Original Article

Critical Thinking of Medical Students: does it Change during the Study in Medical School?

Reza sharifinia [1], Abdolhussein Shakurnia [2*]

[1] General physician, School of Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.
[2] Department of Immunology, School of Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

Article Info

Article history:
Received 27 April 2022
Accepted 16 July 2022
Published 2 August 2022
Keywords:
Critical thinking skills, medical students, California Critical thinking skills Questionnaire Form B

***Corresponding author:**
Abdolhussein Shakurnia
Immunology Department
Medical school
Ahvaz Jundishapur University of Medical Sciences
Golestan St, Ahvaz, Iran.
Email: shakurnia@yahoo.com

Abstract

Background & Objective: Critical thinking (CT) is essential in medical education and improves physicians' clinical ability and competency. The present study aimed to determine the CT level and the trend of its changes in medical education at Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran, in 2021.

Materials & Methods: In this cross-sectional descriptive study, the CT levels of 165 medical students in three curricular phases, namely basic sciences, externship, and internship courses were examined. The data collection tool was the California Critical Thinking Skills Questionnaire Form B. Data were analyzed by SPSS (version 20) using t-test, ANOVA, and Pearson correlation coefficient.

Results: The mean score of medical students' CT was 12.07 ± 4.48 out of a total score of 34. The mean scores of students' CT in basic sciences, externship, and internship courses were 12.75 ± 4.47, 12.82 ± 5.10, and 10.67 ± 3.49, respectively. There was a significant difference between students' mean scores of CT in different curricular phases (P=0.010). In addition, there was a significant difference between the mean scores of students' CT based on gender, and the mean scores of CT of male students were significantly higher (P=0.049).

Conclusion: The mean scores of CT of medical students were low and did not improve during their university years. Since CT plays an essential role in clinical decision-making, it is necessary for medical teachers and university officials to pay more attention to the medical students' CT development.

Introduction

Critical thinking (CT) is among the topics that have attracted attention in medical education worldwide and in recent years in Iran, especially in medical universities (1). Critical thinking is systematic, purposeful, reasoned, logical, and consequential thinking in which the individual searches, scrutinizes, and discusses findings and phenomena based on scientific principles and methods and finally makes judgments accordingly. The World Health Organization believes in the vital role of CT in creating a healthy life and declares that CT and creativity are among the five basic life skills (2, 3).

Given the medical students' heavy responsibilities and the need for making careful decisions in the health system, physicians need to acquire knowledge and skills, think in clinically critical situations, and make judgments accordingly to save human life. Moreover, critical thinking enables physicians to reason and judge correctly regarding patient problems. While listing CT as one of the standards of medical education, the World Federation of Medical Education emphasizes on the importance of teaching CT throughout medical schools' curricula by introducing it as one of the key points in the accreditation of medical schools (4, 5).

Critical thinking development in medical schools has been considered one of the missions of medical education, and medical students are expected to have high levels of CT skills. However, the related literature indicates that the level of CT in Iranian medical students is low (6, 7). Medical schools seem to have no comprehensive program to develop students' CT skills. Numerous studies have shown that the current curricula and teaching methods in medical universities do not promote the development of students' CT since there is no significant difference in this regard between first-year students and graduates (8, 9). The results of a review study described the state of CT in Iranian.

[DOI: 10.52547/edcj.15.45.26]

Medical students as poor and suggested revisiting the methods of improving CT in students (10). Barkhordari and Yasaee investigated the students' CT levels from the first year to the end of their studies at the university, and they reported that there was no significant difference between the CT scores from the first year to the last year at the university and the CT level of medical students did not increase during the period in which they were at university (11, 12). A study at the University of São Paulo, Brazil (2021) also showed that the students' CT level was low and did not change at different stages of their education (13). In addition, in two studies by Athari and Hosseini, it was reported that the CT scores of medical students decreased during their university years (7, 14). Another study by Irwanto (2018) in Indonesia showed a significant difference in CT scores of students across different levels (15). On the other hand, several studies compared CT of the first and final year students and have reported that the mean scores of CT of final year students increased significantly compared to those of first year students; nevertheless, the overall mean scores of CT in all students were below the average, and their CT were generally weak (1, 16, 17).

