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Original Research Article

The impact of medical students' metacognitive awareness level on their academic performance

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ABSTRACT

Background: Metacognition influences the academic performance of medical students. The objective of our study was to determine the metacognitive awareness level of medical students in different academic groups in physiology course and develop a guideline on that basis to provide academic support.
Methods: A 52-items metacognitive awareness inventory (MAI) devised by Schraw and Dennison was used to assess the metacognition level of low (<70%), average (70-84%), and high performing (>85%) students in a physiology course at Trinity Medical Sciences University (TMSU).
Results: Sixty-four students participated in the study. A significant positive correlation (rs=0.462) was found between the total MAI score and the final score in the physiology course. High performing students reported significantly higher score on declarative knowledge (p=0.001); procedural knowledge (p=0.048); implementation of strategies (p=0.003); correction (p=0.000) and evaluation of effectiveness (p=0.000) subscale than their low performing counterparts. Compared to average performing students, high performers were found significantly superior in terms of declarative knowledge (p=0.006), better planning (p=0.047), monitoring (p=0.008) and evaluation of effectiveness (0.004) of the learning process.
Conclusions: Metacognitive awareness level has a significant impact on the academic performance of medical students in the physiology course. Low performers need to improve both declarative and procedural knowledge while average performers should augment their declarative knowledge. In terms of regulation of cognition, low performers should develop better implementation, correction, and evaluation skills while average performers should make better planning other than improving their monitoring and evaluating skills.

Keywords: Conditional, Declarative, Metacognition, Procedural

INTRODUCTION

There are several factors that influence the students' academic performance in a medical school. One of those is the students' awareness of their own knowledge and ability to understand, control and manipulate their cognitive processes, which is called metacognition.[1] Metacognition is essential to successful learning because it enables individuals to better manage their cognitive skills and to determine weaknesses that can be corrected by constructing new cognitive skills.

Two major components of metacognition are: (1) knowledge of cognition (2) regulation of cognition. Knowledge of cognition corresponds to what students know about themselves (declarative knowledge), their strategies (procedural knowledge) and learning conditions in which the strategies are most useful (conditional knowledge). Regulation of cognition corresponds to awareness about the planning, implementation, monitoring, correcting the error and evaluating the overall learning process.

Metacognitively aware learners are more effective learners, show higher performance levels, use more strategies, and better regulate their own learning.[2] Students who use effective metacognitive learning strategies have better study plans; can efficiently monitor and evaluate their learning and perception of the materials and are more accountable to find and solve their problems, and try hard to learn deeply.[3,4] They certainly succeed more than their peers with no skills in the use of such strategies.[5] It has been confirmed that metacognitive learning strategies have a main role in academic success, as shown by the theories and researches.[5-10]

The purpose of the study was to determine students' metacognitive awareness level in different academic groups in physiology course and develop a guideline on that basis to provide an academic support.

METHODS

A cross-sectional study was carried out by the Department of Physiology in Trinity Medical Sciences University (TMSU), St. Vincent and Grenadines during spring and fall term of academic calendar 2022 (January to August) after receiving approval from Institutional Review Board.

Inclusion and exclusion criteria

All term 2 students of preclinical years enrolled in physiology course during spring and fall terms (total 98 students) were invited to participate in this study. An informed written consent was obtained from the participants prior to study. The students who did not sign the consent form (28 students) and also who did not completely fill the questionnaire (6 students) were excluded from the study.

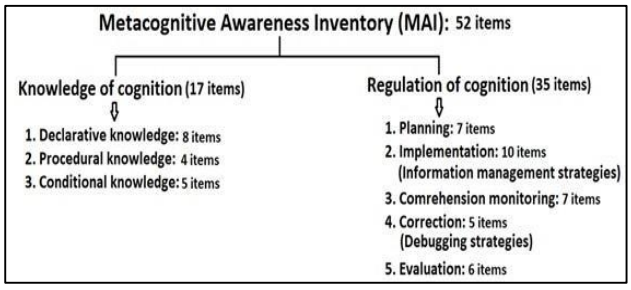

Figure 1: Scales and subscales of metacognitive awareness inventory (MAI).

