



## Is critical thinking potential correlated to critical appraisal skills of medical literature?

### Est-ce que le potentiel en esprit critique est corrélé aux compétences en lecture critique de la littérature médicale?

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#### ABSTRACT

**Introduction:** Critical appraisal of medical literature is a mandatory skill to practice evidence-based medicine. The relation between the critical appraisal skills and the critical thinking potential has been rarely assessed in the literature.

**Aim:** To assess the relation of critical thinking potential to critical appraisal of medical literature competencies. Besides, they tried to highlight the variation of the critical thinking potential according to the students' level.

**Methods:** The authors conducted a mixed study associating a quantitative and a qualitative approach. The study included second year (SYME), third year (TYME) and postgraduate medical students (CME) and family doctors (FD) from the same faculty of medicine. All the students received the same active training focused on critical appraisal of medical literature. They were asked to fulfil a pre-requisite test and a self-assessment questionnaire before the training session and a final test after the training. The self-assessment questionnaire was conceived by an expert committee and assessed the main characteristics of critical thinking consisting of sensitivity to context, self-correction and search for criteria. Three months after the training, the students were interviewed using a semi-structured interview. The SPSS software 16.0 was used.

**Results:** In our study, 58.9% of the students presented a high critical thinking potential profile. Their scores varied according to their levels with better scores in SYME and FD and intermediate scores in TYME and CME. The pre-requisite test scores varied according to the critical thinking profile and the level. On the other hand, final test scores didn't differ according to the critical thinking profile or the level.

**Conclusion:** Our results put emphasis on the variation of the critical thinking potential according to the students' levels. The better results of the SYME students in comparison to those in the TYME put emphasis on the necessity of changing curriculum in order to enhance the sensitivity and the inclination of the students.

**Key words:** critical thinking, critical appraisal of medical literature, knowledge test, qualitative analysis

#### RÉSUMÉ

**Introduction:** La lecture critique d'articles médicaux est une compétence essentielle dans la pratique de la médecine basée sur le niveau d'évidence. La relation entre les compétences en lecture critique et le potentiel en esprit critique a été rarement évaluée dans la littérature. Objectif : Evaluer la relation entre le potentiel en esprit critique et les compétences en lecture critique. De plus, ils ont analysé la variation du potentiel en esprit critique en fonction du niveau des étudiants.

**Méthodes:** Les auteurs ont mené une étude mixte associant une approche quantitative et qualitative. Cette étude a inclus des étudiants en deuxième année des études médicales (DAEM), en troisième année des études médicales (TAEM), post gradués et des médecins de familles (MF) de la même faculté. Tous les étudiants ont reçu le même enseignement interactif centré sur la lecture critique d'articles médicaux. Les étudiants ont rempli un questionnaire évaluant leurs pré-requis, un questionnaire d'auto-évaluation et un test final après l'enseignement, évaluant l'acquisition de nouvelles connaissances. Le questionnaire d'auto-évaluation a été conçu par un comité d'experts et évaluaient les principales caractéristiques de l'esprit critique incluant la sensibilité au contexte, l'autocorrection et la recherche de critères. Trois mois après l'enseignement, les étudiants ont été interviewés en utilisant une interview semi-structurée. Le logiciel SPSS 16.0 a été utilisé pour les analyses statistiques.

**Résultats:** Dans notre étude, 58.9% des étudiants présentaient un potentiel élevé en esprit critique. Ce potentiel variait en fonction du niveau des étudiants avec de meilleurs résultats pour les étudiants en DAEM et les MF et des scores intermédiaires pour les étudiants post-gradués et en TAEM. Les résultats du test de pré-requis variaient en fonction du niveau des étudiants et de leur potentiel en esprit critique. D'un autre côté, les scores du test final ne variaient pas en fonction du niveau ou du potentiel en esprit critique.

**Conclusion:** Nos résultats mettent l'accent sur la variation du potentiel en esprit critique en fonction du niveau des étudiants. Les meilleurs résultats des étudiants en DCEM en comparaison avec ceux en TCEM mettent l'accent sur la nécessité de modifier le curriculum afin d'encourager les étudiants à plus de sensibilité à leur contexte avec une volonté plus forte de dépasser leurs limites cognitives.

