

RESEARCH ARTICLES

The California Critical Thinking Instruments for Benchmarking, Program Assessment, and Directing Curricular Change

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Objectives. To assess pharmacy students' critical thinking (CT) measures and identify areas for curricular reform.

Methods. Pharmacy students were given the California Critical Thinking Skills Test and Disposition Index at various points in the PharmD program. Scores were compared with a national referent group and evaluated for changes across the curriculum and between classes.

Results. Students were comparable to national norms. Pretest and posttest scores for total disposition showed improvement. Scores in all subcategories except for truth-seeking were consistently above 40. The CT skills of the pharmacy students varied compared with those of referent students, but the pharmacy students' overall score of 18 was in the 73rd percentile. Pre- and post-skills scores showed improvement. Students scoring low on the pretest improved more than those scoring high.

Conclusions. Students had a consistent disposition towards CT and compared favorably to national norms. Both disposition and skills improved across the curriculum. Dimensions of critical thinking on which students score low should be areas for curricular and other program changes.

Keywords: critical thinking, assessment, California Critical Thinking Skills Test (CCTST), California Critical Thinking Skills Test Disposition Index (CCTDI)

INTRODUCTION

Within the pharmacy profession, educators and professional organizations suggest that pharmacy students should be taught critical thinking (CT) skills and how to use them.^{1,2} Furthermore, pharmacy programs should be assessed on their implementation of curricula that foster the development of critical thinking. Pharmacy has often tried to assess students' critical thinking skills by observing students in clinical settings, using examination questions that require higher-order thinking in didactic coursework, and evaluating students' written patient assessments and care plans.³ To date, little quantitative measurement and assessment of critical thinking development by pharmacy programs has been published.

The American Association of Colleges of Pharmacy's (AACP's) Commission to Implement Change in Pharmaceutical Education spoke directly on critical thinking in "Background Paper II."¹ "Although critical thinking is a universally desired educational outcome, professionals particularly need a repertoire of thinking strategies that will enable them to acquire, evaluate, and synthesize information and knowledge."

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Similarly, the Accreditation Council for Pharmaceutical Education (ACPE) endorses critical thinking in pharmacy curricula through accreditation standards 12 and 13 and guidelines 12.1, 12.2, and 13.1. Specifically, these guidelines and standards direct colleges and schools of pharmacy to "foster the development and maturation of critical thinking and problem solving skills," have "teaching strategies to ensure the adeptness of critical thinking and problem solving," and ensure their assessments "measure ... the abilities to ... use data in the critical thinking and problem solving processes."²

The pharmacy profession has placed an increased emphasis on critical thinking by pharmacy students as the profession transitions to a patient care role. The fact that the assessment of critical thinking is now part of the accreditation process at colleges and schools of pharmacy only adds to ongoing interest. Thus, there is clearly a need for a more quantitative approach to evaluating pharmacy student progress through a curriculum that includes critical thinking outcomes. To that end, this study was undertaken to analyze critical thinking measures used for evaluating pharmacy students and identify potential areas for curricular reform to enhance critical thinking in our graduates. Specific objectives were to (1) measure baseline critical thinking skills of pharmacy students to determine areas of weakness in incoming stu-

dents, (2) compare pharmacy students' CT scores to national norms, and (3) determine methods for improving CT across the curriculum. (Note: definitions for abbreviations used in this article are provided in Appendix 1.)

Critical Thinking Measures

Although measures such as the Watson-Glaser instrument are available, the California Critical Thinking Disposition Index (CCTDI) and the California Critical Thinking Skills Test (CCTST) are widely used for assessment of college students.^{4,5} Unlike the Watson-Glaser instrument that only tests critical thinking skills, the 2 California critical thinking instruments measure both CT skills and the disposition to think critically. Both the CCTDI and CCTST instruments have been shown to be valid and reliable.⁶ The CCTST measures the critical thinking skills possessed by an individual. The test is comprised of 34 questions that assess one's overall critical thinking skill plus 5 subscales that assess specific areas: analysis, evaluation, inference, deductive reasoning, and inductive reasoning. The maximum possible score on the skills test is 34. The following brief descriptions of these subscales are adapted from the California Academic Press (CAP) CCTST and CCTDI manuals.^{4,5}