The participants were requested to fill the metacognitive awareness inventory (MAI) after completion of the final examination at the end of the term. Participants were also asked to indicate their gender and university identification number in the form. MAI devised by Schraw and Dennison (1994) that comprised 52 items was used for the assessment of metacognition awareness level of participants. The items of MAI represent two components of metacognition: 1) knowledge of cognition, 2) regulation of cognition and their subscales as shown in Figure 1.

Previous studies using MAI have shown that the factors are reliable and inter-correlated.[11-13] Students were asked to tick true or false as appropriate for each item of the MAI. For scoring, 1 point was allotted for each true while 0 point for each false on the MAI. Higher score indicates greater metacognitive awareness for different scales, subscales and overall metacognition.

Based on the academic performance (final percentage score in physiology), participants were categorized into 3 groups: low performers (<70%), average performers (70-84%) and high performer (>85%). Data collected were linked to the student's academic performance to: 1) establish a correlation between metacognition awareness level and academic performance in physiology course, 2) compare scores on different scales, subscales and items of MAI among low, average and high performers in physiology course.

Statistical analysis

Data were entered in excel sheet before exported to SPSS version 20. Data were found to have non-normal distribution (p value of the Shapiro-Wilk test <0.05). Pearson's Chi-square or a maximum likelihood ratio Chi-square test, Mann-Whitney U test, and Spearman correlation (rs) tests were used to determine whether there is a statistically significant difference and the degree of association between variables. A p value ≤0.05 was considered statistically significant. Correlation coefficients magnitudes between 0.7 and 1 were considered highly correlated. Correlation coefficients magnitudes between 0.5 and 0.7 were considered moderately correlated while magnitudes less than 0.3 were considered weakly correlated.

RESULTS

Out of 98 students enrolled in Physiology course over the two terms, 70 students volunteered to participate in this study. However, only sixty-four participants (male: 25 and female: 39) completely filled the questionnaire which were considered for analysis. The average age of those participants was 24.6±2.3 years. Those participants were divided into 3 groups: low performers (LP), average performers (AP) and high performers (HP) based on their final percentage score in the physiology course which is shown in Table 1.

Table 1: Academic performance of students in physiology course.

	Percentage score	Number of students (%)
Low performers (LP)	<70	13 (20.3)
Average performers (AP)	70-84	29 (45.3)
High performers (HP)	>85	22 (34.4)

MAI score

A 52-items MAI was found to have good reliability coefficient (Cronbach's alpha: 0.832). The Cronbach's alpha values for knowledge of cognition and regulation of cognition (two scales of MAI) were 0.638 and 0.777 respectively.

The significant positive correlations were found among knowledge of cognition, regulation of cognition, total MAI score and final score in the physiology course which has been presented in the Table 2. Knowledge of cognition and regulation of cognition were highly correlated to total MAI score while these two scales were modestly correlated to each other. The final score in physiology course was found weakly correlated to total MAI score and its two scales.

Table 2: Spearman's correlations between MAI scores and final score in physiology.

	Knowledge of cognition	Regulation of cognition	Total MAI score	Final score (%) in physiology
Knowledge of cognition	-	0.606**	0.804**	0.409**
Regulation of cognition	0.606**	-	0.955**	0.393**
Total MAI score	0.804**	0.955**	-	0.462**
Final score (%) in physiology	0.409**	0.393**	0.462**	-

**Correlation is significant at the 0.01 level (2-tailed).

Table 3: Spearman's correlation between final score (%) in physiology with different subscales of MAI.

