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A critical issue: assessing the critical thinking skills and dispositions of undergraduate health science students

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Abstract
Critical thinking skills and dispositions are significantly important factors that aid in one's ability to understand and solve complex problems. Within the field of higher education, critical thinking skills and dispositions are valued and encouraged but are not always fully developed at the completion of the undergraduate degree experience. Those students who are studying to enter the healthcare field are particularly in need of strong critical thinking skills and dispositions in order to provide patients and communities with effective, evidence-based care in the midst of an ever-increasingly complex environment. What program of study a student selects, and the unique curriculum design of that program, may impact the development of these skills and dispositions during undergraduate study. This quantitative study sought to explore and understand the critical thinking skills and dispositions of undergraduate students enrolled in a BS in Health Science (BSHS) degree program, and how these skills in particular compared to the national student population. During the Spring 2022 academic semester, 140 senior-level BSHS students were given the opportunity to complete the California Critical Thinking Skills Test and the California Critical Thinking Disposition Inventory. Results show less development in critical thinking skills when compared to the national student population, with Numeracy skills being the most poorly developed, and Truth-Seeking being the most inconsistent disposition possessed by the student participants. The implications of these findings, particularly for faculty who teach students planning to enter the healthcare field, are offered, including recommendations for curricular design and modification.

Keywords Critical thinking · Educational assessment · Health science education · Undergraduate education

1 Introduction

Critical thinking skills and dispositions allow students to gather, interpret, and reflect upon how new information and data can be applied to address personal and professional needs and situations [1]. While there is no one singular definition, critical thinking is often described as an active, attentive, and purposeful method by which one analyzes facts and information to form a judgment or accomplish a specific goal [2]. This is an important set of skills and attitudes for students in the health sciences to possess, as critical thinking allows one to be comfortable with the possibilities of new perspectives and ideas, which is crucial for healthcare practice. Additionally, critical thinking is necessary for the development of current and future clinical reasoning skills [3]. This is partly due to the need for students to learn to be appropriately skeptical when reviewing treatment techniques, best practice guidelines, and new research that may impact their means

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of practice and care delivery [4]. To be able to work effectively and rationally in the healthcare and medical fields, critical thinking skills and dispositions must be properly developed and supported in educational settings [5].

The Carnegie Foundation for Teaching and Learning [6] has proposed four major categories of recommendations for the reform of medical and health science education: Teaching and learning to promote integration, promoting habits of inquiry and improvement, individualizing learning, using standardized assessments, and supporting the progressive development of professional identity. These recommendations parallel the subsequent evolution of education and teaching theories over the past century [7], namely the dynamic nature of the learning and the teaching processes, and the importance of the teaching environment. Both undergraduate and graduate-level health science educational programs are recognizing that these reforms are needed in order to meet the current and future demands being placed upon healthcare professionals, and that the environment in which learning is taking place is as important as the content being shared. Much of the emphasis behind these proposed reforms is centered around the need for future healthcare professionals to not only know the didactic and intellectual aspects of their work, but to also be able to solve complex problems and to think critically about their work and their identities as healthcare workers.

As such, critical thinking is a fundamental aspect of quality clinical decision-making among a variety of healthcare professions. To be able to think rationally and clearly, especially when encountering problems and uncertainty at work, is a necessary skill to be effective in the kinds of environments and situations that are common in the healthcare and medical fields [5]. Undergraduate health-focused students who have critical thinking education embedded into their curriculum have shown improvements in their problem-solving skills [8], which may have particularly important outcomes in promoting patient safety. Health education programs that teach critical thinking have been found to help reduce diagnostic errors, improve overall patient safety, and reduce cognitive those biases that can lead to poorer patient outcomes and professional practice [9]. This need for critical thinking is not just present in professional practice, but during pre-professional educational experiences as well, where the ability to enhance the capacity for problem-solving and wider reasoning is necessary to perform well academically [10]. This is especially important considering the significant pressures that are placed upon students during their academic careers at the undergraduate level to perform well academically to secure spots in clinical and graduate programs after completing their baccalaureate degrees.

The consequences of not possessing critical thinking skills in healthcare and medicine can be significant. Healthcare professionals who do not possess a capacity for critical thinking and problem-solving skills have a measurable impact on the health of their patients and communities, specifically poor rates of compliance with health recommendations and treatments, as well as direct harm to the health and wellbeing of those being served [11]. Given the importance of having a healthcare workforce that can practice critical thinking as part of their professional work, it is necessary to better understand how critical thinking skills and attitudes can be instilled within healthcare professionals, both during their pre-professional education and throughout their professional careers.

By understanding the current level of critical thinking skills and attitudes of health science students before they enter their professional fields of practice, it can be possible to identify those areas of strength, those areas of weakness, and how to make changes as needed within health science education programs to better prepare students for a professional field that demands strong critical thinking skills, attitudes, and applications. In addition, by understanding how skills, attitudes, and overall academic performance relate to one another, health science education programs can be more purposeful in how they advise students, develop curriculum, and track student progress throughout their academic journey.

This study sought to answer the following research questions:

RQ1: What are the critical thinking skills of undergraduate health science students at a four-year, public, comprehensive state university?
RQ2: How do the overall critical thinking skills of undergraduate health science students at a four-year, public, comprehensive state university compare to the national population of undergraduate students?
RQ3: What are the dispositions towards the importance of critical thinking of undergraduate health science students at a four-year, public, comprehensive state university?
RQ4: To what degree is overall academic performance as measured by grade point average (GPA) a reasonable indicator of critical thinking development?

2 Study methods

The theoretical framework for this study was heavily influenced by the work of Dr. Peter Facione, whose seminal work in the field of critical thinking assessment is utilized by educators, employers, and policymakers who recognize the need for students and alumni of institutions of higher education to be able to properly demonstrate these skills and dispositions as a result of their time in higher education [12]. An additional component to the assessment work developed by Facione is the need for not only developing critical thinking skillsets, but also the development of those dispositions and attitudes, what Facione and colleagues call the critical spirit, that are needed in order to possess the internal drive and motivation to apply critical thinking skills in various aspects of one's personal, professional, and social spheres of life [13].

The work done by Facione in the development of this framework has been studied and utilized by other researchers, particularly around assessing the critical thinking skills and disposition of healthcare professionals and health science students. This framework has been utilized by Nair et al. [14] in the development of their Critical Thinking Self-Assessment Scale, which was built specifically to be utilized by nurses as part of their own critical thinking self-assessment. Facione's critical thinking assessment work has also been used to evaluate the effectiveness of different educational interventions with regard to their ability to improve critical thinking in pre- and post-exposure to treatment. A 2020 study by Wu et al. [15] utilized the disposition assessment tool developed using Facione's work to evaluate the effectiveness of mind mapping exercises to increase critical thinking inclination of students. Additionally, the assessment tools built from this framework have been used to evaluate the potential predictors of critical thinking abilities of undergraduate students, such as taking courses online or transferring courses from another college or university [16].