**Mots-clés:** Esprit critique, lecture critique de la littérature médicale, test de connaissances, analyse qualitative

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## INTRODUCTION

Critical appraisal of medical literature is a critical step within the practice of evidence-based medicine (EBM). EBM is defined as an explicit and judicious use of the current best evidence in making decisions about the care of individual patients (1). It is based on 2 fundamentals: the hierarchy of evidence and the clinical decision making. The different steps of the EBM practice consist of facing a health problem, asking a question, critical appraisal of medical literature, searching for the evidence and communicating the result of the process to the patient. Practicing EBM necessitates achieving clinical skills that are necessary to make a good diagnosis of a patient's problem. The latter may be difficult to manage and necessitates critical appraisal skills in order to find evidence. These skills rely on the practitioner expertise to define features that affect the applicability of the results to the patient. The common skills necessary for the EBM practice consist of diagnostic expertise, in-depth background knowledge, effective searching skills, effective critical appraisal skills, ability to define and understand benefits and risks of alternatives, in-depth physiologic understanding allowing application of the evidence to the individual, sensitivity and communication skills required for full understanding of patient context. Good judgment is the goal of the EBM practice and dealing with good sense and judgment is also dealing with critical thinking. Many definitions exist in the literature about the critical thinking with an obvious overlap between different concepts including clinical reasoning, clinical judgment, self-directed learning and autonomy. The most consensual definition was Lipman's definition (2). According to this definition, critical thinking is a mean of reaching a good judgment. It meets 3 criteria: being based on criteria in order to avoid being arbitrary, haphazardous and unstructured, being sensitive to context because critical thinking has to be adapted to the particularities of the different cases and self-correction (3). The Delphi Project defines critical thinking as a purposeful, self-regulatory judgment that results in interpretation, analysis and inference as well as explanation of the evidential, conceptual, methodological, criteriological or contextual considerations upon which that judgment is based (4). The latter definition encompasses the concepts of self-directed learning, autonomy and clinical reasoning. In accordance with these definitions, Perkins et al., proposed that good thinking requires three elements: sensitivity, inclination and ability. The three elements are linked to each other. Sensitivity refers to awareness of a limit, a problem or a challenge. Inclination is the ability to invest effort in thinking. Sensitivity without inclination leads to a cognitive miser. Finally, ability is the capability to think effectively (5). The EBM practice starts also with an interrogation or a kind of sensitivity. It also needs inclination with different cognitive skills in order to be engaged in solving a health problem. The different steps of the EBM practice and the different characteristics of critical thinking seem intimately linked. The majority of the articles dealing with critical appraisal of medical literature skills highlighted the cognitive potential of the learners or satisfaction and attitudes. On the other hand, few publications dealt with the critical thinking potential in the medical field and especially in the practice of EBM and in appraising literature. Numerous questions about critical thinking potential relation to the critical appraisal of medical literature skills remain unresolved. Is critical

thinking part of a hidden curriculum or is it acquired or enhanced through learning and practice prior to or during medical training? Does it vary according to the students' level or gender?. The authors aimed to assess the relation of critical thinking potential to critical appraisal of medical literature competencies. Besides, they tried to highlight the variation of the critical thinking potential according to the students' level and gender.

## METHODS

### Population studied

This study included students from the same Faculty of Medicine. It was dealt from September 2020 to June 2022. All the students from the second year of medical education (SYME), third year of medical education (TYME) and postgraduate students were invited using their institutional e-mails. They were aware that the training wasn't included in their curriculum and that the assessment performed wasn't normative. Family doctors (FD) that were registered in the certificate of Family medicine held in the same Faculty were also invited using their institutional e-mails. Students who didn't accept to answer the different tests and questionnaires weren't included in this study.

### Learning activities

The students were invited to participate to a 9-hour-workshop centered on the critical appraisal of medical literature. All the workshops were tutored by the same tutor and the students were grouped according to their level. Before the workshop, the students were invited to answer a self-assessment questionnaire. The self-assessment questionnaire assessed their critical thinking potential. They were also invited to fulfil a pre-requisite test assessing their knowledge in biostatistics.

