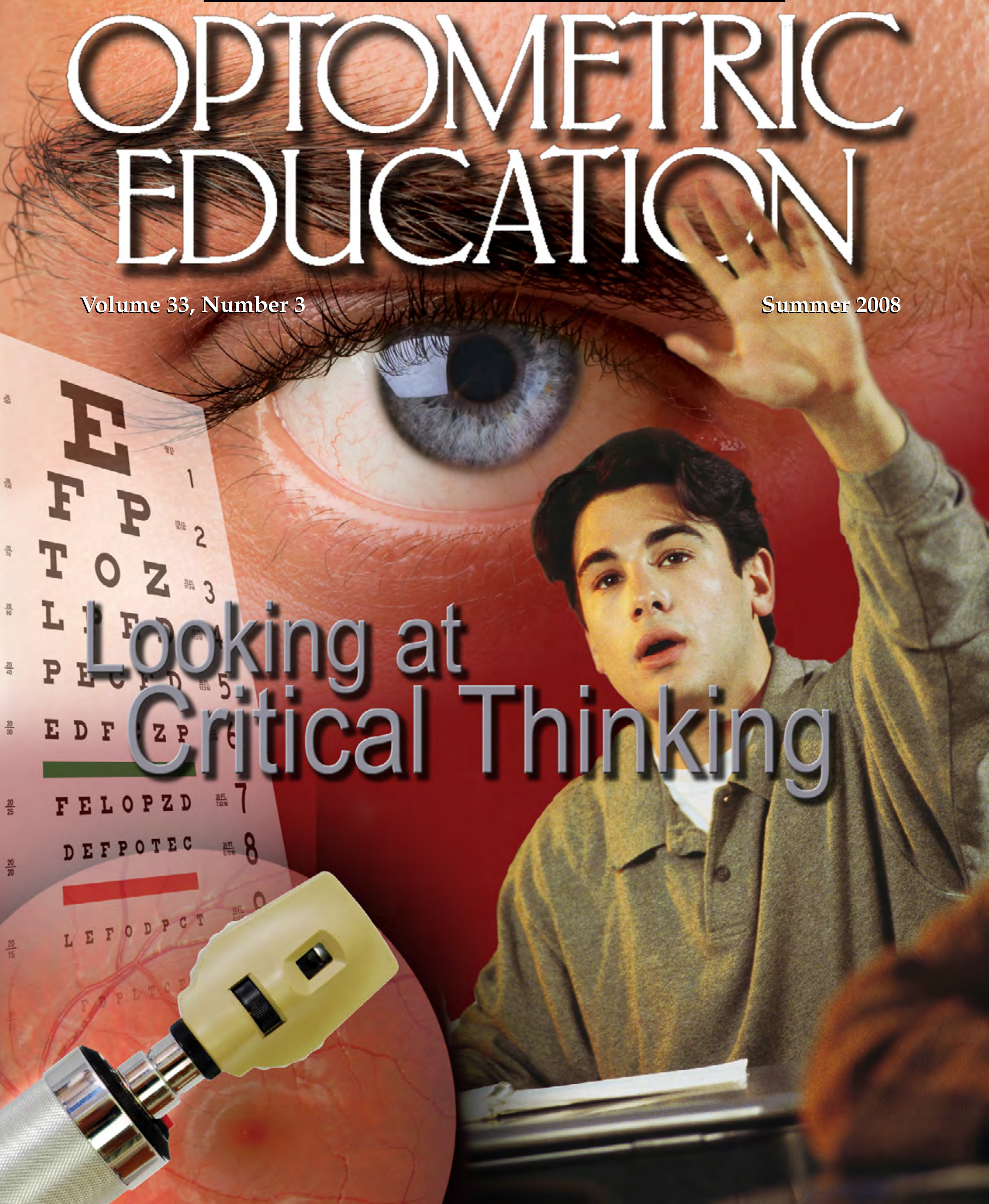
The Journal of the Association of Schools and Colleges of Optometry

OPTOMETRIC EDUCATION

Volume 33, Number 3

Summer 2008



Looking at Critical Thinking

Association of Schools and Colleges of Optometry

The Association of Schools and Colleges of Optometry (ASCO) represents the professional programs of optometric education in the United States. ASCO is a non-profit, tax-exempt professional educational association with national headquarters in Rockville, MD.

OFFICERS AND MEMBERS

OPTOMETRIC EDUCATION

ISSN 1521-4230

VOL. 33
NO. 3

SUMMER
2008

CONTENTS

The Journal of the Association of Schools and Colleges of Optometry

FEATURES AND DEPARTMENTS

ARTICLES

(Continued on page 78)

VOL. 33
NO. 3

SUMMER
2008

Contents (Cont'd)

The Journal of the Association of Schools and Colleges of Optometry

Cover: courtesy of Rick Clapper, Director of Graphics and Branding, Western University of Health Sciences

OPTOMETRIC EDUCATION is published by the Association of Schools and Colleges of Optometry (ASCO). **Managing Editor:** Stephanie Dean. **Art Director:** Carol Nansel, The Darwin Group, Inc.. Business and editorial offices are located at 6110 Executive Boulevard, Suite 510, Rockville, MD 20852 (301) 231-5944. **JOE** is published three times per year. As of the Fall 2007 issue, **JOE** is free to both members and the general public. To access **JOE** online please go to www.opted.org. Postage paid for a non-profit, tax-exempt organization at Rockville, MD. Advertising rates are available upon request. OPTOMETRIC EDUCATION disclaims responsibility for opinions expressed by the authors. Indexed in Current Index to Journals in Education (ERIC).

INDUSTRY NEWS

The following companies support ASCO's national programs and activities benefiting the schools and colleges of optometry in the U.S. and Puerto Rico.*

Benefactors ($25,000 - $49,999)

Alcon Laboratories
CIBA Vision Corporation
Essilor of America
Transitions Optical
The Vision Care Institute™ of Johnson & Johnson Vision Care, Inc.

Supporters ($15,000 - $24,999)

Advanced Medical Optics
Carl Zeiss Vision
Hoya Vision Care, North America
Luxottica / EyeMed Vision Care
M&S Technologies
Vision Service Plan

Friends ($10,000 - $14,999)

Allergan, Inc.
Bausch & Lomb, Inc.
Compulink Business Systems
CooperVision
Genzyme
Optos North America
Volk Optical

Contributors ($5,000 – $9,999)

Marchon Eyewear
Nidek, Inc.
Ophthonix, Inc.
Optovue, Inc.
Safilo Group
TLC Vision
Vision Source!
Vistakon® Division of Johnson & Johnson Vision Care, Inc.
Wal-Mart Stores, Inc.

