Journal of Dental Sciences 20 (2025) 1622–1628

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.e-jds.com

Original Article

A study of critical thinking skills among Thai dental students: From disposition to skills assessment

Kittichai Sireerat [a,b], Naoko Seki [b,c,d*], Richard Foxton [d,e**], Shin-Ru Liao [f], Masako Akiyama [g], Supaporn Sangouam [a], Ikuko Morio [h]

[a] *Department of Preventive Dentistry, Faculty of Dentistry, Naresuan University, Phitsanulok, Thailand*
[b] *Department of Dental Education Development, Graduate School of Medical and Dental Sciences, Institute of Science Tokyo, Tokyo, Japan*
[c] *Office of Global Affairs, Institute of Science Tokyo, Tokyo, Japan*
[d] *Centre for Dental Education, Faculty of Dentistry, Oral & Craniofacial Sciences, King's College London, London, UK*
[e] *Global Education Section, Office of Education, Institute of Science Tokyo, Tokyo, Japan*
[f] *Department of Oral Care for Systemic Health Support, Graduate School of Medical and Dental Sciences, Institute of Science Tokyo, Tokyo, Japan*
[g] *Research Development Center, Institute of Science Tokyo, Tokyo, Japan*
[h] *Institute of Science Tokyo, Tokyo, Japan*

Received 15 December 2024; Final revision received 4 February 2025
Available online 27 February 2025

KEYWORDS
Assessment;
Critical thinking;
Dental education;
Skills;
Undergraduate

Abstract *Background/purpose:* Critical thinking skills might be influenced by culture. There has been no published research to date, on the critical thinking skills of Asian undergraduate students and so this study's purpose was to explore the critical thinking skills of Thai undergraduate dental students to elucidate their level and whether there might be need for training to improve their critical thinking.
Materials and methods: Participants were second- (n = 63) and fifth-year (n = 51) undergraduate dental students in the 2023 academic year at Naresuan University, Thailand. A questionnaire was distributed, which included questions on demographic information and a Thai version of the California Critical Thinking Skills Test (CCTST).
Results: The response rate was 100 % and the overall mean CCTST score of the students was 15.34 (SD 3.6). There were no statistically significant differences between the two years ($P > 0.05$), and "Induction" was not manifested. There was no significant correlation between

* Corresponding author. Office of Global Affairs, Institute of Science Tokyo, 1-5-45 Yushima, Bunkyo-ku, Tokyo, 113-8549, Japan.
** Corresponding author. Centre for Dental Education, Faculty of Dentistry, Oral & Craniofacial Sciences, King's College London, Floor 18, Guy's Hospital, Tower Wing, London, SE1 9RT, UK.
E-mail addresses: nseki.edev@tmd.ac.jp (N. Seki), richard.foxton@kcl.ac.uk (R. Foxton).

https://doi.org/10.1016/j.jds.2025.02.005

GPA and all the domains of the CCTST scores; however, there was a significant correlation between students' frequency of critical thinking use and overall CCTST score ($P = 0.047$, $\rho = 0.187$) and what students thought about the importance of critical thinking and their frequency of critical thinking use ($P < 0.01$, $\rho = 0.337$).

Conclusion: The critical thinking skills scores of all the undergraduate Thai dental students were found to be moderate indicating a need for interventions aimed at improving all the domains of critical thinking skills in particular the domain of "Induction" in the undergraduate curriculum.

Introduction

Person-centred care takes into consideration not only the patient's rights but also those of the care team overseeing the patient as well as placing importance on patient-staff relationships.[1,2] This therefore necessitates that the patient's healthcare team is both culturally-sensitive and has effective team-working skills so that the care provided is relevant and meets the patient's expectations.[2,3] These factors could be considered core values for a healthcare worker and require the application of critical thinking skills to evaluate all the available evidence before arriving at a diagnosis and delivering care, which would help ensure the healthcare professional has a comprehensive understanding of the nature of the patient's particular health condition.[4] Moreover, critical thinking is a crucial element of complex problem solving, which will facilitate the delivery of clinical care with appropriate professional behavior and is now considered to be a very important element of dental education.[5]

