

Psychometric Properties of the Critical Thinking Disposition Assessment Test Amongst Medical Students in China: A Cross-Sectional Study

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Abstract

Background: Critical thinking helps medical students and professionals overcome the effects of personal values and beliefs when exercising clinical judgment. The lack of effective instruments to measure critical thinking disposition in medical students has become an obstacle for training and evaluating students in undergraduate programs in China. The aim of this study was to evaluate the psychometric properties of the CTDA test.

Methods: A total of 278 students participated in this study and responded the CTDA test. Cronbach's coefficient, internal consistency, test-retest reliability, floor effects and ceiling effects were measured to assess the reliability of the questionnaire. Construct validity of the pre-specified three-domain structure of the CTDA was evaluated by the confirmatory factor analysis (CFA). The concurrent validity, convergent validity and discriminant validity were also analyzed.

Results: Cronbach's alpha coefficient for the entire questionnaire was 0.923, all of the domains showed excellent internal consistency (0.814-0.861), and the test-retest reliability indicated acceptable intra-class correlation coefficients (ICCs) (0.710-0.795, $p < 0.01$). The CFA demonstrated that the three-domain model fitted the data adequately. All dimensions were significantly correlated with the Self-assessment Scale on Active Learning and Critical Thinking (SSACT) and subscales ($p < 0.01$), and the instrument showed satisfactory convergent and discriminant validity.

Conclusions: The CTDA has acceptable psychometric characteristics and is a reliable and valid questionnaire to evaluate medical students' disposition towards critical thinking in China. The CTDA could be applied in critical thinking programs and medical education research.

Background

Critical thinking has become an essential skill worldwide [1]. With advances in technology and the increased complexity of societies, researchers argue that critical thinking influences individuals' academic performance, career achievements, human relations, and quality of life [2]. According to Ennis RH, "critical thinking is a kind of reasonable reflective thinking that is focused on deciding what to believe or do" [3]. For decades, the importance of developing critical thinking skills has been emphasized in K-12, college education and STEM education [4]. For the World Federation for Medical Education, critical thinking should be part of the training standards for medical students and practitioners. Critical thinking is essential for medical students and professionals to be able to evaluate, diagnose and treat patients effectively. One major criticism of medical education is the gap that exists between what students learn in the classroom setting and what they experience in the clinical practice [5]. Few students analyze and use critical thinking when they acquire knowledge during their education [6]. Therefore, critical thinking skills are increasingly necessary for medical students and professionals [7].

Critical thinking is an indispensable component of ethical reasoning and clinical judgment, and possessing reasonable critical thinking skills reduces the risk of clinical errors [8]. Adverse events occurred

with human error, and preventable medical errors were frequently caused by failure of cognitive function (e.g., failure to synthesize and/or take action based on information), which were second only to 'failure in technical operation of an indicated procedure' [9, 10]. Similar problems have been reported in several countries such as the United Kingdom, Canada and Denmark [11]. Therefore, medical professionals need to exercise critical thinking, transcend simple issues and make sound judgments in order to handle adverse medical situations [12]. It is beneficial to provide evidence and logical arguments to medical students and professionals in order to support clinical decision-making and assertions [13]. Lipman and Deatrick are of the same opinion; i.e., that critical thinking is a prerequisite for sound clinical decision-making [14]. Therefore, medical students should be exposed to clinical learning experiences that promote the acquisition of critical thinking abilities, needed to provide quality care for patients in modern complex healthcare environments [15].

Currently, critical thinking is the synthesis which entails cognitive abilities and disposition.. The former includes interpretation, analyticity, inference and systematicity, whereas the latter includes having an open mind and being intellectually honest [16]. A disposition to critical thinking is essential for professional clinical judgement [17]. An assessment of critical thinking disposition (CTD) in professional judgment circumstances and educational contexts can establish benchmarks to advance critical thinking through training programs [7]. To investigate and assess critical thinking in medical students, a reliable and valid tool is indispensable.