**As of August 1, 2008*

CIBA VISION
Shared Passion for Healthy Vision and Better Life

New DAILIES® AquaComfort Plus™ Contact Lenses Feature CIBA VISION Triple-Action Moisture

CIBA VISION has announced the U.S. introduction of DAILIES AquaComfort Plus, an innovative new contact lens that takes comfort to a new level for DAILIES. The first and only CIBA VISION lens with Triple Action Moisture, DAILIES AquaComfort Plus lubricates, moisturizes and refreshes the lens for outstanding comfort throughout the day. This new lens includes a lubricant for instant comfort at the start of the day, a wetting agent that, together with the third comfort agent, provides moisture throughout the day, and an optimized blink-activated moisturizing agent that refreshes the lens through the end of the day.\

Three material components contribute to the Triple Action Moisture: HPMC (Hydroxypropyl methylcellulose) lubricates the lens, PEG (Polyethylene glycol) moisturizes the lens, and PVA (Polyvinyl alcohol) refreshes the lens throughout the day. Studies have shown that in individuals who quit wearing their contact lenses, 47 percent cite discomfort as the main reason behind discontinuation of use.

In other news from CIBA VISION, the company has announced the launch of its latest silicone hydrogel innovation – AIR OPTIX™ AQUA breathable contact lenses. AIR OPTIX AQUA lenses deliver an advanced combination of oxygen and moisture, and excellent initial as well as all-day comfort, contributing to a healthy lens-wearing experience. AIR OPTIX AQUA lenses start and stay comfortable with the new AQUA Moisture System, which includes: a unique moisture agent that helps lubricate the lens for initial comfort, a patented lens material that helps maintain moisture by minimizing the rate of lens dehydrationi for comfort all day, and an ultra-smooth surface with superior wetability and excellent deposit resistance for comfort every day. According to studies, seventy percent of patients who experience eye irritation from their contact lenses never mention it to their eye care professional. To help encourage healthy lens wear and higher patient compliance, CIBA VISION is recommending a monthly replacement schedule for AIR OPTIX AQUA lenses.

Eye Allergies Nothing to Sneeze at this Fall

"Eye Health and Allergies" Brochure from Asthma and Allergy Foundation of America Offers Advice for Eye Allergy Sufferers; Includes Seasonal Strategies for Contact Lens Wearers

Come late summer, some 10 to 20 percent of Americans begin to suffer from ragweed allergy, or hay fever. In addition to symptoms of sneezing, stuffy or runny nose, allergic reactions. To help eye allergy sufferers better understand and handle the condition, the Asthma and Allergy Foundation of America (AAFA) is offering a free educational brochure, "Eye Health and Allergies." The brochure can be viewed or downloaded at www.aafa.org. "This brochure offers useful information on how eye allergies occur, common signs and symptoms, and practical advice on how to treat and prevent eye allergies.

Fifty-four percent of those who wear contact lenses find it very uncomfortable to wear their lenses when they have allergy symptoms, according to a 2006 survey of 500 adult contact lens wearers with ocular allergies. The vast majority cope by increasing their use of wetting drops, wearing their lenses less often or removing their lenses during the

(Continued on page 80)

Industry News
(Continued from page 79)

day. A significant minority (42 percent) say they stop wearing lenses and switch to glasses.

In a three-year study[2] comparing the clinical performance of daily disposables (*1•DAY* ACUVUE® Brand Contact Lenses) with that of conventional daily-wear lenses replaced at 1 or 3 months (n=126), frequent replacement lenses replaced every 2 weeks (n=144) and daily disposable wearers (n=68), single-use lens wearers reported fewer symptoms of redness, cloudy vision, and grittiness; at the same time, they reported better vision and overall satisfaction, and had fewer lens surface deposits, complications, or unscheduled doctor's visits than conventional daily lens wearers.

To help allergy sufferers who would like to start wearing or continue wearing contact lenses, the brochure, along with a free trial-pair certificate* for *1•DAY* ACUVUE® MOIST® Brand Contact Lenses, is available at www.acuvue.com/seasons.

Medical and Optometry Schools Turn to Eyemaginations for Education Tools

Eyemaginations continues to be embraced as the preferred source for animated education solutions for higher education institutions. Nearly all of the nation's optometry schools and many leading medical schools have turned to Eyemaginations to develop training tools for their residents and students.

Most recently, the Yale School of Medicine and the George Washington University School of Medicine and Health Services implemented Eyemaginations' flagship software product, 3D-Eye Office, as a new tool for students to use in the classroom and as a supplemental training resource. Many schools also use 3D-Eye Office software in their clinics to educate patients about conditions and procedures. The majority of the optometry programs in the North America currently use Eyemaginations. Selected clients include The Pennsylvania College of Optometry at Salus University, the State University of New York College of Optometry, Pacific University College of Optometry, and Illinois College of Optometry.

Eyemaginations, most known for developing state-of-the-art patient education solutions that help eye care professionals inform their patients about conditions and procedures, expanded its core business to focus on higher education institutions over the last 18 months.

Volk H-R Wide Field Laser Lens

High-resolution lens allows visualization of details approaching the ora serrata

Volk Optical, the leader in aspheric optics, has released a revolutionary new pan retinal lens for diagnosis with the addition of the H-R Wide Field Lens. Its high-resolution imaging, coupled with an extremely wide field capability, provides highly detailed views for pan retinal diagnosis. The H-R Wide Field is a contact type of lens and requires a coupling solution when contacting the eye. Although this may add a step to the examination, it ensures that the optometrist can clearly visualize retinal tears or lesions across the entire retinal surface, all the way to the ora serrata. Most important, it is distortion free across the entire viewing area. The combination of Volk's patented double aspheric glass design with low dispersion glass, ensures the highest resolution imaging across the entire viewing field. This superior viewing power with a 0.50x magnification is contained in a low-profile, reduced-size housing to simplify manipulation of the lens within the orbit.

Volk Optical is an industry leader in the design and manufacture of aspheric optics. Glass lens construction and the company's patented double aspheric technology result in the highest resolution imaging with the best stereopsis for precision diagnostic, therapeutic and surgical work.

Vision Source, a network of private practice optometrists, has added four executives to its management team as it adds Office Number 1,800 to its network. Joining Vision Source, LP are, Kelly Kerksick, O.D., Director of Professional Services, Jason Morris, O.D., General Manager of Vision Source Canada, Derrick Artis, O.D., Vice President of Vendor Relations, and Hans Kell, O.D., Vice President of Network Administration. Coincidental with the announcement of its new executives, Vision Source also added its 1,800th member office in Krugerville, Texas. Founded in 1991, Vision Source provides its members with cost of goods savings, practice management support and a forum for sharing experiences and ideas. Each office is owned and operated by an independent doctor of optometry.

EDITORIAL

Thinking About Thinking

Elizabeth Hoppe, OD, MPH, DrPH

This special theme issue of the journal seeks to help answer the question, "When we think about thinking, what should we be thinking about?" As convoluted as that question sounds, it points out the importance of seeking a deeper understanding of the thought processes and thinking skills required to be a good optometric practitioner and an effective optometric educator. Critical thinking skills are something everyone wants students to have, but not everyone is using the same definition of critical thinking. Perceptions and assumptions about thinking vary, and many different techniques are being used in health profession education to teach our future health care providers "how to think."