An ability to think critically should be fostered during undergraduate dental training in a learning environment that supports its' development rather than encouraging the reciting of facts verbatim.[5] However, unless an undergraduate dental student is willing to cultivate critical thinking, this skill would not be useful in practice. Previous research on critical thinking among undergraduate dental students at a Canadian dental school using the California Critical Thinking Disposition Inventory (CCTDI) and the California Critical Thinking Skills Test (CCTST), found that those students with an ability to think critically and a disposition to do so, were likely to exhibit these same attributes towards the end of their training.[5] Moreover, those students who exhibited the highest grades at graduation also recorded the highest critical thinking scores both at the beginning and end of their training.[5] On the other hand, our previous study, which investigated the critical thinking disposition of Thai undergraduate dental students using the CCTDI, found that open-mindedness, inquisitiveness, analyticity and confidence in reasoning sub-scales gave high scores whereas truth-seeking, systematicity and maturity of judgement sub-scales scored lower and the results did not guarantee a correlation with academic outcomes.[6] These research findings indicate that there might be differences among undergraduate students at different dental schools and with different cultural backgrounds with regards to a disposition towards critical thinking, which might also be the case for critical thinking skills and therefore further research on these is indicated.

Several studies have described the introduction of tools into an undergraduate curriculum in order to improve critical thinking skills and their assessment with dental educators recommending the introduction of training programs to develop these skills.[7–10] However, there is no consensus among educators on the pedagogy for teaching critical thinking.[10] As with critical thinking disposition, critical thinking skills acquisition might be influenced by the characteristic of the students and their attitude, and/or academic performance might be a factor in their development. However there have been no investigations on critical thinking skills among Thai undergraduate dental students and assessing students' critical thinking skills will help educators better understand their students' performance, which might be situation dependent.

Therefore, the aims of this study were to investigate the critical thinking skills of undergraduate dental students in different years of training in a dental school in Thailand to elucidate their levels and whether there was indication for interventions to improve their critical thinking skills.

Materials and methods

This study was approved by the Institute of Education Ethics Committee of Tokyo Medical and Dental University (TMDU), Tokyo, Japan (No. C2022-029), and the Naresuan University (NU) Institutional Review Board, Phitsanulok, Thailand (IRB No. P1-0002/2566).

All second- (n = 63) and fifth- (n = 51) year undergraduate dental students studying at NU in January 2023, were invited to participate this study and if they consented, were asked to complete an anonymous questionnaire. Participation was voluntary and only the data of those who consented to participate in the study were collected. For the second-year students, the data collection was taken after they completed the professional development subjects, which introduced the concept of critical thinking; and for the fifth-year dental students, the data were collected while they were in clinical training at a dental hospital.

The questionnaire consisted of demographic data, questions about their tendency for critical thinking, and the Thai version of the California Critical Thinking Skills Test

(CCTST).[11] Demographic questions were about their gender, age, school year, grade point average (GPA: The course grade is interpreted in NU as excellent (4.00), very good (3.50–3.99), good (3.00–3.49), fairly good (2.50–2.99), fair (2.00–2.49), poor (1.50–1.99), very poor (1.00–1.49), and failed (below 1.00).), and the questions about critical thinking were: "to what level do you think critical thinking skills are important (a 5-point Likert scale from 1 indicating "not important" to 5 "very important")" and "how often do you use critical thinking skills for learning in dental school? (from 1 indicating "never" to 5 "very frequently")". The CCTST measures all the core reasoning skills needed for reflective decision making. There are 34 engaging, scenario-based questions that require 45–55 min to complete.[11] The instruments contain five metrics which are "Analysis", "Inference", "Evaluation", "Induction", and "Deduction".[11] The statements for the metrics and qualitative interpretation of the scale scores are shown in Table 1. The "Overall" score reflects a person's overall ability to use reasoning for making reflective judgments about beliefs and actions. To achieve a high score, individuals need to demonstrate strong, sustained, and cohesive application of "Analysis", "Inference", "Evaluation", "Induction", and "Deduction". This score calculated by an integration of the five-scale serves as an indicator of one's potential for success in educational or professional environments that require rational decision-making and careful problem-solving. The equation for the overall score is not publicly available and is calculated and returned from the developer. The overall score recommended performance assessments are divided into five categories: 0–7: not manifested, 8–12: weak; 13–18: moderate; 19–23: strong; and 24–34: superior.[11]

