001)	0.178 (0.106)	1	0.559 (<0.001)
RCF	0.920 (<0.001)	0.109 (0.323)	0.559 (<0.001)	1

Table 3: Correlation between MAI, KMA, KCF and RCF scores and SESW and SESC (N = 84)

Variable	EOSW score (*p*)	EOSC score (*p*)	EOS total score (*p*)	SESW (*p*)	SESC (*p*)	SEST (*p*)
MAI	0.099 (0.369)	−0.044 (0.689)	−0.074 (0.501)	0.007 (0.952)	−0.033 (0.765)	−0.006 (0.958)
KMA	−0.392 (<0.001)	−0.234 (0.032)	−0.068 (0.537)	−0.235 (0.031)	−0.024 (0.831)	−0.194 (0.077)
KCF	0.037 (0.736)	0.117 (0.290)	−0.002 (0.988)	0.018 (0.869)	−0.055 (0.618)	0.004 (0.971)
RCF	−0.060 (0.590)	0.189 (0.085)	−0.001 (0.366)	−0.015 (0.894)	−0.046 (0.677)	−0.027 (0.807)

Table 4: Correlation between MAI, KMA and KCF and RCF score and the individual assessment tool achievement and estimated scores (N = 84)

Variable	OBA (*p*)	EMQ (*p*)	OSCE (*p*)	SEES OBA (*p*)	SEES EMQ (*p*)	SEES OSCE (*p*)
MAI	−0.063 (0.571)	0.003 (0.978)	0.187 (0.110)	0.015 (0.893)	−0.002 (0.987)	−0.033 (0.765)
KMA	0.092 (0.403)	0.089 (0.418)	−0.044 (0.689)	−0.165 (0.134)	−0.242 (0.027)	−0.024 (0.831)
KCF	0.023 (0.812)	0.043 (0.131)	−0.117 (0.290)	0.060 (0.588)	−0.021 (0.849)	−0.055 (0.618)
RCF	0.003 (0.979)	0.050 (0.711)	0.189 (0.085)	−0.189 (0.946)	0.017 (0.874)	−0.046 (0.677)

DISCUSSION

The SRL theory defines learning as a metacognitively guided process (21, 22). It has been demonstrated that higher levels of SRL are associated with higher academic achievement and greater success in learning clinical skills (23). However, few studies have focused on the relationships among the components of SRL in medical students (24). Knowledge of cognition relates to what students know about their thinking, the strategies and the context under which strategies are most useful. Regulation of cognition relates to knowledge about how students plan, implement and evaluate their learning through reflective practice. Both these categories of metacognition of knowledge and regulation work in integration to enhance students' metacognitive skills that support their clinical learning (3).

The current study intended to explore MAI and its relationship to a single and broad measure achievement score of students and their performance in their EOSA. Metacognition is considered an extended and important component of a structured learning model, from the acquisition of knowledge to the application of knowledge. Metacognition is imperative to successful learning, which requires individuals to reflect on their existing cognitive skills, along with their strengths and weaknesses and to apply corrective measures by constructing new cognitive skills. Honest and realistic self-assessment is recognised as an important contributor to the development of critical capacity, reflective attitude and autonomous lifelong learning (14). Some studies (3, 12) have shown significant correlations between a broad measure achievement score and MAI, as well as achievement score and knowledge of cognition and regulation of cognition. Yet, some other studies (16) suggest good correlations between achievement scores and regulation of cognition, but not between achievement scores and knowledge of cognition. The present study, on the contrary, has shown good correlation between MAI, knowledge of cognition, and regulation of cognition, but poor correlation with achievement scores (Tables 2–4). A correlation was shown between MAI, knowledge of cognition and regulation of cognition factors, which were the only significantly positive correlations in the current study (Table 2), suggesting the validity of the metacognitive inventory items for its overall score versus KCF and RCF components. Most studies have compared MAI score correlation with achievement scores, but none have shown data that compares students' self-administered examination estimated score to compare their perceived score after having taken up the examination with their MAI score. This makes the present study unique in providing evidence of their poor perceptions of metacognition. We found that students with high achievement SEES scores both in written and clinical tests presented lower scores on both MAI domains (knowledge of cognition and regulation of knowledge) and this showed a poor correlation with student's estimated score measured as SEES both in written and clinical tests.