There have been a number of recent publications about critical thinking in journals devoted to higher education and health profession education. Willingham has made the point that it is time to ask the fundamental question, "Can critical thinking actually be taught?"[1] He advised that many people assume that critical thinking is a skill like riding a bicycle and that, once learned, it can be applied in a variety of situations. In response to this assumption, Willingham made the argument that the application of critical thinking is context dependent and that specific strategies, knowledge, and practice are required to improve the ability to think critically.[1]

Beyond the classroom, Delany and Watkin have asserted that clinical education emphasizing experiential learning may not be sufficient to develop many of the components of critical thinking. In particular, they have identified that flexibility, self-awareness, and an understanding of alternative perspectives require supplemental programs to enhance the development of these skills.[2]

Further research has supported the idea that a favorable disposition toward critical thinking is also very important for optometric educators. Research by Profetto-McGrath et al. found that nurse educators who had a higher score on the California Critical Thinking Dispositions Inventory were also more likely to utilize research in the delivery of patient care and student education. They asserted that these characteristics are vital for improving patient and systems outcomes.[3,4]

This theme issue represents one of the first occasions that articles about critical thinking have been published in a journal devoted to optometric education. In this issue, we present articles representing the range from theoretical and conceptual ideas to practical applications and assessments of thinking skills in the context of optometric clinical education.

Elder and Paul set the foundation for our contemplation of critical thinking by describing their working definitions and perceptions of critical thinking and by providing a common framework. Galvin brings in the perspective of classroom education, with examples of implementation from a teacher's perspective. Her work emphasizes the learning process and environment in the educational setting and how that can translate into the development of lifelong learners. Faccione and Faccione bring a clinical perspective by translating critical thinking skills into the patient care environment. Denial provides research that links optometry students' critical thinking skills and clinical skill–building within the optometric curriculum.

This issue's "Think Tank" continues the theme, as contributors share their thoughts about overcoming challenges to encouraging student development of critical thinking skills. Optometric educators from the classroom and the clinic provide us with a variety of perspectives. Carlson reminds us of the joys of watching students learn and grow when she tells us about her "Best Day" in optometric education.

Each of these pieces should help us gain a deeper understanding of the complexities of skillful thinking, and together they showcase important themes that will help us in our roles as educators. We are, after all, creating the next generation of critical thinkers.

References

1. Willingham, DT. Critical thinking: Why is it so hard to teach? Arts Educ Pol Rev. 2008;109(4):21-9.
2. Delany C, Watkin D. A study of critical reflection in health professional education: "learning where others are coming from." Adv Health Sci Educ Theory Pract. 2008 (June). DOI: 10.1007/s10459-008-9128-0. Available from http://www.springerlink.com/content/v05423601p317432/
3. Profetto-McGrath J, Smith KB, Hugo K, Patel A, Dussault B. Nurse educators' critical thinking dispositions and research utilization. Nurse Educ Pract. 2008, August 11: [Epub].
4. Profetto-McGrath J, Hesketh KL, Lang S, Estabrooks CA. A study of critical thinking and research utilization among nurses. West J Nurs Res. 2003;25:322-37.

Dr. Hoppe is founding dean of Western University of Health Sciences College of Optometry. E-mail: ehoppe@western.edu.

GUEST EDITORIAL

Putting Critical Thinking into Action

Aurora Denial, OD, FAAO

The teaching and learning of critical thinking skills have gained prominence in higher education in recent years. In many fields such as medicine, nursing and optometry the attainment of critical thinking skills has become a learning objective for the curriculum. Educators in all fields have recognized the need to cultivate critical thinking ability within their domain of students as well within the context of the curriculum.

I first became interested in teaching critical thinking through my involvement in the Integrative Seminar Tract (IST) at the New England College of Optometry. In 2003, I was named co-course master and developer of the IST. The tract, which consisted of two courses for first and second year students, was dedicated to teaching the skills associated with clinical thinking and integration of knowledge. Case analysis, problem based learning and other activities were used to achieve the goals. However, it soon became apparent that students in the early stages of learning clinical thought process, especially in a didactic setting, needed to learn a strategy for thinking.

The more I learned about critical thinking skills, the more I saw the connection between critical thinking ability and clinical thinking. I began to think of developing critical thinking skills as the key strategy needed to drive clinical thinking. Therefore, it made sense to more formally teach critical thinking concepts. However, our students needed a little more convincing. Most students felt that when they arrived at optometry school they demonstrated good thinking skills and therefore teaching these skills was redundant. All they needed to learn was the knowledge and technical skills associated with the profession. Most of their supporting evidence came from high academic achievement in college and good scores on standardized testing. The evidence they presented only supported being a good student, but not necessarily a good thinker. In reality, even those students who possessed excellent thinking skills could always benefit by taking those skills to a higher level.

In everyday life, we constantly engage in thinking, problem solving and decision making. In most cases, the consequences of our thinking have relatively low stakes. When we are preparing students for a profession that deals with the responsibility of caring for another person's eyesight or in some cases their lives, the consequences of our student's thinking have much higher stakes. In class, I use the analogy of driving a car. If we are driving around a turn at 20 miles per hour and make a mistake in most cases the consequences are not severe. If we are driving at 200 miles per hour and make an error the consequences are significant. Even if you have good skills driving at slower speeds when you engage in driving at fast speeds you need additional training.

The teaching of critical thinking has been an adventure filled with many challenges. The first challenge was increasing my knowledge in critical thinking and the second challenge was changing the student's perception of critical thinking. My first step was to get formal training in the concepts that I felt were so important to our students' education. My first conference was the 26th International Conference for Critical Thinking by the Foundation for Critical Thinking, Dillon Beach, California. This conference provided an excellent foundation. Exposure to key concepts related to critical thinking and teaching with active learning were highlights. The foundation has many resources available such as books, articles, workshops and speakers. I spent the following year reading, researching and talking to other people, who were more expert than I. The next summer I attended the Summer Institute on Teaching Critical Thinking by the National Center for Teaching Thinking, in Newton, Massachusetts. This conference was very productive as it provided more information on how to implement critical thinking concepts into content. The Center also provided many valuable resources.

This past academic year, to help students value the theoretical concepts related to critical thinking I emphasized teaching in context and active learning. Volunteers from the community who served as "patients" were included in the course in a non-clinical interaction. These volunteers provided the context to learn critical thinking in relation to patient care. To engage students in an active manner, instead of lecturing to students about critical thinking concepts, the students extrapolated the strategy for problem solving by watching the movie "Apollo 13". Students were assigned to work in groups of 3 to 4 to encourage brainstorming and peer support. Peer teaching as well as self directed learning were also incorporated into the course.

Helping students develop good thinking skills gives them independence and self reliance. Information, knowledge and techniques can change over time. Developing good thinking skills will last a lifetime. An optometrist's thought process is the best tool they can bring to their patients.

Dr. Denial is associate professor of optometry at the New England College of Optometry. E-mail: deniala@neco.edu

Think Tank . . .

"What Are the Challenges to Encouraging Student Development of Critical Thinking Skills in the Optometric Educational Environment and How Can These Challenges Be Overcome?"