2.1 Population and sample selection

The participants for this study were BS in Health Science (BSHS) students enrolled at a four-year, public, comprehensive state university located on the east coast of the United States. All participants were 18 years of age or older, were enrolled in one of five sections of the senior-level BSHS research course that was offered in the Spring 2022 academic semester, and agreed to participate in this study. Two additional sections of the course were offered that did not participate in the data collection efforts of this study. Participants in this study were those students in attendance during the class period that was utilized to administer the critical thinking assessment tools.

Students had declared one of the following concentrations within the BSHS degree: General Concentration, Pre-Occupational Therapy, Pre-Physical Therapy, or Pre-Communication Disorders. Participants were given the opportunity to complete each assessment tool in a voluntary capacity and were not required to complete either or both assessments under any conditions. As the study participants were recruited as part of the senior-level research course of the BS in Health Science degree, all participants were nearing the culmination of their undergraduate career at the time of data collection. No exclusionary criteria were used in selecting study participants beyond their enrollment within the BS in Health Science degree and current enrollment in the senior-level research course. All data collection took place after obtaining all necessary approvals from the Stockton University IRB Committee, including CITI training by the researcher. IRB approval was obtained after submitting all required documentation, proof of CITI training, study procedures, and informed consent documents (Stockton University IRB Approval Number #2021.175). A total of 194 students were enrolled in the senior-level research course during the Spring 2022 semester, with 5 sections of this course agreeing to participate in data collection efforts, who in total represented 140 enrolled students or 72% of the total student population enrolled in the senior-level research course in the Spring 2022 semester.

2.2 Instrumentation

The researcher used the California Critical Thinking Skills Test (CCTST) and the California Critical Thinking Disposition Inventory (CCTDI) for data collection purposes, and administered each assessment to students enrolled in the senior-level research course for the BS in Health Science degree. These tests are owned and administered by Insight Assessment and were developed in part by the work in Critical Thinking Assessment (CTA) theory as described by Peter et al. [12, 13]. The CCTST is a 34-item, multiple-choice, non-discipline-specific test that evaluates critical thinking along 8 different subscales: Analysis, Interpretation, Inference, Evaluation, Explanation, Inductive Reasoning, Deductive Reasoning, and Numeracy. It is estimated that the CCTST takes an average of 45 min to complete. Each multiple-choice question item is related to generic situations not unique to any particular domain of work. Scores are developed using a proprietary

formula, and range from low or non-manifested, weak development, moderate development, strong development, and superior development [17].

The CCTDI consists of 75 generic statements with a 6-point Likert-selected response scale that is also non-discipline specific. The CCTDI test evaluates disposition towards critical thinking along 7 different subscales: Truth Seeking, Analyticity, Open-Mindedness, Systematicity, Confidence in Reasoning, Inquisitiveness, and Maturity of Judgement. It is estimated that the CCTDI takes an average of 15–20 min to complete. Scores can range from 5 to 60 for each subscale and indicate a level of disposition ranging from weak disposition development, positive disposition development, or strong disposition development [18]. Each tool is delivered via an online web-based portal owned and operated by Insight Assessment. Both of these tools were selected due to their previously established validity and reliability in assessing the critical thinking skills and attitudes of study participants [13]. The CCTST has documented strength in both the content validity of each of the skill domains as well as construct validity. Validity has been demonstrated by correlational studies exploring critical thinking skills with additional measurements such as GPA and GRE scores, as well as for criterion (predictive) validity [13, 19, 20]. The CCTST has also shown strong internal reliability with documented Cronbach's Alpha coefficients ranging from 0.60 to 0.78 on individual scales, and 0.90 or above for the overall measure [17]. See Appendix A for the breakdown of the score ranges that pertain to each level of development for the CCTST and the CCTDI.

The CCTDI has also been researched and assessed for its validity and reliability, with the inventory items being found to be valid with an internal consistency reliability score of 0.887 [21]. This has also been shown with a cross-cultural application of the CCTDI, with high content validity across cultural versions of the inventory with alpha coefficients ranging from 0.81 to 0.97 [22]. A recent meta-analysis by Orhan explored the reliability of the CCTDI using 98 alpha values across 87 unique studies of the CCTDI. Orhan found the CCTDI to be reliable across samples with an alpha value of 0.83 [23]. These studies have shown strong consistent validity and reliability for the CCTDI as an instrument for the assessment of the critical thinking dispositions of students.

To assure ongoing validity and reliability for both the CCTST and the CCTDI in this study, both tools were delivered exactly as instructed by Insight Assessment. No variations were made to either instrument, no questions or sections were added, omitted, or changed, and study participants met all requirements for participation as described by the Insight Assessment user's manual [17, 18].

2.3 Data collection and management

All data collection took place during the first 2 weeks of March 2022. Study participants and faculty were informed that participation in the data collection phase of this study was purely voluntary and that there would be no penalty for not participating in the study. All participant information has been kept confidential, and participants were provided with an informed consent form prior to the data collection beginning. Participants were also informed that the information collected for this study would not be shared with members of the public in any identifiable way and that all study findings would be presented as aggregated data. All data collection took place during the traditional meeting time of each confirmed section of the senior-level research course, with two sections meeting via Zoom conference, and three sections meeting face-to-face in a university computer lab.

Distribution and completion of each of the assessments took place via the online portal offered through Insight Assessment. Each class meeting allowed for adequate time for both assessments to be administered in a single class meeting. Data collection took place as an in-class activity for that day's class meeting, and there was no course penalty for not taking part in the data collection. Should a student have declined to participate in the in-class activity during the day of data collection, they would have been provided with an assigned reading on critical thinking in the healthcare field that would be utilized for in-class discussions after the data collection activity had concluded. No student declined to participate in the study. In an effort to reduce student anxiety, students were assured that all results were purely for the purpose of assessment and that class rankings or comparisons would not be shared. Additionally, there was no additional course credit given for participation, nor were there any extra credit or similar potentially coercive incentives provided for data collection participation. To ensure each student participant had the opportunity to access the online platform, all in-person meetings took place in a university computer lab. For the 2 sections that met with the researcher via Zoom conferencing, all students had access to a laptop or computer with internet access. For these sections, the faculty member teaching the course was present in the Zoom room. It should be noted that since these meetings took place over Zoom, the continuity of the environment in which students were completing the assessment could not be guaranteed when compared to those students completing the assessment in a university computer lab.