Given that the universities of medical sciences have the mission of training a committed and competent workforce in the field of treatment and health, it is necessary to develop CT that can lead to finding creative solutions in dealing with problems and challenges. Furthermore, although nearly similar studies have been conducted on medical students' CT, no study included the trend of changes in this variable during the study period of medical students. Therefore, identifying CT level and the trend of its changes during the study period of medical students is crucial because it can lead to a complete understanding of the trend of these changes in medical school. Clarifying the CT trend in medical students at Ahvaz Jundishapur University of Medical Sciences (AJUMS) can provide appropriate strategies for developing CT in medical students. Due to the importance of this topic and the fact that few studies have so far evaluated the changes in medical students' CT skills, the present study aimed to assess CT among medical students of AJUMS in three curricular phases of their studies: basic sciences, externship, and internship courses. Therefore, the present study aimed to determine the CT level and the trend of its changes in medical education, and identify factors associated with CT like age, gender, and academic performance.

Material & Methods

This cross-sectional descriptive study was conducted from Jan to Mach 2021. The study population included all medical students of AJUMS. According to a previous study (6) and based on Cochran's table, 195 students were selected by convenience sampling (65 students from basic sciences, externship, and internship courses). Inclusion criteria included studying medicine, willingness to participate, and completing the questionnaire. Exclusion criteria were unwillingness to participate in the research and not completing the questionnaire. After coordination with the relevant officials of the medical school, the researcher referred to the research units and proceeded to collect samples while introducing himself. Before distributing the questionnaires, the purpose of the study and the method of completing the questionnaires were explained to the participants, and the confidentiality of information was emphasized. The questionnaire was given to students in medical schools and teaching hospitals. The students completed the questionnaires in a quiet, calm, and appropriate environment for 50 minutes, and after completion, they were handed over to the researchers.

The data collection tool was the California CT Questionnaire Form B, designed by Fashion in 1990, and its validity and reliability were evaluated and approved. The validity and reliability of the Persian translation of this questionnaire have been confirmed in previous studies in Iran (7, 18). This questionnaire is currently one of the most common tools for measuring CT skills. It contains 34 multiple-choice items with one correct answer in five areas of cognitive skills of CT (analysis, evaluation, inference, deductive reasoning, and inductive reasoning). The scoring method is as follows: for each correct answer, a score is assigned, and the sum of the correct answers to the test is the score of CT for each student. The test's total score is 34 (range of possible scores 0-34), and the score obtained in each part of the test varies from zero to 16. That is, in the analysis section, a maximum of nine points (range of possible scores 0-9), in the evaluation section a maximum of 14 points (range of possible scores 0-14), in the inference section, a maximum of 11 points (range of possible scores 0-11), in the inductive reasoning section a maximum of 14 points (range of possible scores 0-14), and finally, in the deductive reasoning section, a maximum of 16 points (range of possible scores 0-16), can be obtained. Therefore, the test entails six scores, including five scores of CT in each section and one total score for CT skills. This study considered students' grade point average (GPA) as their educational performance.

[DOI: 10.52547/edcj.15.45.26]

In this research, "evaluation" means determining the validity of the content and evaluating the relationship between them, "inference" means the ability to conclude and "analysis" means identifying the purpose of the content (and understanding the relationships between them), "deductive reasoning" is the conclusion based on inference or general principle, and "inductive reasoning" means extracting the results based on logical reasons (19).

To observe the ethical principles of the research, the questionnaires were completed anonymously by the respondents, and the confidentiality of the answers was carefully monitored.

Data were analyzed by independent t-test, one-way analysis of variance (ANOVA), and Pearson correlation coefficient using SPSS (version 20). A P-value of less than 0.05 was considered statistically significant.

