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Analysis of Patient Information and Differential Diagnosis with Clinical Reasoning in Pre-Clinical Medical Students

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Abstract: Background: The development of clinical reasoning (CR) abilities in Thai medical students during their pre-clinical years lacked well-designed establishment. Methods: This study utilized a pre-test and post-test design without a control group and was conducted at Walailak University, Thailand, in May 2022. We collected participant baseline characteristics and compared scores evaluated by the instructor and participants before and after the intervention. Additionally, we conducted a post-intervention survey on workshop satisfaction, perspectives on CR, and its learning impact. Results: Nineteen third-year medical students were included in the analysis, and twelve (63.2%) were women. The mean age was 20.6 years (standard deviation, SD: 0.5). The total score evaluated by the instructor after the intervention (8.95; SD, 1.81) was significantly higher than that before the intervention (1.68; SD, 0.67), $p < 0.001$. The total score evaluated by the participants after the intervention (8.22; SD = 1.44) was significantly higher than that before the intervention (2.34; SD, 2.06), $p < 0.001$. Overall, satisfaction was high. Conclusions: A short interactive workshop effectively taught CR principles and practice to Thai third-year medical students. These findings support the possibility of implementing this in pre-clinical curricula to prepare them for clinical practice.

Keywords: clinical reasoning; differential diagnosis; medical informatics; medical students

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Citation: Mettarikanon, D.; Tawanwongsri, W. Analysis of Patient Information and Differential Diagnosis with Clinical Reasoning in Pre-Clinical Medical Students. *Int. Med. Educ.* **2024**, *3*, 23–31. https://doi.org/10.3390/ime3010003

Academic Editor: Hideki Kasuya

Received: 15 November 2023
Revised: 31 December 2023
Accepted: 11 January 2024
Published: 16 January 2024

1. Introduction

Diagnostic errors contribute to morbidity, mortality, and health system costs. Nearly 85% of adverse diagnostic effects have been judged to be preventable [1,2]. Better clinical reasoning (CR) has been proposed as a promising solution for alleviating diagnostic errors that put patient safety at risk [3]. CR is defined as a mental process that is based on gathering patient information and allows one to provide a conclusion about possible causes of patient illness, differential diagnosis, and appropriate strategies as the end goal [4]. The key elements of CR include the identification of the clinical information, the interpretation of its meaning, the generation of hypotheses, the testing and refining of those hypotheses, and constructing a working diagnosis [5]. Among the thinking models of CR [6], the main approaches have been strongly based on dual-process theory, positing two systems of decision making: system one, a fast and intuitive approach, and system two, a slow and analytical approach [7]. System one, so-called pattern recognition, is an approach that allows for the rapid comparison of a pattern in the current clinical scenario with the mental repository of illness scripts. This thinking process is automatic and unconscious [8]. Experienced clinicians were capable of retrieving illness scripts from their long-term memory to facilitate comparisons to generate a diagnostic hypothesis without considerable effort in [9]. Medical students probably see and deal with enough patients to start constructing and remembering illness scripts. System two is employed when they encounter a clinical pattern that does not have a similar pattern in their knowledge base. This analytic reasoning is claimed to be a skill that can be trained [10]. Since a systematic approach is lacking in well-reputed textbooks [11], medical students might find it difficult to achieve targeted skills with non-guided learning. Despite the training provided by clinical facilitators, the important prerequisites include basic scientific knowledge, including knowledge related to anatomy, physiology, pathology, pathophysiology, pathogenesis, epidemiology, and organ systems, combined with abstract descriptors. After a well-organized problem list or illness script is defined, differential diagnoses can be generated under commonly used frameworks, including anatomical, etiology, and system approaches [12]. A combination of approaches is necessary in certain circumstances. Moreover, systems one and two may interact in real clinical practice settings. Possible diagnoses are generated using system one, and they will then be ruled out by system two [13].