Statistical analysis

Statistical analyses were conducted using IBM SPSS Statistics for Windows® (version 26.0, IBM Corp., Armonk, NY, USA). The normality of the data was evaluated using a histogram, a Q–Q plot and was further assessed with the Shapiro–Wilk test and was found to be not normally distributed. The two-sided Mann–Whitney U test was selected to compare CCTST scores, between the scores of second- and fifth-year students, age, and questions about critical thinking. The Chi–Square test was selected to compare their gender and GPA; and for a correlation analysis between the CCTST scores and their demographic data, Spearman's rank correlation test was used. All tests were two-tailed, with the significance level set at $\alpha = 0.05$.

Results

All 114 students agreed to participate in the study giving a response rate of 100 % with 59.6 % of female. Their GPA was mostly in the range of 3.51–4.00 (57.9 %), and seconded in the range of 3.00–3.49 (31.6 %). The participants considered critical thinking to be either "very important" (78.8 %) or "important" (15.8 %) and in their opinion regarding the frequency of using critical thinking, they thought that they "always" (45.6 %) or "often" (43.9 %) used critical thinking. The participating students were homogeneous in that all the students' cultural backgrounds were Thai.

California Critical Thinking Skills Test (CCTST)

The overall mean CCTST score of the students was 15.34 (SD 3.6). The CCTST scores of the second- and fifth-year students showed similar patterns (Table 2) and could be interpreted as follows: Analysis was "Moderate" (score period 3–4); Inference was "Moderate" (score period 6–11); Evaluation was "Moderate" (score period 4–7); Induction was "Not manifested" (score period 0–5); and Deduction was "Moderate" (score period 6–11).

The mean scores of second- and fifth-year students showed no statistically significant differences between the years ($P > 0.05$).

The Spearman's rank correlation test was used to analyze the relationship between the CCTST scores and the demographic information (Table 3). The analyses showed no significant correlation between GPA and all the domains of the CCTST scores; however, there was a significant correlation between students' frequency of critical thinking use and overall CCTST score ($P = 0.047$, $\rho = 0.187$) and what students thought about the importance of critical thinking and their frequency of critical thinking use ($P < 0.01$, $\rho = 0.337$).

Discussion

Previous research has highlighted that while it is now accepted that critical thinking teaching must be integrated into healthcare education, there are multiple challenges to

Table 1 California Critical Thinking Skills Test (CCTST) metric statements and qualitative interpretation of scale scores.

CCTST metric	Statement	Qualitative interpretation of scale scores		
		Not manifested	Moderate	Strong
Analysis	"Accurate identification of the problem and decision-critical elements"	0–2	3–4	5 or more
Inference	"Drawing warranted and logical conclusions from reasons and evidence"	0–5	6–11	12 or more
Evaluation	"Assessing credibility of claims and strength of arguments"	0–3	4–7	8 or more
Induction	"Reasoned judgment in ambiguous, risky, and uncertain contexts"	0–5	6–11	12 or more
Deduction	"Reasoned judgment in precisely defined, logically rigorous contexts"	0–5	6–11	12 or more

Source: California Critical Thinking Skills Test: User Manual and Resource Guide.[11]

Table 2 Comparisons of the demographic data, California Critical Thinking Skills Test (CCTST) mean and median scores of second- and fifth-year students.