- The analysis subscale measures whether someone can comprehend and express the meaning in a wide variety of data, experiences, and judgments. It includes the skills of categorizing, determining significance, and clarifying meaning.
- The evaluation subscale measures an individual's ability to assess information and the strength of actual or inferential relationships. It also relates to the ability to state the results of one's reasoning.
- The inference subscale measures one's ability to identify and secure information needed to draw conclusions. For example, can the person form conjectures and hypotheses, consider relevant information, and come up with potential consequences.
- The deductive reasoning subscale measures the subject's ability to begin with a premise, and by assuming it is true, conclude that the findings are also true (as with algebraic, geometric and mathematical proofs).
- The inductive reasoning subscale measures a person's ability to begin with a premise and by applying related knowledge and experience, reach a conclusion that is likely to be true. Statistical inferences, use of similar experiences, and relevant cases (as in legal reasoning) are examples.

Whereas the CCTST measures skills, the CCTDI measures a student's propensity to think critically. The index is comprised of 75 questions that represent 7 categories or scales: truth-seeking, open-mindedness, analyticity, systematicity, critical thinking self-confidence, inquisitiveness, and cognitive maturity. These 7 "habits of mind" can be thought of as the elements in our character that impel us toward using critical thinking skills.⁶

- Truth-seeking is a desire to gain the best knowledge, even if it undermines one's preconceptions or beliefs.
- Open-mindedness is a tolerance of views other than your own, as well as monitoring oneself for possible bias.
- Analyticity is demonstrated by the demand for application of reason and evidence, awareness of problem situations, and an inclination to anticipate consequences.
- Systematicity relates to one's focus on approaching all levels of problems and valuing organization.
- CT Self confidence is the trusting of one's own reasoning skills.
- Inquisitiveness relates to one's curiosity and eagerness to acquire knowledge and learn explanations.
- Cognitive maturity is indicative of prudence in making, suspending, or revising judgement. It is awareness that multiple solutions can be acceptable.

Each scale has several questions that are totaled for the student score. In addition, there is a total score from all 7 scales. CAP has established "cutscores," which are accepted totals delineating strength or weakness on the overall scale and subscales. For each subscale, a score below the cutscore of 40 represents a general weakness in that area, while a score above the cutscore of 50 indicates consistent strength in that area. A total score below 280 shows serious overall deficiencies in the student's disposition to think critically, while a score greater than 350 shows an overall strength.

The Pharmacy Literature

Critical thinking has been studied in a variety of applications within pharmacy education including its correlation with student success, academic performance, and methods of incorporating CT in the classroom. Allen and Bond studied critical thinking as a predictor of success in pharmacy school.⁷ In addition to considering PCAT score, interview ratings, and academic performance prior to pharmacy school, they included the CCTST. In their population, scores on the CCTST and

the PCAT were the strongest predictors of success in practice-related courses and clerkships.

Adamcik et al used the Watson-Glaser Critical Thinking Appraisal inventory (WGCTA) to show a correlation between critical thinking and both pharmacy GPA and therapeutics course grades.⁸ The WGCTA utilizes reading passages along with 40 questions to assess 5 critical thinking skills: inference, recognition of assumptions, deduction, interpretation, and evaluation of arguments.⁹ Unlike Allen and Bond, Adamcik et al measured critical thinking in students towards the end of their pharmacy program.

Odedina et al used the CCTST to explore a relationship between critical thinking and performance in a pharmacy administration course.¹⁰ They also found a positive correlation between critical thinking and academic performance. Likewise, Kidd and Latif found a significant relationship between scores on the CCTST and students' didactic GPA.¹¹

Other reports have discussed the creation and use of critical thinking assignments and techniques in the classroom.¹²⁻¹⁴ However, these have not focused on any evaluation or assessment of student outcomes as a result of their use.