Education in CR is crucial in the early preclinical stage, as it lays the foundation for medical students' clinical competence, particularly in decision making for later clinical training [14]. It is important that student preparation for clinical encounters be improved to minimize diagnostic errors and negative consequences [15–17]. The pedagogy consisted of small group work guided by preceptors, large group lectures, case-based learning, and asynchronous individual work [14]. However, previous studies have shown that effective learning and teaching strategies for developing CR among pre-clinical medical students include small group activities, case-based learning, and integrated teaching. This approach emphasizes integrating biomedical and clinical knowledge and applying basic science to clinical cases and uses structured frameworks and illness script teaching with worksheets to enhance CR [18–20]. The majority of studies on CR originate from Western countries, making the direct generalization of teaching methods and findings challenging. This is because CR is influenced by personal attitudes, cultural perspectives, and preconceptions [21]. Eastern and Western cultures have different thinking styles, impacting decision making and CR. Western cultures favor an analytic approach, focusing on deterministic categorization, internal behavior attributes, clear choices between opposites, and a linear future view. In contrast, Eastern cultures adopt a holistic approach, emphasizing relationships among objects, behavior influenced by both internal and situational factors, compromise solutions, and a dialectical perspective on future changes [22]. Despite these cultural impacts on CR, research focused on CR in Asian contexts is limited. Findyartini et al. [23] compared medical students' attitudes towards CR in two medical schools and found that Indonesian medical students, in contrast to their Australian peers, tended to score lower in terms of flexibility of thinking, showed more dependence on teachers, and believed that their skills were primarily developed in clinical settings. Sawanyawisuth et al. [24] implemented the SNAPPS CR learning approach, originating from Western culture, at Thailand University. SNAPPS is a six-step process that includes the following: (1) concisely summarizing the patient's history and findings; (2) limiting the differential diagnosis to two or three relevant options; (3) evaluating the differential diagnosis by examining and differentiating between these options; (4) engaging with the preceptor through inquiries about uncertainties, challenges, or different strategies; (5) developing a management plan for the patient's medical problems; and (6) choosing a case-related topic for independent learning [25]. In this study, it was observed that in a CR course utilizing case presentations, Thai medical students, characterized by a generally passive demeanor, demonstrated a notably lower frequency of expressing uncertainties compared to their American peers.

Considering the cultural differences between Eastern and Western contexts, as well as the distinct cultures within Asia, which should be taken into account before implementing teaching and learning methods [26], we designed the course to include a hybrid of large group lectures and small-group activities, using step-by-step facilitation in a safe learning environment to foster CR and focusing particularly on enhancing flexibility of thinking and the ability to express uncertainties. A team discussion led to development of the following specific research questions (RQs): RQ1—What is the effectiveness of this specially designed CR course for Thai medical students in their pre-clinical years? RQ2—What are their perspectives of CR? We organized this short interactive workshop on diagnostic CR for third-year Thai medical students. Therefore, this study aimed to scrutinize the effectiveness of this workshop on Thai medical students' CR skill development, as well as their perspectives on CR at this learning stage.

2. Materials and Methods

2.1. Contexts

Our School of Medicine offers a six-year Doctor of Medicine (MD) program for Thai students, admitting 48 students each academic year. In the first three years (pre-clinical years), students study basic science, chiefly in lecture rooms and laboratories; in the last three years (clinical years), they gain clinical competencies during hospital rotations. Pre-clinical medical students undertake problem-based learning (PBL) for basic health science courses that are categorized by organ systems—the so-called "block system". Ten PBL sessions were conducted in each academic year. A seven-step PBL session was divided into two meetings using paper-based scenarios to drive the learning [27]. The initial five steps of information analysis were covered in the first meeting, including clarifying vocabularies, identifying the problem, exploring pre-existing knowledge, generating hypotheses, and identifying learning objectives. After their own independent study, the students came together in the second meeting to discuss the results as a group. Furthermore, assessment and reflection on learning occurred at the end of the second meeting. However, the PBL is not about clinical problem solving per se; rather, it is a method of achieving learning objectives and subsequently acquiring new knowledge and understanding [27]. The most critical transition period is usually at the beginning of their fourth year, when students move from the pre-clinical learning environment to a clinical setting where CR skills are needed. However, CR has not been well established in a formal pre-clinical curriculum in our setting.