Two original articles dealing with covid-19 were sent to all participants:

Article 1: Hydroxychloroquine in Non hospitalized Adults With Early COVID-19. A Randomized Trial. Skipper CP, Pastick KA, Engen NW, et al. *Ann Intern Med.* doi:10.7326/M20-4207 (6)

Article 2: Diagnostic accuracy of serological tests for covid-19: systematic review and meta-analysis. Bastos ML, Tavaziva G, Abidi SK, et al. *BMJ* 2020;370:m2516 (7). During the workshop, the students were introduced to elementary statistical concepts they learned during the first cycle of medical education through the correction of the prerequisite test, some lectures and 2 problematic situations to solve. The students were asked to perform a critical appraisal of both manuscripts in order to answer particular clinical situations that were presented, using published checklists. At the end of the workshop, the students were asked to fulfil a final test assessing their cognitive abilities. The final test consisted in a modified version of the Fresno test.

### The self-assessment questionnaire

#### **Construction of the questionnaire:**

An expert committee was created in order to conceive the questionnaire assessing the critical thinking potential of the students. This committee used to meet once a month during 3 months in order to assess the literature. It was composed of three full professors who were used to tutor students from different levels and to teach the different principles of EBM. According to the most consensual definitions of critical thinking, assessing the critical thinking

potential focused on the students need to search for criteria, their sensitivity to context and their tendency to regularly assess their competencies and to correct their learning strategies when needed. The questions were inspired by the questionnaire published by Shehata GM, et al., about critical thinking and attitude of physicians toward evidence-based medicine in Egypt (8). The questions related to the critical thinking profile of the participants are presented in table 1.

**Table 1.** Self-assessment questionnaire of the critical thinking potential and the internal consistency analysis

	Proposition	Scores	Cronbach's alpha values
<b>Search for criteria</b>			
1- I have the tendency to always think critically about what I am learning and about its implication in the patients' management	- Totally agree	- 4	0.64
	- Agree	- 3	
	- Not significant	- 0	
	- Disagree	- 2	
	- Totally disagree	- 1	
<b>Sensitivity to context</b>			
2- I learn not only for the exams but mainly to be able to solve medical problems.	- Totally agree	- 4	0.67
	- Agree	- 3	
	- Not significant	- 0	
	- Disagree	- 2	
	- Totally disagree	- 1	
<b>Self-correction</b>			
3- I used to always assess my learning using many exercises	- Totally agree	- 4	0.65
	- Agree	- 3	
	- Not significant	- 0	
	- Disagree	- 2	
	- Totally disagree	- 1	
4- I assess regularly my learning techniques and change them when it is necessary	- Totally agree	- 4	0.64
	- Agree	- 3	
	- Not significant	- 0	
	- Disagree	- 2	
	- Totally disagree	- 1	

**Rating the questionnaire:**

The scores attributed to every question are presented in table 1. The authors considered scores between 0 and 9 [0, 9[ as correlated to a negative critical thinking potential, scores between 9 and 11 [9, 11[ as correlated to an intermediate critical thinking potential and scores between 11 and 16 [11, 16[ as correlated to a high or positive critical thinking potential. After the identification of the construct's dimensionality, the expert committee identified, determined the format questionnaire and diffused it through google forms. They developed the items, determined the questionnaire length and reviewed and revised the initial items pool.

**Preliminary pilot study:**

A preliminary pilot study was conducted including 30 students in the TYME. The unclear items pointed out by the students were modified and the expert committee validated the questionnaire

**Reliability of the questionnaire**

- Internal consistency: The internal consistency reflects the extent to which the questionnaire items are inter-correlated or whether they are consistent in measurement of the same construct. We used the coefficient alpha or Cronbach's alpha. A Cronbach's alpha of at least 0.6- 0.7 indicates adequate internal consistency. The different values of the 4 questions ranged from 0.64 to 0.67 indicating adequacy. Table 1 indicates the Cronbach's alpha values of every question. 3-5 Validity of the questionnaire

- Content validity: The final version of the questionnaire was assessed by 2 experts used to teach the critical appraisal of medical literature. They were asked to judge, whether the questionnaire items are adequately measuring the construct intended to assess and whether the items are sufficient to measure the domains of interest. We choose the process of content validation and the expert were asked whether the questions were clear and

easy, whether they covered all the determinants of critical thinking, whether they would like to use the questionnaires for future assessment and whether they lack important questions. The experts reviewed the questions and didn't add modifications.