Results

Out of the 195 questionnaires, 165 (84.6%) were completed and returned. Of these, 77 (46.7%) were completed by male respondents and 88 (53.3%) by females, with a mean age of 23.7 ± 3.4 years. Around 44 (32.7%) students were studying basic sciences (45% male, 55% female), 53 (32.1%) students at externship (55% male, 45% female), 58 (35.2%) at internship courses (40.5% male, 59.5% female). The GPA of students was at 15.87 ± 1.32.

According to the total score of the CT test, which was 34, the findings showed that medical students achieved a mean score of 12.07 ± 4.48, which was less than half of the total score. Of the 34 scores, the lowest score among medical students was 5, and the highest was 25. The results of the CT subscales scores showed the evaluation (4.76) of 14, the inference (3.72) of 11 and analyzing (3.59) of 9, Deductive reasoning (6.08) of 16 and the inductive reasoning (4.63) of 14 (Table 1).

A comparison of the mean scores of students' CT showed that the level of CT of male students was significantly higher than that of female students (P=0.049). The mean scores of the five subscales of CT and its subscales by gender are illustrated in Table 1. The highest score was in the field of deductive reasoning, and the lowest score was in the analysis field.

Table 1. Comparison of mean scores of critical thinking and its subscales by gender

variable	Total (n=165)	Male (n=77)	Female (n=88)	t	P
evaluation	4.76±2.47	5.26±2.43	4.30±2.28	2.62	0.009
Inference	3.72±1.81	3.74±1.79	3.64±1.73	0.378	0.706
Analysis	3.59±1.60	3.75±1.52	3.50±1.58	1.04	0.298
Inductive reasoning	4.63±2.33	5.08±2.23	4.18±2.28	2.54	0.012
Deductive reasoning	6.08±2.55	6.18±2.63	5.97±2.25	0.562	0.575
Total critical thinking	12.07±4.48	12.92±4.47	11.33±4.39	2.21	0.028

The comparison of the mean scores of CT in basic sciences, externship, and internship courses showed a significant difference between the scores of CT in the three curricular phases (P=0.010). Turkeys' exact test was used to examine the differences between groups.

The results showed a statistically significant difference between the mean scores of basic sciences and externship students compared to those at the clinical levels (P=0.014). However, no significant difference was found between the mean score of basic sciences and externship students (P=0.921).

Table 2. Comparison of mean scores of critical thinking and its subscales by curricular phase

variable	Basic (n=54)	Externship (n=53)	Internship (n=58)	F	p
evaluation	5.09±2.59	5.11±2.55	4.09±1.90	3.49	0.033
Inference	3.91±1.93	4.17±1.77	3.037±1.36	6.89	0.001
Analysis	3.63±1.57	3.66±1.75	3.57±1.36	0.049	0.952
Inductive reasoning	4.63±2.46	5.13±2.42	4.09±1.91	2.94	0.055
Deductive reasoning	6.67±3.05	6.38±2.24	5.22±1.61	5.89	0.003
Total critical thinking	12.75±4.47	12.82±5.10	10.67±3.49	3.96	0.021

[DOI: 10.52547/edcj.15.45.26]

