RESEARCH

Incorporation of an Explicit Critical-Thinking Curriculum to Improve Pharmacy Students' Critical-Thinking Skills

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Objective. The Health Sciences Reasoning Test (HSRT) is a validated instrument to assess critical-thinking skills. The objective of this study was to determine if HSRT results improved in second-year student pharmacists after exposure to an explicit curriculum designed to develop critical-thinking skills.

Methods. In December 2012, the HSRT was administered to students who were in their first year of pharmacy school. Starting in August 2013, students attended a 16-week laboratory curriculum using simulation, formative feedback, and clinical reasoning to teach critical-thinking skills. Following completion of this course, the HSRT was readministered to the same cohort of students.

Results. All students enrolled in the course (83) took the HSRT, and following exclusion criteria, 90% of the scores were included in the statistical analysis. Exclusion criteria included students who did not finish more than 60% of the questions or who took less than 15 minutes to complete the test. Significant changes in the HSRT occurred in overall scores and in the subdomains of deduction, evaluation, and inference after students completed the critical-thinking curriculum.

Conclusions. Significant improvement in HSRT scores occurred following student immersion in an explicit critical-thinking curriculum. The HSRT was useful in detecting these changes, showing that critical-thinking skills can be learned and then assessed over a relatively short period using a standardized, validated assessment tool like the HSRT.

Keywords: critical thinking, Health Sciences Reasoning Test, curriculum, clinical reasoning

INTRODUCTION

Critical thinking is a process of purposeful, self-regulatory judgment that gives reasoned consideration to evidence, contexts, conceptualizations, methods, and criteria.[1] In the health care field, critical thinking is often put into the context of clinical reasoning or judgment as it relates to patient care.[1] However, critical thinking differs from clinical reasoning in that it is more general and can be applied to a variety of settings. Students are "immersed" or "infused" in a clinical context (or reasoning) of their profession and explicitly taught how to think critically.[2] Critical thinking provides the platform from which students can learn to apply their clinical-reasoning skills. Teaching strategies that foster critical-thinking skills, specifically reasoning skills, which are deliberative, reflective, analytical, and procedural, are associated with the development of reflective problem-solving and critical-thinking skills.[1] Pharmacy curricula can be threaded with assessments that identify and measure critical-thinking skills.

Pharmacy faculty members may expect incoming pharmacy students to possess baseline critical-thinking skills when admitted to a pharmacy program, but evidence supports the need for students to be explicitly taught critical thinking in their education to develop critical-thinking skills.[2] The format with which educators teach critical-thinking skills impacts student learning. Critical-thinking curricula that incorporate active learning such as problem-based learning, case studies, think-aloud or reflective exercises, role-play, or team-based problem solving are more successful in engaging students in critical thinking.[1] Furthermore, active-learning strategies that foster and sustain positive habits of mind such as truth-seeking, inquisitiveness, open-mindedness, maturity of judgment, and confidence in reasoning may also be beneficial in the development of critical-thinking skills.[1]

Pharmacy programs that seek to add critical-thinking skills development into their curriculum must consider

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how to assess these skills. Currently, there are three nationally recognized and validated critical-thinking assessment instruments: the California Critical Thinking Skills Test (CCTST), the California Critical Thinking Disposition Inventory (CCTDI), and the Health Science Reasoning Test (HSRT). Measurement of critical-thinking skills is done extensively using the CCTST for undergraduate students and is considered the "gold-standard" for this population. It predicts success in professional licensure examinations and nonpharmacy careers after graduation.[3] Pharmacy programs that used the CCTST and CCTDI to evaluate pharmacy students' critical-thinking skills throughout the curriculum showed a 14% increase in student abilities over a 4-year period.[4] However, in a different study using the CCTST and CCTDI to assess pharmacy students critical-thinking skills over a shorter length of time (one-year period), no significant changes in critical thinking were noted.[5] This led to a questioning of the consistency and validity of the CCTDI for evaluation of changes in critical-thinking skills in pharmacy students over shorter periods of time as would be needed to evaluate a course.[5] Some studies in dental students using the HSRT over shorter periods of time (10 weeks and one year) have shown significant improvement in critical-thinking skills.[6,7]

