Report on the Development, Implementation, and Evaluation of an Evidence-Based Skills Course
A Lesson in Incremental Curricular Change

Monica Smith, D.C., Ph.D., **Cynthia Long**, Ph.D., **Chuck Henderson**, D.C., Ph.D., **Dennis Marchiori**, D.C., Palmer Center for Chiropractic Research, **Cheryl Hawk**, D.C., Ph.D., Parker College of Chiropractic, **William Meeker**, D.C., M.P.H., and **Lisa Killinger**, D.C., Palmer Center for Chiropractic Research

Purpose: This article reports on the design and implementation of one innovative curricular strategy for creating competent, evidence-based chiropractic health care practitioners. **Methods:** Didactic, experiential, and Socratic methods were used to teach literature retrieval, critical appraisal, and critical thinking skills to students at a U.S. chiropractic college. In addition to course and faculty evaluations, a survey gathered pre- and postcourse data on students' attitudes, perceived abilities, and knowledge and skills. **Results:** Most course and instructor evaluation measures demonstrated a positive trend over six terms. General descriptive comparisons of pre- and postsurvey data indicate some improvements in students' perceived abilities and skills to search for, retrieve, and critically evaluate the literature. **Conclusions:** Trends of evaluation results over time, rather than single course evaluations, are particularly useful when considering innovative curricular changes, as are pre- and postmeasurement of student performance. (The Journal of Chiropractic Education 18(2):116–126, 2004)

Key words: critical appraisal, critical thinking, curriculum, evaluation, evidence-based, innovation

INTRODUCTION

The current era of health care reform increasingly emphasizes evidence-based health care and provider accountability, requiring that chiropractors possess the necessary knowledge and skills to function effectively as clinical practitioners in a highly competitive and complex health care system. Chiropractors must be able to access, appraise, and apply the body of current scientific evidence to chiropractic practice.

This case study reports on the experience of the faculty at Palmer College of Chiropractic in Davenport, Iowa, to create and implement a curricular change intended to impart evidence-based skills to chiropractic students. The "Introduction to Research" course formerly in existence had been initially designed to introduce chiropractic students to the fundamental nomenclature of research and to give them a general appreciation for the principles of scientific research. Although the course was sufficient in meeting those prior goals, it was deemed inadequate to address the revised mandate of developing the practical skills in chiropractic students needed to foster competent evidence-based chiropractic health care practice. The strategies for curricular change reported in this article involved the design and implementation of a new course and included incremental and ongoing development of the course over successive trimesters based on evaluations of course outcomes.

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METHODS

Course Development

Guided by a number of articles on evidence-based skills development (1–33), the authors designed a

Table 1. Breakdown of Course Topics

Topic	Number of lectures
Nature of scientific inquiry	5
Structure of a research article	1
Searching the literature	2
Critically appraising articles:	
Case studies, case series	1
Prevalence, risk, prognostic studies	2
Diagnostic studies	1
Intervention, outcomes studies	4
Fundamentals of measurement	2
Current evidence	1–2

team-taught course to teach literature retrieval, critical appraisal of the clinical literature, and critical thinking skills to students at Palmer College Davenport. The course employed didactic, experiential, and Socratic teaching methods (see Appendix for an example of the Socratic method as used in this course). It was determined that published clinical research articles needed to be incorporated into all aspects of the course. Articles on chiropractic and related topics were chosen both to illustrate course material and to give students a familiarity with the peer-reviewed literature.

The number of 50-minute classes held each trimester ranged from 23 to 25; with 19 to 20 of these dedicated to the topics listed in Table 1. The remaining classes were used for small group discussions, examinations, and review sessions. Lectures were principally delivered by a core of four to five instructors, who taught at least two consecutive lectures in an attempt to strengthen the cohesiveness of the course.

The course began with lectures on the nature of scientific inquiry, including the introduction of evidence-based health care; an overview of study types for clinical research; general issues in study design, methodology, and analysis in addressing clinical research questions; and the concept of association versus causality. The *literature search and retrieval* skills development was coordinated with college library faculty and staff. This included classroom lectures and demonstrations, as well as a "hands-on" search and retrieval homework exercise conducted on electronic library databases and facilitated by librarians on-site.