It is likely that several colleges have begun to measure CT as an outcome for assessment of their programs but have not completed or disseminated actual results. A few researchers have presented data at national pharmacy meetings that begin to address assessment of critical thinking as a pharmacy curricular outcome. Chambers et al have discussed the use of a critical thinking rubric used to begin evaluating changes in CT throughout a curriculum.¹⁵ Similarly, Jackson et al have begun to develop an "authentic" assessment of CT as an outcome of a PharmD program.¹⁶ Also, Miller described using the CCTST and the CCTDI to track changes in critical thinking scores over the 4 years of the professional pharmacy curriculum.¹⁷ Early findings suggested that students at that school increased their ability to think critically over the course of the program. Later findings showed no statistical change in total disposition scores, but a 2.64 point (14%) increase in overall skills score.¹⁸

Nonpharmacy Research

Nursing researchers have produced the most data on CT assessment among healthcare professions. Several researchers have identified changes in critical thinking skills and dispositions based on class year.^{3,19} Both McCarthy et al and Colucciello evaluated the CT skills and dispositions among nursing students.^{3,19} Their research revealed higher scores among nursing students at varying points in the curriculum. However, they were not able to show improvement in scores over the course

of a curriculum since both used cross-sectional designs where students at each class level were independent groups. Later, Colucciello revisited CT disposition for senior nursing students.²⁰ In that work, senior students had weak scores on CT self-confidence, analyticity, systematicity, and inquisitiveness, while their scores on maturity and truth-seeking were relatively strong.

In a similar study, Smith-Blair and Neighbors also evaluated CT disposition among nurses entering critical care orientation programs.²¹ They noted that measuring disposition subscales could help identify areas for improvement using personalized orientation programs.

Leppa used a pretest-posttest design to evaluate changes in critical thinking scores over time. This research found that RN-baccalaureate nursing students did not improve in their CT skills, but did have statistically significant improvements in their dispositions to think critically.²²

METHODS

The California Critical Thinking instruments were administered to pharmacy students at a private, Midwest college at various points in their 6-year PharmD program. The program is a 2-4 program; 2 years of prepharmacy, followed by 4 years in the professional program (DP1-DP4). The 2002 graduating class was given the disposition test in an orientation course during their first year at the college. The first year was further defined as their entering freshman year (first prepharmacy year) or the year they transferred to the pharmacy program. These same students were tested a second time during the spring semester of their third professional (DP3) year, just prior to their advanced practice experience year. In addition, students who will be graduating in 2004, 2005, and 2006 were given the disposition test in their first year at the college.

A separate cohort of students who graduated in 2003 was given the skills tests on 2 occasions; as first-year students and just prior to beginning their advanced practice experience year. This pre- and post-testing provided the opportunity to evaluate changes in the students' skills scores over the length of the didactic curriculum and to compare their scores to national norms.

Both the disposition and skills tests were given to the 2 cohorts during regularly scheduled classes and proctored according to the directions provided by the California Academic Press (CAP), the testing institute that created the tests. Skills tests and disposition indexes were hand-graded and entered into a database for analysis.

All analyses were performed using *Statview 5.0*. (SAS Institute Inc., Cary, NC, 1998). An a priori alpha

Table 1. Comparison of CCTDI Scores of Incoming Pharmacy Students* With Those of a Referent Group†

Category	Percent of Students Who Scored Below 40		Percent of Students Who Scored Above 50	
	First Year		First Year	
	Pharmacy Students, n=89	CAP Referent Group, n=587	Pharmacy Students, n=89	CAP Referent Group, n=587
Truth-seeking	74	60	1	2
Open-mindedness	25	15	10	28
Analyticity	20‡	23	19‡	16
Systematicity	34‡	44	13‡	11
Confidence	21‡	25	16	19
Inquisitiveness	15	14	37	41
Maturity	31	17	13	29
Overall CCTDI	20	22	7	6

*Class of 2002

†Demographics between the 2 groups were similar. Mean age for both groups was 18 years. Mean high school GPA and ACT scores were 3.62 and 24.7, respectively, for first-year pharmacy students and 3.47 and 24 (1095 SAT), respectively, for students in the referent group.

