# Clinical ReasoningAssessment Tool(CRAT) forPreclinical Medical Students: a validation study.


## Abstract

**Background:** Case-based learning, a clinical reasoning inductive methodology,can be a pedagogical strategy for preclinical medical students. Self-confidence is also an essential issue in this phase of the medical course. Specific tools, such as questionnaires specially designed for this purpose, can better assess the development of these skills.
**Objective:**To validate a questionnaire that assesses preclinical medical students' clinical reasoning accuracy and self-confidence.
**Methods:**We designed the Clinical Reasoning Assessment Tool (CRAT), developed and validated to measure accuracy and self-confidence. The target population is the first- and second-year medical students. The questionnaire is compounded by 7 clinical cases of commonly known diseases, with 5 to 6 questions for each case. An expert panel developed the answers' template. A Likert scale was used to measure self-confidence. CRAT was applied in November 2022 to a more advanced samplethan the preclinical students: fourth-year students (4YMS, n=7) and internal medicine medical residents (IMMR, n=7). Statisticalanalysis included the Kolmogorov-Smirnov test to determine normality and Cronbach's alpha to determine the reliability of Likert scale answers. The student's t-test comprised CRAT measures. Pearson's correlation was applied for the primary measures. Statistical significance was set at $P < .050$.
**Results:**We observed an increase in average accuracy from 4YMS to IMMR (65.2±2.9% and 77.7±2.3%, respectively; $P = .006$). Although there was no difference in self-confidence averages, a moderate correlation was found between self-confidence and accuracy ($R = .663$, $P = .010$). The validation population considered the CRAT friendly and easy to answer.
**Conclusions:**The CRAT, a clinical reasoning assessment tooldeveloped for preclinical medical students, was applied to fourth-year students and medical residents, had discriminateaccuracy and correlated it to self-confidenceaverages.



**Keywords:**medical education, clinical reasoning, medical student assessment, assessment tool.




## Introduction

Medical education presents numerous pedagogical challenges, encompassing psychosocial [1-4] methodological and assessment concerns. [5-7] Clinical reasoning (CR) is a pivotal process for accurate diagnosis,[8] thereby mitigating errors. [9] Case-based learning is a methodology for CR development based on illness scripts and analytic habits. [10-14] It employs a framework for each case study to organize information, summarize the case, generate hypotheses, justify the choices, and plan management. [15] Testing this framework is essential for CR assessment. [15-19]. Once there are few

initiatives to evaluate clinical reasoning [20] systematically, this studyaimed to validate a tool for clinical reasoning assessment in preclinical medical students.