The poor correlation between the students' perceptions of metacognitive skills and their expected achievement scores is a challenge for faculty and students to effectively understand teaching, learning and assessment in curriculum delivery. This demands that metacognition be taught as a generalised skill to enable the students to perceive the curriculum goals and objectives and how they need to set their learning strategies. A mixed pattern of MAI scores documented on metacognition awareness with poor relevance to their performance at the end of summative assessments (Table 3) is an indication to make them aware of what they think about their learning process and what it exists. Introduction to metacognition as a skill to strategise learning must be well understood by the students for all aspects of knowledge of cognition and regulation of cognition. In the present study, the MAI was completed without being well understood for its critical value and the score of each item. Students, while completing the inventory, placed the items on a higher and more positive side of what they were meant to describe. MAI, without being understood for its value, was likely considered to implicate their achievement scores on the tests.

The MAI could be used to begin discussions to help improve experiential learning towards competence-based education. As the first step in practicing metacognition, it is important to acknowledge its existence and its difference from cognition. The promotion of metacognitive awareness among learners may enhance academic achievement or at least realistically estimate their performance to think correctly about their thinking. The next step is to teach strategies to help students construct explicit knowledge about when and where to use them. Finally, a flexible strategy can be used to make careful regulatory decisions that enable students to plan, monitor and evaluate their learning. Poor correlation between MAI and students' achievement scores (Tables 2 and 3) are alarming indicators of necessary corrective measures in the implementation of the curriculum, with explicit teaching sessions in metacognition.

Metacognitive awareness, if appropriately and timely used, can operationalise a complex method of critically thinking and analytically analysing for decision making in clinical practice and teaching by health profession educators to enhance clinical reasoning. Learning the components of metacognitive awareness is essential for both teachers and students in clinical settings. Critical thinkers manage cognitive load more appropriately when they think critically; they evaluate the outcomes of the thought processes needed for problem solving (2).

The poor correlation coefficient between MAI and the student's achievement scores in EOSA and individual assessment tools (Tables 3 and 4) in this study indicate the problems of effective curriculum delivery. The purpose of this study was to examine the relationship between MAI score and EOSA score and a broad measure assessment and individual test scores (Tables 3 and 4). A poor correlation between MAI and EOSA and a negative correlation between MAI and most of the assessment tools, as well as SEES on EOSW and clinical tests of individual assessment, suggest students' unrealistic self-evaluation of their cognition in terms of knowledge and regulation of cognition, the so-called metacognition. The MAI score was also used to analyse the relationship between metacognitive skills and specific measures of assessment tests (Table 4), both in the written knowledge of objective test (OBA and EMQ) and subjective test (OSCE). An insignificant low correlation was found between them. A comparatively better but insignificant correlation (p = <0.05) in terms of MAI and OSCE score may be attributed to the students' proficiency of a limited number of procedures in the skills domain than a more extensive content in the domain of written knowledge. Another purpose of this study was exploratory in nature, to determine the validity of MAI in terms of the statistical relationship between metacognitive skills such as KCF and RCF, which was significantly correlated (Table 2). However, the validity and consistency of items in the MAI were not revalidated using principal component analysis or Cronbach's alpha, as this was beyond the scope of the study. The correlation between metacognitive knowledge and metacognitive regulation in terms of KCF and RCF was found to be highly correlated. Other researchers have shown that metacognitive knowledge may develop independently of the metacognition of regulation (17). The actual test of performance (EOSA) achievement scores on written tests (OBA and EMQ) and clinical tests (OSCE) poorly and often negatively correlated with KCF rather than RCF, which seems not consistent with findings in literature, are due to students' underestimating their metacognitive skills keeping with modesty as the inherited characteristics of their personality.