The HSRT is a 33-point, multiple-choice examination designed to be used in health care-related fields, although it requires no a priori health science knowledge.[3] It is scaled with an overall score of 26 or above indicating superior critical thinking, and a score of 14 or below indicating critical thinking that is "not manifested."[3] The HSRT requires 30-50 minutes to administer, compared to 1.5 hours for the CCTST or the CCTDI.[3] Much like the CCTST, high scores on the HSRT have predictive value in professional licensure examinations and clinical performance ratings outside the profession of pharmacy.[3] Given that the CCTST may require years to show changes in critical-thinking scores, the alignment of the HSRT to health sciences, the possibility of showing significant changes in critical thinking over shorter periods of time, and the shorter time requirement to administer the HSRT, using the HSRT to evaluate curriculum over shorter periods of time should be investigated.

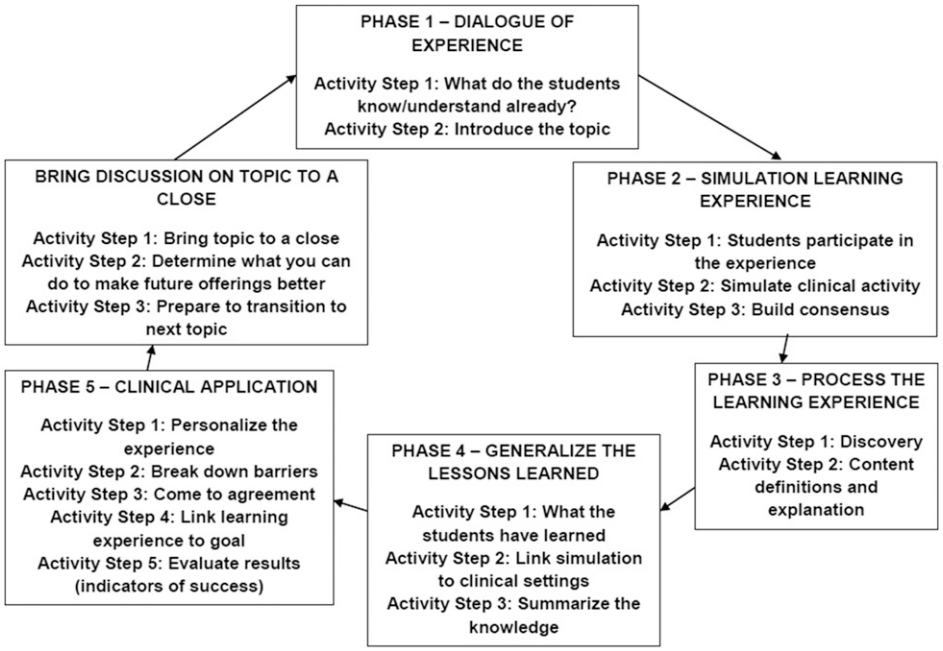
At the University of New Mexico (UNM) College of Pharmacy, critical-thinking skills development has been intentionally and explicitly taught and practiced in a second professional year (P2) doctor of pharmacy (PharmD) course. As with any curricular change, it is important to assess if the curriculum achieved the intended goals. First professional year (P1) students through fourth professional year students were administered the HSRT simultaneously. Preliminary data showed a significant increase in HSRT scores immediately following the P2 course (overall scores in P1 20.0 and overall scores P2, 21.7; $p<0.05$). However, there was a significant limitation with this data in that students could have been intrinsically different at baseline in their ability to think critically. To resolve this limitation and to determine if a true difference exists, one cohort of pharmacy students needed to be followed prospectively through the P1 and P2 years. The aim of this study was to analyze the impact of an explicit critical-thinking curriculum embedded in one course on pharmacy students' ability to critically think as measured by the HSRT.

METHODS

A single-center, prospective cohort study design was employed to determine if the P2 critical-thinking curriculum resulted in changes in HSRT scores. This research was approved by the UNM Institutional Review Board prior to study initiation. PharmD students enrolled in the P1 year in 2012 were invited to participate in the study during the fall semester through announcements in classes and via e-mails. Investigators discussed the HSRT and the aim of the study in an open forum where student questions were encouraged. The following year the HSRT was readministered to the same cohort of students (now P2s) to measure their growth after they went through an explicit critical-thinking curriculum. Participation in the study was voluntary.