Critical thinking cannot be expected to develop on its own but, like every other skill, needs to be required and practiced. I think optometric education falls short in the area of requiring it and then giving students genuine opportunities to practice it. In large classrooms, most material is delivered by lecture and PowerPoint, and even when we query the class, we either don't wait long enough for them to think, much less work up the courage to speak, or we accept one or two answers from a short list of outspoken individuals and then move on. Solutions for the classroom include waiting longer after we ask the class a question (such as silently counting to 10) and reformulating queries as multiple-choice questions, demanding the class vote for one, and having the patience and courage not to move on until most of the students have voted. Personal experience with both methods suggests that they work, albeit imperfectly. In the clinical setting, the urge on the part of the preceptor to give answers is almost irresistible, especially when there is time pressure in a busy clinic, but the best way to help students develop their thinking skills is to demand it of them and then give them time, and more time, to formulate and express their thoughts. The recurrent themes are to demand critical thinking from students and then to give them time to do it.

Daniel Kurtz, PhD, OD, FAAO
Associate Dean of Academic Affairs
Western University College of Optometry

What we really want is for our students to apply critical thinking skills, clinically. Attempting to teach critical thinking skills in general terms may not seem relevant to our students. If we put an emphasis on heuristics as they enter clinic, it will seem more meaningful. Successful clinicians use *heuristics*—conceptual rules of thumb—that allow them to sift though information quickly and efficiently to answer diagnostic questions. If we want our students to effectively use heuristics, faculty need to be aware of how they apply them. Faculty and students both need to be aware of the common pitfalls of heuristics and how common errors and cognitive biases can lead them astray. One example is the error of *availability*—the tendency to judge the likelihood of an event by the ease with which relevant examples come to mind. Another example of a cognitive error is *anchoring*, where the clinician latches on to one single answer and doesn't consider other possibilities.

Jerome Groopman has written an excellent book, *How Doctors Think* (Houghton Mifflin; 2007). In it he introduces the topic of heuristics. The book is written for a lay audience; therefore, even students who are early in their clinical career would benefit from his presentation. Experienced clinicians use heuristics without ever analyzing the process. Clinical faculty need to be acquainted with heuristics enough to be conversant in the subject and be able to model for students their own clinical thinking.

Melanie A. Crandall, OD, MBA, FAAO
Associate Professor
Nova Southeastern University College of Optometry

Think Tank . . .

Although, egocentrically speaking, it is uplifting to create small images of ourselves in the form of students, the better good is realized by an instructor who refuses to impose the intellectual box on the surrounding student population, offering instead a general knowledge of systems that can then be expanded to include the details. Classical approaches of instruction and testing have rewarded the students who memorize large lists of facts. We can all recount individuals who topped the class in written tests but were mediocre in clinical application of this knowledge.

Rather than scholastically supporting the "cramming–regurgitation–brain dump" cycle, could we not effectively facilitate our students' learning and understanding by routinely requiring the students to engage in the holistic, creative application of the multitude of details in a problem-solving activity? This approach not only requires a thorough knowledge of the facts, found as an emphasis in the classical model, but advances creativity both in thought and application of the minutiae, based on a thorough knowledge of systemic function. The greater the knowledge of body systems, for instance, the more variables that can be called into the solution or into clinical and research science and the greater the complexity of the problems that can be solved. Internships, externships, residencies, postdoctoral fellowships, and the like effectively instruct using systemic assessment in problem-solving experiences. Why not incorporate this same effective method into the initial years of professional instruction?

Nothing here is news to any educator, but an increase in initial emphasis on the picture or system as a whole—to which is added detail versus instruction, and testing of detail, even in the initial stages of the learning process—enhances not only learning but creativity of thought and mastery of the subject material. From my first-year medical students all the way to the residents, all are asking for more of this instructional approach. The educational journey through the training of health professionals is not inexpensive. As the old song says, "Who could ask for more?" Well, perhaps we all could and most likely should.

Clifford D. Brown, OD, MPH, FAAO
Chief of the
Crow North Cheyenne Hospital Eye Services

Critical thinking does not begin in optometry school but is used by students in other environments long before the onset of their optometric training. It cannot be taught in isolation but is facilitated by a strong knowledge base within the discipline in which it is used. The challenge to enabling critical thinking in optometric training, therefore, is to create an educational environment where knowledge is taught in the service of clinical practice.

Information must be taught in a clinically relevant fashion from the beginning of the curriculum. Rather than solely regurgitating course content, students must learn to transform and apply classroom material into clinical practice. Development of critical thinking skills necessarily lags behind content learning earlier in the educational process. As the student's knowledge base expands, critical thinking assumes a more significant role in optometric training.

Critical thinking skills are advanced in the clinic setting, as patient encounters progress from those more heavily involving information gathering to those with greater emphasis on clinical decision making. One barrier in this process is student anxiety. Beginning interns are unaccustomed to working with patients and highly focused on technical performance. This interferes with their ability to view the big picture, as it relates to their cases. Starting patient interaction early in the optometric curriculum works to desensitize students and relieve some of this anxiety. The student gains experience in performing an examination not solely in the laboratory on a fellow student but on a clinic patient. Clinical instruction must require that interns go through the process of, and demonstrate competency in, critical thinking in their patient encounters. This is fostered by support and encouragement on the part of the supervisor and working through the clinical decision-making process with the student.

Leon Nehmad, OD, MSW, FAAO
State University of New York College of Optometry

In this age of increased healthcare costs, there are pressures for every mode of practice to be as efficient as possible. Taking the time to allow students to perform the exam and still providing good clinical education is not necessarily more efficient than seeing the patients on your own. There are numerous articles in the literature on how to make clinical teaching cost effective, but it is not easy to do. Generally, the students need to present their explanation to the licensed practitioner and discuss it before any discussion with the patient. That gives the opportunity for discussion of other possible ways to analyze the findings and provides feedback to the student. However, the time the licensed practitioner saves in testing time is sometimes used up in rechecking findings, documentation, and teaching the students.

Students need to learn how to change their wording to customize their approach based on the particular characteristics of the patient in subjective testing and in speaking to the patients. The wording they learned from practicing on fellow optometry students may not yield the same examination results in the general population without specific knowledge of the subjective tests and questions asked of the patient. It takes repeated patient exposures for them to learn how to modify their wording to adapt to the patient. I usually tell the students that if the patient does not give reliable results, the examiner needs to change the instructions. Time needs to be allocated to discuss alternative ways to request the subjective information of the patient.

When the students take the patient-education portion of the exam, they may end up taking longer than an established practitioner to adequately confirm patient understanding. Students need the practice in presenting the case to the patient. This can decrease the efficiency of patient care in a busy, multi-specialty clinical environment where being efficient is necessary. However, this is also the type of environment with the patient base that is unique enough to be a great educational experience. My preference is to have them watch the techniques I use for these explanations and, then, when the clinic is running on time, have the students present to patients, with the licensed practitioner still in the room to observe and fill in any gaps. This allows the students to observe the unique differences in each clinical environment.