Critical appraisal of the clinical literature was introduced in classroom lectures and included instruction on the structure of a research article and on reading and developing the skills to appraise the reports of several different types of clinical studies. Materials were developed based on several sources (1,4,8,11,12,16,21) to guide students through reading each type of study report. Student comprehension of important yet complex research concepts was facilitated by "user-friendly" graphical learning aids such as the "hierarchies of evidence" triangles depicted in Figure 1. Students were assigned to read articles prior to the related lectures and short homework assignments on general aspects of a given article were due at the beginning of the class period. Students who had read the article with the use of the guides were able to easily complete the assignments. The lectures were then used to further develop the critical appraisal skills using the assigned article.

We employed two approaches to familiarize the students with fundamental scientific and clinically oriented *critical thinking*. First, we convened instructor-led small group Socratic discussions (see Appendix) wherein students were encouraged to critique, question, and challenge the methods, findings, generalizability, and clinical applicability of the assigned reading of published research studies. Second, students were provided the opportunity to complete an optional extra credit essay assignment, wherein they were challenged to reconcile a fictitious patient's anecdotal experience (e.g., the longevity and apparent good health of an older relative who was a lifelong smoker) to the established scientific evidence on the negative health effects of smoking.

To best facilitate similar learning experiences for all students, the small group discussion sessions were carefully planned. An article, as described above, was also used in these sessions and a homework assignment on the article was due at the beginning of the class. All of the course lecture instructors with additional faculty and research residents were used to facilitate the small groups. Therefore, guided notes of key discussion points were prepared and discussed in meetings prior to use (see Appendix). Debriefing meetings were attended by all facilitators each trimester and informed the lecture material following the small group sessions.

Course Implementation and Examinations

Delivery of various components of the new course was piloted for four terms, within the already existing Introduction to Research course, as per the timeline in Figure 2. During the pilot phase of new course delivery, examination questions for the new "critical appraisal/thinking" material were