**The pre-requisite test design**

The pre-requisite test was designed in order to assess the students' background in biostatistics. Biostatistics knowledge is necessary in order to appraise the methods' sections of the different manuscripts. According to the Faculty's curriculum, the students are taught biostatistics principles during the first two years of medical education. All the students included in this study are supposed to have achieved the same objectives concerning biostatistics. The experts agreed to ask the students questions about the methods sections of different articles published in the Tunisie Médicale journal. They performed nine-multiple-choice questions assessing the students' knowledge of confidence interval, significance of statistical tests, judgement of causality, comparability of the groups, the number of participants needed to treat calculation in a clinical trial, the management strategy of the patients loss of view in a clinical trial, the sensitivity, specificity, positive predictive value and negative predictive value of a diagnostic test and the judgement criteria in a study. The prerequisite test was rated over 10 and was sent to all participants through a google form link.

**The checklists used to perform the critical appraisal of the two manuscripts**

Both manuscripts represented the evidence to appraise in order to answer 2 problematic situations. The critical appraisal of both manuscripts was performed following 3 steps. The first step consisted in assessing the validity of the methods' section. The second step consisted in analysing the results. The third step consisted in answering the research question. The students used the CONSORT checklist 2010 in order to appraise the first manuscript and they used the AMSTAR 2 checklist to appraise the second manuscript.

**The problematic situations used to initiate the critical appraisal of the manuscripts**

Two problematic situations were designed by the expert committee in order to initiate the critical appraisal process. This approach was chosen in accordance with the cognitivist theory of learning and aimed to help students achieve new knowledge by solving realistic and professional situations.

**The final test**

The final test was adapted from the Fresno test (9). It is a consensual, published test assessing medical residents' knowledge of basic EBM principles, including how to frame a research question, how to search for evidence to answer the question, understanding the hierarchy of evidence, being able to interpret its magnitude, internal and external validity of the evidence and basic and statistical concepts. It contains 7 short-answer questions, 2 questions that require a series of mathematical calculations, and three fill-in-the-blank questions. All of the questions are rated in details. We modified the Fresno test because we weren't assessing all of the EBM practice steps. The workshop focused on the critical appraisal of medical literature. For that reason, we included 5 short-answer questions from the Fresno test that were related to the critical appraisal of medical literature and we added 6 short-answer questions related to an original manuscript part dealing with a diagnostic test. The final tests were rated by the same tutor.

**Quantitative analysis**

*Judgement criteria:* The judgement criteria consisted in the final test scores and the self-assessment questionnaires scores. Quantitative data related to the self-assessment questionnaires scores and the final tests scores were represented as means.

*Statistical tests:* Statistical differences in mean scores according to the level and gender were assessed using ANOVA test. The Pearson correlation coefficient @ was used to assess the strength and direction of the linear association between two paired outcomes including associations between the students' final scores and the pre-requisite test scores with the critical thinking profile of the students. A p-value <0.05 was considered significant. The SPSS software 16.0 was used.

**Qualitative analysis**

Three months after the workshops, the participants were invited to answer a semi-structured interview. As the self-assessment questionnaire was centered on the three characteristics for critical thinking as defined by Lipman, the interviewer (the same interviewer for all students) asked only a few predetermined questions while the rest of the questions were not planned in advance. Examples of interview questions were as follows: Do you expect changes in your practice or learning after this workshop? Do you feel that this training will impact on you or on your routine practice?. All the interviews were recorded with the consent of the participants. We proceeded to a content analysis following 3 steps: a pre-analysis, the treatment of the results and the interpretation

**Research approval**

This study was approved by the research committee of Abderrahman Mami Hospital (Ref 01/2022).

**Ethics**

The present study has been conducted according to the principles of the Declaration of Helsinki. Ethical approval for the study was obtained from the ethic committee of Abderrahman Mami Hospital (Ref 07/2022). Besides, participants were made aware of the purpose of the study, the anonymous nature of the purpose, the anonymous nature of the dataset generated and the option to not respond if they so wished. This information served as the basis for an informed consent from each respondent.

non-inclusion and exclusion criteria, 23 participants were excluded and 95 participants were included with 76 women and 19 men. Six participants (6.3%) were in SYME, 54 in TYME (56.8%), 16 in CME (16.8%) and 19 participants were FD with a minimum of 10 years of expertise (20%).

**Quantitative study**

- *Critical thinking potential scores:* The general critical thinking mean score reached 10.98 reflecting a moderate critical thinking potential among the participants. Twenty-three students (24.2%) had a negative critical thinking potential, 16 students (16.8%) had an intermediate critical thinking potential and 56 students (58.9%) had a high critical thinking potential (Figure 1a). The means scores reached 13 in SYME, 10.76 in TYME, 9.63 in CME and 12.11 in FD revealing a high critical thinking potential in SYME and in FD and an intermediate potential in TYME and CME. There was a significant difference between means scores according to the levels (p=0.04) (Figure 1b). The means scores reached 10.59 in women and 11.06 in men highlighting a moderate critical thinking potential (Figure 1c).