During their clinical education, students build rapport by talking to the patients about things that may be peripheral to the examination, which can be time consuming. There is a fine line between bonding with the patient and getting off-task. It is difficult to direct a patient back to the examination without them feeling like they are being rushed. To be efficient, I usually demonstrate to the student how to repeat the patient's last comment and then direct them back to the exam rather than allowing the patients to take the conversation off the task at hand.

Clinical education in this era of spiraling healthcare costs will continue to challenge the quality and the efficiency of patient care. This challenge is well worth the satisfaction of seeing the clinical confidence of students' handling difficult cases improve in front of you.

Debbie L. Hettler, OD, MPH, FAAO
Harry S. Truman Memorial Veterans Affairs Hospital

In my role as a clinical preceptor during my residency, I had the opportunity to work closely with optometry students at all levels of clinical development. There are many challenges to encouraging the development of critical thinking skills in students, but I saw three specific challenges common to most students. First, students do not always get enough opportunities at an early stage to have the number of patient encounters necessary to reinforce the importance of critical thinking. Students need to have a large enough number of encounters with a broad diversity of patient populations and clinical settings so that they quickly develop the technical confidence to move beyond the tendency to spend their mental energy on technique rather than on the significance of findings. Second, clinical preceptors do not always make time to effectively model and encourage the critical thinking process. Clinical preceptors need to be empowered (and motivated) to spend the time necessary to discuss each case with students for the students to understand the practitioner's thought process in approaching the case and to receive valuable, constructive feedback. Third, students do not always view the critical thinking process as a powerful tool that can improve your ability to care for your patients *and* your efficiency. Often, students sacrifice the time necessary to develop good critical thinking skills in the rush to get through the exam quickly enough to please their clinical preceptor by having data for all the important points of an encounter. It is critical that students spend the time before and outside of clinic to practice their efficiency and work toward better time management so that they have the time to stop and think about how the patient encounter findings fit into the big picture of the patient's health. This allows a practitioner to prevent wasted time by approaching problems in a targeted fashion and allows them to better care for their patients as a whole.

Justin Smith, OD
Pediatric Optometrist
Harvard Vanguard Medical Associates

Think Tank . . .

The ongoing challenges among optometric educators to continually expand the curriculum as our scope of practice grows but still maintain the optometric curriculum's finite length will always persist. Greater scope of practice not only entails acquiring new diagnostic and management skills but the basic science knowledge that forms the basis of those techniques, procedures, and/or treatments.

There will always be inadequate time to convey to students the evolution of basic/clinical science knowledge with regard to every clinical test, procedure, or treatment. Yet, an adequate amount of didactic knowledge must be acquired, as it is the foundation for its application to clinical care. The historical approach has been to teach the basic sciences (e.g., geometric optics and ocular motility) and subsequently build on this knowledge base with clinical science courses (e.g., ophthalmic optics and binocular vision). Although this is logical and students should indeed retain all of knowledge they have acquired cumulatively in a curriculum, it is often challenging for students to recall the details of the basic-science coursework while learning the clinical science coursework.

While the historical approach has already been improved on by initiating clinical science courses earlier into the curriculum, supplementing with or implementing courses that have as their explicit goal to integrate basic and clinical science will have an impact on the challenge presented here. Of course, no traditional didactic course could accomplish this easily. So-called problem-based learning and/or self-directed learning approaches have already been implemented at some schools and colleges of optometry. These courses ask students to think critically about how an ocular condition affects the ocular anatomy/physiology, how the signs and symptoms manifest themselves due to the alterations in the anatomy/physiology, and the scientific basis for how a proposed intervention would ameliorate the condition. This thought process is intended to be much more in-depth than that involved in a typical optometric exam.

Of course, a closely related, but perhaps more challenging, aspect of this issue is developing critical thinking skills for direct patient care. Didactic coursework is often filled with lab reports and written tests, which students have a, relatively speaking, "adequate and uninterrupted time" to work on. On entering clinical care, students suddenly have inadequate and interrupted time to care for a patient. Clinical care in the optometric education model puts pressure on the students not only from the standpoint of "getting a grade," just as in basic or clinical science coursework, but the very real pressure of caring for patient sitting in the chair (and staring at you) is present. The unique anxiety that clinical care represents can easily overwhelm students so that the critically thinking skills become secondary to the data collection.

The present shift in among all schools and colleges of optometry to integrate students into clinical care as soon as possible will address part of this challenge. Early in a program, students shadowing more senior students should be active observers in the decision-making processes interns and faculty work through on each and every patient. Transitioning from these observation assignments to clinical interns will hopefully allow students to acquire a good grasp of the critical thinking skills involved in the majority of primary care exams. Of course, part of the challenge in learning this way is that the student has not necessarily acquired the basic knowledge to understand the full process, but as more coursework is undertaken students can relate these experiences to their coursework at the time of instruction (rather than the other way around).

Critical thinking skills for patient care really must develop from devoted students and faculty to treat each patient encounter as a learning experience. The demands (and surprises) that patient care presents to new optometric interns coupled with the "rush hour" atmosphere that clinical faculty may experience are stressful. Nevertheless, student–faculty ratios need to be optimized and time should be allocated to reviewing patient cases the same day so that the student and faculty feel satisfied that each patient encounter was a useful learning experience, and the decision-making processes that lead to a primary diagnosis from a chief complaint need to be obvious from both standpoints.

The challenge of developing critical thinking skills during optometric education will continue. The good news is that every year, optometric graduates are more highly educated than previous classes. Diversity in the optometric curricula (e.g., problem-based learning, grand-round seminars) sparks students' motivation to develop critical thinking skills earlier in the curricula, but, ultimately, the enrollment of talented, passionate, and self-motivated students coupled with devoted faculty will allow the graduating classes to be the most highly educated and caring doctors every year.

Jason Ng, OD, PhD, FAAO
Assistant Professor
Southern California College of Optometry

Think Tank . . .

FEATURE

My Best Day in Optometric Education Getting to Know Students and Watching Them Learn

Nancy B. Carlson, OD, FAAO

My best day in optometric education is Thursday—not a specific Thursday, but just about every Thursday since the fall of 1982 when I started teaching first-year optometry labs. Over the years, the name of the course has changed from Optometric Methods, to Optometry: Theory and Methods, to Principles and Practice of Optometry, but my lab assignment has somehow remained on Thursdays. The content has changed some too, but what has not changed is that teaching lab is a great opportunity to get to know students personally and to see learning taking place during every session.

The first lab of the year is always fun for me. The students come in nervous and unsure. They spend 30 minutes attempting to measure visual acuity with a projected Snellen chart on a classmate who speaks their language, is obviously intelligent, and who most likely has 20/20 vision. They are confused when the patient cannot read the near chart and amazed to see vision improve several lines by simply directing the overhead lamp onto the near card. Even in that first hour, learning can be seen not only by me but by the students too. The second patient tested in the first lab only takes 15 minutes and the third takes about 10 minutes. The students lose their awkwardness and start to look like clinicians. In just six weeks, the same students come in for their first proficiency exam. They dress up so that they look like doctors, and they are able to complete nine tests in addition to Snellen acuity in less than 25 minutes. It is an amazing transformation.