Several critical thinking disposition measurement tools are available, such as the California Critical Thinking Dispositions Inventory (CCTDI), Yoon's Critical Thinking Disposition (YCTD) and the Critical Thinking Disposition Assessment (CTDA). The CCTDI was developed to evaluate normal adults' CTD [18] and has been translated into Chinese and Korean. However, it was developed in the context of a Western culture [19]. Both tests demonstrated that based on their slightly poorer psychometric characteristics, the semantics was less equivalent with the notion [20, 21]. Low Cronbach's alpha values for the CCTDI and its subscales were reported in studies conducted in Norway, South Korea and Iran; therefore, it may not be a suitable test for Norwegian, South Korean and Iranian populations [22, 23]. Yoon created the YCTD instrument based on the CCTDI for nursing students in South Korea [24]. The reliability of the YCTD instrument is considered to be satisfactory in nursing students, although there are still no studies assessing its validity in medical students [25]. On the other hand, Yuan et al. developed the CTDA to measure CTD in medical students and professionals and evaluated its psychometric properties in Taiwan Chung Shan Medical University in 2014 [26]. Therefore, the CTDA may be especially valuable for institutes or universities in Asian countries or with an Eastern culture for assessing critical thinking in medical students. Given the lack of effective instruments to assess CTD in undergraduate medical programs in mainland China, the objective of this investigation was to evaluate the psychometric properties of the CTDA.

Methods

Participants and procedures

This study involved stratified-cluster random sampling and participants from grade one to grade five (60 students per grade) at China Medical University were surveyed by means of a self-administered questionnaire. Three hundred medical students completed the online survey between March and June 2019. Subjects gave their approval to participate in the study via the online informed consent form.

Students in China must undergo five years of medical training. The first and second years are dedicated to basic sciences, the third and fourth years to clinical medicine and the fifth year is the internship. Investigators were well-trained with respect to the purpose and content of the questionnaire and they inspected the score after participants had completed it for quality control. Moreover, when more than 20% of the information was missing, it was considered unacceptable and the questionnaire was sent back to the participants. The total number of participants who completed the online study was 300, 278 and the valid response rate was 92.6%. The test-retest reliability was 0.931 and was assessed by Pearson's correlation between items and factors at two points in time. The published literature shows that the sample for test-retest reliability to assess the ICCs is 14 [27]. Forty-nine respondents were randomly selected to finish the online survey two weeks later and 43 participants completed it.

Instrument

The questionnaire consisted of two components: part A included sociodemographic characteristics (e.g., gender, whether the participant was an only child, religion and ethnicity), while part B contained the CTDA. The CTDA assessed the CTD of medical students and professionals and comprised 19 items grouped in three categories, as follows: factor 1: "systematicity and analyticity", factor 2: "inquisitiveness and conversance", and factor 3: "maturity and skepticism". Items were rated on a seven-point Likert scale ranging from 1 to 7 (1 for very *strongly disagree* and 7 for very *strongly agree*). Each category of the Chinese version of the CTDA was evaluated and added to obtain a total sum score. Higher scores in each domain revealed higher critical thinking.

Statistical analysis

Reliability

With the purpose of ensuring the reliability of the investigation, missing information was replaced with the median. We computed Cronbach's α as a measure of internal consistency along with the means, standard deviation, ceiling and floor effects of the questionnaire and its categories. The ceiling and floor effects were considered abnormal when the highest/lowest scores were higher than 20%. Following Kline's recommendations, a Cronbach's α above 0.70 was considered satisfactory [28]. The test-retest reliability was good if the ICC was higher than 0.70.

Validity

With the purpose of assessing construct validity, the original three-factor structure of the CTDA was applied for the CFA. The instrument category was assessed based on selected criteria through the following indexes: a) $CMIN/DF < 3$; b) $RMSEA < 0.08$; c) $AGFI > 0.80$; d) the p value should be significant [29,

30]. Pearson's correlation coefficient between each category of the CTDA was used to test the inter-correlation of the scale.

To evaluate the concurrent validity, whole categories were correlated with the SSACT. The SSACT is a tool for evaluating medical students' critical thinking ability. The convergent and discriminant validity of the questionnaire was measured by computing item-domain Pearson's correlations. If the former was more than 0.4, it indicated that the items and their categories were excellent [31]. The latter was considered satisfactory if items showed correlations with other categories that were lower than those with their own categories [32]. Data analysis was performed by SPSS version 23(for Windows), as well as IBM AMOS version 23(for Windows), and statistical significance was defined by p value(< 0.05).