Table 1 Ethnicity of students completing the CCTST

Ethnicity	Frequency	Percent
Asian, Asian American, Pacific Islander	10	8.0
Black, African American	9	7.2
Hispanic, Latino, Mexican American	18	14.4
Other	1	0.8
White, Caucasian, Anglo American	87	69.6
Total	125	100.0

Table 2 Declared BSHS degree concentrations

Concentration	Frequency	Percent
Pre-occupational therapy	26	20.8
Pre-physical therapy	23	18.4
Pre-communication disorders	20	16.0
General	56	44.8
Total	125	100.0

2.4 Data analysis

All data collection took place during the first 2 weeks of March 2022, with all data being collected before the beginning of the Spring break period of the term. After all data collection was completed, reports were generated by Insight Assessment to provide results of Overall Critical Thinking Skills, Critical Thinking Skills across each Subscale, Overall Critical Thinking Dispositions, and Critical Thinking Dispositions across each Subscale. The overall critical thinking skill score population means for both the national undergraduate student population and the national health science undergraduate student population were obtained through Insight Assessment to allow for comparison between these two national populations and the study sample.

Descriptive statistics were generated for overall and subscale scores for the CCTST and the CCTDI, and frequency statistics were generated for ethnicity, gender, and declared concentration within the BSHS degree. T-tests for independent samples were conducted for gender for both the CCTST and the CCTDI. Overall student scores for the CCTST were analyzed for comparison to the national population of undergraduate students via one sample t-test. For the demographic variable of Degree Concentration, which includes General Concentration, Pre-Occupational Therapy Concentration, Pre-Physical Therapy Concentration, and Pre-Communication Disorders Concentration, the researcher conducted a one-way analysis of variance. All statistical analysis was conducted using the IBM SPSS software Version 25.

3 Results

3.1 Research question 1

RQ1 sought to understand the critical thinking skills of undergraduate health science students at a four-year, public, comprehensive state university by utilizing the CCTST offered through Insight Assessment. Of the 140 total students who were invited to participate in this, 130 students completed the CCTST, as 10 students in total did not attend class on the day of data collection. Using the criteria set forward by Insight Assessment, the data results from 5 student participants were removed from the final report of the data, as they completed the CCTST in under 15 min, which would not be considered an adequate amount of time to thoughtfully respond to each question being asked. As a result, a total of 125 students completed the CCTST in full, representing approximately 89% of the potential sample. The mean age was 22 years of age, with 79% indicating female gender identity. See Table 1 for ethnicity findings and Table 2 for the frequency of each concentration identified within the BS in Health Science degree.

The CCTST is designed to assess and measure the critical thinking and numeracy skills that are used in the process of reflective reasoning in order to make an informed judgment about what to do, or what to believe, in a particular situation or setting. The CCTST provides an overall critical thinking score, as well as scores across 8 sub-domains: Analysis, Inference, Evaluation, Induction, Deduction, Interpretation, Explanation, and Numeracy. A brief description of each domain is described in Appendix B.

The CCTST scores are calculated by Insight Assessment via a proprietary formula for both the overall score and the score of each sub-domain. Study sample scores for overall critical thinking ability, as well as across each sub-domain, are shown via descriptive statistics in Table 3. One-way analysis of variance showed no statistically significant difference ($p = 0.708$) in the Overall Critical Thinking Skills Scores of participants among the different degree concentration options (Pre-Occupational Therapy, Pre-Physical Therapy, Pre-Communication Disorders, and General) within the BS in Health Science students (see Tables 4, 5).

3.2 Research question 2

RQ2 sought to answer was to understand how the overall critical thinking skills of undergraduate health science students at a four-year, public, comprehensive state university compared to the national population of undergraduate students. Aggregate data provided by Insight Assessment shows that the population mean score for overall critical thinking skills of four-year college/university undergraduate students is currently 75.3, which can be compared to the overall critical thinking skills score of 69.96 for the study's sample. The results of the one-sample t-test showed that the overall critical thinking skills score of the study sample is significantly lower than that of the national four-year college/university undergraduate student population (see Table 6).

As Insight Assessment does not collect aggregate data for the sub-domain measurements, comparison between the national four-year college/university undergraduate student population and the study sample for each sub-domain was not possible.

3.3 Research question 3

RQ3 sought to understand the dispositions towards the importance of critical thinking of undergraduate health science students at a four-year, public, comprehensive state university. Of the 140 total students who were invited to participate in this, 130 students completed the CCTDI, as 10 students in total did not attend class on the day of data collection, representing approximately 93% of the potential sample. The mean age was 22 years of age, with 80% indicating female gender identity. See Table 7 for ethnicity findings, and Table 8 for frequency of each concentration identified within the BS in Health Science degree. It is important to note that the sample size is larger for RQ4 (n = 130) than for RQ1, RQ2, and RQ3 (n = 125), as all students who completed the CCTDI did so at or above the minimum amount of time deemed necessary to ensure validity and accuracy of the results.

The CCTDI is designed to assess the critical thinking mindset and attitudes of individuals toward critical thinking. The CCTDI provides scores across 7 subdomains: Truth-Seeking, Open-Mindedness, Inquisitiveness, Analyticity, Systematicity, Confidence in Reasoning, and Maturity of Judgment. A brief description of each domain is described in Appendix C.

Table 3 Descriptive statistics of study sample CCTST performance

CCTST category	Minimum	Maximum	Mean	Standard deviation	Level of development
Overall	61	85	69.96	5.161	Weak/moderate
Analysis	55	92	69.78	7.411	Weak/moderate
Inference	61	85	71.90	5.162	Moderate
Evaluation	55	92	69.07	7.323	Weak
Induction	60	90	72.54	5.720	Moderate
Deduction	58	84	68.87	5.702	Weak
Interpretation	59	88	71.97	6.370	Weak/moderate
Explanation	55	92	69.11	7.617	Weak
Numeracy	55	90	67.62	6.574	Not manifested/weak

Table 4 Descriptive results of concentration comparisons

Concentration	N	Mean	Std. deviation	Std. error	95% confidence interval for mean lower bound	95% confidence interval for mean upper bound	Minimum
Pre-OT	25	70.12	4.893	0.979	68.10	72.14	62
Pre-PT	23	70.78	4.899	1.021	68.66	72.90	64
Pre-CD	21	68.95	4.387	0.957	66.96	70.95	61
General	56	69.93	5.685	0.760	68.41	71.45	61
Total	125	69.96	5.161	0.462	69.05	70.87	61

Table 5 One-way analysis of variance of concentrations for critical thinking skills

Overall	Sum of squares	Df	Mean square	F	Sig
Between groups	37.580	3	12.527	0.464	0.708
Within groups	3265.220	121	26.985		
Total	3302.800	124			

Study sample scores for overall critical thinking dispositions, as well as across each sub-domain, are shown via descriptive statistics in Table 9, with the sub-domain of Inquisitiveness showing the highest mean score of 46.5, and the sub-domain of Truth-Seeking showing the lowest mean score of 35.4. It is important to note that there are no national population means available for comparative purposes, as Insight Assessment does not collect this kind of national mean data for the CCTDI. The reason for this is that there is no correct or incorrect answer for each of the 6-point Likert questions asked in the CCTDI, and there is no ideal mean score for study results to be measured against.