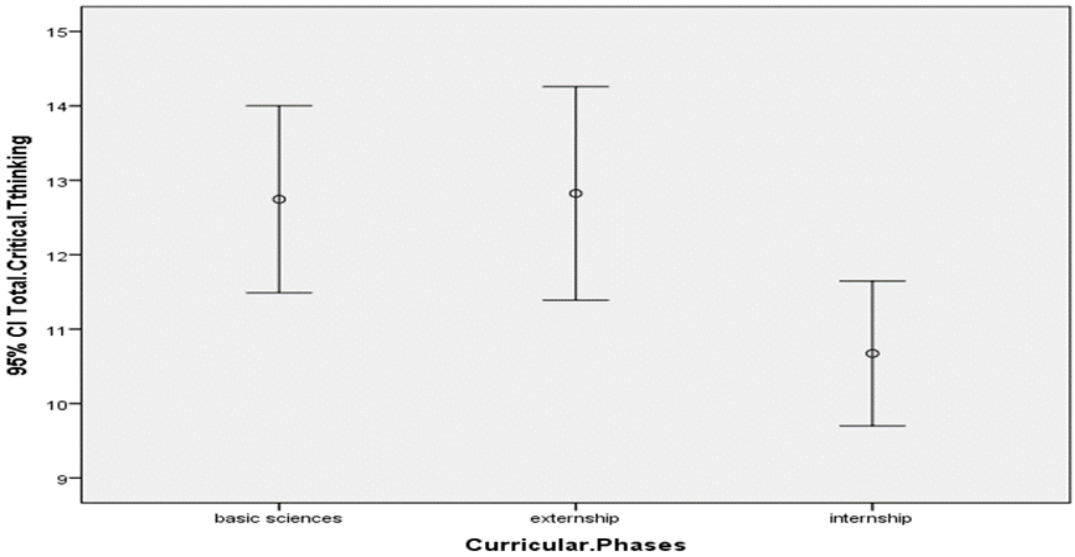

Fig 1. Trend of critical thinking rate in curricular phase in medical students

Pearson correlation coefficient was used to determine the correlation between students' CT scores with their age, gender, curricular phase, and GPA. The results showed a significant relationship between the mean scores of CT with gender and a significant negative relationship with the age and curricular phase ($P<0.05$). There was a significant negative relationship between age and curricular phase with the subscales of "evaluation", "inference", and "inductive reasoning"; however, this relationship was not significant with the subscales of "analysis" and " deductive reasoning". Moreover, the GPA was not significantly related to CT and its subscales (Table 3).

Table 3. Correlation between participants' demographic data and critical thinking scores

Variable		sex	age	curricular phases	grade point average (GPA)
Total critical thinking	r	0.177	-0.273	-0.190	-.0123
	p	0.028	0.003	0.018	0.129
evaluation	r	0.223	-0.230	-0.179	-.043
	p	0.005	0.004	0.026	0.596
Inference	r	0.051	-0.212	-0.183	-.0112
	p	0.529	0.008	0.023	0.165
Analysis	r	0.093	-0.067	-0.048	-.150
	p	0.251	0.407	0.558	0.064
Inductive reasoning	r	0.205	-0.105	-0.046	-.107
	p	0.011	0.196	0.567	0.187
Deductive reasoning	r	0.079	-0.325	-0.309	-.055
	p	0.331	0.000	0.000	0.502

Discussion

The present study aimed to investigate the status of medical students' CT during their studies at the university. The findings indicated that CT of medical students is poor and below the average, and different educational programs and student attendance during university years did not contribute to improving

[DOI: 10.52547/edcj.15.45.26]

students' CT skills. This finding is consistent with previous studies conducted in Iran that reported the CT level of medical students as weak (9, 20-23). The low mean score of CT of medical students in this study (12.05) is below the standard mean score of CT (15.89) of students (1). Given the low score of CT in medical students, it can be argued that perhaps part of the blame should be put on the few mechanisms devised for CT development in medical schools. Researchers point to several intertwined factors giving rise to the poor level of students' CT skills, including shortcomings of the educational system, lack of interactive teaching methods, emphasis on memorization, and lack of appropriate techniques for cultivating CT skills. Similar findings were also reported by Hakim et al. (2016), Hadi et al. (2018), Kasalaei A et al. (2020), in which they explained that the poor result might be caused by failures in the teaching and learning of CT strategies (24-26). Given that CT is necessary for the empowerment of medical students in the field of clinical reasoning and that after graduation, they have a serious responsibility in the health system as leaders of healthcare teams, it is imperative to pay attention to cultivating and strengthening these skills in the curriculum of medical education.