			2nd year	5th year	Mean difference	*P*-value
Number of participants			63	51		
Gender	Female	n (%)	22 (35)	21 (41)	–	0.435[a]
	Male	n (%)	38 (60)	30 (59)	–	
	No answered	n (%)	1 (2)	0 (0)	–	
	Other	n (%)	2 (3)	0 (0)	–	
GPA	<1.50	n (%)	0 (0)	0 (0)	–	0.000[a]
	1.50–1.99	n (%)	0 (0)	0 (0)	–	
	2.00–2.49	n (%)	0 (0)	3 (6)	–	
	2.50–2.99	n (%)	1 (2)	8 (16)	–	
	3.00–3.49	n (%)	11 (17)	25 (49)	–	
	3.50–4.00	n (%)	51 (81)	15 (29)	–	
Age		Median (min–max)	21 (19–25)	23 (22–25)		
		Mean (SD)	21.1 (1.8)	23.3 (1.0)	2.2	0.000[b]
Importance		Median (min–max)	5 (3–5)	5 (3–5)		
		Mean (SD)	4.7 (0.6)	4.8 (0.4)	0.1	0.114[b]
Frequency		Median (min–max)	4 (2–5)	4 (3–5)		
		Mean (SD)	4.4 (0.8)	4.3 (0.6)	0.1	0.533[b]
CCTST scores	Overall	Median (min–max)	16 (6–24)	14 (8–23)		
		Mean (SD)	15.6 (3.8)	15.1 (3.4)	0.5	0.339[b]
	Analysis	Median (min–max)	5 (0–8)	4 (1–8)		
		Mean (SD)	4.5 (1.7)	4.5 (1.7)	0.0	0.799[b]
	Inference	Median (min–max)	7 (1–10)	7 (2–9)		
		Mean (SD)	6.6 (1.8)	6.3 (1.6)	0.3	0.384[b]
	Evaluation	Median (min–max)	4 (0–8)	4 (0–9)		
		Mean (SD)	4.5 (1.7)	4.3 (2.1)	0.2	0.571[b]
	Induction	Median (min–max)	5 (1–9)	4 (0–9)		
		Mean (SD)	5.7 (1.8)	4.3 (2.1)	0.1	0.704[b]
	Deduction	Median (min–max)	8 (1–14)	6 (1–11)		
		Mean (SD)	8.5 (2.7)	5.6 (2.1)	0.6	0.184[b]

SD, standard deviation; Importance, the extent to which participants believe critical thinking skills are important; Frequency, how often participants use critical thinking skills for learning in dental school; GPA, grade point average; CCTST scores, California critical thinking skills test scores.
Analyzed by [a] the Chi-Square test; and [b] the two-sided Mann-Whitney U test.

bring this about successfully.[5,12] Pedagogy maybe influenced by culture, and recent published research has emphasized cultural differences in the construction and teaching of critical thinking between Western and Eastern education systems particularly in higher education.[12,13] Previous research has investigated western and eastern thinking and reported that East Asians are holistic, consider the entire surroundings, assign causality and rather than using categories or formal logic, rely more on "dialectical" reasoning, however a different approach tends to be preferred in Western cultures.[14] A study looking at possible cultural differences towards critical thinking in international higher education reported that Asian students tended to display more self-reported dialectical thinking to solve problems than their Western peers, however, while academic performance was predicted by critical thinking skills, it was not susceptible to the influence of culture.[15] The researchers indicated that because critical thinking involves different cognitive skills and dispositions, further research on the relationship between skills, dispositions and behaviors and how culture might be related to critical thinking skills was indicated.[15]

The results of the CCTST in this study, which involved Thai undergraduate dental students studying at a university in Thailand, revealed that both the second and fifth-year students displayed similar patterns of scoring for the different critical thinking skills. However, while the CCTST for both years revealed "Moderate" critical thinking skills levels for "Analysis", "Inference", "Evaluation" and "Deduction", "Induction" was "Not manifested" and there was no significant correlation between academic performance with all these domains. Without inductive thinking, students might find it more challenging to question assumptions, evaluate evidence, and form reasoned arguments. Recognizing this, Thai education has identified the issue and should actively work to develop thinking skills. The learning environment could be transformed to encourage students to ask more questions. This shift prompts them to engage in discussions and debates with their peers to find the best solutions.[16]

Previously published research on the critical thinking skills of undergraduate dental students using the CCTST found that students recorded the highest scores for "Inference" and the lowest scores for "Analysis" although

Table 3 Correlation between California Critical Thinking Skills Test (CCTST) score and demographic data (N = 114).