To balance anonymity with the need to pair pretest and posttest data, students were tracked using "Banner ID" numbers (student numbers assigned by the university). Banner ID was removed after pairing and before analysis. The investigators administered the HSRT in a controlled environment (computer laboratory). Exclusion criteria included students who did not finish more than 60% of the questions or who took less than 15 minutes to complete the test (as recommended by HSRT developers).[3]

The curriculum designed to develop critical-thinking skills was a 16-week skills-based course in the P2 fall semester. A 5-phase experiential learning cycle (Figure 1) provided the framework for the development of critical-thinking skills.[8] The framework provided a basis for implementing the critical-thinking curriculum that embodied an interactive, intellectually stimulating environment supportive of reflective self-learning, which required both analytical and procedural skills development.[1,2] Repetition of the framework ensured sustainability of the environment for developing critical-thinking skills. The framework made the critical-thinking learning explicit and the value of critical-thinking learning activities apparent to the learner.[2] The course sessions incorporated the 5-phase experiential learning cycle framework approximately 50% of the time.



[a]Cone CJ, Bond R, Pierson J. Teaching critical thinking and problem solving in a pharmacy self-care lab: a skills-based approach. *Curr Pharm Teach Learn*. 2013;5(5):342-350.

Figure 1. 5-phase learning cycle – framework for development of critical-thinking skills[a].

Through the use of simulation and formative feedback, the explicit critical-thinking curriculum incorporated active-learning techniques. The contextual elements for critical-thinking skills development included patient interviews, subjective, objective, assessment and plan (SOAP) notes, drug information (DI) responses, evidenced-based-medicine practices, and medication therapy management methods. The SOAP note and DI activities served as the platform to develop critical-thinking skills through the promotion of information gathering, problem identification and analysis, patient specific application, assessment and evaluation, and synthesis of an answer or plan. The laboratory course met for 2.5 hours once weekly with additional prelaboratory materials and occasional homework assignments. The curriculum including the 5-phase experiential learning cycle framework is published in detail elsewhere.[8] The HSRT provides the examinee information on the overall score, overall percentile score, and subdomains including induction, deduction, inference, analysis, and evaluation.[3] The overall score of critical-thinking ability described test taker strengths using reasoning to form "reflective judgments" regarding what to believe or not believe. The definitions and categorical interpretations of the scores were: Superior – skills at this level reflect a potential for more advanced learning and leadership; Strong – a skill set consistent with a potential for academic success and career development; Moderate – reflect a potential challenge when the test taker is engaged in decision making or problem solving requiring reflection; Not manifested – the lowest score indicating possible insufficient test-taker effort, cognitive fatigue, or a language or reading comprehension situation.[3] Percentile scores offered insight about the test taker's relative strength compared to others at a national level.[3]

Data gathered and included as part of this analysis were year in pharmacy school, HSRT overall scores, percentile scores, and domain-specific subscores. Statistical analysis of students HSRT results was completed using Excel and SAS v9.3 (SAS Institute Inc., Cary, NC). The overall, percentile, and subdomain scores from the HSRT failed a test for normality. As a result, the Wilcoxon signed rank test was used to assess changes from P1 to P2. For all analyses, p values were set at a significance level of <0.05.

RESULTS

Table 1 shows the results from the HSRT. The response rate for the HSRT was 100%. However, not all results were usable. Based on exclusion criteria, eight students were excluded from analyses: three did not finish more than 60% of the questions; three took less than 15 minutes on the test; and two did not finish more than 60% and took less than 15 minutes on the test. Student scores improved by 1.8 points on the HSRT scale representing an 8.9% overall improvement, which took students from below the national mean (43.7%) to above it (55.4%) in

Table 1. HSRT Scores in Pharmacy Students During Their First and Second Years

Domain	Mean (SD) P1[b]	Mean (SD) P2[b]	*p* value
Analysis	4.3 (1.2)	4.5 (1.2)	0.078
Deduction	5.8 (1.9)	6.9 (2.3)	<0.001[a]
Evaluation	4.5 (1.2)	4.9 (1.0)	0.039[a]
Induction	7.3 (1.5)	7.5 (1.3)	0.22
Inference	2.9 (1.0)	4.0 (1.3)	<0.001[a]
Overall	20.2 (4.2)	22.0 (4.3)	<0.001[a]
Overall Percentile	43.7 (23.9)	55.4 (26.8)	<0.001[a]

[a]Wilcoxon signed rank test with alpha at <0.05,[b] n=75
P1=first-year; P2=second-year

a relatively short period. Subdomain scores also improved in all categories: analysis by 4.7%, deduction by 19.0%, evaluation by 8.9%, induction by 2.7%, and inference by 37.9%. The subdomains of deduction, inference, and evaluation showed a significant improvement. While numerical values for the subdomain for analysis trended towards improvement, the improvement did not reach significance ($p=0.08$). These results were similar to preliminary data gathered prior to initiation of this study.