Results

Sample

Two hundred seventy-eight participants out of a total of 300 responded the questionnaire, resulting in an overall response rate of 92.6%. Gender, only child and ethnicity characteristics are listed in Table 1.

Score distributions

The CTDA descriptive data is shown in Table 2. Across dimensions, "systematicity and analyticity" obtained the highest score (43.93 ± 5.71), whereas "maturity and skepticism" scored the lowest (28.41 ± 3.96). The skewness and kurtosis coefficients of the whole questionnaire were acceptable, with the former ranging from -0.98 to -0.32 and the latter ranging from -0.13 to 2.05. There were no floor effects in the three categories. However, item 19 showed a significant ceiling effect (23.74%).

Table 1. Sociodemographic characteristics of participants (n=278)

Characteristic	No.	%
Gender		
Male	113	40.6
Female	165	59.4
Only child		
Yes	148	53.2
No	130	46.8
Ethnicity		
Han nationality	214	77.0
Ethnic minorities	64	23.0

Table 2. Item scores and internal consistency of each factor (n=278)

Item	Mean±SD	Skewness	Kurtosis	Floor (%)	Ceiling (%)
Factor 1: "Systematicity and analyticity"	43.93±5.71	-0.61	1.04	0.00	1.79
(1) Find a conflicting statement in an article	5.27±1.09	-0.50	0.26	0.00	11.87
(2) Analyze all information before making a judgment	5.47±.96	-0.93	2.05	0.35	10.07
(3) Evaluate the rationality of the conclusion	5.43±0.95	-0.52	0.50	0.00	10.79
(4) Make sure the information is reliable	5.56±1.05	-0.76	0.63	0.00	17.26
(5) Know details about controversial problems	5.65±.98	-0.79	0.87	0.00	17.98
(6) Draw conclusions by logical thinking	5.39±.99	-0.62	1.12	0.35	11.15
(7) Examine advantages and disadvantages of each opinion	5.68±.96	-0.82	1.09	0.00	17.62
(8) Contemplate the right and wrong of things	5.49±1.01	-0.85	1.55	0.35	13.30
Factor 2: "Inquisitiveness and conversance"	32.67±4.59	-0.32	-0.13	0.00	2.15
(9) Learn as much as possible	5.12±1.25	-0.61	0.21	0.71	11.51
(10) Make an effort to collect all relevant information before a decision	5.64±1.05	-0.97	1.40	0.35	19.06
(11) Solve a problem with updated information	5.64±.95	-0.54	0.54	0.00	17.62
(12) Delve into any novel viewpoint	5.65±1.00	-0.72	0.95	0.00	20.14
(13) Make a decision with proper rules	4.93±1.15	-0.59	0.48	0.71	5.39
(14) Strive to seek potential solutions before deciding	5.70±.92	-0.91	1.23	0.00	15.82
Factor 3: "Maturity and skepticism"	28.41±3.96	-0.73	1.48	0.00	8.27
(15) Raise questions and respond to others' opinions	5.45±1.06	-0.80	1.17	0.35	13.66
(16) Comprehend and listen to different opinions before communicating	5.72±.94	-0.92	1.42	0.00	18.34
(17) Tolerate different viewpoints	5.80±.87	-0.82	1.77	0.00	19.78
(18) Correct the viewpoint with enough evidence	5.70±1.09	-0.98	0.89	0.00	23.02
(19) Question my prejudice, assumption, or belief	5.75±1.01	-0.94	1.85	0.35	23.74

Reliability

The overall Cronbach's α coefficient of the CTDA was acceptable (0.923) and showed great internal consistency. Three domains were considered to show excellent internal consistency (0.814-0.861). The overall split-half reliability coefficient of the CTDA was excellent (0.889). The retest response rate was 83.6% (41/49), and test-retest reliability revealed a statistically significant ICCs for the three domains. In this study, the ICCs ranged from 0.710 ("Inquisitiveness and conversance") to 0.795 ("Maturity and skepticism") ($p < 0.01$) (Table 3).