- *Final test results:* The general final test mean reached 4.529 over 10. The mean scores reached 5.83 in SYME, 4.287 in TYME, 3.813 in CME, and 5.41 in FD. There was a significant difference between final test means scores according to the levels (p=0.024). The final test mean score reached 4.33 in women and 4.235 in men. There was no significant difference in means scores according to the gender.

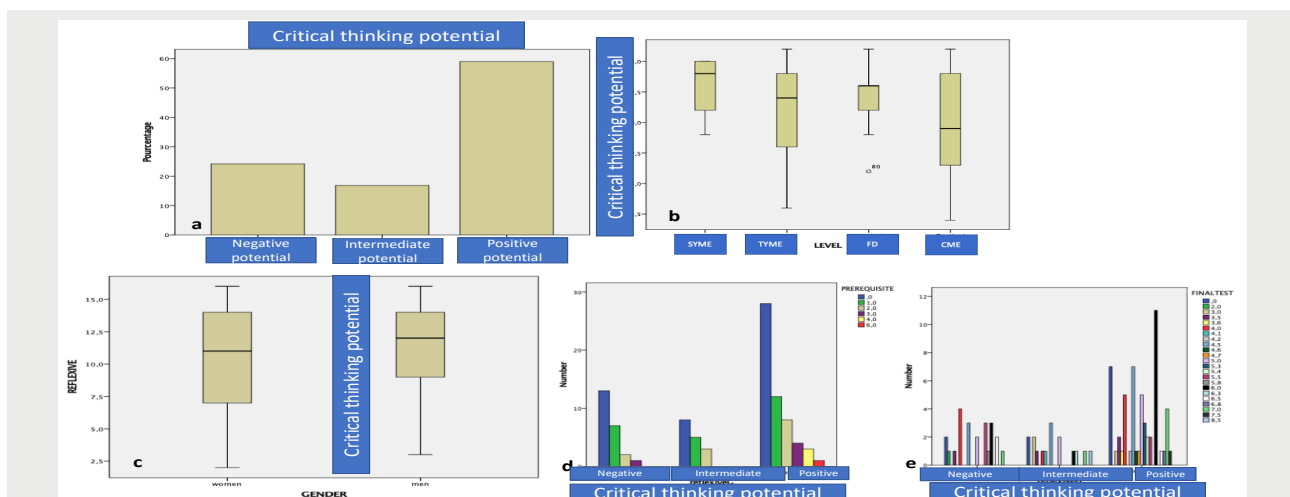
- *Pre-requisite test results:* The general prerequisite test mean reached 0.874 over 10. The mean scores reached 1.16 in the SYME, 0.593 in the TYME, 1.563 in CME, and 1 in FD. There was a significant difference between means scores according to the level (p=0.027). The prerequisite mean scores reached 0.729 in women and 1.235 in men. Tables 2 and 3 illustrate the different scores according to the level and gender of the students

- *Pre-requisite test scores according to the critical thinking potential:* The figure 1d illustrates the different pre-requisite scores according to the critical thinking profiles. There was a significant difference in pre-requisite scores according to the critical thinking potential (p=0.06).

- *Final test scores according to the critical thinking potential:* The figure 1e illustrates the different final test scores according to the critical thinking profiles. There was no significant difference in final tests scores between the students according to their critical thinking profile.

**RESULTS**

Eight workshops were organized. According to our inclusion,



**Figure 1. a.** The critical thinking profile of the students, **b.** The critical thinking potential means according to the level, **c.** The critical tinkling means scores according to the gender, **d.** The pre-requisite scores according to the critical thinking scores, **e.** The final test scores according to the preworkshop reflexive score

- *Variation of the critical thinking potential according to the students' level:* The variation of the critical thinking profiles according to the students' levels revealed a significant statistical difference (p= 0.026). The Pearson's test reached -0.228 highlighting a negative correlation between the levels and the critical thinking profiles. The variation of the means' scores according to the students' gender revealed no significant statistical difference in the critical thinking scores according to the gender (p=0.428)

- *Correlation between the final test and the critical thinking potential:* The variation of the final test means' scores according to the critical thinking potential revealed no significant statistical difference between the students (p= 0.77). The pearson's test reached -0.03 (p=0.77) with a rho coefficient reaching 0.023 (p=0.828) revealing a weakly negative association between the final test and the critical thinking potentials.