	Final score (%) in physiology	
Subscales	**Spearman's correlation**	**P vale**
Declarative knowledge	0.497	0.000*
Procedural knowledge	0.176	0.165
Conditional knowledge	0.195	0.122
Planning	0.128	0.314
Implementation (information management strategies)	0.349	0.005*
Comprehension monitoring	0.153	0.228
Correction (debugging strategies)	0.349	0.005*
Evaluation	0.385	0.002*

*p<0.05: statistically significant

Table 4: Participants' score for MAI scales and subscales.

MAI scales and subscales	Maximum possible score	Overall mean score±SD	Mean score ±SD of LP	Mean score ±SD of AP	Mean score ±SD of HP
Scale 1: knowledge of cognition	17	13.4±2.5	12.46±1.8	12.90±2.8	14.73±2.0
Subscale 1.1: declarative knowledge	8	6.1±1.6	4.92±1.7	6.03±1.5	7.09±1.3
Subscale 1.2: procedural knowledge	4	3.2± 0.9	3.0±1.1	3.23±0.6	3.62±0.7
Subscale 1.3: conditional knowledge	5	4.0±0.9	3.92±0.7	3.86±1.0	4.41±0.7
Scale 2: regulation of cognition	35	24.9±5.1	21.69±4.1	23.97±5.2	28.05±3.8
Scale 2.1: planning	7	4.1±1.5	4.15±1.2	3.72±1.5	4.64±1.6
Subscale 2.2: information management strategies	10	7.7±1.6	6.77±1.3	7.59±1.6	8.41±1.5
Subscale 2.3: comprehension monitoring	7	5.3±1.5	5.31±1.6	4.86±1.6	6.05±0.9
Subscale 2.4: debugging strategies	5	4.1±1.0	2.77±0.9	4.48±0.9	4.41±0.5
Subscale 2.5: evaluation	6	3.6 ±1.5	2.69±1.4	3.31±1.6	4.55±0.9
Total MAI score	52	38.3± 7.0	34.15±5.6	36.86±7.4	42.77±4.6

LP: Low performers; AP: Average performers; HP: High performers.

The correlation between final score in physiology with different subscales of MAI has been presented in Table 3. Among different subscales, the final score in physiology was found to have significant weak correlation with declarative knowledge, implementation (information management strategies), correction (debugging strategies) and evaluation of effectiveness.

Participants' mean total MAI score and mean score on its two scales and different subscales is presented in Table 4.

High performers achieved higher total MAI score and also in both the scales than average and low performers. Surprisingly, average performers' score in planning subscale was even lesser than the low performing group.

Differences between low, average and high performers in MAI scales, subscales and items

Knowledge of cognition (scale 1)

We found significant differences in knowledge of cognition only between low and high performers and between average and high performers (see Table 5). In this scale, the high academic achievers outperformed the average and low achievers.

Subscales of knowledge of cognition

The tests on subscales of knowledge of cognition revealed the following results (see Table 5):

Declarative knowledge

There were significant differences in the score of this subscale between all three groups of academic performance. The score indicated that average and high performers had better declarative knowledge than low performers.

Table 5: Differences between low, average and high academic performers in relation to different scales and subscales of MAI.