## Methods

We developed the Clinical Reasoning Assessment Tool (CRAT) based on Daniel et al. [15] and Cate [21] for clinical reasoning accuracy measures and associated a Likert scale for self-confidence measurement [22]. The types of questions suggested to assess each component of Clinical Reasoning (CR) were selected from a large constructive systematic review study, which selected the most discriminative questions among 377 articles on CR assessment, establishing weights for each type of assessment about each type of component. [15]. Questions based on the *Utrecht Case-based clinical reasoning test* (UCT) were also included[21].The assessed components of CR accuracy included compilation, summarization, differential diagnosis, central hypothesis, justification, pathophysiological explanation, and clinical management. CRAT has seven cases with five or six questions per case. As most studies on CR assessment included 12 to 40 questions, we used 40 questions in the CRAT (Table 1). The cases are about commonly known diseases, as the target population is preclinical. The distribution of the was as follows: extended multiple-choice(EMC)questions: 3; written case brief (WCB) questions: 5; Utrecht Case-based Clinical Reasoning Test (UCT) questions: 12; Modified essay questions (MEQ) in series questions: 6; Short open questions (SOQ): 12; Conventional multiple choice (CMC) questions: 2. Self-confidence questions: 7.A time of 120 minutes was established for the total resolution of the instrument.A Likert scale [22]was used to measure self-confidence. This research is registered in the Brazilian Ethical Committee for Human Beings Research under the number 66975122.9.0000.8967**.** CRAT was applied in November 2022 to a more advanced sample than the preclinical students: fourth-year students (4YMS, n=7) and internal medicine medical residents (IMMR, n=7) recruited by convenience. The standard answers from the template of the CR components were prepared by a panel of 3 *CR* experts who did not communicate with the validation responders. They made suggestions for writing or formulating questions to improve the instrument's clarityanddeveloped keywords that are expected in an answer considered correct. The following scale of answers was established for the CR questions: answers would be regarded asentirelyaccurate when they met the criteria of the answer and received a score of 1 (one); partially correct when elements provided for in the template were predominant to other components and, in this case, the score would be 0.5 (half); and considered wrong when they are entirely different from the template or with elements not predominant over the non-foreseen ones, receiving a score of 0 (zero). Thus, the minimum overall score was 0 (zero, 0%), and the maximum possible score was 40 (forty, 100%) in the questions on CR. The presentation of accuracyaverages was standardized in percentages.The 7 answers about self-confidence are not part of the template and were elaborated through visual means where the respondent should mark from 1 to 5 the self-confidence in selectedanswers, with 1 being the least confident and 5 the most confident, and can generate a total of 0 (zero) to 35 (thirty-five), with an average between 1 and 5. This result was presented as averages with the possibility of using percentages for graphical comparison.Statistical analysis included the Kolmogorov-Smirnov test to determine normality and Cronbach's alpha to determine the reliability of Likert scale answers. The student's t-test comprised CRAT measures. Pearson's correlation was applied for the primary measures. Statistical significance was set at $P < .050$.

Table 1. Questions' models and references on CRAT questions.

| Component | Method | Command | Reference |
|---|---|---|---|
| Data Compilation | Extended multiple choice (with more than one correct) (EMC) | In the case presented above, you classify the following information as relevant: (You can mark more than one correct). | Case, Swanson, Ripkey, 1994 [16] |
| | Written Case Briefs (WCB) | Write a case summary in 3 lines. | Dory et al., 2016 [18] |
| Hypothesis generation | Modified essay questions (in series, one linkedto the next) (MEQ) | You classify the following findings as relevant... Given the answer above you will summarize the case as... and then his central hypothesis is: ... Name 3 more differential diagnoses... | Rademakers, Cate, Bär2005 [23] |
| | Utrecht CBCR Test (UCT) | Choose one alternative for each question in the answer box. | Cate, 2017 [21] |
| Summary and Case headline | Short open questions (SOQ) | Summarize in 3 lines and/or in one sentence the clinical problem. | Rademakers, Cate, Bär, 2005 [23] |
| Differential diagnosis | Short open questions (SOQ) | Answers in 1 or 2 lines. | Rademakers, Cate, Bär, 2005 [23] |
| | Utrecht CBCR Test(UCT) | Choose one alternative for each question in the answer box. | Cate, 2017 [21] |
| Central Hypothesis | Conventional multiple choice (only one correct option) (CMC) | Conventional 5-option test | Daniel et al., 2019 [15] |
| | Utrecht CBCR Test (UCT) | Choose one alternative for each question in the answer box. | Cate, 2017 [21] |
| Diagnostic justification | Short open questions (SOQ) | Answers in 2 or 3 lines. | Rademakers, Cate, Bär, 2005 [23] |
| Workout | Conventional multiple choice (CMC) | Conventional 5-option test | Daniel et al., 2019 [15] |
| | Short open questions (SOQ) | Answers in 2 or 3 lines. | Rademakers, Cate, Bär, 2005 [23] |
| | Modified essay questions (in series, one linked to the next) (MEQ) | By raising such a hypothesis, you would request... and if this examination gives the result..., what would be your next step? ... In the event of a failed diagnosis or therapy, you would do... | Rademakers, Cate, Bär, 2005 [23] |
| | Utrecht CBCR Test (UCT) | Choose one alternative for each question in the answer box. | Cate, 2017 [21] |
| Self-confidence | Self-assessment | How confident are you with your answer to question number ... ? | Likert, 1932 [22] |

CRAT: Clinical Reasoning Assessment Tool. EMC: extended multiple-choice questions. WCB: written case brief. MEQ: modified essay questions. CBCR: Case-based clinical reasoning. UCT: Utrecht CBCR Test. SOQ: short open questions. CMC: conventional multiple-choice questions. Source: the authors, based on Daniel et al. [20] and Cate [28].