2.2. Study Design

This pilot study, which was conducted at Walailak University, Thailand, in May 2022, utilized a pre-test and post-test design without a control group. A recruitment poster uploaded to a closed social media group (on Facebook) asked potential participants who were interested in the study to enroll. To minimize undue influence, our co-investigators organized the research register and withdrawal process. The inclusion criteria were as follows: (1) third-year medical students; (2) 18 years of age and older; (3) being able to attend a two-day CR workshop; and (4) voluntarily providing written informed consent. The exclusion criteria were as follows: (1) providing incomplete survey responses and (2) never attending the workshop. A participant could withdraw without consequences at any time for any reason. After eligible participants were voluntarily recruited, they were randomly divided into four groups using Excel 2019 (Microsoft Corporation, Redmond, WA, USA).

We collected the participants' baseline characteristics, including age, sex, and overall grade point average (GPAX). Tests and surveys on self-reported CR competencies before and after the intervention were used to assess the students' prior knowledge and any gains resulting from the workshop attendance. At the end of the study, a post-intervention survey asked the participants about their satisfaction with the workshop organization, perspectives on CR, and its impact on their learning. With a time allowance of 20 min, the participants were asked to complete a one-vignette test which was designed using short open-ended questions to monitor the participants' progress [28]. The questions included the following: (1) What are the pertinent subjective data? (2) What are the pertinent objective data points? (3) What is the problem list? (4) What is the differential diagnosis? (5) What is the most likely diagnosis and why? (6) What are the appropriate investigations? The answers were scored using the modified rubrics following Min Simpkins et al. [29]. We utilized the three-point score rubric to define four levels of performance: pre-emergent (no point), emerging (1 point), acquiring (2 points), and mastering (3 points). To the best of our knowledge, there is no existing standardized tool for self-assessment in CR, particularly for pre-clinical medical students whose primary language is Thai. To track changes in CR performance through self-assessment, we employed a visual analogue scale. This scale, which ranges from 0 (representing extremely poor) to 10 (indicating excellence), is based on a summative self-rating approach and was utilized to evaluate their skills [30]. Furthermore, in the survey on the participants' perspectives, the scores representing the level of agreement were rated on a scale ranging from 1 (completely disagree) to 5 (completely agree).

Sample size calculation was carried out based on a previous study [31] with an alpha of 0.05 and a power of 80%. Accounting for a potential loss to follow-up of 20%, the sample size calculation required approximately 19 participants to be recruited for the study. This study was approved by the Walailak Ethics Committee (WUEC-22-127-01). The ethics committee considered and complied with the laws of Thailand, including the Personal Data Protection Act (PDPA). We complied with the World Medical Association Declaration of Helsinki, which provides guidelines for the ethical conduction of research involving human subjects. The study was registered in the Thai Clinical Trials Registry (TCTR20220430006). All data files and personal information were encrypted, password-protected, and saved to a secure computer that was only accessible to the study coordinators to ensure confidentiality. The participants could access their own data by directly contacting the study coordinators. No information that could link an individual to the data was published or revealed beyond the immediate research team. All personal data were deleted after the completion of the study.

2.3. Workshop Protocol

We held a two-day interactive workshop in May, 2022 (Supplementary File, Table S1). The course required 3 h per day to complete. After the participants were divided into small groups of 4–5 members, they were instructed to practice CR by partaking in small-group learning. On day one, we delivered interactive mini-lectures that addressed the following topics: (1) the process of CR using dual-process theory; (2) the methods of analyzing patients' information, generating illness scripts, and defining a problem list; (3) the construction of a differential diagnosis using various diagnostic frameworks, i.e., anatomical, etiology, and system approaches; and (4) contrasting competing illness scripts and a contrastive learning strategy [32] to establish the most likely diagnosis. On day two, we delivered additional mini-lectures that addressed the following topics: (1) how to apply CR in PBL and (2) how to raise background questions; how to ask for general knowledge about a medical condition, investigation, or treatment; how to raise foreground questions; and how to ask for specific knowledge to effectively inform clinical decisions. The instructor taught the participants using step-by-step explanations. The participants were allowed to ask questions at any time during the workshop sessions. After each lecture, we distributed a clinical scenario with open-ended questions to each group. They were allowed to collaborate with existing members of the group. Their answers were shared with the class to ensure they met the learning objectives of each lecture. The instructor provided constructive feedback for improvement. A summary of the entire process is presented in Supplementary File, Table S1.