**Table 2.** Summary of the different results according to the level

	General mean			Means according to level											
	Mean	Extremes	SD	SYME			TYME			CME			FD		
				Mean	95%CI	SD	Mean	95%CI	SD	Mean	95%CI	SD	Mean	95%CI	SD
Prerequisite test	0.842	[0,6]	1.19	1.17	[0.14,2.2]	0.4	0.6	[0.3,0.85]	0.13	1.6	[0.6,2.4]	0.42	1	[0.42,1.57]	1.2
Final test	4.3	[0,8.5]	2.12	5.8	[4.6,7]	0.48	4.3	[3.7,4.8]	0.27	3.8	[2.4,5.2]	0.65	5.41	[4.94,5.87]	0.96
Critical thinking score	10.7	[2,16]	3.9	13	[10.35,15.65]	1.033	10.76	[9.75,11.7]	0.5	9.63	[7.18,12.07]	1.14	12.11	[10.96,13.25]	2.37

SYME: second year of medical education, TYME: third year of medical education, CME: continuing medical education, FD: family doctors, SD: standard deviation.

**Table 3.** Summary of the different results according to the gender

	Women			Men		
	Mean	95% CI	SD	Mean	95%CI	SD
Prerequisite test	0.7	[0.4, 1]	0.14	1.2	[0.5, 1.9]	0.33
Final test	4.3	[3.8, 4.8]	0.26	4.2	[2.9, 5.5]	0.6
Critical thinking score	10.59	[9.5, 11.65]	0.5	11.6	[9.4, 12.7]	0.7

95%CI: 95% confidence interval, SD: standard deviat

**Qualitative analysis**

Five students from the TYME, 2 students from the SYME, 2 students from the CME and 2 FD were interviewed. The content analysis highlighted 4 themes including the training program, the institutional assessment, the impact on the research practice and the impact on the patients' management. The most cited words were: training, medical assessment, think, curriculum and techniques. Concerning the training program, comments varied according to the students' levels. Students from the SYME, CME and FD agreed that the workshop structure and length were available and motivating. TYME students felt that the workshop was too long and expressed the need for shorter but multiple learning sessions. The students appreciated the use of interactive techniques that enhanced their participation and engagement. The family doctors interviewed appreciated the 3-step-method used to appraise medical literature. In fact, the first step consisted in assessing the validity of the article. It consists in analysing the methods used. The second step consisted in analysing the results and the third step consisted in wondering about the applicability of the results to the problematic situation used. The concept of institutional assessment was expressed differently according to the students' levels. Students from the TYME expressed the need for institutional assessment: «there is no institutional exam allowing us to assess our competencies. All of us are centred on the exams and felt that we were wasting our time because we were dealing with notions that aren't included in our curriculum». Students from the SYME expressed their wish to attend more certified courses about EBM. The impact on the research practice was mentioned differently according to the students' levels. TYME students didn't understand the impact of such a teaching on the research practice: « we need all the principles of critical appraisal when we'll be enrolled in research projects and this will happen in the future years. At that time, we'll forget all what we've learned about critical appraisal of medical literature». The other students agreed that improving their competencies in EBM will motivate them to be enrolled

or to conduct research projects in the future. Concerning the impact on the patients' management, SYME students, CME students and FD agreed that this learning will improve their patients' management. The TYME students expressed that they weren't aware of the impact of this learning on the patients' management: «we are more interested in passing the exams than in thinking about the patients' management».