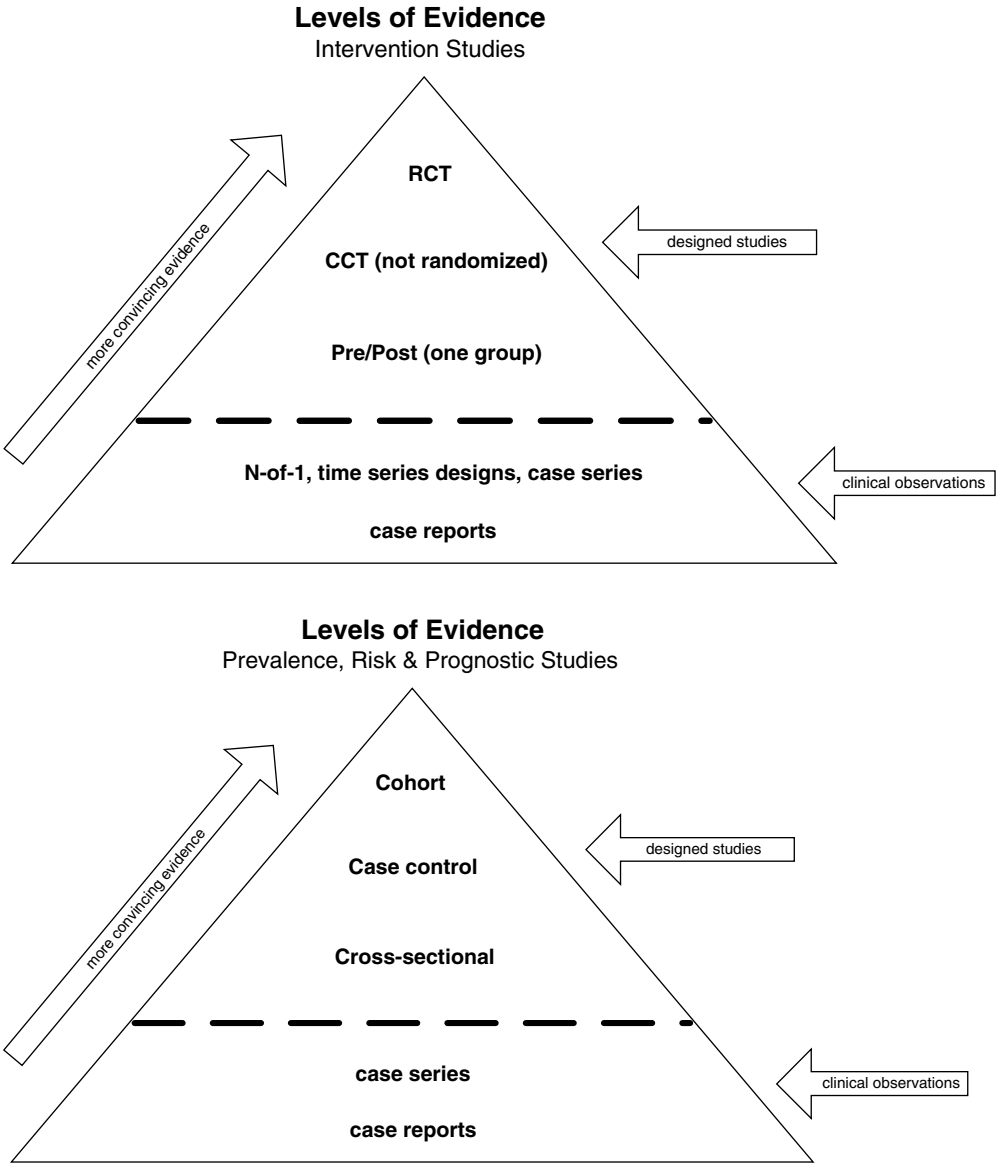

Figure 1. User-friendly graphics summarizing study designs.

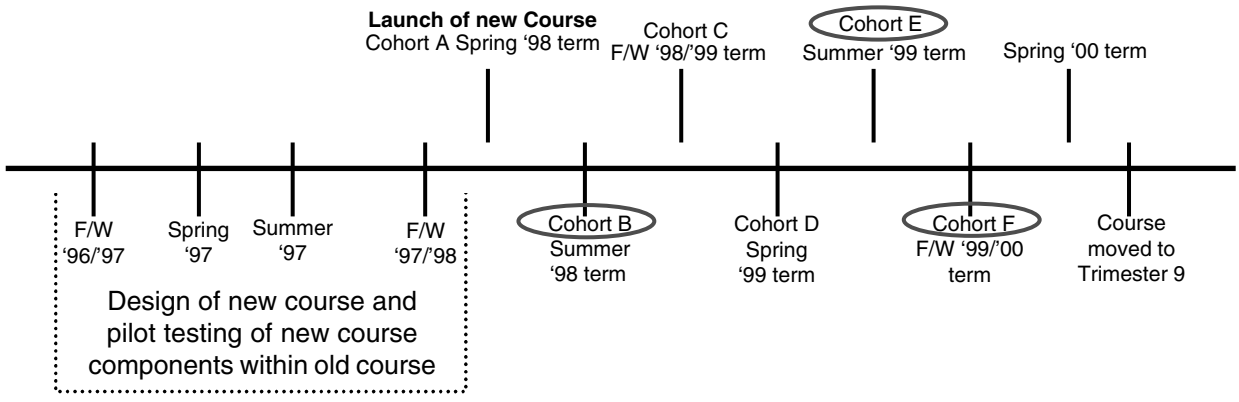

Figure 2. Timeline for new course development, implementation, and evaluation.

also prevalidated. New exam items were introduced in pilot-phase exams as nonpenalty items (either as "extra credit" or dropped during exam grading). Following postexam item analysis, items were modified to improve validity and reliability, and retested and reanalyzed. New items were then incorporated into the main bank of future exam questions.

Exam items on each topic were prepared by the member of the teaching team who taught that topic. For example, the college librarians designed the exam questions on the topic of literature search and retrieval skills. Testing on critical appraisal skills was accomplished by using excerpted paragraphs, tables, and figures from clinical articles and asking a block of examination questions relating to the excerpted material. All members of the teaching team critiqued examination questions prior to their incorporation into the bank of exam questions. Exams contained multiple-choice questions and were essentially "open-book." Each student was allowed a 13-page glossary of terms (handed out the first day of class) and one sheet of paper with notes for each exam. Exams were machine graded, whereas homework assignments and the essay portion of the exams were hand graded with comments and returned to students within a week. Small group discussion attendance was mandatory and an associated take-home essay test was assigned and hand graded.

Student Cohorts

Following the pilot-testing phase, the course was delivered for six complete terms to six separate student cohorts (cohort A [$n = 182$]; B [$n = 115$]; C [$n = 169$], D [$n = 157$], E [$n = 102$], F [$n = 166$]). The course was two credits and offered during the second trimester of the first year. All other courses that trimester were in the basic sciences.