2.4. Statistical Analysis

For descriptive statistics, the mean and standard deviation (SD) were used to describe continuous data. Frequencies and percentages were used for categorical data. For inferential statistics, differences in pre- and post-intervention scores were evaluated using paired t-tests. A p-value of <0.05 in the two-tailed tests was considered statistically significant. Statistical analysis was performed using SPSS software version 18 (SPSS Inc., Chicago, IL, USA).

3. Results

A total of 22 participants were enrolled in the study, and 3 were excluded because of incomplete survey responses. The remaining 19 participants, all third-year medical students, were included in the statistical analysis; 12 (63.2%) patients were female. The mean age was 20.6 years (standard deviation, SD: 0.5). The mean GPAX of the participants was 3.80 (SD, 0.17; range: 3.41–4.00). The mean scores for all specific competencies for CR increased significantly after the intervention ($p < 0.001$) (Table 1). The total score after the intervention (8.95; SD, 1.81) was significantly higher than that before the intervention (1.68; SD = 0.67), $p < 0.001$. Self-evaluated CR skills also improved significantly. Consistent with the instructors' scores (Table 1), self-evaluated CR skills also improved significantly (Table 2).

Table 1. Participants' scores regarding specific competencies related to clinical reasoning, evaluated by comparing the pre- and post-workshop measures ($n = 19$).

Specific Competencies for Clinical Reasoning	**Mean Score (SD)**			***p*-Value**
	Pre-Intervention	**Post-Intervention**	**Change Score (Post–Pre)**	
Identify the pertinent facts of a clinical case	1.11 (0.57)	2.37 (0.50)	1.26 (0.73)	<0.001
Define a problem list	0.53 (0.61)	2.37 (0.50)	1.84 (0.76)	<0.001
Develop multiple working hypotheses (differential diagnosis)	0.05 (0.23)	1.95 (0.91)	1.89 (0.94)	<0.001
Provide the most likely diagnosis with a rationale	0.00 (0.00)	2.26 (1.10)	2.26 (1.10)	<0.001
A sum score of all performances	1.68 (0.67)	8.95 (1.81)	7.26 (1.88)	<0.001

Notes: The scale consists of four items, with each scored from 0 to 3 for a maximum of 12 points. Abbreviations: *n*, number of cases; SD, standard deviation.

Table 2. Self-evaluated clinical reasoning skills, evaluated by comparing the pre- and post-workshop measures ($n = 19$).

Observable Behaviors for Clinical Reasoning Course	**Mean Score (SD)**			***p*-Value**
	Pre-Intervention	**Post-Intervention**	**Change Score (Post–Pre)**	
Identify the pertinent facts of a clinical case	1.89 (2.58)	8.26 (1.37)	8.26 (2.24)	<0.001
Define a problem list	2.47 (2.22)	8.42 (1.46)	8.42 (2.12)	<0.001
Develop multiple working hypotheses (differential diagnosis)	2.47 (2.01)	8.05 (1.54)	8.05 (2.29)	<0.001
Provide the most likely diagnosis with a rationale	2.53 (2.29)	8.16 (1.77)	8.16 (2.52)	<0.001
A total score of overall performances	2.34 (2.06)	8.22 (1.44)	8.22 (2.13)	<0.001

Notes: The perceived scores of clinical reasoning skills were evaluated using a visual analog scale ranging from 0 (extremely poor) to 10 (excellent). Abbreviations: *n*, number of cases; SD, standard deviation.