‡A lower percentage of pharmacy students scoring below 40 compared to the referent group, or a higher percentage of pharmacy students scoring above 50 compared to the referent group, equates to the pharmacy students scoring better than the referent group on that item.

CCTDI= California Critical Thinking Disposition Index; CAP=California Academic Press; GPA=grade point average; SAT= Scholastic Aptitude Test

level of 0.05 was used for all analyses. For comparison to national norms, pharmacy student scores on the 2 tests were compared with scores from referent groups of undergraduate college student provided by CAP. Disposition scores were also compared across 4 classes in order to determine whether the scores were consistent from year to year. This provided a means of assessing whether entering classes differ from year to year as admission requirements change.

Due to the high correlation between the total disposition score and the 6 subcategories of disposition, MANOVA was used to analyze these outcome measures simultaneously. Independent variables in the MANOVA were (1) year entering the program and (2) entering status (freshman or transfer). Dependent variables included the total disposition score and each of the 6 subscale scores. This provided a baseline assessment of incoming classes and allowed for identifying any consistent trends in areas of strength or weakness. The 2 independent variables tested for differences between prepharmacy students entering directly from high school and those admitted as transfers after completing prepharmacy courses at other institutions. The hypothesis was that transfer students would have a higher disposition towards critical thinking than first-year college students, since many transfer students had completed more years of college than those who were first-year college students. If the hypothesis were true, it would support keeping positions in the professional program available for students from other institutions. The Wilks' Lambda statistic was used for the MANOVA and the Fisher Protected Least Significant Difference was used as the multiple comparisons statistic.

In order to identify any changes in critical thinking scores across the curriculum, pre- and post- CCTST measurements were used. The students' first year in the program represented the pre-CCTST measurement and their last didactic year just prior to advanced practice experiences represented the post-CCTST measurement. Paired *t* tests were used for analyzing these potential differences in pre-CCTST and post-CCTST measures within the classes.

In addition, the pre-CCTST and post-CCTST were used to determine whether students coming into the program with relatively low CCTST scores improved more than those coming in with relatively high scores. The CAP referent group median score of 16 was used to reference students with either low or high critical thinking skills. Low incoming scores were defined as a total CCTST score of 15 or below on the pretest and high incoming scores were defined as a total score of 16 or greater. A Student's *t* test was used to compare mean changes in pre-CCTST and post-CCTST scores between the 2 groups.

RESULTS

The student groups studied were similar to the CAP referent groups with regard to demographics. The disposition referent group was similar to the study group in age, high school grade point average (GPA), and ACT scores (Table 1). The skills referent group were also similar to our study population in that the average age of the students in the study group was 21 years vs 22 years for the referent group; college standing for both groups was "junior," and ACT scores were 24.7 for the study group vs 19 (900 SAT) for the referent group.

Table 2. Mean (SD) Disposition Scores From the First Year in the Program by Subcategory and Graduation Year*

Subcategory	2002, n=89	2004, n=121	2005, n=130	2006, n=173	Mean, n=513
Truth-seeking	35.6 (6.1)	35.7 (5.7)	36.8 (6.1)	37.3 (5.8)	36.5 (5.9)
Open-minded	43.6 (6.3)	42.9 (5.4)	44.5 (4.8)	43.2 (6.2)	43.5 (5.7)
Analyticity	44.7 (5.4)	44.0 (6.2)	44.1 (5.2)	42.1 (7.9)	43.5 (6.6)
Systematicity	42.5 (7.0)	42.4 (6.8)	43.5 (6.6)	41.9 (7.2)	42.5 (6.9)
Self-confidence	44.7 (6.4)	43.9 (6.5)	43.3 (5.8)	40.1 (9.4)	42.6 (7.7)
Inquisitiveness	46.8 (6.7)	47.0 (6.6)	48.3 (5.8)	45.5 (9.6)	46.8 (7.6)
Maturity	42.8 (6.7)	43.7 (6.6)	44.4 (5.9)	44.9 (5.7)	44.1 (6.2)
Total CCTDI	300.7 (30.4)	299.6 (30.9)	304.5 (28.7)	295.0 (38.7)	299.5 (33.2)