	Analysis	Inference	Evaluation	Induction	Deduction	GPA	Importance	Frequency
Overall	0.678** (0.000)	0.641** (0.000)	0.677** (0.000)	0.731** (0.000)	0.775** (0.000)	0.007 (0.942)	0.046 (0.630)	0.187* (0.047)
Analysis		0.211* (0.025)	0.246** (0.008)	0.375** (0.000)	0.493** (0.000)	-0.012 (0.903)	0.029 (0.760)	0.102 (0.278)
Inference			0.110 (0.246)	0.366** (0.000)	0.692** (0.000)	0.082 (0.385)	0.078 (0.409)	0.142 (0.131)
Evaluation				0.730** (0.000)	0.369** (0.000)	-0.060 (0.527)	-0.006 (0.945)	0.174 (0.064)
Induction					0.233* (0.013)	-0.050 (0.594)	-0.058 (0.542)	0.143 (0.128)
Deduction						0.048 (0.609)	0.087 (0.609)	0.188* (0.045)
GPA							0.068 (0.469)	0.158 (0.094)
Importance								0.337** (0.000)

The Spearman's rank correlation test was performed for the correlation analysis between the CCTST scores and demographic data (two-tailed, significance level was set at $\alpha = 0.05$). Values represent Spearman's rank correlation coefficients, and in parentheses indicated *P*-values.
Importance, the extent to which participants believe critical thinking skills are important; Frequency, how often participants use critical thinking skills for learning in dental school; GPA, grade point average.

the level of critical thinking (not manifested, weak, moderate, strong, superior) as indicated in the CCTST was not reported.[5,11] Moreover, the cultural backgrounds of the undergraduate students attending the dental school in the previous study were not reported.[5] The findings of the present study therefore indicate that there might be differences with respect to "Induction" with previously published research and that further research is indicated on whether a dental student's cultural background or "adopted" culture has an influence on the level of particular critical thinking skills.

Previously published research using the CCTST shows variability in the scores, and therefore creates a dilemma as to how to interpret such findings.[5,17–22] In addition, the mean CCTST scores of this study (15.3, SD 3.6) were lower than the optimal CCTST scores (17.1, SD 5.0) reported by the developer.[11] and were less than a previous study's mean CCTST scores for undergraduate dental students (24.7, SD 4.0).[5] Therefore, introducing critical thinking assessment into Thai dental education seems essential but how to develop students' optimal critical thinking skills remains a conundrum.

In healthcare such as medicine and dentistry, clinical reasoning is used to assess and analyze a patient's medical and dental status then make a diagnosis in order to plan and deliver the appropriate care.[23] Clinical reasoning can be classified as two types "inductive/forward and deductive/backward",[23,24] and in the case of inductive reasoning, several facts are considered together and then a conclusion is arrived based on these facts, however if all the relevant facts are not observed, then it's possible that the incorrect conclusion will be drawn.[23] In the deductive reasoning process, a mental model for solving particular problems is built based around solid principles and this is used to draw a particular conclusion.[23] These different types of reasoning will have different roles when it comes to solving complex problems and in regards to delivering healthcare, it is thought that an inductive approach is effective for actions that do not have a defined goal such as planning and designing, whereas a "deductive approach is more helpful for a diagnostic task".[23] The type of reasoning likely to be used by both novices and experts has also been discussed and it was reported that experts used an inductive approach when tackling simple, straightforward problems and a deductive approach for more challenging and complex problems, whereas novices were recommended to use deductive reasoning for problem solving because they have a lower level of prior knowledge.[23] This has led to the conclusion that critical thinking skills necessary for clinical reasoning should be taught in medical schools.[23]

The CCTST was chosen to investigate the critical thinking skills of the undergraduate dental students as this tool has been previously validated.[5] The utilization of the CCTST instrument requires consideration of potential language or cultural barriers when interpreting assessment items. The Thai version of the CCTST, developed and authorized by the instrument developer team in collaboration with international scholars, addresses this need.[5] Nevertheless, to ensure it accurately measures the critical thinking skills of dental students, the instrument's psychometric properties should be revised and specifically evaluated for this population.