Course Evaluation Methods

In addition to the standardized institution-administered student evaluations of the course and course instructors collected at the end of every semester, an additional survey was administered to student cohorts B, E, and F (see Fig. 2). The survey gathered pre- and postcourse data on the students' attitudes about the purpose and relevance of research to clinical practice and their perceived abilities to search for, retrieve, and critically evaluate the scientific clinical literature. The survey also tested students' fundamental knowledge of effective literature searching, by asking them to identify the number of chiropractic journals indexed in Medline, to identify an appropriate database for conducting a comprehensive search for chiropractic journals, and to differentiate between a peer-reviewed and non-peer-reviewed journal.

Precourse surveys were administered on Day 1 prior to the course orientation, and postcourse surveys were administered at a one-semester lag after course completion in order to assess the sustainability of any potential improvements outside of the controlled classroom environment. Due to the sporadic nature of data collection posed by the difficulty of coordinating and administering the postcourse surveys during other instructors' class times, both pre- and postcourse survey data were collected and available on only the three cohorts, B, E and F, circled on the Figure 2 timeline. Postcourse evaluations and pre- and postcourse surveys were anonymous and therefore could not be linked to analyze differences using paired comparisons. Neither could the pre- and postcourse data be treated as independent, since both represented unknown samples drawn from the same class cohort. Therefore, all data were analyzed and are reported as descriptive trends and comparisons; no inferential statistical analyses were conducted.

RESULTS

Course Evaluation Results

Standardized student evaluations of the course demonstrated a general upward trend over the six terms of course implementation, as indicated on Figure 3. Similarly, student evaluations of individual faculty performance improved over time, for each instructor (Fig. 4). Student evaluations also included their self-report of whether the course met the goals of giving them adequate instruction or interest in reading the clinical literature (Fig. 5). While students generally demonstrated a perception of having received adequate instruction as a result of the course, there was minimal to no effective change in their level of interest.

Within-course examination of critical appraisal skills measured the students' ability to identify, interpret, or apply concepts of study design, sampling, statistical significance, and generalizability of study findings. On general knowledge and interpretation exam questions, such as identifying a study design or interpreting p values, 80%–90% of all students performed successfully. For more difficult applications, such as determining the appropriateness of a

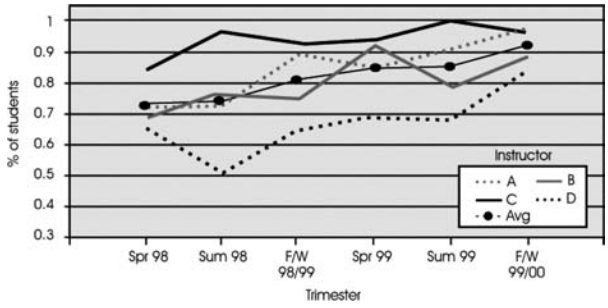

Figure 3. Percent of students that strongly agree, agree, or at least partially agree with the statement: "Instructor 'X' was an effective instructor."

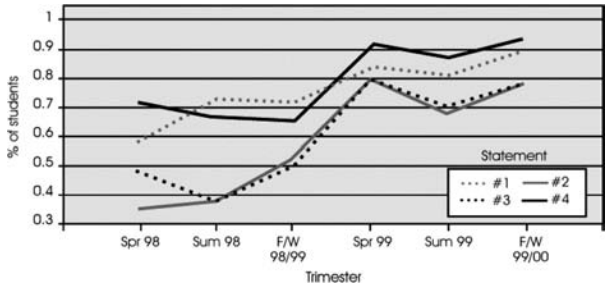

Figure 4. Percent of students that strongly agree, agree, or at least partially agree with the statements:
1) "Faculty seemed to have interest in student's performance and progress."
2) "The class was well organized."
3) "Ideas were clearly presented in class."
4) "Faculty frequently answered questions in a understandable manner."