Table 3. CTDA internal consistency and test-retest reliability

	Cronbach's α coefficient(n=278)	ICCs (95%CI) (n=43)
Dimensions		
Factor 1: Systematicity and analyticity	0.861	0.722(0.357-0.788) **
Factor 2: Inquisitiveness and conversance	0.814	0.710(0.336-0.809) **
Factor 3: Maturity and skepticism	0.852	0.795(0.387-0.847) **
CTDA	0.923	0.792(0.336-0.809) **

** $p < 0.01$. ICCs, intraclass correlation coefficients.

Validity

Construct validity

We performed a confirmatory factor analysis of the three-factor structure with 19 items to demonstrate that the structure showed an acceptable fit with the data ($\chi^2=410.747$, $df=149$, $CMIN/DF=2.757$, $CFI=0.896$, $AGFI=0.828$, $p < 0.001$, $RMSEA=0.080$ [90% CI: 0.071 to 0.089]). factor loadings were higher than 0.40 and ranged from ($r = 0.50 - 0.85$), as illustrated in Fig.1.

Correlation analysis between CTDA dimensions

The CTDA showed significant correlation between any two assessment categories ($r = 0.605-0.722$), with p values less than 0.01. The correlations between assessment categories based on Pearson's correlation are shown in Table 4.

Table 4. Correlations between CTDA dimensions (n=278)

Dimension	1	2	3
1	—	0.722**	0.613**
2	0.722**	—	0.605**
3	0.613**	0.605**	—

**p < 0.01.

Concurrent validity

The correlation coefficients of the three dimensions with the SSACT scale and subscales are shown in Table 5. This analysis demonstrated a significantly correlation ($p < 0.01$) between the whole CTDA scale and subscales and the whole SSACT scale. The correlation coefficients were higher than 0.40 ($r = 0.459$ - 0.775), indicating that the concurrent validity of the CTDA was satisfactory.

Table 5 Concurrent validity of the CTDA (n=278)

Dimensions	Correlation coefficient		
	Active learning	Critical thinking	SSACT
Factor 1: Systematicity and analyticity	0.652**	0.769**	0.771**
Factor 2: Inquisitiveness and conversance	0.620**	0.661**	0.691**
Factor 3: Maturity and skepticism	0.459**	0.542**	0.543**
CTDA	0.669**	0.763**	0.775**

**p < 0.01.

Convergent validity and discriminant validity

Based on item-domain correlations, the scores of each item correlated with their own dimension to an acceptable degree ($r = 0.651$ - 0.857 , $p < 0.01$), and the convergent validity of the CTDA was excellent. In addition, whole items showed a higher correlation with their own categories than with other categories, and the discriminant validity was satisfactory, as shown in Table 6.

Table 6. Convergent and discriminant validity of the CTDA (n=278)

Domain	Correlation coefficient range		Convergent validity		Discriminant validity	
	Convergent validity	Discriminant validity	Success/total	Percentage (%)	Success/total	Percentage (%)
1	0.663-0.786**	0.360-0.578**	8/8	100	8/8	100
2	0.651-0.806**	0.272-0.629**	6/6	100	6/6	100
3	0.720-0.857**	0.436-0.545**	5/5	100	5/5	100

**p < 0.01.

Discussion

Results demonstrate that the CTDA is of reliability and validity for Chinese medical students. The psychometric sensitivity of the questionnaire was satisfactory and all items and subscales showed acceptable kurtosis and skewness coefficients. Our results were similar to those of previous studies conducted in Ireland and Iran using other critical thinking instruments [33, 34]. However, three items showed a significant ceiling effect, above the accepted threshold of 20%. This result was comparable to that reported in two critical thinking studies which showed evidence of a ceiling effect in overall scores in the United States and China [35, 36]. The ceiling effect might be attributable to the population distribution at schools or universities [36].

It is clear that the domains of the CTDA showed rationally acceptable reliability when evaluating the medical students' CTD. The satisfactory Cronbach's α coefficient values of the domains demonstrate the high internal consistency of the total questionnaire. Our results are in line with other studies conducted in Asian countries, since the Cronbach's α reliability of the CCTDI was shown to be 0.87 in Turkey by Gökhan [37], and 0.80 in Iran by Gupta [23]. Our study showed the Cronbach's α of the CTDA was 0.923, which was similar to the value reported in the original study [26]. Therefore, the Cronbach's α indicates that the whole internal reliability of the CTDA test is satisfactory.