**DISCUSSION**

In our study, 58.9% of the students presented a high critical thinking potential profile. Their critical thinking potential scores varied according to their levels with better scores in SYME and FD and intermediate scores in TYME and CME. The pre-requisite test scores varied according to the level and to the critical thinking profile. On the other hand, final test scores varied according to the level but didn't differ according to the critical thinking profile. Pre-requisite test consisted in 10 questions related to methods sections and results sections extracted from published manuscripts. These questions consisted in higher-order questions because they didn't assess simple definitions or terminologies but they included analysis, synthesis and evaluation of information highlighting the critical thinking potential related to the context. Even the final test contained higher-order questions related to a manuscript dealing with a diagnostic test in addition to other questions adapted from the Fresno test. The absence of a statistically significant difference in final test scores according to the students' level or critical thinking potential could be explained by the training effect. All the students received the same interactive training centered on solving 2 realistic situation-problems using 2 evidences: a clinical trial and a systematic review with a meta-analysis. The absence of difference between the students final scores or critical thinking scores according to their level highlights the immediate positive effect of the training. The variation of the critical thinking potential according to the level of the students have been reported in the literature. McCarthy, et al., reported the same results in a cross-sectional study including 241 nursing students (10). McGrath, et al. and Zettegren, et al. reported also a difference in critical thinking potential according to the level of the students in cross sectional studies about respectively 228 nursing students and 200 master of Physical therapy students (11,12). These results were also shared by Scott et al., in a longitudinal pre-test and post-test design study (13). Other studies dealing with critical thinking potential reported no

significant statistical difference between students according to the level and even before and after a training period. These studies presented some methodological flaws. McGrath, et al showed no statistically significant change in critical thinking skills of 228 nursing students (12). The defined groups were not matched for age, gender or baseline academic level. Solberg B, et al., assessed the critical thinking as a predictor at certification exam performance in medical laboratory science(14). They reported that critical thinking skills weren't correlated to academic scores. The authors didn't analyse the kind of questions used to assess the students or whether they were knowledge-questions or higher-order ones. Even studies reporting a statistical difference according to the students' levels contain methodological flaws related to the number of students included, the nature of the training, the difference in measurement instruments. In fact, many instruments and techniques have been used to assess the critical thinking potential. These instruments consist in scales or questions assessing the cognitive skills (15). The common general critical thinking measures consist of California Critical Thinking Disposition Inventory, California Critical Thinking Skills Tests, Critical Thinking Process Test, Health Sciences Reasoning Test, Problem Solving Inventory or Watson-Glaser Critical thinking Appraisal (14). This variation in the instruments used in the literature could be explained by the varying definitions of critical thinking. Krupat E, et al., assessed the description of critical thinking made by different health workers interviewed. They reported an absence of consensus with different concepts describing critical thinking such as a process, an ability, personality traits or habits or even an ability to read articles and assess new information (16). The unacknowledged lack of consensus in critical thinking definition constitutes a major block to productive discussion and management of successful assessing strategies. In our study, the tendency of the students in the SYME to be positive critical thinkers and the moderate critical thinking potential of students in the TYME highlights some interrogations concerning the training and the curriculum in the faculty. In fact, the majority of the studies that reported a difference in the critical thinking potential according to the level recorded higher scores in senior students than in junior ones. In a questionnaire-based study, Godwin M and coworkers reported that younger physicians were more knowledgeable than older ones (17). The authors didn't try to explain this fact that could be explained by the higher propensity of young learners to recall facts. In our case, the curriculum of the Faculty is Flexner-inspired and students in the SYME mainly learn fundamental notions. The clinical clerkship starts in the TYME. It is quite disappointing to notice that the students facing clinical situations and dilemma aren't conscious of the utility of the critical thinking and the EBM practice. In fact, the qualitative study revealed that the TYME students are more interested in passing the exams than in solving medical problems. This could point out the assessment techniques and methods used in the Faculty that may include a majority of knowledge questions assessing a simple recall of facts than the critical reasoning process of the students. Pieterse T, et al. reported also in a study assessing the critical thinking ability of TYME radiography students, that the majority of the students demonstrated minimal ability to think critically (18). The authors pointed out the need for curriculum adjustment but they focused only on the knowledge when assessing the students and didn't assess the other characteristics of critical thinking. In this study, we tried to assess the critical thinking potential of the students using a mixed approach. The self-assessment questionnaire focused on the 3 characteristics of the critical thinking