Variables	Academic performance	Mann-Whitney U value	P value
Scale 1: Knowledge of cognition	LP versus AP	154.5	0.345
	LP versus HP	55	0.002
	AP versus HP	187.5	0.011
Subscale 1.1: Declarative knowledge	LP versus AP	114.5	0.041
	LP versus HP	51.5	0.001
	AP versus HP	180	0.006
Subscale 1.2: Procedural knowledge	LP versus AP	132	0.087
	LP versus HP	90.5	0.048
	AP versus HP	315	0.935
Subscale 1.3: Conditional knowledge	LP versus AP	185	0.920
	LP versus HP	93	0.066
	AP versus HP	229	0.068
Scale 2: Regulation of cognition	LP versus AP	141	0.194
	LP versus HP	39.5	0.000
	AP versus HP	167.5	0.004
Subscale 2.1: Planning	LP versus AP	159	0.413
	LP versus HP	114	0.312
	AP versus HP	216.5	0.047
Subscale 2.2: Implementation	LP versus AP	136	0.145
	LP versus HP	56.5	0.003
	AP versus HP	222.5	0.062
Subscale 2.3: Comprehension monitoring	LP versus AP	155.5	0.359
	LP versus HP	102	0.144
	AP versus HP	183.5	0.008
Subscale 2.4: Debugging strategies	LP versus AP	34	0.000
	LP versus HP	22	0.000
	AP versus HP	268.5	0.274
Subscale 2.5: Evaluation of effectiveness	LP versus AP	141	0.188
	LP versus HP	40.5	0.000
	AP versus HP	172	0.004
Total score of MAI	LP versus AP	135.5	0.148
	LP versus HP	35.5	0.000
	AP versus HP	144.5	0.001

LP: Low performers; AP: Average performers; HP: High performers.

Table 6: MAI items score having significant difference between low and high performers.

Item no.	Statement	Mean rank	P value
3	I try to use strategies that have worked in the past.	LP: 22.50; HP: 15.34	0.008
7	I know how well I did once I finish a test.	LP: 14.08; HP: 20.32	0.030
9	I slow down when I encounter important information.	LP: 15.12; HP: 19.70	0.035
10	I know what kind of information is most important to learn.	LP: 12.38; HP: 21.32	0.003
13	I consciously focus my attention on important information.	LP: 13.92; HP: 20.41	0.013
16	I know what the teacher expects me to learn.	LP: 13.38; HP: 20.73	0.017
17	I am good at remembering information.	LP: 14.42; HP: 20.11	0.036
19	I ask myself if there was an easier way to do things after I finish a task.	LP: 11.88; HP: 21.61	0.001
20	I have control over how well I learn.	LP: 14.27; HP: 20.20	0.011
24	I summarize what I've learned after I finish.	LP: 14.42; HP: 20.11	0.036
25	I ask others for help when I don't understand something.	LP: 12.88; HP: 21.02	0.007
32	I am a good judge of how well I understand something.	LP: 13.23; HP: 20.82	0.010
36	I ask myself how well I accomplish my goals once I'm finished.	LP: 14.23; HP: 20.23	0.049
39	I try to translate new information into my own words.	LP: 13.08; HP: 20.91	0.004
40	I change strategies when I fail to understand.	LP: 18.23; HP: 20.82	0.010
43	I ask myself if what I'm reading is related to what I already know.	LP: 13.58; HP: 20.61	0.012
44	I reevaluate my assumptions when I get confused.	LP: 14.08; HP: 20.32	0.030
47	I try to break studying down into smaller steps.	LP: 12.73; HP: 21.11	0.004
50	I ask myself if I learned as much as I could have once I finish a task.	LP: 12.54; HP: 21.23	0.005
51	I stop and go back over new information that is not clear.	LP: 14.62; HP: 20.00	0.006

AP: Average performers; HP: High performers

Table 7: MAI items score having significant difference between average and high performers.

Item no.	Statement	Mean rank	P value
2	I consider several alternatives to a problem before I answer.	AP: 24.10; HP: 28.50	0.042
7	I know how well I did once I finish a test.	AP: 21.93; HP: 31.26	0.008
13	I consciously focus my attention on important information.	AP: 23.21; HP: 29.68	0.036
20	I have control over how well I learn.	AP: 22.71; HP: 30.34	0.011
21	I periodically review to help me understand important relationships.	AP: 22.83; HP: 30.18	0.020
24	I summarize what I've learned after I finish.	AP: 22.57; HP: 30.52	0.019
34	I find myself pausing regularly to check my comprehension.	AP: 21.32; HP: 30.82	0.008
36	I ask myself how well I accomplish my goals once I'm finished.	AP: 21.41; HP: 32.05	0.003
45	I organize my time to best accomplish my goals.	AP: 20.16; HP: 33.70	0.000
49	I ask myself questions about how well I am doing while I am learning something new.	AP: 22.95; HP: 30.02	0.033

AP: Average performers; HP: High performers.