## Results

The Kolmogorov-Smirnov test determined the normality of the means of the primary objectives:accuracy (.200) and self-confidence (.131). The clinical reasoning components 'central hypothesis' (.200) and 'workout' (.187) also had normal distributions; the others did not. Cronbach's alpha was calculated to assess the reliability of the answers on the Likert scale, with results considered good to excellent (alpha= .768).

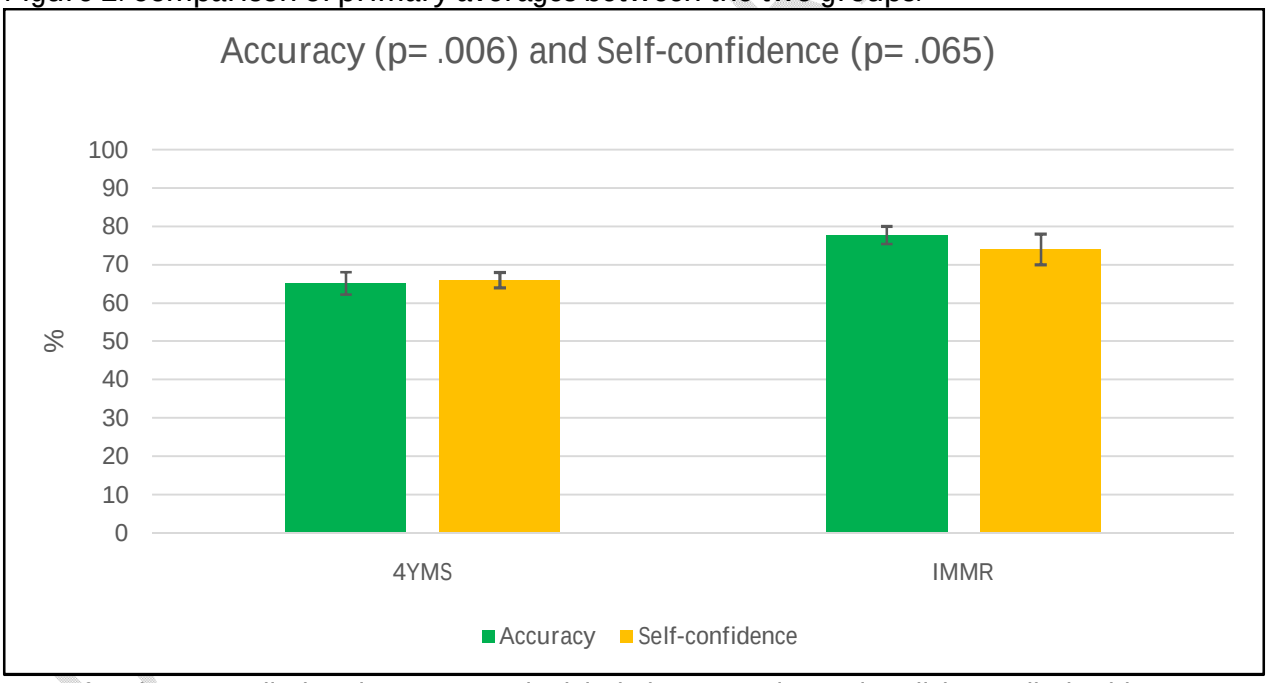
The accuracy averages differed between the two groups, but no difference was observed in the self-confidence averages (Table 2, Figure 1).