Calibration of students' performance as KMA was measured as the difference between students' estimated versus actual knowledge on tests. The KMA determines the students' monitoring of their knowledge in terms of the RCF. A poor correlation between the KMA and EOSA assessment scores of OBA and EMQ, though positive, was determined to be negatively correlated and was an unexpected finding (Table 4). This can be attributed to students' lack of confidence about the assessment and testing of higher-order thinking skills.

Another interesting finding in the current study was the correlation between the SEES in the EOSA of individual assessment instruments and the actual achievement scores in these instruments. A poorly correlated SEES in written and clinical scores on individual EOSA tests is an obvious lack of metacognitive skills among the students (Table 5). Some of these negative correlations are quite alarming regarding what students think about their own thinking and how they estimate their performance, even in those undertaken assessment tools immediately after the test. The correlation between MAI and KMA of individual measurement tools shows that MAI is slightly better correlated with test of knowledge than the clinical test of OSCE and the SEES of all individual test instruments. This indicates that students overestimate their metacognitive abilities.

The findings of the present study emphasise the importance of metacognition in learning. Teaching and learning should be delivered in a way that encourages metacognition and has a relevant and effective impact on students' achievement scores. Metacognition plays a significant role in meaningful learning. Therefore, it is imperative to redesign the curriculum and its delivery with an emphasis on developing awareness, enhancement and practice of metacognitive skills among the students to become competent learners. Once they can recognise their metacognitive skills, they may be able to generalise those skills to be applied in different situations encountered in learning, especially during emergency remote teaching, with unprecedented challenges of COVID-19-like pandemics in the future.

Strong metacognition helps students in self-directed learning (SDL) and studies have also confirmed that problem-based learning (PBL) improved SDL skills (25–27). In light of the literature findings, it could be said that PBL achieves the goal of improving the self-directedness of medical students in a learner-centred curriculum with higher metacognition awareness. The authors' experience of metacognition status among the students in the present study is not that encouraging from the PBL perspective, which is the mainstay of teaching and learning strategies adopted in the earlier phase of curriculum delivery; however, the reasons for poor metacognition mentioned in the present study may be the contributing factor.

Table 5: Correlation between KMA individually calculated assessment tools' scores and the corresponding SEES

Variable	OBA score (*p*)	EMQ score (*p*)	OSCE score (*p*)	SEES OBA (*p*)	SEES EMQ (*p*)	SEES OSCE (*p*)
KMA OBA	–0.009 (0.938)	–	–	–0.243 (0.026)	–	–
KMA EMQ	–	0.363 (<0.001)	–	–	–0.632 (<0.001)	–
KMA OSCE	–	–	–0.082 (0.457)	–	–	0.085 (0.439)

Periodic use of metacognitive awareness recorded using the MAI among students is an effective practice and a useful exercise that may help faculty involved in teaching and learning and assessment adopt appropriate interventional strategies to create awareness and enhance students' metacognition, with a positive impact on their academic performance. Metacognitive awareness can be enhanced by innovative teaching methods such as team-based learning (TBL), case-based learning (CBL), flipped classrooms and SDL, where students can be taught to reflect on their thinking (23, 24). However, metacognition's poor awareness score in undergraduate training, as in the present study, is alarming and may be attributed to faculty and students' lack of knowledge about metacognition and its measurement among students. This, in turn, has also been reflected in students' poor correlation between metacognition and their self-administered estimations of achievement scores. Another possible reason for this poor correlation may be validation issues, as the metacognition instrument (MAI) used in the present study was not revalidated. However, studies conducted by previous authors in the area of MAI validation indicated that it is an authentic tool to assess the metacognitive ability of students in different fields of undergraduate education (28), with high internal consistency and recommendation for usage in the field of education (29–31).