3.4 Research question 4

RQ4 sought to understand to what degree overall academic performance, as measured by grade point average (GPA), is a reasonable indicator of critical thinking development. To help correct for multiple comparisons, a Bonferroni Correction was conducted. An adjusted p-value was computed by dividing a 0.05 level of significance by the number of correlations for both the CCTST and the CCTDI. For the CCTST, the adjusted p-value (0.05/9) was 0.005. For the CCTDI, the adjusted p-value (0.05/8) was 0.006. Tables 10 and 11 shows the correlation matrix between Critical Thinking Skills and GPA, and Critical Thinking Dispositions and GPA, respectfully, that indicated a statistically significant relationship. For both tables, relationships that are significant at the 0.05 level are marked with a single asterisk (*) and those that are significant at the adjusted p-value levels are marked with a double asterisk (**). Pearson correlation shows a statistically significant positive correlation between GPA and overall critical thinking skills (0.235, $p = 0.008$), as well as across all critical thinking subscales (Table 10), with the subscale of numeracy showing the highest correlation with GPA (0.300, $p = 0.001$). Pearson correlation shows a statistically significant positive correlation between GPA and the critical thinking disposition subscale of systematicity only (0.175, $p = 0.047$), with no other subscale showing a statistically significant correlation (Table 11).

4 Discussion

The aim of this study was to understand the critical thinking skills and dispositions of undergraduate students enrolled in a BS in Health Science degree program at a four-year university. The findings of this study are in agreement with the published research pertaining to critical thinking skills development in undergraduate students as a whole, as some estimates have described that 45% of undergraduate students do not show meaningful improvement in their critical thinking skills upon graduation, with even this number potentially being underestimated [24]. As this study was not longitudinal in nature, it is not known to what degree critical thinking skills or dispositions did or did not improve over the course of a student's higher education experience. Rather, this study provides a snapshot of the skills and dispositions found at the culmination of their program of study. Therefore, the findings of this study do not necessarily suggest a failure to develop critical thinking skills and dispositions of this particular Health Science undergraduate program. Instead, it provides insight into the degree to which critical thinking skills and attitudes have been developed upon the conclusion of academic study, with opportunities to evaluate ways in which to further enhance critical thinking skill and disposition development by understanding the current baseline.

Earlier research conducted by Keeley et al. [25] points to a common resistance of students to engage in critical thinking, which these authors suggest may be due to a generalized resistance to engaging in different forms of learning and studying behaviors than they have previously utilized in their education in an effort to "avoid change, work, and pain." The authors also suggest that students who do not regularly engage in self-reflection (i.e. why am I resistant to engaging in critical thinking?) are less likely to be aware of their hesitation in the first place.

Table 6 Results of One-sample T-test of critical thinking skills

t	df	Sig (2-tailed)	Mean difference	95% confidence interval of the difference lower	95% confidence interval of the difference upper
– 11.568	124	0.000	– 5.34000	– 6.2537	– 4.4263

Test value = 75.3

Another potential reason for this deficiency in critical thinking skill development may be pedagogical in nature. Higher education pedagogy is often content-based and seeks to imbue students and learners with deep knowledge about a series of subjects, whereas a more critical thinking-oriented pedagogy is rooted in teaching students and learners how to think complexly and across a number of different areas [26]. As a result of a heavily content-based pedagogy, undergraduate students may not be receiving the kind of complex and problem-based learning environment needed to develop a more robust critical thinking skillset. Research by Matthews & Lowe also suggests both pedagogical and environmental reasons as to why students may be resistant to engaging in more critical thinking and critically reflective mindsets [27]. Particularly, these researchers highlight the need for the development of the critical thinking disposition (the critical spirit described by Facione) in order for students to overcome resistance to both developing and utilizing critical thinking skills in their educational and professional endeavors. Without possession of a strong disposition toward critical thinking, more overt resistance to the utilization of critical thinking may remain.

Participants in this study showed the strongest development in Inference and Induction skills. Inference, the ability to draw logical conclusions based on presented data, is an important subdomain of critical thinking skills. Healthcare practice and research both require the utilization of inferential reasoning in order to appropriately draw conclusions and make recommendations in situations and environments that are not always pristine or ideal [28]. This allows for the greater development of a "what if?" mindset that can be of significant importance in health-related environments. The similar level of development found within induction is interesting to note, as induction can be seen as a sub-category of inferential reasoning. Clinical reasoning requires the development and application of inductive reasoning in order to make larger generalizations and conclusions based on the individual clinical scenarios or patterns that are being witnessed and observed [29]. While development in the areas of Inference and Induction was only at a moderate level, as opposed to strong or superior development as described by the CCTST, it is still important to note that these areas are of significant importance when it comes to future work in the healthcare field.

What starts to become more concerning are the areas within critical thinking skillsets that were more weakly developed and demonstrated in this study. Weak development in the area of evaluation is worthy of special attention, as the healthcare field is riddled with dubious claims, misinformation campaigns, and conspiracy theories. Recent research done by Lantian, Bagneux, Delouvée, & Gauvrit provided insight into the link between evaluative and critical thinking abilities and subscribing to conspiratorial beliefs and theories [30]. Courses that emphasize evaluation skills have been shown to reduce adherence to pseudoscientific beliefs while also building a more skeptical frame of mind when coming across new information or claims [31].

The skillset with the lowest level of development was numeracy, with weak to no development in this area being shown by the CCTST. This is, in some ways, not surprising, as adults in the United States have been found to perform well below average in numeracy skills when compared to adults in other developed nations according to the Organization for Economic Cooperation and Development [32]. However, in this present study, it must be noted that not only was numeracy the most poorly developed critical thinking skillset, numeracy mean scores fell within the weak to not developed range. This is a finding of great importance, as numeracy is a required skill within the field of healthcare. Regarding critical thinking as a whole, the study sample's mean score was 69.96 for overall critical thinking skills, which was statistically significantly lower than the overall critical thinking skills of 4-year college/university undergraduate students' mean score of 75.3. Utilizing the criteria provided in the CCTST, the study sample mean shows weak to moderate development, whereas the national student population shows moderate development at the higher end of the moderate development range. This shows that not only do the study participants show lower development in their critical thinking skills when compared to the national population, but that the study participants are a full category of development lower.