*Data not collected for Class of 2003

Table 3. CCTST Results for 2002 Graduates,* n=89†

Scale	Mean (SD)	Minimum Maximum	Median	Percentile Rank*
Analysis	4.9 (1.6)	0, 8	5	75th
Evaluation	6.7 (2.5)	1, 12	7	81st
Inference	5.8 (1.8)	1, 10	6	55th
Deductive	7.6 (2.5)	1, 13	8	62nd
Inductive	7.8 (2.5)	3, 13	8	79th
Total Score	17.4 (4.1)	9, 26	18	73rd

*scores from the third professional year

†Compared to data for CAP referent group from 1989-1990

Objective 1 And 2: Determine Baseline CT Scores and Compare Them to National Norms

Critical Thinking Disposition. Table 1 provides percentages above and below the accepted cut scores depicting strength or weakness in each subscale. The first-year disposition scores for 2002 pharmacy graduates were compared with those of a representative sample of entering college freshman from the United States and Canada. Based on the overall disposition score, the pharmacy students were comparable to the referent group. As entering students, the 2002 graduating students scored slightly better on the analyticity, systematicity, and confidence scales than students in the reference group, but scored lower on the truth seeking, open-mindedness, and maturity scales. For the same 2002 graduates, comparisons of scores on the pre-CCTST and post-CCTST showed some change over time. There was a statistically significant improvement of 7 points on the total disposition score (mean total of 300.7 vs 307.6 scored as DP3s; $P = 0.03$).

When comparing subsequent classes' first-year scores, disposition subcategory mean scores were consistently above the 40-point cutscore for all subcategories except truth-seeking (see Table 2). In addition, the total disposition scores were consistently above the 280-point cutscore suggested by CAP. Differences in disposition scores were found in the MANOVA between entering freshman and transfer students (Wilks' Lambda = 0.946,

$P = 0.0034$). Also, differences were found across the 3 matriculating classes of 2004, 2005, and 2006 (Wilks' Lambda = 1.0, $P = 0.0417$). The MANOVA identified only 4 significant multiple comparisons. Student status had a significant impact on only 2 disposition scores: the self-confidence and the inquisitiveness categories. Transfer students scored roughly 3 points higher on the self-confidence subcategory ($P = 0.0009$) and approximately 2 points higher on inquisitiveness ($P = 0.0105$).

The class year also affected scores for 2 categories, that for self-confidence and that for truth-seeking. Students graduating in 2004 and 2005 scored 4 and 3 points higher on self-confidence than those entering in 2000 ($P < 0.0001$ and $P = 0.0003$, respectively). Those graduating in 2006 were 2 points higher than 2004 on truth-seeking (0.0201).

Critical Thinking Skills. Critical thinking skills possessed by the 2002 graduates varied from those of CAP's referent students (Table 3). Using median scores for the pharmacy group, their score of 18 on the overall scale placed them in the 73rd percentile. They scored in the 75th percentile for the analysis sub-scale, the 81st percentile in evaluation, and the 55th percentile for inference. Their scores on deductive and inductive reasoning placed the pharmacy students in the 62nd and 79th percentiles, respectively. Further inspection shows dramatic variations in scores within the class, with total scores on the skills test ranging from a minimum score of 9 to a maximum of 26 (Table 3).

Table 4. Paired Comparison of Mean Overall CCTST Score for 2003 Graduates, n=60

Year	Mean (SD)	Minimum Score	Maximum Score
1998	17.05 (4.22)	9	27
2002	18.95 (4.52)	6	29

Difference 1.90 ($P=0.0004$)

Objective 3: Determining Improvement Across the Curriculum

When comparing the pretest and posttest skills scores for the 2003 pharmacy graduates, a statistically significant improvement was observed. The mean overall skills score improved nearly 2 points from when the students took the skills test in 1998 as entering students until they took the post-CCTST in 2002, during their 3rd professional year (Table 4).