Procedural knowledge

There was significant difference in the score of this subscale between low and high performers in physiology. But no significant differences were observed between other groups of academic performance.

Conditional knowledge

No significant differences in the score of this subscale were observed between any of the academic performing groups.

Regulation of cognition (scale 2)

In this scale we noted significant differences only between low and high performers and between average and high performers (see Table 5). Their score suggested that high achievers had better ability to regulate the cognition as compared to their average and low performing counterparts.

Subscales of regulation of cognition

The tests on the subscales of regulation of cognition discovered the following results (see Table 5).

Planning

Only high performers scored significantly higher than average performers in this subscale. There was no significant difference between other academic performing groups.

Implementation

On this subscale of information management strategies, the significant difference was observed only between low and high performers where high performers reported to have better implementation skills. However, there were no significant differences between other academic performing groups.

Comprehension monitoring

A significant difference was noted in this subscale between average and high performers suggesting high performers were better aware of monitoring the learning process than average performers. However, no significant differences were there between other groups of academic performance.

Correction

We noticed significant differences in debugging strategies only between low and average performers and between low and high performers.

Evaluation

There were significant differences in this subscale only between low and high performers and between average and high performers.

MAI items

The items of MAI in which there were significant differences between low and high performers in physiology course are mentioned in Table 6. For all these items mean ranks of high performers were found higher than that of low performers except for the item number 3.

Similarly, significant differences in the items of MAI between average and high performers in physiology course are mentioned in Table 7. Mean rank value of all these items were found to be superior for high performers compared to average performers.

DISCUSSION

We investigated the metacognitive awareness level of term 2 preclinical students and its impact on their academic performance in physiology course. The purpose of the study was to make evidence-based recommendations to the low and average performing students for greater academic success.

In our study, a positive correlation was recognized among knowledge and regulation of cognition; total MAI score; and final score of the participants in a course. This substantiates the association between the two major components of metacognition and their influence on academic achievement of the students. Similar reference was made by a previous study conducted in undergraduate and graduate education students in an institution located in southeast Texas.[14] Some other previous studies also indicated that metacognitively aware learners are more strategic and perform better than unaware learners.[15,16] The mean MAI scores (73%) of our students was comparable to the 646 preclinical students from different Turkish medical school (70.5%).[17] Our high performing students in the course had significantly higher MAI score than average and low performers same as in another study conducted by Turan and Demirel.[11] Modest MAI score of low academic performing students reveal their poor ability to self-reflect upon their knowledge and control on own learning process.

A positive correlation between level of academic performance and knowledge of cognition was found in our study. High performing students reported superior declarative and procedural knowledge compared to the low academic performers. However, the conditional knowledge of the participants was not significantly different between the groups. This explains mere being conscious about the right conditions of learning does not lead to academic success unless students are extremely aware of their ability, skills, resources, strategies and how to use them. This finding was in line with a previous study which showed that after acquisition of declarative knowledge students perform better than their average and low ability counterparts.[14,18] Average performers in our study were no significantly different than high performing students in procedural and conditional knowledge but in terms of declarative knowledge. Our findings in relation to these subscales of knowledge of cognition was in contrast to a study in which high achieving group's score on declarative and procedural knowledge was not significantly different than low performers but the low achieving group reported unexpectedly significantly higher levels of conditional knowledge compared to high performers.[19]

We found positive correlation between regulation of cognition and level of academic performance of the students in our study. Significantly higher score was reported by the high performers compared to their low performing counterparts in the implementation and correction of strategies and also in evaluation of own learning process. No significant difference between low and high academic achievers in planning and monitoring suggests low performers are equally good as high performers on these two subscales of regulation of cognition. This demonstrates that our low performing students should focus on to improve managing and debugging the strategies skills and their ability to evaluate while maintaining their ability to plan and monitor the learning process. While further scrutinizing the subscales of regulation of cognition, the lowest score obtained in planning by average academic achievers among the groups surprisingly indicated that they plan their learning even worse than the low academic achievers. Average performers' scores were also lower in monitoring and evaluation than high performers.