Results show that the majority of dispositions assessed in the CCTDI showed positive development among the study participants. Open-Mindedness, Inquisitiveness, Analyticity, and Confidence in Reasoning were all found to fall within the positive range of personal development. Higher scores on the CCTDI have been found to be associated with greater

Table 7 Ethnicity of students completing the CCTDI

Ethnicity	Frequency	Percent
Asian, Asian American, Pacific Islander	10	7.7
Black, African American	10	7.7
Hispanic, Latino, Mexican American	19	14.6
Other	1	0.8
White, Caucasian, Anglo American	90	69.2
Total	130	100.0

Table 8 Declared BSHS degree concentrations

Concentration	Frequency	Percent
Pre-occupational therapy	27	20.8
Pre-physical therapy	23	17.6
Pre-communication disorders	20	15.4
General	60	46.2
Total	130	100.0

Table 9 Descriptive statistics of study sample CCTDI performance

CCTDI category	Min	Max	Mean	Stand dev	Level of development
Truth-seeking	21	50	35.4	5.7	Inconsistent/ambivalent
Open-mindedness	23	53	42.5	4.7	Positive development
Inquisitiveness	30	59	46.5	5.4	Positive development
Analyticity	29	56	44.8	4.4	Positive development
Systematicity	21	55	39.8	6.4	Inconsistent development
Confidence in reasoning	29	59	45.8	5.5	Positive development
Maturity of judgment	23	58	41.0	6.1	Inconsistent development

problem-solving skills, showing that these affective qualities are important in the overall critical thinking attributes of students [33]. Open-mindedness and inquisitiveness are especially important dispositions to possess, as they are paramount to supporting the desire to learn and to enhance personal knowledge within students, which has further been associated with better student performance in higher education [34].

Particularly with students pursuing health-related careers, open-mindedness again has been found to be associated with academic success and graded work in courses [35]. While these other domains of analyticity and confidence in reasoning are associated with problem-solving overall, they are not as predictive of student success and readiness as open-mindedness and inquisitiveness [36], although higher dispositions overall are an important aspect of building problem-based learning skills.

What is perhaps most concerning amongst the findings pertaining to this research question is that Truth-Seeking showed the lowest disposition development, with results showing inconsistent to ambivalent demonstration. Truth-seeking is a necessary disposition to possess in order to seek out the best possible evidence and information to understand a situation or issue. As such, truth-seeking behavior has been described as the main predictive dispositional factor of an individual possessing a robust overall critical thinking behavior [37]. In particular, truth-seeking allows one to question their previously held beliefs or ideas about a topic, which is critical in the healthcare field, as new information and science are always coming forward. This new information often may displace or change previously held theories or practices, and a truth-seeking disposition is required in order to critically evaluate and accept new information that is found to be factually based.

Part of the reason why dispositions and attitudes towards Truth-Seeking may be so hard to foster is the subjective and often abstract nature of what constitutes truth, which is then further compounded by the copious amounts of information that students are tasked with processing when attempting to determine factualness. As described by Arth et al. [38], "…information is available to people in unrecordable amounts and insurmountable ways." The sheer amount of information that students are being confronted with is only increasing, and without proper information literacy

Table 10 Correlation matrix between critical thinking skills and student GPA

	Overall	Analysis	Inference	Evaluation	Induction	Deduction	Interpretation	Explanation	Numeracy	Total GPA
Overall										
Pearson correlation	1	0.798**	0.782**	0.682**	0.800**	0.775**	0.576**	0.646**	0.592**	0.235**
Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008
N	125	125	125	125	125	125	125	125	125	125
Analysis										
Pearson correlation	0.798**	1	0.687**	0.429**	0.534**	0.806**	0.386**	0.505**	0.608**	0.243*
Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006
N	125	125	125	125	125	125	125	125	125	125
Inference										
Pearson correlation	0.782**	0.687**	1	0.462**	0.643**	0.666**	0.429**	0.405**	0.602**	0.221*
Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.013
N	125	125	125	125	125	125	125	125	125	125
Evaluation										
Pearson correlation	0.682**	0.429**	0.462**	1	0.683**	0.420**	0.340**	0.739**	0.600**	0.239*
Sig. (2-tailed)	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.007
N	125	125	125	125	125	125	125	125	125	125
Induction										
Pearson correlation	0.800**	0.534**	0.643**	0.683**	1	0.327**	0.488**	0.608**	0.561**	0.195*
Sig. (2-tailed)	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.029
N	125	125	125	125	125	125	125	125	125	125
Deduction										
Pearson correlation	0.775**	0.806**	0.666**	0.420**	0.327**	1	0.521**	0.411**	0.529**	0.248*
Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.005
N	125	125	125	125	125	125	125	125	125	125
Interpretation										
Pearson correlation	0.576**	0.386**	0.429**	0.340**	0.488**	0.521**	1	0.281**	0.542**	0.121
Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000		0.001	0.000	0.177
N	125	125	125	125	125	125	125	125	125	125
Explanation										
Pearson correlation	0.646**	0.505**	0.405**	0.739**	0.608**	0.411**	0.281**	1	0.644**	0.276**
Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.001		0.000	0.002
N	125	125	125	125	125	125	125	125	125	125

Table 10 (continued)

	Overall	Analysis	Inference	Evaluation	Induction	Deduction	Interpretation	Explanation	Numeracy	Total GPA
Numeracy										
Pearson correlation	0.592**	0.608**	0.602**	0.600**	0.561**	0.529**	0.542**	0.644**	1	0.300**
Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.001
N	125	125	125	125	125	125	125	125	125	125
Total GPA										
Pearson correlation	0.235*	0.243*	0.221*	0.239*	0.195*	0.248*	0.121	0.276**	0.300**	1
Sig. (2-tailed)	0.008	0.006	0.013	0.007	0.029	0.005	0.177	0.002	0.001	
N	125	125	125	125	125	125	125	125	125	125

**Correlation is significant at the 0.005 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

Table 11 Correlation matrix between critical thinking dispositions and student GPA