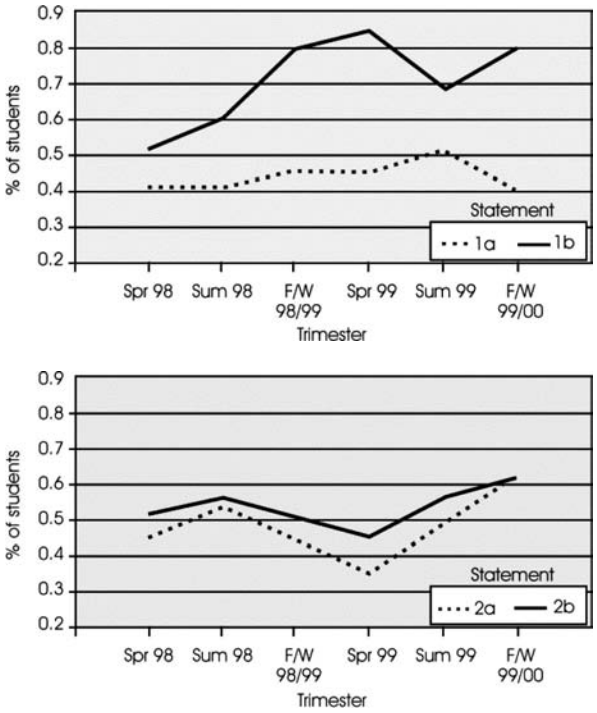

Figure 5. Percent of students answering "yes" to statements:
1a) "Prior to this course, I had **sufficient instruction** *in reading clinical research literature."*
1b) "Having taken this course, I have **sufficient instruction** *in reading clinical research literature."*
2a) "Prior to this course, I had **real interest** *in reading clinical research literature."*
2b) "Having taken this course, I have **real interest** *in reading clinical research literature."*

study design to answer a specific research question, more than 60% of students were successful.

General descriptive comparisons of pre- and post-survey data indicate some positive differences in students' perceived abilities to search for, retrieve, and critically evaluate the literature, as reported in Table 2. Student knowledge of effective search and retrieval skills (i.e., their familiarity with the content of search databases and correctly identifying peer-reviewed journals) also demonstrated a noticeable difference between pre- and postscores.

DISCUSSION

A valuable lesson gained from this experience was that the "success" of a course such as the one described here cannot and should not be measured on the basis of single course evaluations. As demonstrated here, the trends of evaluation results over successive course administrations will yield a more accurate picture, particularly when considering the implementation of course changes or other curricular innovations. Course evaluations, as well as individual instructor evaluations, may be greatly impacted by such innovations as evidenced here. This holds implications for chiropractic colleges seeking to encourage innovation and overcome "academic inertia," because administrative attention must also be directed toward appropriately recognizing and addressing possible faculty hesitancy toward change and to reward faculty, or at least not penalize them, for assuming the inherent risks and taking the initiative to innovate. Also, pre- and postmeasurement of student performance can present additional useful insight into the true value of a given course on a number of important dimensions

Table 2. Precourse vs. Postcourse Survey Descriptive Statistics of Student Perceived Abilities, Knowledge, and Skills to Search for and Critically Evaluate Clinical Research Literature, Averaged Over Cohorts B, E, and F

Student *perceived abilities* to search for and critically evaluate research literature. Percent agree completely or somewhat with the statement:	Before Course	After Course
1. I feel prepared to run a MedLine search.	24%	77%
2. I am able to do a computer search of chiropractic journals.	57%	83%
3. I feel able to critically evaluate an article about a clinical trial of chiropractic care	38%	71%
Student *knowledge and skills* to search for literature. Percent correct response to question:	Before Course	After Course
4. How many chiropractic journals are on MedLine? *(1)*	23%	43%
5. To do a comprehensive search of the chiropractic literature, use which database? (*MANTIS*)	17%	25%
6. JMPT is a peer-reviewed journal. (*True*)	62%	85%
7. *Chiropractic Economics* is peer-reviewed journal. (*False*)	58%	71%

Cohort B: Pre, $n = 107$, Post, $n = 78$. Cohort E: Pre, $n = 45$, Post, $n = 126$. Cohort F: Pre, $n = 120$, Post, $n = 72$.

and further guide course improvements, which also requires cooperation and coordination at an institutional level.

The general positive trend in student evaluations reported in this institutional case study likely reflects both the incorporation of student feedback into the course development process and the "settling down" over time of a course that had undergone a major redirection and transformation (e.g., increasing instructor familiarity with new material and teaching methods and getting the "teaching team" in sync). Also, the number of "core instructors" delivering lectures was decreased from seven to four over time, which improved the cohesiveness of the didactic classroom experience.

Critical appraisal skills were routinely tested during the course, and the vast majority of students demonstrated an ability to understand and apply basic scientific concepts to specific studies drawn as examples from the clinical literature. As reported, within-course exam scores (averaged over cohorts) testing student knowledge and application of concepts of study design, sampling, statistical significance, and generalizability of results exceeded 60% for difficult applications and 80%–90% for general knowledge and interpretation items. However, it is not known whether or to what extent the learning of this particular skill set was sustained or even reinforced (e.g., by other courses, instructors, or experiences) outside of the controlled classroom environment of this single course. A comprehensive critical appraisal skill set should also include the ability to compare and contrast sources for secondary summaries of information, such as those exemplified in the user-friendly graphical aid in Figure 6.