Working with a small group of students in a lab is much less formal than lecturing to the whole class. Students become individuals in lab; their personalities and their learning styles become very evident. There is time to talk to the students, find out about where they are from, where they went to school, where they are living in the Boston area, how they spend their free time, and all about their families. Over the years, students have told me about great restaurants in the Boston area, advised me on vacation destinations, recommended great novels they are reading and want to share, and other fun, free-time activities. I have attended weddings, christenings, and (sadly) funerals of students and their family members.

Because of the relationships that I have made in lab, I have been able to help students who are having problems in understanding material in my course who I might not have known about otherwise. Students who are not keeping up in lab stand out because of the "up close and personal" nature of lab. Sometimes, just a short discussion in my office with a few extra examples straightens out the problem and the students find that they can succeed. Sometimes a referral for tutoring or for help in sorting out personal problems is warranted. And sometimes a recommendation to work harder is the right thing for a student. It is a privilege to be a part of helping students find what they need to do to succeed.

Lab teaching has been great feedback for me on how well the lecture portion of the course is going. If things are not clear in lecture, precious lab time is wasted going over things that should have already been understood. Working with individuals in lab has also given me ideas about better ways of presenting material to the whole class in lecture.

Why would any senior faculty member continue to teach first year labs year after year? Surely, this is one of those dreadful assignments that are usually delegated to new faculty who move on to bigger and better things as soon as it is possible. I have chosen to continue to teach labs because it is such a great opportunity to get to know my future colleagues and because, over the years, I have learned at least as much from my students as I have taught them. It may be the same topics year after year, but the students are fresh, new, and eager to learn when they arrive in the fall of their first year. It is great to be so much a part of their education, and I plan to continue teaching labs for the rest of my career.

Dr. Carlson is a professor of optometry at the New England College of Optometry. E-mail: carlsonn@neco.edu

Critical Thinking: The Nuts and Bolts of Education

Linda Elder, PhD
Richard Paul, PhD

Abstract

Critical thinking provides a vehicle for educating the mind. Although most educators strive to teach and foster critical thinking skills in their students many do not have a clear understanding of the concepts and tools of critical thinking. Critical thinking provides the intellectual tools students need to reason well within every subject and discipline, within every mode of human thought. Critical thinking offers intellectual tools for the analysis and assessment of thinking. It enables students to see the interconnected logic of any subject or specialty and to think with discipline and skill within that logic. It entails effective communication and problem-solving abilities, as well as a commitment to overcome our native egocentrism and sociocentrism. There are three primary intellectual sets that critical thinking offers us: tools for the analysis of thinking, tools for the assessment of thinking and tools for fostering intellectual dispositions of mind. The purpose of this article is to describe each of these sets and discuss their implications for teaching and education. With a clear and accurate understanding of critical thinking concepts, educators will be able to lay the foundation for learning and education. This article represents a review and consolidation of original work by Drs. Linda Elder and Richard Paul. The concepts presented in this article incorporate text which has been previously published and was specifically compiled to provide foundational information for the optometric educator. It reflects years of thinking about thinking – about what it entails, about where it goes wrong, about how it can be improved.

Key Words: *critical thinking, education, reasoning*

Dr. Linda Elder is an educational psychologist and a prominent authority on critical thinking. She is President of the Foundation for Critical Thinking and Executive Director of the Center for Critical Thinking. Dr. Richard Paul is the Director of Research and Professional Development at the Center for Critical Thinking and Chair of the National Council for Excellence in Critical Thinking.

Critical Thinking[1]

To think within a discipline is to think within the system of meanings that constitute the discipline. What we call *knowledge* are systems of interconnected ideas, ideas that together create a logic: the logic of biology, the logic of chemistry, the logic of mathematics. Yet most students think of what they are learning as disconnected sentences from a textbook or lecture. By the time they reach the college level, they have successfully *mislearned* what it means to learn. They have successfully constructed a misconception of knowledge. They do not see the need for thinking their way through the content, or for finding connections within and across disciplines. They see subjects and disciplines as atomic facts, bits, and pieces of meaning to store in their minds for a test, and then to forget to make room for more bits and pieces for another test, and so on. It is our job to disabuse our students of their caricatures of knowledge and learning. It is our job to teach them how to think: clearly, accurately, precisely, relevantly, deeply, broadly, logically, significantly, fairly. Enter critical thinking.

"Critical thinking is that mode of thinking—about any subject, content, or problem—in which the thinker improves the quality of his or her thinking by skillfully analyzing, assessing, and reconstructing it. Critical thinking is self-directed, self-disciplined, self-monitored, and self-corrective thinking. It presupposes assent to rigorous standards of excellence and mindful command of their use. It entails effective communication and problem-solving abilities, as well as a commitment to overcome our native egocentrism and sociocentrism."[2] It is an abiding concern with the problems in thinking.

Critical thinking provides the intellectual tools students need to reason well within every subject and discipline, within every mode of human thought. Critical thinking offers intellectual tools for the analysis and assessment of thinking within and across disciplines. It enables students to see the interconnected logic of any subject or specialty and to think with discipline and skill within that logic. In short, it provides a vehicle for educating the mind.

There are three primary intellectual sets that critical thinking offers us:

1. Tools for the *analysis* of thinking—the elements of reasoning.
2. Tools for the *assessment* of thinking—universal intellectual standards
3. Tools for fostering *intellectual dispositions* of mind—intellectual virtues

The purpose of this article is to describe each of these sets and discuss their implications for teaching and education. With a clear and accurate understanding of critical thinking concepts, educators will be able to lay the foundation for learning and education. This article represents a review and consolidation of original work by Drs Linda Elder and Richard Paul. The concepts presented in this article, incorporate text that has been previously published and was specifically compiled to provide foundational information for the optometric educator. It reflects years of thinking about thinking—about what it entails, about where it goes wrong, and about how it can be improved.

The Analysis of Thinking[3]

"Everyone thinks; it is our nature to do so. But much of our thinking, left to itself, is biased, distorted, partial, uninformed, or downright prejudiced. Yet the quality of our life and of what we produce, make, or build depends precisely on the quality of our thought. Shoddy thinking is costly, both in money and in quality of life."[3,4] If we want to think well, we must understand at least the rudiments of thought, the most basic structures out of which all thinking is made. We must learn how to take thinking apart.