CONCLUSION

Most students with high achievement scores showed an insignificant correlation associated with metacognitive awareness scores on the MAI. After short strategic metacognitive training, both the study and control groups completed another round of the MAI. However, there was little difference between their previous and new MAI scores. The findings of the present study suggest that through repeated guided practice, metacognitive proficiency can improve. For good learning practice, metacognitive skills are necessary to understand the learning process and accomplish tasks in routine teaching and learning activities. The poor correlation between students' perceptions of metacognitive skills is a challenge for the faculty and demands that curriculum delivery incorporate students' awareness of metacognition into their learning process. Metacognition as self-assessment also affects outcome learning as the self-efficiency of students' critical and analytic thinking and problem-solving skills. Also, metacognitive ability can lead students to become more aware of their own thinking and cognition in learning. Good metacognitive skills support students in taking responsibility for their own learning to develop scientific concepts appropriately. Similarly, the difference between students' examination estimated scores and MAI scores showed no significant differences between the study and control groups. This may be attributed to short and random strategic training, which needs to be replaced with well-organised planned training of at least 6–12 weeks' time. Understanding metacognitive awareness may help students during medical training. Thus, with continued metacognitive training, a higher follow-up test scores from the experimental group can be expected.

ACKNOWLEDGEMENTS

The authors would like to thank all the students from the Clinical School, International Medical University who participated in the study. The authors would like to thank the International Medical University for supporting this research through grant 4.20/JCM-173/2018 (Project ID no: IMU 424/2018).

ETHICAL APPROVAL

The research proposal was presented in the 173rd IMU Joint Committee on Research and Ethics on 13th December 2018 and was given full approval with reference No. 4.20/JCM-173/2018 and Project ID no: IMU 424/2018.

REFERENCES

1. Khan AS, Cansever Z, Avsar UZ, Acemoglu H. Perceived self-efficacy and academic performance of medical students at Ataturk University, Turkey. J Coll Physicians Surg Pak. 2013;23(7):495–8.
2. Dijkstra J, Van der Vleuten CPM, Schuwirth LWT. A new framework for designing programmes of assessment. Adv in Health Sci Educ. 2010;15:379–93. https://doi.org/10.1007/s10459-009-9205-z
3. Schraw G, Dennison RS. Assessing metacognitive awareness. Contemp Educ Psychol. 1994;19(4):460–75. https://doi.org/10.1006/ceps.1994.1033
4. Brown AL. Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In: Weinert FE, Kluwe R, editors. Metacognition, motivation and understanding. Hillsdale, NJ: Lawrence Erlbaum Associates; 1987. p. 65–116.
5. Flavell JH. Speculations about the nature and development of metacognition. In: Weinert FE, Kluwe R, editors. Metacognition, motivation and understanding. Hillsdale, NJ: Lawrence Erlbaum Associates; 1987. p. 21–9.
6. Jacobs JE, Paris SG. Children's metacognition about reading: issues in definition, measurement and instruction. Educ Psychol. 1987;22(3–4):255–78. https://doi.org/10.1080/00461520.1987.9653052
7. Ormrod J. Human learning. 4th ed. Upper Saddle River, NJ: Pearson; 2004.
8. Schraw G, Moshman D. Metacognitive theories. Educ Psychol Rev. 1995;7(4):351–71. https://doi.org/10.1007/BF02212307
9. Artz AF, Armour-Thomas E. Development of a cognitive-metacognitive framework for protocol analysis of mathematical problem-solving in small groups. Cogn Instr. 1992;9(2):137–75. https://doi.org/10.1207/s1532690xci0902_3
10. Baker L. Metacognition, comprehension monitoring, and adult reader. Educ Psychol Rev. 1989;1:3–38. https://doi.org/10.1007/BF01326548
11. Garner R, Alexander PA. Metacognition: answered and unanswered questions. Educ Psychol. 1989;24(2):143–58. https://doi.org/10.1207/s15326985ep2402_2
12. Pressley M, Ghatala ES. Self-regulated learning: monitoring learning from text. Educ Psychol. 1990;25(1):19–33. https://doi.org/10.1207/s15326985ep2501_3
13. Young A, Fry JD. Metacognition awareness and academic achievement in college students. J. Scholarsh Teach Learn. 2008;8(2):1–10.
14. Kapa, E. A metacognitive support during the process of problem solving in a computerized environment. Educ Stud Math. 2001;47:317–36. https://doi.org/10.1023/A:1015124013119
15. Cambra-Fierro J, Cambra-Berdun J. Students' self-evaluation and reflection (part 2): an empirical study. Educ Train. 2007;49(2):103–11. https://doi.org/10.1108/00400910710739469
16. McDonald B, Boud D. The impact of self-assessment on achievement: the effects of self-assessment training on performance in external examinations. Assess Educ. 2003;10(2):209–20. https://doi.org/10.1080/0969594032000121289
17. Gregory S. The effect of metacognitive knowledge on local and global monitoring. Contemp Educ Psychol. 1994;19(2):143–54. https://doi.org/10.1006/ceps.1994.1013