In addition, students who scored low on the pretest showed a significantly greater improvement in their posttest scores compared with students who scored high on the pretest. The CAP median score of 16 was used as the cutoff. A low score was defined as 15 or less on the CCTST; a high score was 16 or above. The scores of students who initially scored low showed a mean improvement of 3.3 points on the posttest (Table 5) compared with a 0.8-point increase in the posttest scores of students who scored high on the pretest ($P = 0.0136$).

DISCUSSION

Critical Thinking Disposition

In terms of their disposition to think critically, pharmacy students at this institution compared favorably overall with national norms. These baseline disposition and skills data are the start of producing internal norms for comparison with future classes.

When compared with the published standards by Facione,⁵ entering students consistently met or exceeded the 40-point cut on all disposition categories except truth-seeking. This suggests a potential area for curricular emphasis that could increase the likelihood of students using their truth-seeking abilities. Experiences or didactic course work that promote the idea of gaining the best knowledge and challenging one's preconceptions

may afford improvement on scores in the truth-seeking category. As an example, further reinforcing the idea of evidence-based medicine in the curriculum may be advantageous.

We found the disposition scores of entering students (2002, 2004–2006 graduating classes) changed little over 4 years. There was no difference between the total disposition scores of entering and transfer students. Likewise, there was no difference between the total scores of one class and the next.

As with the total disposition scores, there appeared to be little difference in scores on disposition subcategories between those students entering as freshman and those transferring into the program. Likewise, there was little difference on subcategory scores from one class to the next. When differences did exist, they were not consistent from one class to the next. These findings suggest a consistently homogenous group of students entering the program each year. By identifying these dispositions, pharmacy curricula could be altered to enhance or promote student disposition to think critically. Hopefully, this would improve student performance in the program as has been shown by others.^{7,8,10,11}

Like Leppa's study of nursing students, but contrary to Miller's study of pharmacy students, we found that overall disposition did improve over the course of the didactic program when comparing pretest and posttest measurements. More specifically, our study showed improvement in analyticity and systematicity for the class of 2002. The data from Table 1 suggest that students from this class arrived with strong scores in these 2 subscales. However, the classes of 2004, 2005, and 2006 appear to have strengths in inquisitiveness and cognitive maturity. Perhaps curricular issues can be addressed to specifically enhance the other subscales of the disposition construct. Although this would seem to suggest the need for continuous curricular change based on entering class scores, a better approach may be to provide data to faculty members so that individual courses can focus class exercises on specific CT areas. Experiences and or content areas need to be reviewed for their effects on subcategories such as truth-seeking. Truth seeking targets how predisposed a person is to asking questions, being eager to seek

Table 5. Mean Improvement on CCTST Score Between Students* Scoring Low and High on the Pretest, n=60

Group	Mean PretestScore (SD)	Mean PosttestScore (SD)	Mean Difference (SD)
Scored high (n=34)	20.118 (2.59)	20.941 (3.18)	0.824 (3.38)
Scored low (n=26)	13.038 (1.93)	16.346 (4.72)	3.308 (4.18)
			2.48 (p=0.0136)

*Class of 2003 graduates

CCTST =California Critical Thinking Skills Test. The test measures the critical thinking skills possessed by an individual and targets one's overall critical thinking skill plus five sub-scales: analysis, evaluation, inference, deductive reasoning, and inductive reasoning.

the truth, and being honest and objective about pursuing inquiry. Given this description, this subscale is an area that we continually try to impact. The use of case-based learning, problem-based learning, and group work are continually stressed in the curriculum.

Critical Thinking Skills

CT skills for the pharmacy students also compared favorably with those of the referent group but were quite varied. The inference subcategory was the lowest score (55th percentile), but since these data are from only one class, more data would be useful before altering the curriculum. If other classes show similar scores, even more emphasis on case-based instruction may promote better inferential skills. Other options vary but could include anything from incorporating a true critical thinking course to requiring more student research projects that focused on the scientific method and inferring from samples to populations.