defined by Lipman and associating sensitivity to context, self-correction and searching for criteria. Kpazai G, et al. reported a pedagogical analysis of critical thinking which was developed to assess this competence in health and physical education teachers. They used a questionnaire dedicated to teachers assessing the 3 components of reflexive thinking. In our study, we adapted the Kpazai G's questionnaire to students (19). The pre-requisite test and the final tests assessed the students' cognitive skills but they couldn't assess the different elements of the critical thinking process including sensitivity, inclination and ability. In fact, focusing exclusively on cognitive skills leave little space in which sensitivity or inclination might manifest themselves. The qualitative analysis based on semi-structured interviews didn't highlight factors influencing the critical thinking potential of the students. CME students complained about the time-consuming activity represented by the appraisal of medical literature highlighting a low sensitivity and inclination. On the other hand, TYME students were more interested in academic results than in solving patients' problems. SYME students and FD pointed out the impact of this practice on their routine and the research practice. The purpose of this study was to shed light on the relation between the critical thinking and the critical appraisal skills in medical students without making judgment about the quality of their critical thinking. Even if, we established a correlation between the critical thinking potential and the students levels, the decrease of this potential in the TYME and CME put emphasis on the necessity of integrating teaching students to embrace complexity and be open to uncertainty in the curriculum rather than to shy away from these issues. The major limitations of our study consist of the unequal number of the students from the different levels with a majority of students in the TYME. Further research should focus on the teaching techniques to perform in order to enhance the sensitivity and the inclination of the students early in the medical curriculum.

## REFERENCES

1. Bhandari M, Giannoudis P. Evidence-based medicine: What it is and what it is not. *Injury*. 2006;37(4):302-6.
2. Lipman M. Moral education higher-order thinking and philosophy for children. *Early Child Dev Care*. 1995;107(1):61-70.
3. Kpazai G, Daniel MF. Manifestations of Critical Thinking in Health and Physical Education Teachers: An Examination of Three Case Studies. *Intell Transport Sys J*. 2011;3:1-15
4. Facione NC, Facione PA. Externalizing the Critical Thinking in Knowledge. *Develop and Clin Judgment*. 1996;1:12-22
5. Perkins DN, Jay E, Tishman S. Invitational Issue: The Development of Rationality and Critical Thinking. *JSTOR*. 1993;39:12-34
6. Skipper CP, Pastick KA, Engen NW, Bangdiwala AS, Abassi M, Lofgren SM, et al. Hydroxychloroquine in nonhospitalized adults with early covid-19: A randomized trial. *Ann Intern Med*. 2020;173(8):623-31.
7. Lisboa Bastos M, Tavaziva G, Abidi SK, Campbell JR, Haraoui LP, Johnston JC, et al. Diagnostic accuracy of serological tests for covid-19: Systematic review and meta-analysis. *The BMJ*. 2020;370.
8. Shehata GM, Zaki A, Dowidar NL, Sayeda I et al. Critical thinking and attitude of physicians toward evidence-based medicine in Alexandria, Egypt. *J Egypt Pub Health Assoc*. 2015;90(3):115-20.
9. Atler K, Stephens J. Pilot use of the adapted Fresno Test for evaluating evidence-based practice knowledge in occupational therapy students. *Am J Occup Ther*. 2020;74:34-42
10. McCarthy P, Schuster P, Zehr P, McDougal D. Evaluation of critical thinking in Baccalaureate Nursing Program. *J Nurs Educ*. 2013;1:12
11. Zettergren K, Beckett R. Changes in critical thinking scores: An examination of one group of physical therapist students. *J Physic Ther Educ*. 2004;18:2
12. Profetto-Mcgrath J. The relationship of critical thinking skills and critical thinking dispositions of baccalaureate nursing students. *Issues and innov in nursing education*. 2013;12:12-16
13. Scott JN, Markert RJ, Dunn MM. Critical thinking: change during medical school and relationship to performance in clinical clerkships. *Medical Education*. 1998;32:14-18

14. Solberg BL. Critical Thinking as a Predictor of Certification Exam Performance in Medical Laboratory Science. *Clin lab science*. 2015;15:23-32
15. Martindale R, Ward C, Fraser M. How effective are your questions when training students on the bench. *CJMLS*. 2011;1:12-13
16. Krupat E, Sprague JM, Wolpaw D, Haidet P, Hatem D, O'Brien B. Thinking critically about critical thinking: Ability, disposition or both? *Med Educ*. 2011;45(6):625–35.
17. Godwin M, Seguin R. Critical appraisal skills of family physicians in Ontario, Canada. *BMC Med Educ*. 2003;3:10.
18. Pieterse T, Lawrence H, Friedrich-Nel H. Critical thinking ability of 3rd year radiography students. *Health SA Gesondheid*. 2016;21:381–90.
19. Kpazaĩ G, Daniel MF. Manifestations of Critical Thinking in Health and Physical Education Teachers: An Examination of Three Case Studies. *PHEnex J*. 2011;3 :12-20