Exploratory factor analysis of the CTDA conducted with medical students and professionals yielded a three-domain model in the original study [26]. Our CFA results indicated that the three-factor structure (factor 1: "systematicity and analyticity", factor 2: "inquisitiveness and conversance" and factor 3: "maturity and skepticism") of the CTDA (AGFI=0.828, RMSEA=0.080) showed an acceptable fit with the data. It is likely that the difference in the dimensions depend on the different theoretical models [38]. The domains of the CTDA test were similar to those reported in other studies conducted in Asian countries like Turkey, Japan and Korea, based on the theoretical model of Facione. The CFA of Koksals' Critical Thinking Test (AGFI=0.90, RMSEA=0.03) revealed a seven-factor structure, including similar domains (inquisitiveness, systematicity, analyticity, and self-confidence in reasoning) to those of our study [39].

Yoshinori reported that the CFA of the Critical Thinking Disposition Scale displayed four subfactors, similar to our study [40]. Shin noted that the CFA of the YCTD revealed a seven-domain model, and three of the domains (systematicity, intellectual eagerness/curiosity, and healthy skepticism) were similar to those of our study [25]. However, Zuriguel-Pérez reported that the CFA of the Critical Thinking Questionnaire completed by Spanish students yielded a four-factor model (personal, intellectual and cognitive, interpersonal/self-management and technical), based on the Alfaro-LeFevre theoretical model [41].

The concurrent validity results for the CTDA demonstrated significant correlations with the SSACT and subscales ($r=0.459-0.769$, $p<0.01$), a similar finding to that reported in the original study [26]. It was noticed that the correlation coefficient of concurrent validity for the “systematicity and analyticity” dimensions demonstrated the highest correlation with the SSACT. The result is consistent with the studies reported by Huang and Hu in their Master thesis [42, 43]. It is likely that Chinese students have excellent performance in mathematics and science subjects, which might depend on the ability to think logically to understand analyticity and systematicity [43]. On the other hand, it was noticed that “the maturity and skepticism” dimension demonstrated the lowest correlation with the SSACT. It is possible that the development of critical thinking in Chinese culture may face some complications since certain conventional principles and perspectives have been considered obstacles to the development of maturity and skepticism [44].

Our research demonstrated that the convergent validity and discriminant validity of the CTDA was satisfactory, and all items displayed a higher correlation with their own subscale than with other subscales. Therefore, no items need to be modified or reassigned to another subscale. Other studies conducted in China have reported similar results in terms of convergent and discriminant validity of the critical thinking disposition instrument [31] [45].

The CTDA shows promise as an instrument for future studies on critical thinking by medical students in China. However, certain limitations of our research should be acknowledged. First, the medical students were recruited from a single medical institution in China, so the sample representativeness was limited. Second, due to time constraints, the findings of our study were limited by the size of the study population. Future studies could increase the representativeness of the study population by expanding sample diversity and size.

Conclusions

Our findings demonstrate promising applicability of the CTDA, since the questionnaire is of reliability and validity to measuring CTD amongst Chinese medical students. The results may be valuable to other institutions involved in assessing critical thinking in students.

Abbreviations

CMIN/DF: Chi square divided by degrees of freedom; SSACT: Self-assessment Scale on Active Learning and Critical Thinking; ICCs: Intra-class correlation coefficients; SD: Standard deviation; CFA: Confirmatory factor analysis; CTDA: Critical Thinking Disposition Assessment; K-12: Kindergarten to 12th grades; RMSEA: Root mean square error of approximation; YCTD: Yoon's Critical Thinking Disposition; AGFI: Adjusted goodness-of-fit index; No.: Number; CCTDI: California Critical Thinking Dispositions Inventory; CFI: comparative fit index.

Declarations

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Availability of data and materials

All data and information used in this investigation is available upon request.

Authors' Contributions

CLY contributed significantly to the writing of the manuscript, TLM collected data, ZYX, QJL and WZQ analyzed the data, and QB conceived the study and rigorously revised the article. Final version was read and approved by all the authors.

Ethics Approval

Ethics approval for the investigation was granted by the Bioethics Advisory Commission of China Medical University. Participants voluntarily signed a consent form and understand the aim of the survey and that data collection would be non-anonymous. However, participant's privacy was guaranteed.

Consent for Publication

Not applicable.

Competing interests

None declared.

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