	CCTDI Overall	Truth-seeking	Open-mindedness	Inquisitiveness	Analyticity	Systematicity	Confidence in reasoning	Maturity of judgment	Total GPA
CCTDI overall									
Pearson correlation	1	0.716**	0.603**	0.634**	0.623**	0.662**	0.660**	0.632**	0.147
Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.097
N	129	129	129	129	129	129	129	129	129
Truth-seeking									
Pearson correlation	0.716**	1	0.448**	0.253**	0.182*	0.381**	0.250**	0.660**	0.040
Sig. (2-tailed)	0.000		0.000	0.004	0.039	0.000	0.004	0.000	0.654
N	129	129	129	129	129	129	129	129	129
Open-mindedness									
Pearson correlation	0.603**	0.448**	1	0.325**	0.215*	0.158	0.304**	0.377**	0.156
Sig. (2-tailed)	0.000	0.000		0.000	0.015	0.073	0.000	0.000	0.077
N	129	129	129	129	129	129	129	129	129
Inquisitiveness									
Pearson correlation	0.634**	0.253**	0.325**	1	0.369**	0.248**	0.503**	0.224*	0.093
Sig. (2-tailed)	0.000	0.004	0.000		0.000	0.005	0.000	0.011	0.294
N	129	129	129	129	129	129	129	129	129
Analyticity									
Pearson correlation	0.623**	0.182*	0.215*	0.369**	1	0.481**	0.490**	0.212*	0.098
Sig. (2-tailed)	0.000	0.039	0.015	0.000		0.000	0.000	0.016	0.270
N	129	129	129	129	129	129	129	129	129
Systematicity									
Pearson correlation	0.662**	0.381**	0.158	0.248**	0.481**	1	0.428**	0.216*	0.175*
Sig. (2-tailed)	0.000	0.000	0.073	0.005	0.000		0.000	0.014	0.047
N	129	129	129	129	129	129	129	129	129
Confidence in reasoning									
Pearson correlation	0.660**	0.250**	0.304**	0.503**	0.490**	0.428**	1	0.081	0.004
Sig. (2-tailed)	0.000	0.004	0.000	0.000	0.000	0.000		0.364	0.961
N	129	129	129	129	129	129	129	129	129
Maturity of judgment									
Pearson correlation	0.632**	0.660**	0.377**	0.224*	0.212*	0.216*	0.081	1	0.081
Sig. (2-tailed)	0.000	0.000	0.000	0.011	0.016	0.014	0.364		0.359
N	129	129	129	129	129	129	129	129	129
Total GPA									
Pearson correlation	0.147	0.040	0.156	0.093	0.098	0.175*	0.004	0.081	1
Sig. (2-tailed)	0.097	0.654	0.077	0.294	0.270	0.047	0.961	0.359	
N	129	129	129	129	129	129	129	129	129

**Correlation is significant at the 0.006 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

preparation, and particularly digital information literacy, students may be both unprepared and unmotivated to seek out that information which would point towards the truth. This point is reinforced by Gibbs [39], who emphasizes the additional consideration of trust in self. Without a level of trust in one's own ability to both seek out true information and simultaneously recognize false or misleading information, students may not possess the confidence necessary to develop a stronger attitudes towards truth-seeking as a behavior.

Regarding the findings pertaining to correlations between GPA and critical thinking skills and dispositions, academic performance and GPA have been shown to be associated with greater critical thinking skill development [40]. And while GPA is not the only indicator of skill development, overall academic performance and success may be one way of measuring the potential for critical thinking skillset enhancement. The finding of numeracy being the most positively correlated subscale with GPA is an important one, given the overall poor development of numeracy skill development in this study sample. However, numeracy as a skill that was shown to be poorly developed in this study may be impacted by more than overall GPA and academic development. Within the research seeking to understanding why mathematics and numeracy skills are often poorly developed in American students, negative stereotypes, stigma, and poor sense of self have been identified as significant influences. The psychological impact of negative self-stereotyping can be a double-edged sword, both in terms of instructor biases towards what kind of student tends to be better at mathematics, as well as student self-belief regarding whether or not they are the kind of student who is good at math [41]. The impact of stereotype threat on mathematics and numeracy achievement has been identified as a potential key factor in the overall lack of mathematics development across student groups and demographics [42], with female-identifying students in particular being highly vulnerable to these stereotyping images and messages [43]. Considering the high percentage of female-identifying students within this study, the potential impact of stereotyping and stereotype threat, particularly its role in mathematics and numeracy skill development and utilization, cannot be ignored.

With critical thinking dispositions, the fact that systematicity was the only subscale found to be associated with GPA is in some ways not surprising, as systematicity is the tendency to approach problems in an ordered, disciplined, and systematic way. Those with higher GPAs may naturally be inclined to a more systematic way of approaching their work and studies, which may explain this correlation. However, it should also be noted that no other disposition subscale was found to be correlated with GPA, which brings attention to the fact that GPA and academic grade achievement may not be an indicator of disposition and attitude towards critical thinking. This highlights the limitation of using GPA as a barometer for critical thinking development, as it cannot fully capture or predict how a student will conceptualize and utilize critical thinking in their personal or professional lives.

However, this finding does highlight the phenomenon that students may possess critical thinking skills but not possess the disposition necessary to put these skills into use, which may in part be influenced by the dispositions of the educators who are teaching these students. A recent study by Shin et al. [44] explored the role of a critical reflection competency program for nurse educators in improving the educators' dispositions. Participation in a 4-week critical reflection competency program was found to improve the critical thinking dispositions and teaching efficacy of nurse educators, which simultaneously allows for greater opportunity for nursing educators to imbue these dispositions and attitudes within their students. How an educator is projecting their own attitudes towards the importance of critical thinking utilization may have a significant impact on how they are not only designing curriculum and teaching methods, but also in how they are creating a general environment that fosters a curious mind and a stronger disposition towards employing critical thinking skills in work.

An additional influential factor on the development of critical thinking dispositions may be the opportunity for a student to explore and utilize creativity in their classroom. Qiang et al. [45] found that a student's critical thinking disposition was positively related to their self-concepts of creativity and scientific creativity in particular. This was further emphasized by Khoshgoftar et al. [46], who found a direct relationship with critical thinking dispositions and reflective creative capacities. The significance of these findings are two-fold. First, that classroom learning opportunities that emphasize creativity and reflection opportunities may help to further bolster critical thinking dispositions within students, and secondly, that a student's ability to be reflective and creative may not always be properly captured in GPA scoring. Educators, particularly those working with students in the health sciences, may find benefit in not only improving their own dispositions towards critical thinking, but also find opportunities to properly assign, assess, and capture reflection and creative capacity in their students to further enhance student disposition development.

4.1 Implications for practice

The findings of this study are of great importance, as future healthcare professionals need to possess the critical thinking skills and dispositions necessary to perform their work accurately and safely, especially given a work environment that is ever-increasing in its complexity. As this study was conducted with pre-professional health science students, the ways in which the findings of this study may be applied to the field of health pre-professional education are specific to the development of these skills and dispositions before clinical education and/or encounters with patients or community members begins. This speaks specifically to the general development of cognitive skills and attitudes versus clinical skills and attitudes, which would be developed during their post-baccalaureate education and training.