The most striking finding of the study is that there is a negative relationship between the curricular phase and CT and their subscales. Although students' CT is expected to increase with their university years and curricular phases, the findings of the current study, in line with many studies, have shown no CT promotion in medical students during their university years (7, 14, 16, 20, 22, 27). The results of the present study largely reflect those of the above-cited studies, which reported no significant difference in the CT levels of students in different years, suggesting that in most universities, the CT level of students does not change during their university studies. In other words, the university has no role in strengthening students' CT skills. Although some recent researchers have stated that the average CT of students has increased during different academic years (28, 29), it is essential to note that the students' CT in both the first and the last years is poor. Therefore, it seems that medical education in universities pays little attention to CT skill development, and students do not receive the necessary training in this field.

In a study by Rezaian (21) on medical students of different curricular levels, the CT rate of students of basic sciences and externship did not differ significantly; however, a significant decrease was observed in the internship. This finding is in line with the present study, where clinical students with the highest education level had lower CT scores than students of other levels. Irwanto (2018) showed that the mean scores of medical students' CT changed by grade level (15). On the other hand, clinical students should have a higher level of CT due to their direct contact with patients and greater sensitivity to their health and life. Medical students seem to have less opportunity to apply CT in clinical settings. While techniques such as questioning, discussions and debates, problem-based learning, learning in small groups, and other types of interactive and participative learning, have been showed to be effective in developing CT. Consequently, making a balance between the course content and time available may be the key step in preparing the context for educators to assign more time for the development of the students' CT.

A review of studies reported that in none of the studies in Asian countries has CT been evaluated to be positive in students. In contrast, studies conducted in Western countries have reported positive evaluations of these skills among students (30, 31). One of the reasons for the discrepancies in the results is the dominant culture of the study populations. In Western countries, as opposed to Asian countries, the dominant culture encourages individuals to think critically. However, traditional beliefs in Asian countries, even in developed countries such as Japan, have influenced teaching methods and communication between students and instructors (32).

Consistent with the results of previous studies, the findings of the current study suggest that the process of improving CT in universities is not satisfactory. One of the factors that can play a role in giving rise to this in Iranian universities is that there is less emphasis on active teaching methods in these universities, and lecturing as the dominant teaching method in many educational centers promotes a passive method of education. Medical teachers mostly use the lecture method to present lessons in which CT is implicitly never taught. In a review article, al-Maliki stated that one of the reasons for students' weakness in CT is the use of traditional teaching and assessment methods. He introduced active teaching styles and assessment methods to strengthen learners' CT (32).

The results of this study showed that there is no significant relationship between medical students' CT and their GPA. This finding is in the same vein as the findings of Darban (20), Mohammadi (33), and Aghamolaei (34), which showed that there is no significant relationship between orientation to CT and academic performance. A study in California, US, also reported no significant correlation between CT and academic achievement (35). This finding can be explained by the fact that inappropriate educational methods and emphasis on memorization and superficial learning during academic years at university did not

[DOI: 10.52547/edcj.15.45.26]

contribute to the students' CT as one of the factors affecting academic performance. This finding is in contrast with that of the studies by Musa (2000) and Barry (2020) reporting a significant relationship between academic levels and students' CT (36, 37).

Other findings of the current study demonstrated a significant difference between students' CT and gender. That is, the level of CT and the subscales of evaluation and deductive reasoning was significantly higher in male students compared to female students, which suggests that female students rely more on memorization than on reasoning and analysis, and this may, in turn, be due to differences in the learning styles of males and females. The results of the present study are consistent with the study of Rezaian et al. in Rafsanjan, Iran, where male students had a higher level of critical thinking skills (21). However, in some studies, such as Amini (22), Rezaei (27), and Ramia (38), no significant relationship was found between male and female students.

The present study found a relationship between the CT levels and the students' age. According to the research, a negative correlation has been observed between age and CT. In other words, CT decreases as age increases. This finding is consistent with that of the study by Hosseini and Athari (7, 14), reporting that younger students had higher levels of CT and its subscales. However, no significant relationship was found between the two subscales of analysis and deductive reasoning and students' age. Moreover, there was no significant relationship between these two subscales in other variables (e.g., gender, curricular phases, and GPA), which shows that the rates of these two subscales were identical among all medical students.