The results of this study indicate that with regards to teaching critical thinking skills to undergraduate dental students studying dentistry, in particular Thai undergraduate students, interventions aimed at improving all the domains of critical thinking skills should be delivered and that the domain of "Induction" might need to be particularly focused on. Recently, a dental critical thinking model has been introduced using the concept of the expert's thought processes which have become critical thinking skillsets to guide student learning and for measuring their thinking.[7] Also, previous research using the CCTST has reported on the benefit of teaching "concept mapping" to medical students taking an anatomy course to improve critical thinking skills.[25] It was found that those medical students who were taught through concept mapping exhibited an increase in the CCTST scores compared to those who were not.[26] It is considered that constructing maps helps students develop clinical reasoning skills through the stimulation of analysis, interpretation and evaluation thinking skills and therefore the enhancement of their critical thinking skills.[25,26] In NU, at the beginning of the dental program, pre-clinical students engage in problem-based learning (PBL) by working on basic science problems designed to encourage group discussions and collaboration. During the clinical phase, PBL is applied to problems related to clinical cases, allowing students to engage in more in-depth discussions and practice evidence-based decision-making. Concept mapping is predominantly utilized in students' research projects, which are a mandatory component of their clinical training. This tool enables students to visually organize their ideas, identify relationships between concepts, and systematically plan their work. It is particularly valuable for presenting research findings in a clear and structured manner. However, further research on the educational benefits of introducing concept mapping into Thai undergraduate dental training to improve their critical thinking skills is indicated.

In the present study, dental students perceived critical thinking to be important and were willing to practice critical thinking. Similar findings were also observed in our previous study in that although their dispositions were positive, this may not equate to a high skill level.[6] Therefore, a learning environment should be created to reinforce and challenge them to practice critical thinking.[27] Educators are encouraged to be aware of the influence of learning environment disruption,[28] that integrates effective instructional approaches,[29] in which the selection of learning strategies together with appropriate course design as an instructional institution intervention should also be focused on.[30] In such learning environments, previous research indicated the immersion and infusion-based instructional interventions based on five instructional design principles, which are problem-centered, activation, demonstration, application, and integration, would foster the acquisition of critical thinking skills.[31]

In NU, while teaching methods including PBL, team-based learning, reflection, and active learning have been implemented, and the results of this study have provided information on the level of the critical thinking skills of different years of undergraduate students and indicate that interventions to improve critical thinking skills should be developed further and implemented in their undergraduate curricula. Further research on the critical thinking skills of Thai undergraduate students in different dental schools in Thailand and at institutions overseas, is also indicated to determine if the findings of the present study can be applied more widely.

It is important that pedagogies for improving the critical thinking skills are introduced into undergraduate dental curricula worldwide as critical thinking is essential for delivering dental care successfully and it is important that critical thinking skills learnt during undergraduate training are practiced after graduation.[32] Specifically assessing undergraduate dental students' critical thinking skills using tests such as the CCTST provides useful information on whether pedagogies, which were considered to teach critical thinking, are actually doing so in practice.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

Acknowledgments

This work was supported by JST SPRING, Grant Number JPMJSP2120.

References

1. Meranius MS, Holmström IK, Håkannson J, et al. Paradoxes of person-centred care: a discussion paper. *Nurs open* 2020;7:1321–9.
2. Kanamori Y, Seki N, Foxton R, et al. Fostering globally competent dental students through virtual team-working, problem-solving and person-centred multi-disciplinary care planning. *J Dent Sci* 2023;18:95–104.
3. Tucker CM, Marsiske M, Rice KG, Jones JD, Herman KC. Patient-centered culturally sensitive health care: model testing and refinement. *Health Psychol* 2011;30:342e50.
4. Ditmeyer MM, Mobley CC, Devenport WD. Evaluation of an integrative model for professional development and research in a dental curriculum. *J Dent Educ* 2014;78:368–79.
5. Whitney EM, Aleksejuniene J, Walton JN. Critical thinking disposition skills in dental students: development and relationship to academic outcomes. *J Dent Educ* 2016;80:948–58.
6. Sireerat K, Seki N, Akiyama M, Kinoshita A, Morio I. Critical thinking disposition among Thai dental students. *J Dent Educ* 2022;86:968–75.
7. Johnsen DC, Lipp MJ, Finkelstein MW, Cunningham-Ford MA. Guiding dental student learning and assessing performance in critical thinking with analysis of emerging strategies. *J Dent Educ* 2012;76:1548–58.
8. Marshall TA, Straub-Morarend CL, Handoo N, Solow CM, Cunningham-Ford MA, Finkelstein MW. Integrating critical thinking and evidence-based dentistry across a four-year dental curriculum: a model for independent learning. *J Dent Educ* 2014;78:359–67.
9. Krupp MM, Holloway JA, Johnsen DC, Marchini L, Butali A. A national window on critical thinking by dental educators following an ADEA webinar. *J Dent Educ* 2021;85:699–703.
10. Seki N, Sireerat K, Foxton R, Liao SR, Morio I. Critical thinking education for dental schools in Asia: perception of educators. *J Dent Sci* 2023;18:443–7.