Table 2. Comparison of accuracy and self-confidence averages in the validation process.

| | 4YMS (SD) | IMMR (SD) | p |
|---|---|---|---|
| Accuracy | 65.2 (2.9) | 77.7 (2.3) | 0,006 |
| Self-confidence | 3.3 (0.1) | 3.7 (0.2) | 0,065 |

4YMS: fourth-year medical students. SD: standard deviation. IMMR: internal medicine medical residents. Source: the authors.

Figure 1. Comparison of primary averages between the two groups.

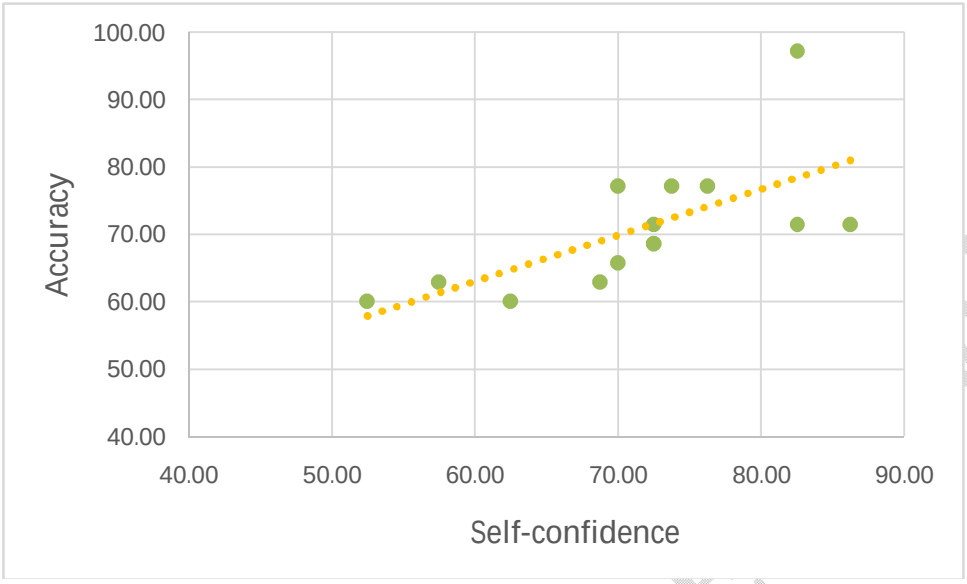



4YMS: fourth-year medical students. SD: standard deviation. IMMR: internal medicine medicalresidents. Source: the authors.

When compared by components of clinical reasoning, there was a difference only in the differential diagnosis skill (4YMS: 71% vs. IMMR: 91%, p= .006). The other components did not differ between the two groups.

We also found a moderate positive correlation between accuracy and self-confidence, with an R value of .6632 and a p value of .010 (Figure 2).