An important area to note is the correlational relationship that exists between the different subscales of both the CCTST and the CCTDI, particularly those correlations that showed the strongest relationship to one another. Overall critical thinking skill was most strongly correlated with analysis, inference, induction, and deduction skills, which provides insight into ways to focus potential curricular and pedagogical changes that may work to increase overall critical thinking skills within students. Course assignments, projects, educational lessons, and readings that require students to utilize analytical, inferential, and both inductive and deductive skills may be of particular benefit to shaping an overall improvement and strengthening of critical thinking within students. Numeracy skills, which were the most poorly developed, were most positively correlated with explanatory skills. This is an important finding, as strengthening explanatory skills, which refers to a student's ability to defend and justify a belief or a response to a question, may have a simultaneous benefit of supporting a student's development in numeracy.

Regarding critical thinking dispositions, while truth-seeking was the most poorly developed attitude, it also showed the strongest correlation with overall critical thinking dispositions. Therefore, in an effort to improve truth-seeking dispositions within students, exposing students to opportunities that will overall strengthen and support their dispositions towards critical thinking may have the added benefit of supporting their desires to seek out the truth. Maturity of judgment also showed a higher correlation with truth-seeking, which again provides helpful insight. As maturity of judgment allows a student to understand and accept that multiple solutions or options may be possible when approaching a question or issue, and that complexity is an inherent aspect of many problems and issues, fostering this disposition within students may again help to support their development within truth-seeking.

In an effort to put these findings into practical use, the first and most immediate practice-based recommendation based on the findings of this study is to evaluate programmatic curriculum and teaching approaches that have been shown to promote critical thinking skill development in higher education settings. Mahmoud & Mohamed [47] provide several evidence-based recommendations for the enhancement of critical thinking skills and abilities. While a few of these recommendations are described below, readers are encouraged to read the paper by Mahmoud & Mohamed in its entirety, particularly those educators who work with health-oriented students, in order to fully recognize the breadth of curricular and teaching approaches recommended.

Problem-Based Learning A major component of pre-health profession education should be problem-based learning, which is a student-centered approach to the learning process that focuses on solving open-ended problems through collaborative engagement with other learners in a group setting.

Programmatic Orientation Students often do not fully understand the philosophy and core concepts of the programs they are selecting to study. As students are often oriented to their college or university after admittance, so too should they be fully orientated to the program of study they are choosing as their major.

Clinical Scenarios Context-dependent activities ask the learner to bring their life experiences, prior learning, and personal skills into the classroom. In this way, improved recall and application of knowledge have been shown to be enhanced, allowing students to encode information learned in such a way that it can be easily retrieved when they are in a specific scenario.

An additional recommendation is to encourage faculty members of pre-health educational programs to adjust their curriculum and teaching styles, such as the utilization of a flipped classroom model, to promote critical thinking dispositions. This may be particularly helpful in developing the disposition of truth-seeking, which was not only found to be poorly developed in this study but in other studies that have sought to understand the dispositions of students in the healthcare field [48]. However, as previously shared, resistance to new methods of teaching can influence how effective a flipped-classroom approach can be in fostering critical thinking skills and dispositions. Oudbier, Spaai, Timmermans, & Boerboom highlight how student self-regulation, the motivation of the faulty member, and variation in assessment approaches can all play a significant role in whether a flipped classroom approach will be effective [48]. To increase the

positive possible outcomes of such an approach, Arth et al. [38] provide valuable insights and recommendations made by professors on how to encourage critical thinking and truth-seeking dispositions within undergraduate students. Selected examples of their recommendations are particularly linked with curricular design and teaching strategies.

Research Information Skills The ability to properly seek out and evaluate information should be incorporated throughout the curriculum in a variety of classes versus localizing these skills in a research-specific course. Specifically, students need to learn the difference between researching information via the scientific method versus simply looking up information.

Belief Bias & Skepticism An important aspect of developing a critically oriented mindset is to understand one's own biases, and how these personal biases can influence the way in which information is sought out and interpreted. In this way, confirmation bias can be avoided, and a healthy level of skepticism can be maintained.

Discernment of Good vs. Bad Information Avoiding belief bias and maintaining a skeptical mindset also links to the desire to find reliable information and to be able to discern good quality from poor quality information. Given the proliferation of questionable claims that are found through online sources, educators need to be teaching the necessary skills to determine the reliability of the information that is obtained during the research process.

The Constant Pursuit of Truth Although it may initially seem counterintuitive, one of the most important ways to encourage a truth-seeking disposition in undergraduate students is to design a curriculum that reinforces the idea that nothing can ever be known with complete certainty, particularly in the health sciences. Not only because of the abundance of information of questionable validity and reliability, but also due to the fact that information is constantly changing as new research is conducted and new evidence is gathered. As previously shared in the research by Arth et al. [38], students need to be encouraged to see the pursuit of truth as an ever evolving behavior due to the plethora of new information that is being shared, particularly via digital platforms. This requires students to be comfortable with a lack of finality when it comes to the pursuit of truthful and factual information. Students who are exposed to educational environments that encourage comfortability with the ever-present need to seek out truth through purposefully designed learning experiences, modeling techniques, and reflection time from their faculty have been shown to improve in both their critical thinking skills as well as their attitudes towards seeking out truth [49, 50].

It should be noted that this study serves as an internal review and assessment of a single academic program within the field of health science. While this may lead to a reduction in generalizability to other educational program, what this study can contribute is the necessity for higher education programs to engage in this very kind of assessment and evaluation of critical thinking skills and attitudes of their students. Without engaging in an internal assessment and audit of student critical thinking skills and attitudes, educators and curriculum developers will not have the information and data needed to determine whether or not their curricular program, as well as the pedagogical methods being employed by faculty, is leading to a robust development in critical thinking skills and attitudes. These methods are not currently in place in meaningful levels within the current program of study that the students within this study were enrolled in, and it is the hope of this researcher that these methods will be increased in an effort to increase critical thinking skills and dispositions over time.

4.2 Study strengths and weaknesses

As with any scholarly research, there are limitations to the methods of research design and data collection that influence the results of the study itself. First, the collection of data for this study utilized a sample of convenience. This researcher is a faculty member in this BS in Health Science program and therefore was able to focus data collection solely on students with which he had easy and convenient access. Since all students who responded were a part of this single program, it is difficult to be able to fully generalize the results of the CCTST and the CCTDI to the undergraduate health science population as a whole. While this does allow for a more specific analysis of this particular cohort of students, it does introduce limitations into how study findings can be then expanded to additional institutions of higher education.