11. Insight Assessment. *California critical thinking skills test: user manual and Resource guide*. Hermosa Beach, CA: California Academic Press, 2021.
12. Ho YR, Chen BY, Li CM. Thinking more wisely: using the Socratic method to develop critical thinking skills amongst healthcare students. *BMC Med Educ* 2023;23:173.
13. Chuenjitwongsa S, Bullock A, Oliver RG. Culture and its influences on dental education. *Eur J Dent Educ* 2018;22:57e66.
14. Nisbett RE, Peng K, Choi I, Norenzayan A. Culture and systems of thought: holistic versus analytic cognition. *Psychol Rev* 2001; 108:291—310.
15. Lun VMC, Fischer R, Ward C. Exploring cultural differences in critical thinking: is it about my thinking style or the language I speak? *Learn Indiv Differ* 2010;20:604—16.
16. Sithsungnoen C. *Implementation of case-based learning for thinking skills development: essential skills of the 21st century of Thai students*, vol. 11. Veridian E-Journal, Silpakorn University, 2018:19—31.
17. Tsai TH. Validating use of a critical thinking test for the dental admission test. *J Dent Educ* 2014;78:552—7.
18. Williams KB, Schmidt C, Tilliss TS, et al. Predictive validity of critical thinking skills and disposition for the national board dental hygiene examination: a preliminary investigation. *J Dent Educ* 2006;70:536—44.
19. Williams KB, Glasnapp DR, Tilliss TS, et al. Predictive validity of critical thinking skills for initial clinical dental hygiene performance. *J Dent Educ* 2003;67:1180—92.
20. Azizi-Fini I, Hajibagheri A, Adib-Hajbaghery M. Critical thinking skills in nursing students: a comparison between freshmen and senior students. *Nurs Midwifery Stud* 2015;4: e25721.
21. Fero LJ, O'Donnell JM, Zullo TG, et al. Critical thinking skills in nursing students: comparison of simulation-based performance with metrics. *J Adv Nurs* 2010;66:2182—93.
22. Vendrely A. Critical thinking skills during a physical therapist professional education program. *J Phys Ther Educ* 2005;19:55—9.
23. Shin HS. Reasoning processes in clinical reasoning: from the perspective of cognitive psychology. *Korean J of Med Educ* 2019;31:299—308.
24. Fischer R. Public relations problem solving: heuristics and expertise. *J Publ Relat Res* 1998;10:137—53.
25. Maryan A, Mohammadreza D, Abdolhussein S, Ghobad R, Javad K. Effect of concept mapping education on critical thinking skills of medical students: a quasi-experimental study. *Ethiop J Health Sci* 2021;31:409—18.
26. Bilik Ö, Kankaya EA, Deveci Z. Effects of web-based concept mapping on students' concept mapping critical thinking skills; a double blind, randomized controlled study. *Nurse Educ Today* 2020;86:104312.
27. Ebbeling S, Adam L, Meldrum A, Rich A, McLean A, Aitken W. Oral health and dental students' perceptions of their clinical learning environment: a focus group study. *J Dent Educ* 2018; 82:1036—42.
28. The AJM, Adam L, Meldrum A, Brunton P. Dental students' and staff perceptions of the impact of learning environment disruption on their learning and teaching experiences. *Eur J Dent Educ* 2018;22:151—9.
29. Tiruneh DT, Verburgh A, Elen J. Effectiveness of critical thinking instruction in higher education: a systematic review of intervention studies. *High Educ Stud* 2014;4:1—17.
30. Alsaleh N. Teaching critical thinking skills: literature review. *Turkish Online J Educ Technol* 2020;19:21—39.
31. Tiruneh DT, Cock M, Elen J. Designing learning environments for critical thinking: examining effective instructional approaches. *Int J Sci Math Educ* 2018;16:1065—89.
32. Johnsen DC, Marchini L, Syrbu J, et al. Impact of dental school critical thinking demonstrations carryover to practice: survey of 5-year graduates. *J Dent Educ* 2025;89:107—15.