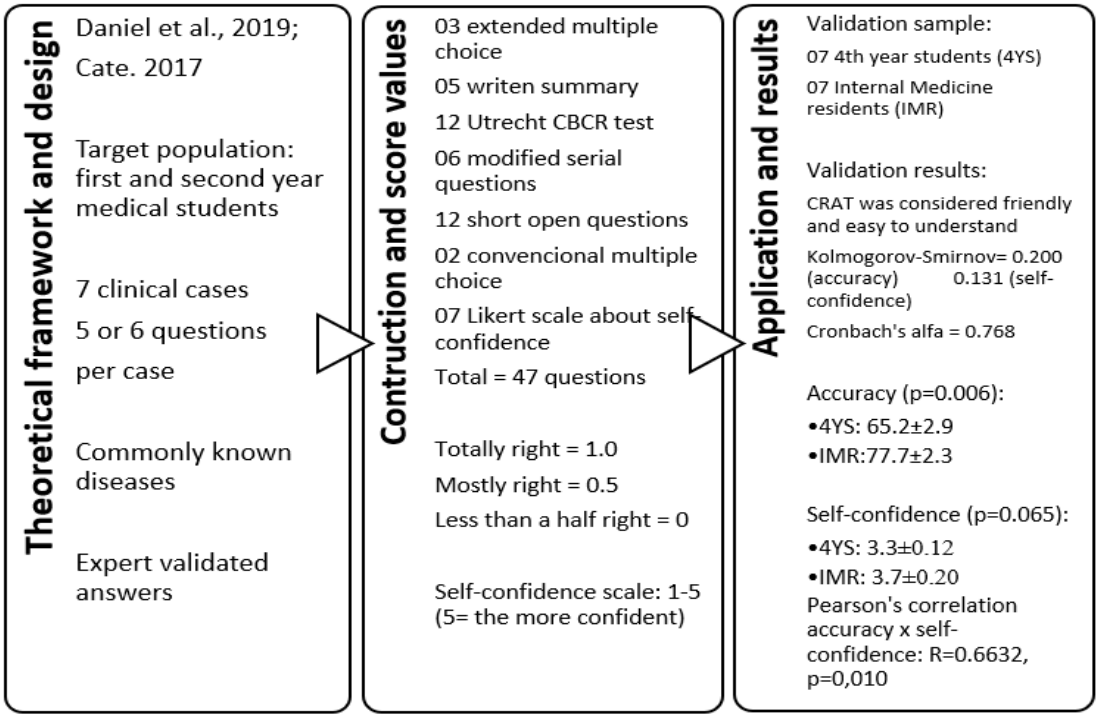
Figure2. Scatter plot between accuracy and self-confidence. Pearson's correlation.




Source: the authors.

All validation processes, from creation to results, are summarized in Figure 3.

Figure 3. Validation processes.




CBCR: case-based clinical reasoning. CRAT: Clinical Reasoning Assessment Tool. 4YS: fourth-year medical students. IMR: internal medicine medical residents. R: Pearson's coefficient. Source: the authors.

## Discussion

The questions developed derived from a robust, constructive review [15]. The added questions are supported by the literature [21,22]. After building solid articles, the Clinical Reasoning Assessment Tool (CRAT) was verified by experts, had an easy understanding of the application, and was evaluated through a template created by experts, with good to excellent reliability in self-confidence answers.An increasing accuracy resultwas obtained with the level of practice, and a correlation between accuracy and self-confidence was observed. There were differences only in the 'differential diagnosis'component of clinical reasoning.

These findings support the teaching and assessment of clinical reasoning in preclinical medical students once a systematic methodology is applied [21, 24]. The case-based learning (CBL) methodology is now understood to have pedagogical components that can complement students' psychological properties, giving learning a sense [25-27]. The primary objective of CBL is to clear students' medical decision-making [28] and to avoid diagnostic errors [29].

The accuracy growingwhile self-confidence has no difference suggests that medical students, having initial medical knowledge, tend to inflate their self-assessment [30]. This is highly suggestive of the phase I Dunning-Kruger effect [31]. In the artificial intelligence era, the illusion of competence can be dangerous [32] and must be fought by metacognitive awareness [33]. Enhancing critical thinking is one strategy to give students true-based self-confidence [25-27].

The correlation between accuracy and self-confidence suggests adouble-handed process in which better knowledge guides to better self-confidence, and true-based self-confidence leads to better skill achievements [21,34]. Critical thinking seems to be a moderator [25-27], and clinical reasoning teaching [34] and assessment [20] contribute to refiningmedical student's cognition.

Although our study has limitations, such as the limited sample size and groups, it can suggest that the CRAT assesses clinical reasoning in preclinical medical students. The next step is to apply the CRAT to a larger sample and compare it between medical schools with diverse pedagogical methodologies.

## Conclusion

The results show that the CRAT is easily applicable and has questions specially formulated for clinical reasoning assessment. The results of this validation study suggest that this methodology can discriminate between different levels of practiceand be applied to preclinical students' curricula.

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