Faculty and student time commitment was minimized as a result of using the HSRT (30-60 minutes to administer/monitor, take, receive results, and show students their areas of strengths and weaknesses immediately following the assessment). The HSRT measured changes in pharmacy students' overall scores, percentile scores, and subdomain scores following the 16-week course.

DISCUSSION

The P2 curriculum designed to teach critical-thinking skills significantly improved overall HSRT scores, showing that students improved their critical-thinking abilities following this 16-week curriculum. The results were similar to preliminary data, so the changes in HSRT are likely not chance. In addition to critical thinking, the overall score in the HSRT is also considered an estimate of a student's strength in meta-cognition as described in the HSRT manual.[3] Meta-cognition is a component of Standard 4 in the Accreditation Council of Pharmacy Education's (ACPE) 2016 Standards.[9] A program that can improve critical thinking and meta-cognition while simultaneously using objective evidence like the HSRT to measure these abilities would be helpful with assessment and accreditation. The HSRT manual indicates that for every one point increase in overall average score, everyone in the cohort "no longer made at least one of the common reasoning errors."[3] Students improved their scores on average by almost two points, which the manual states is "evidence of effective training programs."[3] The manual also indicates that students who score three or more points lower than their previous test score were likely less engaged in the test, as an individual's critical-thinking ability does not decrease significantly over time, except in case of disease or accidental injury.[3] When we removed from the analysis students who scored three points or more lower than their previous test score (n=10 students), the overall scores for the remaining cohort increased on average by more than three points following the curriculum.

While critical thinking can be taught without clinical reasoning, combining the two into one curriculum makes sense given the time constraints of school and the need for students to develop reasoned professional judgment. Activities developed to teach critical-thinking skills such as SOAP note writing, DI skill development, or other proven techniques, can serve as intermediate learning assessments of critical-thinking. However, objective evidence is needed that the curriculum will improve students overall ability to think critically. Some studies indicated that changes in critical thinking should be measured over years not weeks,[4,5] although studies in nursing and dental students showed improvements in HSRT scores or subdomain scores over shorter periods of time (10 weeks to 16 weeks).[7,10] The P2 curriculum occurred over a 16-week period and significantly improved scores by 8.9% overall, taking students from below the national mean to above it in a relatively short period. Purposely adding an explicit critical-thinking curriculum to develop clinical reasoning in pharmacy students was successful in our student population, and the HSRT was sensitive enough to detect a difference in student critical-thinking skills.

Two articles suggested that the HSRT did not correlate well with grades or with academic performance.[11,12] Grades will not likely be highly linked to or predictive of critical thinking unless a course is explicitly designed to teach and assess critical thinking. Job performance, positive decision making, leadership abilities, implementation of evidenced-based-medicine, job retention, creativity in problem solving, and many other positive qualities are strongly and positively correlated with critical thinking, unlike grades, SAT scores, and class rank.[12-16] Individuals who test highly in critical-thinking are less likely to display problem behaviors or make biased decisions.[16] These less tangible aspects of any professional practice are linked with one's ability to think critically, so the HSRT would be better than grades or academic performance at predicting these measures of success. Critical-thinking tests reveal what individuals can do now, as well as predict how they will do in the future.[13] Thus, if we can educate and train students to improve their critical-thinking skills, it would be advantageous to the students, the profession, and

presumably patients. Many programs across the United States likely have components of critical thinking in their curricula, but may need to add an explicit curriculum to build foundational critical-thinking skills. A concerted effort to thread critical-thinking throughout courses using the active-learning techniques described by Facione and Facione would give students the skills necessary to be successful post-graduation.[1] If we want to move the profession forward and promote these qualities in students, then critical thinking is one means by which to achieve it.