A second limitation of this study is the lack of ability to compare the critical thinking skills and dispositions of BS in Health Science students to other undergraduate students at the same university who are enrolled in other programs of study. While a comparison to national population means was possible for overall critical thinking scores, it would have been illuminating to be able to compare the mean scores across each subdomain of critical thinking skill as well. Since these data are not collected or stored by Insight Assessment, being able to draw data from other students at the same university would have made this kind of comparison possible. Given the logistical and financial constraints that existed, it would not have been possible to collect data from an adequate number of non-health science students, leaving this kind of subdomain comparison absent from this particular study. It should also be noted that 2 sections of students did

complete the assessment over Zoom versus being in an in-person computer lab setting. While there is no evidence to suggest a significant difference in student performance or adherence to assessment guidelines between those completing the assessment online versus those in person, nonetheless it may have played a role in impacting student outcomes.

An additional consideration is the comparison of data from the study sample to the national population of students providing Overall Critical Thinking Skill scores. Since the exact demographic breakdown and program of study breakdown of this national population of students is not known, there is a natural limit to what degree this comparison is helpful. Future research hoping to compare a study sample to another sample or population would benefit from knowing more specific details pertaining to the demographic and educational descriptors in order to extrapolate greater findings.

Lastly, data collection took place amongst a group of senior-level students who had spent the previous 2 years of their undergraduate-level education in the COVID-19 global pandemic environment. The impact of COVID-19, and especially the way in which it significantly impacted the field of higher education and of learning as a whole, is still being assessed and understood. For the purposes of this study, it would not have been possible to control for the ways in which COVID-19 may have temporarily or permanently impacted critical thinking skills and dispositions. As such, the results of this study must be viewed through this lens, as it is possible that the scores for skills and dispositions would have been different in a non-COVID-impacted learning environment.

5 Conclusion

Undergraduate health science students within this study population show low to moderate development of critical thinking skills, with numeracy skills being particularly poorly developed, and grade point average being moderately but significantly associated with critical thinking skill development across all subscales. And while students show positive development across most critical thinking disposition subscales, they also show inconsistent and ambivalent dispositions towards truth-seeking, with grade point average not being a significant indicator of attitudes and dispositions. Health science education programs that hope to enhance and strengthen both critical thinking skill and disposition development may wish to implement evidence-based pedagogical practices to ensure students are prepared for professional practice within the field of health science that require strong critical thinking development.

Author contributions Author completed all data collection, analysis, table formatting, literature review, and manuscript writing.

Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate The research instruments and research methods for this study were approved by the Stockton University Institutional Review Board. All data collection took place after obtaining all necessary approvals from the Stockton University IRB Committee, including CITI training by the researcher. IRB approval was obtained after submitting all required documentation, proof of CITI training, study procedures, and informed consent documents (Stockton University IRB Approval Number #2021.175). All research activities were carried out following the guidelines set forth by the Stockton University IRB.

Competing interests The author received no funding as part of this study, nor does he have any Competing interests related to the design or implementation of this study.

Appendix A: Score ranges for CCTST and CCTDI

CCTST score ranges

	Not manifested	Weak	Moderate	Strong	Superior
CCTST score range	50–62	63–69	70–78	79–85	86 or higher

CCTDI score ranges

	Strong negative	Negative	Inconsistent/ambivalent	Positive
CCDI score range	10–19	20–29	30–39	40–49

Appendix B: California critical thinking skills test domain descriptions

Overall critical thinking skills score overall ability and strength of a student to use reflective judgement and reasoning about how to make choices regarding a particular set of actions or how to develop an informed belief or opinion. This predicts capacities for success in educational and professional settings that require reasoned decision making and complex problem-solving.

Analysis score a measurement of overall analytical skill. This score is used to identify reasons, themes, assumptions, and evidence present that all must be considered and utilized when making an argument or offering explanation for phenomena.

Inference score refers to those skills and abilities that allow one to draw conclusions from the evidence, experiences, and observations being presented. In addition, Inference Scores show how one uses their personal values, beliefs, and reasoning skills to draw conclusions.

Evaluation scores the ability of someone to assess the credibility of claims and assertions being made by others, as well as their ability to assess the quality of the reasoning being used by others when an argument is being made or an explanation is being given.

Induction skill score one's ability to estimate the likely outcomes of certain decisions or choices. Inductive reasoning and decision making is often assessed after reviewing case studies, reflecting upon prior life experiences, performing statistical analyses, participating in simulations, reviewing hypothetical situations, or studying patterns that emerge in a set of events.

Deduction critical thinking skills score the ability to engage in logical decision making that is based on a given set of rules, beliefs, conditions, values, principles, and/or policies.

Interpretation critical thinking skills score the development in the process of discovering and assigning meaning to information or events. Interpretive skills can be applied to verbal information, written text, and graphical and/or pictorial information.

Explanation critical thinking skills score the development in the process of justifying a decision that has been made or a belief that has been stated. Strong skills in this sub-domain rely upon the ability to provide evidence and to explain the methods used to explain the decision that has been made.

Numeracy critical thinking skills score the ability to make judgments and decisions based on quantitative information within a variety of different environments and contexts. This can include description on how quantitative information is gathered, adjusted, manipulated, represented, and explained.

Appendix C: California critical thinking disposition inventory domain descriptions

Truth-seeking score the habit and desire to seek out the best possible understanding of any given situation or issue. Truth-Seeking requires the goal of following the best available evidence to come to an informed conclusion, even if this leads one to question previously held beliefs or ideas.

Open-mindedness score the tendency to give space to others to voice their views, opinions, and beliefs, even when one may not personally agree with what is being shared. Open-Mindedness is a necessary disposition to be able to regard the opinions of others, and to understand the complexities that exist in a pluralistic and intersectional society.

Inquisitiveness score a curiosity at the intellectual level that is motivated by a desire to know and understand. Inquisitiveness is particularly related to an inherent desire to know this information, even if it does not appear to be immediately useful or relevant.

Analyticity Score the tendency to be actively aware of the next stage of actions that occur during an occurrence or event. Analyticity involves anticipating both positive and negative outcomes, and the various choices, plans, and proposals that can be considered at any given time.

Systematicity score the tendency to strive to approach issues or problems in an ordered, disciplined, and systematic way. Systematicity provides one with the desire to approach questions and uncertain situations in a purposeful manner, even when they do not possess a strong background or skill in using a particular approach.

Confidence in reasoning score the tendency and habit to solve problems and make decisions by trusting in reflective thinking and assessment. This relates to not only the confidence in one's own reasoning process, but also in the reasoning that is utilized by groups and teams.

Maturity of judgment score refers to the habit and desire to be able to make timely decisions when confronted with complex issues and situations. Possessing an attitude that emphasizes Maturity of Judgment allows one to understand and accept that multiple solutions or options may be possible when approaching a question or issue and recognize that black-and-white thinking is not appropriate.

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