Of further interest is the improvement shown in critical thinking skills over the course of the didactic curriculum. This improvement in overall CT skills is contrary to the findings in the nursing study by Leppa.²² The nearly 2-point improvement in total skills score is statistically important, but more information is needed on its practical significance. When compared with the CAP reference group, the move from a score of 17 to 19 represents a jump from the 65th to the 80th percentile.

The 2-point improvement is only a general fact that may indicate some success in the overall curriculum. Other questions are equally important: Is the increase due to a specific experience, course, or instructor, or is it an outcome of the curriculum in its entirety? Is the increase a result of student maturation and a function of experiences outside of the curriculum? Are students with a high disposition more likely to improve in their skills? Does the improvement in skills score translate into a better practitioner?

Similarly, the improvement in skills was most pronounced in those students scoring low on their pretest. Although this points to program experiences that help students improve their critical thinking, it may also point out a need to better challenge other students coming into the program with already strong CT skills.

Bond and Allen found that the CCTST was a good predictor of success in practice-related courses and clerkships. Therefore, identifying students with low scores (relative to internal norms) just prior to the advanced practice experience year may present an intervention point for remediation prior to entering the last year. As of yet, we have not retrospectively reviewed the CCTST scores of those students who needed some sort

of remediation during their final year. Given the small number of students in this category, results would likely be anecdotal.

Limitations

One limitation to this research is the lack of data after the conclusion of the advanced practice experiential year. Given the intent and methods used during that year to have students integrate information and form clinical judgments, one would hypothesize an even greater increase in both the CT disposition and skills subscales. Since the students do not come together as a group prior to commencement ceremonies, some other means of testing would need to be employed to gather this data. The California Academic Press now offers both instruments online. This would facilitate testing immediately prior to graduation.

Additionally, there were gaps in the data gathered over the years. For example, pretest and posttest measures on the disposition and skills were only available for 2 different graduating classes. Having the pretest and posttest scores on both the CCTST and the CCTDI for the same group of students would have been more desirable.

In addition, the study method does not allow for determining potential causes for the observed changes in both disposition and skills over the course of the didactic curriculum. There was no control group and no specific intervention, such as a required CT course, implemented to allow for a true experimental design. Future interventions by faculty members would need to be documented and tracked for their effects on students' CT scores.

Finally, this is still preliminary data. There are insufficient numbers to establish internal norms for the 2 scales. On the positive side, it is a relatively large sample to begin internal comparisons with new classes and external comparisons to other colleges of pharmacy.

CONCLUSIONS

Based on the data, our entering students' disposition towards critical thinking scores were consistently above the desired minimum CAP score. The overall disposition scores compare favorably to national norms. Both the disposition of the students to think critically and their critical thinking skills improved over the course of the didactic curriculum. Further research is needed to identify those areas and/or experiences that promoted this improvement so that additional efforts can be undertaken. Dimensions of critical thinking that students score relatively low on should be areas that the faculty members address through curricular and other program changes.

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Appendix 1. Definitions

CAP - California Academic Press

CCTST - California Critical Thinking Skills Test. The test measures the critical thinking skills possessed by an individual and targets one's overall critical thinking skill plus five sub-scales: analysis, evaluation, inference, deductive reasoning, and inductive reasoning.

CCTDI - California Critical Thinking Disposition Index. The test measures a student's propensity to think critically. The index uses seven categories or scales: Truth-seeking, Open-mindedness, Analyticity, Systematicity, Critical thinking self-confidence, Inquisitiveness, and Cognitive maturity.

MANOVA - Multiple Analysis of Variance. The statistical testing of multiple dependent variables or constructs simultaneously with one or more independent variables in a general linear model.

PCAT - Pharmacy College Admissions Test

WGCTA - Watson-Glaser Critical Thinking Appraisal inventory