Limitations of this study include uncontrollable variables. The explicit critical-thinking curriculum in the course cannot be assumed to be solely responsible for the increase in scores. Other courses occurred during the time frame of this study including four weeks of an introductory pharmacy practice experience (IPPE). These courses and the IPPE, to the extent of the authors' knowledge, do not implement an explicit critical-thinking framework, but they do incorporate activities capable of critical-thinking skill building. Also, it is possible that increasing student maturity is partly responsible for the improvement in critical-thinking skills over this time frame.

CONCLUSION

Significant improvement in HSRT scores occurred among students following a course designed to teach foundational and explicit critical-thinking skills. Incorporating active learning using simulation, formative feedback, and clinical reasoning built on knowledge that students were obtaining in other courses and was put into the context of patient-centered care. This study shows that the HSRT can measure the impact of a critical-thinking curriculum among pharmacy students. The results represent a significant change and a potential clinically relevant advance for students in their critical-thinking and clinical-reasoning skills. If professional organizations agree that critical-thinking skills are important for pharmacy students to master, these results could be the impetus for integrating foundational and explicit critical-thinking curriculum and using the HSRT or another validated test to assess its impact on students.

REFERENCES

1. Facione NC and Facione PA. *Critical Thinking and Clinical Reasoning in the Health Sciences: An International Multidisciplinary Teaching Anthology*. 4th ed. Millbrae, CA: The California Academic Press LLC; 2008.
2. Abrami PC, Bernard RB, Borokhovski E, et al. Instructional interventions affecting critical thinking skills and dispositions: a stage 1 meta-analysis. *Rev Educ Res.* 2008;78(4):1102-1134.
3. Insight Assessment. http://www.insightassessment.com/. Accessed November 23, 2015.
4. Miller D. Longitudinal assessment of critical thinking in pharmacy students. *Am J Pharm Educ*. 2003;67(4):Article 120.
5. Cisneros RM. Assessment of critical thinking in pharmacy students. *Am J Pharm Educ*. 2009;73(4):Article 66.
6. Quitadamo IJ, Kurtz MJ. Learning to improve: using writing to increase critical thinking performance in general education biology. *CBE Life Sci Educ*. 2007;6(2):140-154.
7. Wetmore AO, Boyd LD, Bowen DM, Pattillo RE. Reflective blogs in clinical education to promote critical thinking in dental hygiene students. *J Dent Educ*. 2010;74(12):1337-1350.
8. Cone CJ, Bond R, Pierson J. Teaching critical thinking and problem-solving in a pharmacy self-care lab: a skills-based approach. *Curr Pharm Teach Learn*. 2013;5(5):342-350.
9. Accreditation standards and key elements for the professional program in pharmacy leading to the doctor of pharmacy degree. Accreditation Council for Pharmacy Education. https://www.acpe-accredit.org/pdf/Standards2016FINAL.pdf. Published February 2, 2015. Accessed November 23, 2015.
10. Sullivan-Mann J, Perron CA, Fellner AN. The effects of simulation on nursing students' critical thinking scores: a quantitative study. *New Inf Nurs Rev.* 2009;9(2):111-116.
11. Cox WC, Persky A, Blalock SJ. Correlation of the Health Science Reasoning Test with student admission variables. *Am J Pharm Educ*. 2013;77(6):Article 118.
12. Cox WC, McLaughlin JE. Association of Health Sciences Reasoning Test scores with academic and experiential performance. *Am J Pharm Educ*. 2014;78(4):Article 73.
13. Stanley TJ and Robbin J. *The Millionaire Mind*. Kansas City, MO: Andrews McMeel Publishing, LLC; 2000.
14. Dilchert S, Ones DS, Davis RD, Rostow CD. Cognitive ability predicts objectively measured counterproductive work behaviors. *J Appl Psychol*. 2007;92(3):616-627.
15. Kuncel NR and Hezlett SA. Fact and Fiction in cognitive ability testing for admissions and hiring decisions. *Curr Dir Psychol Sci.* 2010;19(6):339-345.
16. West RF, Toplak ME, Stanovich KE. Heuristics and biases as measures of critical thinking: associations with cognitive ability and thinking dispositions. *J Educ Psychol*. 2008;100(4):930-941.