Therefore, the factors that differentiate high from average academic achievers are awareness of their own ability and skills (declarative), better planning, monitoring and evaluation of learning rather than procedural and conditional knowledge, implementation and correction of strategies. Other studies also described high achieving students displayed better skills required of regulation of metacognition.[14, 19-20] Researches indicate that allowing individuals to plan, sequence, and monitor their learning in a way directly improves performance.[21-25] As regulatory skill of the students has been found to improve with personal experience in previous study, we hope to find higher score on this scale of metacognition as these student progresses to advanced semester.[14]

There is a room for improvement in both components, knowledge of cognition and regulation of cognition, to enhance metacognitive awareness level among our students. Some studies have delineated the enhancement of metacognitive capabilities of the students by continuous training.[22,26]

Therefore, appropriate measures through curriculum planning and teaching might be helpful to improve the metacognitive awareness level of the students and achieve better academic results in our context.

There were some limitations also. Final score only in physiology course was used as measure of academic performance of the participants which might vary with their metacognitive awareness level in other courses. Associations between various measures within this study may be confounded by personal characteristics and study habits of the participants that were not measured. Examining the relation between components of MAI and measures of academic achievement with larger sample size in a longitudinal study may demonstrate more robust correlations between the variables and enhancement in metacognitive awareness level of students in advance semesters.

CONCLUSION

According to the results of our study, we determined that the metacognitive awareness level of medical students has a significant impact on their academic performance in Physiology course. Low performers need to improve their declarative and procedural knowledge and also should make progress in management and correction of their strategies and in evaluating the learning process. Average performers should expand their declarative knowledge, develop better plan, and improve their monitoring and evaluating skills of learning process. Identifying and focusing on important information, intelligent handling of new information with flexible strategies, summarizing the content at the end, and mastering the control over one's learning styles could be some of the important practices for students to achieve greater academic success in a medical school.

Recommendations

Our study suggested that the MAI can be used to determine what type of metacognitive knowledge and regulatory skills the student reportedly utilizes while learning. We used the result of the study to make the recommendations to the low and average performing students to improve their score.

Based on our findings, low performers need to get better on declarative and procedural knowledge along with implementation, correction and evaluation of their learning process.

The following recommendations are made for low performing students: 1) Be flexible with your strategies. The strategies that have worked in the past may not always work. 2) Assess how much you accomplished after you finish. Think if there was an easier way to finish the task. 3) Master the control over your learning styles. 4) Take a moment to think what you are reading is related to what you already know. If not, stop and go back over new information and try to translate it into your own words. 5) Break the studying or task into smaller steps and ask yourself did you learn to your potential after every step. 6) Identify and focus on the important information in the course. It is also important to slow down when encountering important information and summarize after you finish. 7) Ask others for help when you don't understand something and re-evaluate your assumptions. 8) Besides improving your memory and comprehension power, figure out the learning expectation of your teacher.

Based on the result of our study, average academic performers should develop better planning, monitoring and evaluation skills along with declarative knowledge.

We recommend the following to the average performing students in a course to further improve their score. 1) Better organize your time to best accomplish the set goals and evaluate your achievement after you finish. 2) Pause regularly to check your comprehension on important information and periodically review them. 3) Consider several alternatives to a problem before you answer. 4) Occasionally ask yourself how well you are doing while leaning something new and summarize the whole thing at the end. 5) Feel confident about your learning strategies and have a better control over it.

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