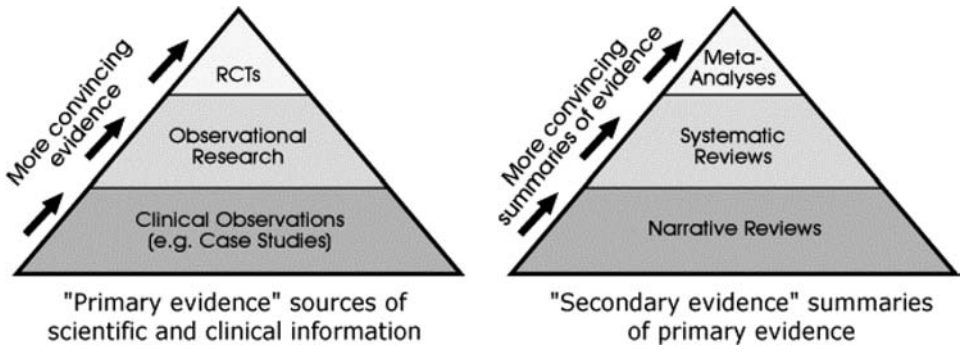

Figure 6. Hierarchies of evidence for primary and secondary information sources of peer-reviewed scientific literature.

Critical thinking skills developed within the context of self-directed clinical reasoning exercises may be more ideally suited to facilitate comprehension, to assist in transitioning students from "passive" to "active" learning modes, and to also impress upon the students the practical application and utility of an evidence-based approach to their future clinical care of patients. However, the default placement of this course into the second trimester early in the curriculum limited our opportunities for rigorously applying or testing critical thinking skills using self-directed approaches or appropriate clinical reasoning scenarios.

In this course, we were only able to develop the skills of students to *access and appraise the literature*, as students had not yet been exposed to the clinical sciences. Ideally, this skill set should be learned early and then utilized throughout the curriculum, so that by the time students are working with patients in the clinic environment they have the relevant instruction and experience needed in developing the skills to *apply* the evidence. Literature search and retrieval, critical appraisal, and critical thinking skills are more likely to be successfully developed and maintained if such skills are reinforced through other courses and training experiences throughout the entire curriculum.

Equally important are the findings from this study indicating a noticeable and positive difference in students' attitudes toward, and perceived abilities of, their evidence-based skills precourse versus postcourse. Such positive student attitudes and perceptions may serve to reinforce their feelings of being empowered to take an evidence-based approach to practice as a result of the course, and consequently may also result in a more favorable perspective toward evidence-based principles of chiropractic health care provision. The totality of the study findings underscores the importance and utility of inspiring a confident, "evidence-based mindset" early in the students' curricular experience, as well as the need to reinforce and emphasize the development of critical appraisal and critical thinking skills throughout the *entire continuum* of the chiropractic curriculum and clinical training. As graphically represented in Figure 7, although foundational basic science coursework is typically "blocked" into early terms and applied clinical courses into later terms for practical and logistical reasons, the student's experience is enhanced when both aspects are well integrated into a coordinated continuum of learning. Similarly, the development of evidence-based skill sets should follow a path that continually reinforces the use of critical appraisal skills learned early and applies those skills to increasingly challenging exercises and experiences in critical thinking and clinical decision making. Further, chiropractic college libraries and librarians are an institutional resource whose contribution is also central to empowering an "information literate" constituency.

A 1998 Pew Health Professions Commission report (34) outlined 21 competencies for emerging health professions, which included providing evidence-based, clinically competent care; applying knowledge of the new sciences; and demonstrating critical thinking, reflection, and problem-solving skills. The model presented in Figure 7 graphically summarizes our suggestion that the successful development of various evidence-based skills in chiropractic students requires an institutional and system-wide approach. Similar to the curricular progression of students from early foundational basic science coursework to their later applied clinical science courses and experiences, the development of "evidence-based skills" should follow a similar progression and shifting of emphasis: from early exposure and experience with fundamental literature searching and critical appraisal skills, to later development of critical thinking and the application of those skills to clinical decision making. These skills need to be integrated and continuously