In the post-intervention survey about their satisfaction with the organization of the workshop, perspectives on CR (Table 3), and its impact on their learning, participants agreed that the CR course should be offered to second-year medical students ($n = 8$, 42.1%) and third-year medical students ($n = 11$, 57.9%). They all preferred on-site learning to online learning, and nearly all participants ($n = 17$, 89.5%) declared that CR should be carried out with small-group learning rather than individual learning. The number of days and hours needed in each day to go through the key concepts and to allow time for the students to practice these concepts were 2.37 (SD, 0.94) and 2.68 (SD, 1.29), respectively. The participants' perspectives on CR are shown in Table 3.

Table 3. Participants' perspectives on clinical reasoning (*n* = 19).

	Mean Score (SD)
Organization of the workshop	
Given contents were specified.	4.89 (0.32)
Principle of CR process was well described.	4.84 (0.37)
The workshop had appropriate methods for achieving its objectives.	4.95 (0.23)
Instructor's teaching skills with a learning-by-doing approach.	5.00 (0.00)
Importance of evidence-based medicine was conveyed to the participants.	4.84 (0.37)
Enough time to go through the key concepts and allow time to practice these concepts.	4.89 (0.32)
Overall satisfaction.	4.95 (0.23)
CR in medical students in pre-clinical years	
Importance of pre-existing knowledge of basic science.	4.74 (0.45)
Importance of pre-existing knowledge of epidemiology.	4.42 (0.77)
Appropriacy of learning in pre-clinical years.	4.95 (0.23)
Agreement on implementing a formal CR curriculum.	4.89 (0.32)
I felt well prepared for clinical practice since it filled the gaps between basic science and clinical practice.	4.95 (0.23)
Benefits of learning CR	
CR will enhance the learning process of problem-based learning.	4.79 (0.42)
CR will heighten my appreciation of basic science and its application.	4.89 (0.32)
CR plays an important role in patient safety.	4.89 (0.32)

Notes: Scores representing the level of agreement were rated on a scale ranging from 1 (completely disagree) to 5 (completely agree). Abbreviations: CR, clinical reasoning; *n*, number of cases; SD, standard deviation.

4. Discussion

Our study aimed to assess the effectiveness of the early introduction of CR via hosting a workshop for Thai pre-clinical medical students and asking for their perspectives on CR. We found that the pre-intervention scores were low. However, the scores evaluated by the instructor and participants were significantly improved after the intervention. Furthermore, the participants declared a high level of satisfaction with the workshop and recognized that it may have an important impact on their future practice. To our knowledge, studies focusing on evaluating the effectiveness of CR in pre-clinical medical students in Asia [22,33], where ways of learning and thinking generally differ from those in Western countries, are scarce [23,34]. We designed a two-day interactive workshop to practice CR using small-group learning. Since the participants had not previously attended a CR course, we provided mini-lectures on the CR framework to prepare them for case-based learning. Considering the potential influence of flexibility in thinking and expressing uncertainties, which previous studies [23,24] suggest may negatively impact the development of CR skills in Asian medical students, we emphasized the importance of step-by-step explanations. We also allocated time for group discussions, promoting open-mindedness to enhance flexibility in thinking [35]. Additionally, we established a safe learning environment wherein providing wrong answers did not lead to penalization and instead provided opportunities for reflection and constructive feedback, thereby improving the students' abilities to express uncertainties [36,37]. These may be crucial components for fostering clinical reasoning skills among Thai pre-clinical medical students and essential for achieving significant improvements in learning outcomes.