In general, the findings of the present study indicated that the average score of CT and its subscales in medical students is not satisfactory and does not increase during the years of study. Therefore, it seems that CT is not sufficiently developed in the Iranian medical educational system, and a serious revision of the medical curriculum is necessary. Researchers believe that the development of CT in educational institutions requires a significant overhaul of teaching methods (39-41). Unfortunately, the predominant style in medical universities is passive and teacher-centered. This teaching style does not help the development of CT in medical students. Therefore, medical teachers must reconsider their teaching methods and use more active methods to promote CT in students. Many studies have shown that educational interventions and changes in teaching and assessment methods can increase learners' CT skills. As Saka has demonstrated in a study, exploratory teaching methods have promoted CT and improved academic achievement (42). Therefore, by reviewing the current educational methods in universities and using appropriate teaching methods, we must provide backgrounds for fostering and developing the students' CT. Consequently, educating and training medical students to improve their CT skills would be advantageous to the students, the profession, and presumably patients. Education experts believe that the first step in training critical thinkers in universities is to hire teachers with the knowledge and skills of CT.

The present study had the following limitations. First, we utilized a convenience sample of a medical school within a single university; the results may not be generalizable to other populations and Universities. Second, our sample had high attrition levels, and more than 15% of students did not complete the questionnaires. Students who were asked to participate in the study refused to participate, causing selection bias to threaten the results. And the reason for this refusal to complete the questionnaire and the poor cooperation of students was the difficulty and time-consuming completion of the questionnaire. And this caused some students, especially clinical students, to complete the questionnaires with reluctance and inaccurately. A longitudinal study is recommended to measure the CT of a specific group of university entrants and track a trend in this skill through different years of education. This way, valuable information on CT development among medical students in the various curricular phases will be provided.

Conclusion

The findings of the present study showed that the average score of medical students' CT was low and did not improve during their study years at the university. Therefore, it might be concluded that the studied medical education program did not affect the students' CT. Based on this finding, it can be argued that although CT is essential, it has not been taken seriously into account during education years at the university. Considering the role and position of CT in clinical decision-making, it is suggested that training on this skill be included in students' curricula. Hence, it is necessary to promote their CT skills by revising the medical curriculum and implementing new teaching strategies like engaging the students in debate, case-based discussions, applying new teaching methods, and active learning strategies. The implementation of further studies in this regard is recommended.

Acknowledgements

The authors wish to thank the medical students of AJUMS for completing the questionnaire.

[DOI: 10.52547/edcj.15.45.26]