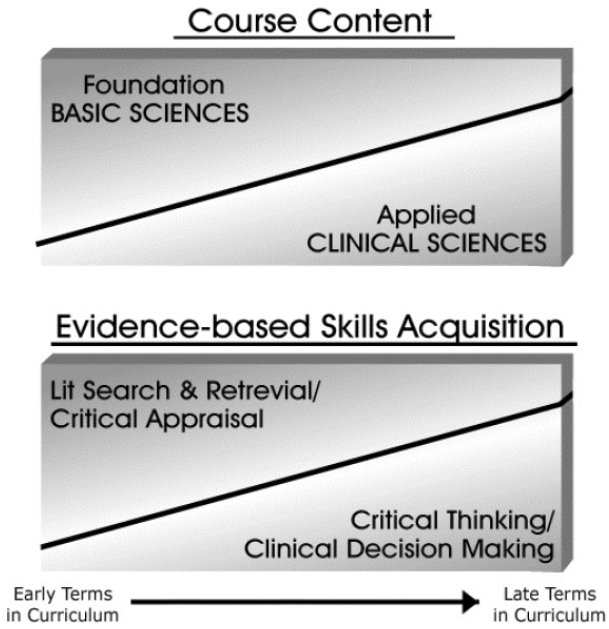

Figure 7. A graphical model for integrating and reinforcing evidence-based skills throughout the chiropractic college curriculum.

reinforced across courses and throughout the curriculum. Inherent in this model is the additional expectation that students progressing through the curriculum should also shift from a passive directed learning mode, to that of active self-directed lifelong learners. Evidence-based skills can aid students in that transition and empower them to better meet the challenges as tomorrow's Doctor of Chiropractic.

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APPENDIX: DEFINITION AND EXAMPLE OF SOCRATIC TEACHING

Definition of Socratic Teaching in a Health Professions Curriculum

Aside from pure philosophical discourse, the Socratic method has broader utility as a teaching approach that engages teacher and students in a cooperative open-ended dialogue of participatory learning. Rather than lecturing students about reasoning (for instance, in the legal or clinical professions), Socratic dialogue fosters as much active learning as possible, creates opportunities for students to engage in independent critical thinking that can lead them to a deeper understanding, and inculcates in students the habit of rigorous and critical analysis, as well as the practice of assessing and revising their own ideas and approaches in light of new information or different reasoning. Socratic methods work well for demonstrating the complexity and uncertainty inherent in certain subject areas and for exploring difficult concepts and principles. Socratic teaching can help develop reasoning skills that can be applied to clinical problems and questions.

Socratic questioning aids students by posing facilitating questions that advance the discussion, and follows up answers with further questions. The Socratic questioner guides the class to think in a disciplined, intellectually responsible manner by acting as the logical equivalent of the inner critical voice that the mind develops with critical thinking abilities.

For further useful information, the above definition was derived from the following Web sites:

http://www.stanford.edu/dept/news/pr/03/socratic528.html
http://www.law.uchicago.edu/prospective/headnotes/socratic.html
http://lonestar.texas.net/~mseifert/crit3.html
http://www.cyberhigh.fcoe.k12.ca.us/PASS_Program/methodology/Socraticteaching.htm

Example of Socratic Teaching in a Health Professions Curriculum

We facilitated our small group discussions using the following six question sets, referencing the research journal article: Spinal manipulation vs. amitriptyline for the treatment of chronic tension-type headaches: a randomized clinical trial (Boline PD, Kassak K, Bronfort G, Nelson C, Anderson AV, J Manipulative Physiol Ther 1995;18(3):148–154.

Q1a. Are the specific AIMS of study clearly stated?
[*Note to Facilitator*: Yes, the authors clearly state the study aim is to compare effectiveness of spinal manipulation and pharmaceutical (amitriptyline) for chronic tension-type headache (CTTH).]

Q1b. Why is this important to the reader/clinician?
[*Facilitator note*: The study aim provides theoretical justification (based on investigator's review of past studies provided in the article introduction) for conducting this particular study (the "body of evidence" that this study builds on). Stated aims should be consistent with methods, analysis, results (e.g., study design should be appropriate for addressing the stated aims).]

Q2a. Are the METHODS of the study clearly stated?
[*Facilitator note*: Yes, the authors clearly identify the Research Study Design as a randomized clinical trial (RCT), two parallel groups (spinal manipulation therapy, SMT; and drug therapy, DT), and no control group. All patients were accounted for: Of 448 respondents, 298 were ineligible and 150 enrolled; there were 24 dropouts (5 in SMT group; 19 in DT group).]

Q2b. Why is this important to the reader/clinician?