Our findings were consistent with that of a previous study. Yousefichaijan et al. [31] revealed that a two-day workshop was effective in promoting problem-solving skills. However, all the participants were clinical medical students attending a pediatric ward rotation. Therefore, their results might not be directly comparable with those of our study because of the different levels of background knowledge and evaluation methods. In light of the low pre-intervention scores, the findings support the statement that components of PBL were not designed for clinical problem solving but rather as a method of identifying knowledge gaps and reporting findings via self-directed and small-group learning [27,38]. The low pre-test scores of the participants who have experienced PBL sessions for at least two years could conceivably reflect a lack of awareness of the concept of CR and CR skills. These skills are tremendously important when medical students practice with their real patients, not in case-based scenarios, particularly in clinical settings. It has been assumed that these skills will be learned by observing expert clinicians during the clinical years [39]. As a result, most students learn CR passively, with varying levels of supervision, and in a haphazard manner. Therefore, it is time to address these limitations and organize pre-clinical CR courses to prepare them with respect to how to deal with clinical experiences they will likely encounter in the future [40]. Additionally, we agreed that early introduction to CR during the pre-clinical years heightens student's meaningful appreciation of basic science and its application [41]. However, several factors contributing to a successful CR course should be considered, including prerequisite knowledge, the compatibility of the designed curriculum, the awareness of its importance, teaching techniques, the learning environment, student–teacher relationships, regular practice, and cultural contexts [5,14]. Further studies should be conducted to scrutinize the impacts of these factors on CR. This will help medical schools implement a formal CR curriculum that is horizontally and vertically integrated throughout the program [42].

Miller's model has been used for the assessment of clinical competence [43]. It comprises four levels: knows, knows how, shows how, and does. The first level reflects a learners' cognitive performance, whereas the second level corresponds to applied knowledge. The 'shows how' level requires the learner to show acquired and well-built competencies. The highest level ('does') represents what they would do in real-life practice. The workshop aimed to enhance the capacity for clinical-context application and the achievement at the 'knows how' level. Thus far, the effectiveness of the constructed response methods for CR evaluation has not been thoroughly tested. Nonetheless, a test comprising short open-ended questions was used because of its high internal consistencies and benefits in terms of progress evaluation [4].

The strengths of this study include the fact that it is the first study involving Thai medical students in their pre-clinical years that supports the assertion that it is never too early to teach CR. However, there are several limitations of this study that should be mentioned. First, no control group was included. We could not clearly demonstrate that the workshop enhanced CR skills better than a self-developed approach with suboptimal supervision would have. Second, this was a single-center study; therefore, it might not represent the findings of other medical schools with different curricula and settings. Third, skill retention after the workshop was not assessed. With regular monitoring, instructors can identify who might need further feedback and opportunities to brush up on their core knowledge and skills. Further randomized controlled studies with long-term follow-up in a multicenter setting with a similar curriculum are needed to determine the actual effectiveness of the well-designed CR course used in our investigation to ensure the appropriate generalization of the findings of this study. Fourth, the validity of using a summative self-rating approach for self-assessment in CR performances remains underexplored. Notably, there is a lack of standardized self-assessment tools for CR, particularly for pre-clinical medical students whose primary language is Thai. Therefore, further research is needed to develop and validate an appropriate tool.

5. Conclusions

Hosting a short interactive workshop on diagnostic CR for Thai third-year medical students proved to be an effective way to deliver the principles of CR and allow them to learn through practice with small-group learning. Remarkable improvements in CR skills (evaluated by the instructor and participants) were noted. Additionally, the students shared positive perspectives on CR. These findings support the possibility of implementing it into pre-clinical curricula to better prepare them for clinical practice.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/ime3010003/s1, Table S1: Learning organization and data collection in the short interactive workshop.

Author Contributions: All authors made a significant contribution to the work reported, whether in the conception of the study, the design of the study, the execution of the study, the acquisition of data, analysis and interpretation, or in all these areas; in drafting, revising, or critically reviewing the article; and in providing final approval regarding the published version of the manuscript. All authors have agreed on the journal to which the article has been submitted and agree to be accountable for all aspects of the work. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: This study was approved by the Walailak Ethics Committee (WUEC-22-127-01). We complied with the World Medical Association Declaration of Helsinki by ensuring the ethical conduction of research involving human subjects. Informed consent was obtained from all participants before they started participating in the study.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent to publish this study has been obtained from the participants.

Data Availability Statement: The datasets used or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflicts of interest.

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