18. Sperling RA, Howard BC, Staley R, DuBois N. Metacognition and self-regulated learning constructs. Educ Res Eval. 2004;10(2):117–39. https://doi.org/10.1076/edre.10.2.117.27905

19. Corbetta L, Arru LB, Mereu C, Pasini V, Patelli M. Competence and training in interventional pulmonology. Panminerva Med. 2019;61(3):203–31. https://doi.org/10.23736/S0031-0808.18.03562-0

20. Nietfeld JL, Cao L, Osborne JW. Metacognitive monitoring accuracy and student performance in the postsecondary classroom. J Exp Educ. 2005;74(1):7–28.

21. Winne PH. Inherent details in self-regulated learning. Educ Psychol. 1995;30(4):173–87. https://doi.org/10.1207/s15326985ep3004_2

22. Zimmerman BJ. Self-regulated learning and academic achievement: an overview. Educ Psychol. 1990;25(1):3–17. https://doi.org/10.1207/s15326985ep2501_2

23. Cho KK, Marjadi B, Langendyk V, Hu W. The self-regulated learning of medical students in the clinical environment: a scoping review. BMC Med Educ. 2017;17:112. https://doi.org/10.1186/s12909-017-0956-6

24. Hayat AA, Shateri K, Amini M, Shokrpour N. Relationships between academic self-efficacy, learning-related emotions, and metacognitive learning strategies with academic performance in medical students: A structural equation model. BMC Med Educ. 2020;20:76. https://doi.org/10.1186/s12909-020-01995-9

25. Hmelo C, Gotterer GS, Bransford JD. The cognitive effects of problem-based learning: a preliminary study. Paper presented at the Annual Meeting of the American Educational Research Association; 1994 Apr 4–8; New Orleans, LA.

26. Litzinger T, Wise J, Lee S, Simpson T, Joshi S. Assessing readiness for lifelong learning. Proceedings of the 2001 American Society for Engineering Education Annual Conference & Exposition; 2001 Jun 24–27; Albuquerque, NM. Washington DC: American Society for Engineering Education; 2001. p. 2211–9.

27. Yeung E, Au-Yeung S, Chiu T, Mok N, Lai P. Problem design in problem-based learning: evaluating students' learning and self-directed learning practice. Innov Educ Teach Int. 2003;40(3):237–44. https://doi.org/10.1080/1470329032000103762

28. Abdullah R, Soemantri D. Validation of metacognitive awareness inventory in academic stage of undergraduate medical education. eJournal Kedokt Indones. 2018;6(1):15–23. https://doi.org/10.23886/ejki.6.8621

29. Akın A, Abacı R, Çetin B. The validity and reliability study of the Turkish version of the metacognitive awareness inventory. Educ Sci Theory Pract. 2007;7(2):671–8.

30. Favieri AG. General metacognitive strategies inventory (GMSI) and the metacognitive integrals strategies inventory (MISI). Electron J Res Educ Psychol. 2013;11(31):831–50. https://doi.org/10.14204/ejrep.31.13067

31. Teo T, Lee CB. Assessing the factorial validity of the metacognitive awareness inventory (MAI) in an Asian country: a confirmatory factor analysis. Int J Educ Psychol Assess. 2012;10(2):92–103.