[*Facilitator note*: Again, to check whether the method supports the aims. Also allows reader to compare/contrast this study with other studies in the literature (to build a "body of evidence" to apply in their practice). *Side note*: journal page limitations often impose space constraints on methods reporting. Therefore, the reader must sometimes trust that the journal's expert peer reviewers were satisfied that the study methods were appropriate.]

Q3a. Does the METHODS section clearly state INCLUSION/EXCLUSION criteria?

[*Facilitator note*: Yes, the authors clearly identify the target population as CTTH sufferers, 18–70 years old, headache history of at least 3 months, headache frequency of at least 1 per week, with CTTH operationally defined by International Headache Society (IHS) criteria. The Sampling Method clearly states that study participants were recruited from Minneapolis/St. Paul metro area; that recruitment methods included radio ads, newspaper ads, public service announcements, flyers, and news story on local TV; and that participants were screened by phone and face-to-face interviews based on inclusion and exclusion criteria.]

Q3b. Why is this important to the reader/clinician?

[*Facilitator note*: Student should appreciate the inherent *tradeoff*, that imposing inclusion/exclusion criteria limits the **generalizability** of the study findings (e.g., reader/clinician may not be able to generalize absolutely to their own patient base). However, there are *key reasons* that may require study investigators to impose greater **control** of the characteristics of the study population (and thereby limit generalizability). *Three key reasons*, all of which are exemplified in the Boline study: a) certain patient/subject characteristics could *bias study results* (e.g., Boline study excluded patients who had been actively treated for HA within the past 3 months); b) *practical issues* (e.g., Boline study used IHS criteria and limited the study to only CTTH; and limited to subjects currently experiencing a manifest headache (HA) "condition"—i.e., have for past 3 months, at least 1 HA/week); c) *safety/ethical/legal issues* (e.g., Boline study excluded patients for whom this treatment intervention was contraindicated; pregnant, probably for x-rays, and very young/old).]

Q4a. Methods—Are important operational definitions offered for key constructs? <Yes>

[*Examples from Boline et al.*: a) They used widely accepted IHS criteria for HA Dx.; b) Treatment intervention of spinal manipulation therapy (short-lever, high-amplitude thrust) is a widely used operational definition in the chiropractic scientific literature (although not always agreed upon) that serves as a description of observable physical characteristics of this treatment; c) For the operational definition of "subluxation" diagnosis (as part of the treatment protocol), the Boline study referred the reader to earlier studies in other cited articles, so unless the reader retrieves and reviews those articles, they do not know if, and how well, that construct was operationally defined for *this* article.]

Q4b. Why is this important to the reader/clinician?

[Allows reader to compare/contrast across studies. Allows reader/clinician to determine degree to which findings generalize to their own patient base.]

Q5a. Does OUTCOMES/RESULTS section include compliance data? <Yes>

[Boline et al. report participants' compliance with adhering to the treatment plan (e.g., following their drug regimen off-site), compliance with completing the self-administered outcome measurement instrument, and compliance as a study participant (dropout/attrition rates).]

Q5b. Why is this important to the reader/clinician?

[If compliance is different across groups, this may introduce bias, or limit generalizability of study findings (e.g., if missing data or dropout/attrition alters the makeup of study sample data available for analysis, such that the remaining sample data are no longer truly representative of target population). If investigators/readers do not know the reason(s) for dropout, then they can't speculate on the nature/severity of the potential bias/generalizability problem. *Note*: Boline et al. do an excellent job of documenting their attrition algorithm, so that the reader can judge/speculate on the nature of bias introduced by dropouts (e.g., amitriptyline dropouts could bias comparison across groups). Boline also includes a best/worst case sensitivity analysis as a means of explicitly speculating on the nature and severity of potential bias; authors did a very good job of dealing with a very important issue.]

Q6a. Is there an adequate DISCUSSION section?
<**Yes**>
[Boline et al. provide a comprehensive and well thought out Discussion section.]

Q6b. Why is this important to the reader/clinician?
[Guides reader in comparing/contrasting this study to other related studies (the current "body of evidence"). Boline et al. do a good job of identifying similar problems in other studies (e.g., dropout with amitriptyline, Tx side effects), similar outcomes in other studies, other SMT studies on HA, a theoretical basis for the therapeutic effects of SMT on tension-type HA, as well as articulating other possible explanations of positive findings.]

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Address correspondence to: Monica Smith, Palmer Center for Chiropractic Research, 741 Brady Street, Davenport, IA 52803.

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