All Thinking Is Defined by the Eight Elements That Make It Up[3,5]

"Eight basic structures are present in all thinking: Whenever we think, we think for a purpose within a point of view based on assumptions leading to implications and consequences. We use concepts, ideas and theories to interpret data, facts, and experiences in order to answer questions, solve problems, and resolve issues."[3,5]

"Thinking, then:

- **generates purposes**
- **raises questions**
- **uses information**
- **utilizes concepts**
- **makes inferences**
- **makes assumptions**
- **generates implications**
- **embodies a point of view"[3,5]**

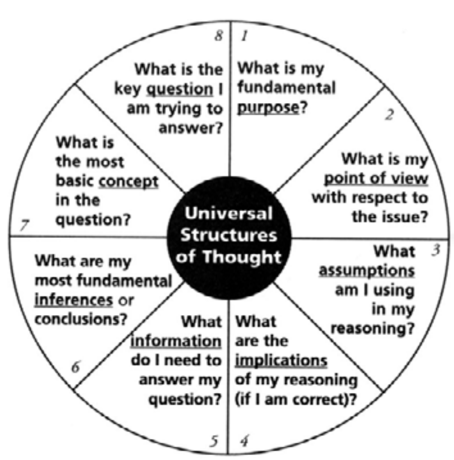
The figure to the right illustrates the "Elements of Thought" (Copyright 2007 by the Foundation for Critical Thinking. Reproduced with permission.[3])

"Each of these structures has implications for the others. If we change our purpose or agenda, we change our questions and problems. If we change our questions and problems, we are forced to seek new information and data."[3,5] If we collect new information and data, we are forced to consider alternative inferences or conclusions. And so forth. When we understand the elements of reasoning, we realize that all subjects, all disciplines, have a fundamental logic defined by the structures of thought embedded in them.

"Therefore, to lay bare a subject's most fundamental logic, we should begin with these questions:

- What is the main purpose or goal of studying this subject? What are people in this field trying to accomplish?
- What kinds of questions do they ask? What kinds of problems do they try to solve?
- What sorts of information or data do they gather?
- What types of inferences or judgments do they typically make? (Judgments about...)
- How do they go about gathering information in ways that are distinctive to this field?
- What are the most basic ideas, concepts or theories in this field?
- What do professionals in this field take for granted or assume?
- How should studying this field affect my view of the world?
- What viewpoint is fostered in this field?

Figure 1
Element of Thought



- What implications follow from studying this discipline? How are the products of this field used in everyday life?" [3,6]

"These questions can be contextualized for any given class day, chapter in the textbook and dimension of study. For example, on any given day you, or your students, might ask one or more of the following questions:

- What is our main purpose or goal today? What are we trying to accomplish?
- What kinds of questions are we asking? What kinds of problems are we trying to solve? How does this problem relate to everyday life?
- What sort of information or data do we need? How can we get that information?
- What is the most basic idea, concept or theory we need to understand to solve the problem we are most immediately posing?
- From what point of view should we look at this problem?
- What can we safely assume as we reason through this problem?
- Should we call into question any of the inferences that have been made?
- What are the implications of what we are studying?" [3,7]

The Assessment of Thinking[3]

To reason well within any discipline also presupposes our ability to assess our reasoning within the discipline. One of the fundamentals of critical thinking, then, is the ability to assess one's own reasoning. "To be good at assessment requires that we consistently take apart our thinking and examine the parts with respect to standards of quality. We do this using criteria based on clarity, accuracy, precision, relevance, depth, breadth, logicalness, and significance,"[3,4] to name some of the important standards for thought.

As we have said, "Critical thinkers recognize that, whenever they are reasoning, they reason to some purpose (element of reasoning). Implicit goals are built into their thought processes. But their reasoning is improved when they are clear (intellectual standard) about that purpose or goal. Similarly, to reason well, they need to know that, consciously or unconsciously, they are using information (element of reasoning) in thinking. But their reasoning improves if and when they make sure that the information they are using is accurate (intellectual standard)."[3,4]

"Put another way, when we assess our reasoning, we want to know how well we are reasoning."[3,4] We want to avoid the negative consequences of failing to do so.

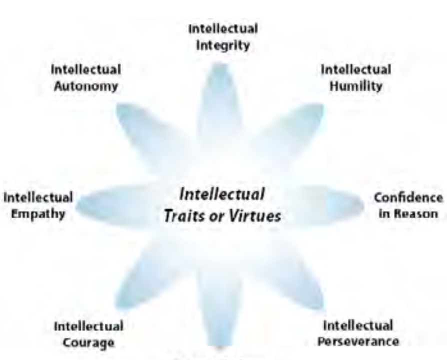
"In assessing reasoning, within any subject or discipline, we recommend these intellectual standards as minimal:

- clarity
- relevance
- logicalness
- accuracy
- depth
- significance
- precision
- breadth
- fairness"[3,4]

"These are not the *only* intellectual standards a person might use. They are simply among those most fundamental."[3,4] Additional standards might be needed for high-quality reasoning within a particular discipline. However, these universal standards will always apply when relevant to a particular issue or context.

"In this respect, the elements of thought are more basic, because the eight elements we have identified are *universal*—present in all reasoning of all subjects in all cultures"[3,4] for all time. "On the one hand, one cannot reason with no information about no question from no point of view with no assumptions. On the other hand, there is a wide variety of intellectual standards from which to choose—such as credibility, predictability, feasibility, and completeness"[3,4]— in addition to those we have already named.

Figure 2
Intellectual Traits and Virtues



(Copyright 2002 by the Foundation for Critical Thinking. Reproduced with permission.[1,3])

"As critical thinkers, then, we think about our thinking with these kinds of questions in mind: Am I being clear? Accurate? Precise? Relevant? Am I thinking logically? Am I dealing with a matter of significance? Is my thinking justifiable in context? Typically, we apply these standards to one or more elements."[3,8]

"Reasonable people, then, judge thinking by intellectual standards, no matter the subject, discipline, or domain in which they are thinking. When students internalize these standards and explicitly use them in their thinking, their thinking becomes more clear, accurate, precise, relevant. Their thinking becomes deeper, broader and more fair."[3,9]

The Intellectual Virtues: The Key to Fair-minded Critical Thinking[1]

"It is possible to develop as a thinker, and yet not to develop as a *fair-minded* thinker. In other words, it is possible to learn to use one's skills of mind in a narrow, self-serving way. Many highly skilled thinkers do just that. Think of politicians, for example, who manipulate people through smooth (fallacious) talk, who promise what they have no intention of delivering, who say whatever they need to say to maintain their positions of power and prestige. In a sense, these people are skilled thinkers because their thinking enables them to *get what they want*. But the best thinkers do not pursue selfish goals. They do not seek to manipulate others. They strive to be fair-minded, even when it means they have to give something up in the process. They recognize that the mind is not naturally fair-minded, but selfish. And they recognize that to be fair-minded, they must also develop specific traits of mind, traits such as intellectual humility, intellectual integrity, intellectual courage, intellectual autonomy, intellectual empathy, intellectual perseverance and confidence in reason."[1]

"Critical thinking, then, can be used to serve two incompatible ends: self-centeredness or fair-mindedness. As we learn the basic intellectual skills that critical thinking entails, we can begin to use those skills either in a selfish or in a fair-minded way."[1]

"Liberals see mistakes in the arguments of conservatives; conservatives see mistakes in the arguments of liberals. Believers see mistakes in the thinking of nonbelievers; nonbelievers see mistakes in the thinking of believers. Those who oppose abortion readily see mistakes in the arguments for abortion; those who favor abortion readily see mistakes in the arguments against it."[1]