References

1. Maleki Z, Rezaee M. Medical sciences students' critical thinking skills and the effect of the university curriculum: a literature review. Sci.J.Rehabi.Med. 2016;4(4):156-65.
2. Kahlke R, Eva K. Constructing critical thinking in health professional education. Perspective. Med. Educ. 2018;7(3):156-65.
3. Susetyarini E, Fauzi A. Trend of critical thinking skill researches in biology education journals across Indonesia: From research design to data analysis. Int. J. Instruction. 2020;13(1):535-50.
4. Zarea Gavgani V, Hazrati H, Shohrabi Z. Effect of Problem-Based Learning and Reasoning Tests on Learners' Critical Thinking Skills Before and After the Educational Intervention in Graduate Students of Basic Sciences. Depiction of Health. 2021;12(1):35-44.
5. Education WFfM. Basic Medical Education: WFME Global Standards for Quality Improvments. In: 2003 WOUoCD, 2003.Available from: http://wwwiaomcorg/wfmehtm Accessed: December 7, 2021
6. Shakurnia A, Aslami M. Critical thinking skills of medical students at Ahvaz Jundishapur University of Medical Sciences. Iran J Med Educ. 2017; 17:420-7.
7. Hosseini R, Esna Ashari F, Mamani M, Jiryaee N. Study of Critical Thinking skills among Medical Students of Hamadan University of Medical Sciences. Res. Med. Educ. 2021;13(1):4-13.
8. sabouri kashani a, Faal Ostadzar N, karimi moonaghi h, m g. Critical thinking dispositions among medical students in two stages: Basic medical sciences and pre-internship. Iran J Med Educ. 2013;12(10):778-85.
9. Sheikhmoonesi F, Barani H, Khademloo M, Sharifian R, Jahani M, Lamsechi H. Critical thinking abilities among students of medicine in Mazandaran University of Medical Sciences, 2011. J Mazandaran Univ. Med. Sci. 2013;23(98):98-103.
10. Jafari F, Azizi SM, Soroush A, Khatony A. Critical Thinking Level among Medical Sciences Students in Iran. Educ. Res. Int. 2020; https://doi.org/10.1155/2020/1348365).
11. Barkhordary M. Comparing critical thinking disposition in baccalaureate nursing students at different grades and its relationship with state anxiety. Iran J Med Edu. 2012;11(7):768-88.
12. Yasayi S, Navasanian V, Davari A. Critical thinking skills among dental students of Shahid Sadoughi University of Medical Sciences: a comparison in 2013. J.Med. Educ.Dev. 2014;9(1):70-8.
13. de Almeida AL, Portella DL. The assessment of critical thinking: an approach to Brazilian medical students. Res., Soc. Dev. 2021;10(12): e122101220203-e.
14. Athari ZS, Sharif SM, Nasr AR, Nematbakhshb M. Evaluation of Students' Critical Thinking Skills in Isfahan University and Isfahan University of Medical Sciences for Two Sequence Semesters: Critical Thinking, the Lost Ring in Curriculums. Iran J Med Educ. 2012;11(9):1040-9.
15. Irwanto I, Rohaeti E, Prodjosantoso A. A survey analysis of pre-service chemistry teachers' critical thinking skills. Mier J. Educ. Stud. Trends. Practices. 2018;8(1):57-73.
16. Mirmolaei T, Shabani H, Babaei G, Abdehagh Z. Comparison of critical thinking among first and last trimester baccalaureate midwifery students. HAYAT. 2004;10(3):69-77.
17. Aslami M, Dehghani M, Shakurnia A, Ramezani G, Kojuri J. Effect of Concept Mapping Education on Critical Thinking Skills of Medical Students: A Quasi-experimental Study. Ethiop J Health Sci. 2021;31 (2):409. doi: http://dx.doi.org/ J.
18. Khalili H, Hosseini ZM. Investigation of reliability, validity and normality Persian version of the California Critical Thinking Skills Test; Form B (CCTST). J. Med.Educ. 2003;3(1):29-32.
19. Carranza JP. Review of the Theories of Critical Thinking. An Approach Directed to the Professional Career of Medical Technology of the National University of Jaén in Peru. Asian J. Educ. Soc. Stud. 2021;14(1):11-21.
20. Darban L, Ashtari S, Forghani Z, Yazdani S. Evaluation of critical thinking skills among medical sciences students in Shahid Beheshti and Tehran University of Medical Sciences. Med. Sci. J Islamic Azd Univ 2016;26(4):229-37.
21. Rezaeian M, Zare-Bidaki M, Bakhtar M, Afsharmanesh K. Comparison of the critical thinking skills among medical students in different educational levels in Rafsanjan University of Medical Sciences in 2013. J.Rafsanjan Univ Med. Sci. 2015;13(8):715-24.
22. Amini M, Fazlinejad N. Critical thinking skill in Shiraz University of medical sciences students. Hormozgan Med. J. 2010;14(3):213-8.
23. Jafarzadeh S, Akbarzadeh Z, Mobasheri F. Comparison critical thinking skills among medical and paramedical students in Fasa University of Medical Science. J Med Edu Dev. 2017;12(1,2):87-99.
24. Kasalaei A, MITRA AMINI M, Nabeiei P, Bazrafkan L, Mousavinezhad H. Barriers of Critical Thinking in Medical Students' Curriculum from the Viewpoint of Medical Education Experts: A Qualitative Study. J Adv Med Educ Prof. 2020;8(2):72-82.
25. Hadi SA, Susantini E, Agustini R, editors. Training of students' critical thinking skills through the implementation of a modified free inquiry model. J. Phys.: Conference Series; 2018: IOP Publishing.
26. Hakim A, Liliasari L, Kadarohman A, Syah YM. Improvement of student critical thinking skills with the natural product mini project laboratory learning. Indones. J Chem 2016;16(3):322-8.
27. Rezaee R, Mazareie E, Momeni Danaei S, Mirzaei S. Critical Thinking Skills in Shiraz Dental Students. Interdisciplinary Virtual Learn. Med. Sci. 2020;5(2):35-43.
28. Javidi T, Abdoli A. Critical thinking skills of students in the baccalaureate program in Ferdowsi University of Mashhad. Res. Clin. Psychol. Cons. 2011;11(2).
29 .Mahbobi M, Jafarian Jazi M M, Khorasani E. A comparative study of critical thinking skills and critical thinking disposition in veteran and non-veteran students.J. Mil Med Journal Mil Med. 2013;14(4):293-8.

[DOI: 10.52547/edcj.15.45.26]

30. D'Alessio FA, Avolio BE, Charles V. Studying the impact of critical thinking on the academic performance of executive MBA students. Think Skills Creat. 2019; 31:275-83.
31. Anders PL, Stellrecht EM, Davis EL, McCall Jr W. A systematic review of critical thinking instruments for use in dental education. J Dent Educ. 2019;83(4):381-97.
32. Maleki Z, Rezaee M, Mirzakhany N, Shafiee Z, Tabatabaee SM. Occupational Therapy BSc students' Critical Thinking Skills at Shahid Beheshti University of Medical Sciences, Tehran. Sci. J. Rehabil Med. 2016;5(4):84-93.
33. Mohammadi D, Moslemi Z, Ghomi M. The relationship between critical thinking skills with creativity and academic achievement in students Qom University of Medical Sciences. Educ. Strategies Med. Sci. 2016;9(1):79-89.
34. Aghaei N, Souri R, Ghanbari S. Comparison of the relationship between critical thinking and academic achievement among physical education students and students in other fields of study in Bu Ali Sina University, Hamedan. Res. Manage. Motor Behav. 2013;2(4):35-45.
35. Searing LM, Kooken WC. The relationship between the California Critical Thinking Disposition Inventory and student learning outcomes in baccalaureate nursing students. J Nurs Educ. 2016;55(4):224-6.
36. Mihriay M. Investigation of the relationship between critical thinking levels and academic achievement levels of students in Faculty of Sports Science. Educ. Res. Rev. 2020;15(7):370-6.
37. Barry A, Parvan K, Sarbakhsh P, Safa B, Allahbakhshian A. Critical thinking in nursing students and its relationship with professional self-concept and relevant factors. Res. Dev. Med.Educ. 2020;9(1):7-.
38. Ramia E, Maasri A, Abdallah J. Critical thinking among pharmacy students: Do age, sex and academic variants matter? Pharm. Educ. 2022;22(1):236-48.
39. Sarmadi M, Ebrahimzadeh I, Zare H, gharib M. Learning critical thinking in virtual medical education: a qualitative study of faculty members' and students' experiences. J. Sabzevar Univ. Med. Sci. 2010;17(3):169-79.
40. Vodgani F. Some strategies to foster the students' critical thinking, with emphasis on the role of faculty. High. Educ. Letter. 2015;8(29):133-52.
41. Eslami E, Abbasi E, Bijani M. Mechanisms of developing critical thinking skills among students in agricultural higher education system. Iran Agric. Exte. Educ. J. 2017;12(2):183-96.
42. Saka AZ. Hitting two birds with a stone: Assessment of an effective approach in science teaching and improving professional skills of student teachers. Procedia Soc Behav Sci. 2009;1(1):1533-44.

Reza sharifinia, Abdolhussein Shakurnia. Critical Thinking of Medical Students: Does it Change During the study in medical school? J Med Educ Dev. 2022; 15 (45): 26-33

[DOI: 10.52547/edcj.15.45.26]