"We call these thinkers *weak-sense* critical thinkers. We call the thinking 'weak' because, though it is working well for the thinker in some respects, it is missing certain important higher-level skills and values of critical thinking. Most significantly, it fails to consider, in good faith, viewpoints that contradict its own viewpoint. It lacks fair-mindedness."[1]

"Another traditional name for the weak-sense thinker is found in the word sophist. Sophistry is the art of winning arguments regardless of whether there are problems in the thinking being used, regardless of whether relevant viewpoints are being ignored. The objective in sophistic thinking is to win. Period. Sophistic thinkers generally use lower-level skills of rhetoric, or argumentation, by which they make unreasonable thinking look reasonable and reasonable thinking look unreasonable. This form of thinking can be easily seen in unethical lawyers, prosecutors, and politicians who are more concerned with winning than with being fair. But all of us sometimes think in this way."[1]

"We believe that the world already has too many skilled selfish thinkers, too many sophists and intellectual con artists, too many unscrupulous lawyers and politicians who specialize in twisting information and evidence to support their selfish interests and the vested interests of those who pay them."[1]

"To think critically in the strong sense requires that we develop fair-mindedness at the same time that we learn basic critical thinking skills, and thus begin to 'practice' fair-mindedness in our thinking. If we do, we avoid using our skills to gain advantage over others. We treat all thinking by the same high standards. We expect good reasoning from those who support us as well as those who oppose us. We subject our own reasoning to the same criteria we apply to reasoning to which we are unsympathetic. We question our own purposes, evidence, conclusions, implications, and point of view with the same vigor as we question those of others."[1]

It is important for students to internalize the intellectual virtues and to work toward fostering these dispositions in their own minds, so that they learn to function more fair-mindedly in their lives in general. Moreover, every professional discipline has an obligation to foster fair-mindness, so that students learn to reason, with a sense of justice, through any issues within their profession that have an ethical dimension. In other words, when the rights and needs of people or sentient creatures are relevant to decisions and behavior within a field, we have an obligation, as instructors to foster ethical reasoning abilities in student thinking.

Critical Thinking and the Educated Person

We cannot be educated persons without possessing the skills and traits of the critical mind. Educated persons are able to enter viewpoints alien to them and think within those viewpoints clearly and accurately in good faith. They change their position when faced with reasoning better than their own. Educated persons are able to consider alternate conclusions when reasoning through a complex issue, to think logically, and to think with bread and depth when the question at issue requires them to do so. Educated persons are able to formulate their purposes clearly and accurately, to check multiple purposes for consistency, to determine how their purposes relate with the question at issue. They are able to persevere through the difficulties in issues. They apply the same standards to their own thinking and behavior that they expect of others. They have the courage to examine their beliefs and to stand alone, using disciplined reasoning, when opposed by others. Implicit in all of these skills, abilities, and dispositions are the elements of reasoning, intellectual standards, and intellectual virtues discussed herein.

Critical thinking is not now a cultural or educational value, as is evidenced by the sad lack of it in our schools, colleges, and universities at all levels and in all subjects. In our opinion, students are now leaving our "educational" institutions without the ability to reason well through complex issues, to reason with skill through the subjects and disciplines that have been the focus of their schooling, or to read, write, and think deeply, broadly, logically, and significantly. Only when institutions begin to take critical thinking seriously and, thus, foster it systematically within and across departments and divisions will we begin to educate the mind in the true sense of the word.

References

1. Paul R, Elder L. Critical thinking: tools for taking charge of your learning and your life, 2nd ed. Upper Saddle River, NJ: Pearson Prentice Hall; 2006.
2. Our concept of critical thinking. Retrieved May 23, 2008, from http://www.criticalthinking.org/aboutCT/ourConceptCT.cfm
3. Elder L, Paul R. The Thinker's guide to analytic thinking. Dillon Beach, CA: Foundation for Critical Thinking Press; 2006.
4. Paul R, Elder L. Critical thinking: tools for taking charge of your professional and personal life. Upper Saddle River, NJ: FT Press; 2002.
5. Analyzing and assessing thinking. Retrieved May 23, 2008, from http://www.criticalthinking.org/courses/Elements_standards_model.cfm
6. Elder, L. & Paul R. A *Miniature Guide For Students and Faculty To The Foundations Of Analytic Thinking*. Dillon Beach, CA: The Foundation for Critical Thinking; 2003.
7. Elder L, Paul R, Hiler W. The miniature guide to the art of asking essential questions. Dillon Beach, CA: The Foundation for Critical Thinking; 2005.
8. An interview with Linda Elder about using critical thinking concepts and tools. Retrieved June16, 2008, from http://www.criticalthinking.org/articles/an-interview-linda-elder.cfm
9. Paul R., Elder L. Critical thinking competency standard. Retrieved June16, 2008, from http://www.udlap.mx/promueve/ciedd/CR/pensamiento/criticalthinking competencies.pdf

The Teaching of Skillful Thinking: Lifelong Learners

T. Bridgett Galvin, PhD

Abstract

An educational history of student passivity in the classroom and the emphasis on testing have shifted the learning process away from skillful thinking. It is time to explore the learning process and create a learning environment that is more conducive to the development of skillful thinking. Changing the classroom experience, creating a course map (the syllabus), and reevaluating how progress is measured are starting points in creating a different environment that is more conducive for deeper learning and understanding. The purpose of this article is twofold: first, to provide information on the learning process and skillful thinking and, second, to provide educators with tangible suggestions on how to change the learning environment to enhance skillful thinking.

Key Words: *education, pedagogy, skillful thinking, critical thinking*

Dr. Galvin is professor of psychology and codirector of the Center for Excellence in Teaching, Scholarship, and Service at Framingham State College, Framingham, MA. Email: bperry@frc.mass.edu

The Case for Skillful Thinking

As educators it is important to begin a new dialogue about teaching and engaging students in skillful thinking. For the last several decades, students have come from an educational system that has emphasized the role of teaching and placed the responsibility of learning on the teacher instead of the student. This system has encouraged students to expect a passive learning environment in the college classroom.[1] Educators have become increasingly responsible for providing students with information necessary to complete graduation requirements and on completion, to pass, with high marks, a deluge of standardized tests.[2]

From grade school to graduate school, the No Child Left Behind Act seems to have taken hold of our educational system and prompted a drive to cover material on the tests. In fact, the too often asked question, "Will this be on the test?," is one that now even the teachers seem to be asking.[3] Student passivity and the emphasis on testing have shifted the learning process toward more shallow processing of information and away from developing deeper skillful thinking.[3] It is time to explore the learning process and create a learning environment that is more conducive to skillful thinking. Changing the classroom experience, creating a course map (the syllabus), and reevaluating how we measure progress are starting points in creating a different environment for learning. The purpose of this article is twofold: first, to provide information on the learning process and skillful thinking and, second, to provide educators with tangible suggestions on how to change the learning environment to enhance skillful thinking.

The Learning Process: A Knowledge Triangle

Ideally, the learning process consists of three components: the teacher or expert in the discipline, the student, and the learning environment, which includes the content of the discipline. At the most basic level, each of these components plays a significant role in the acquisition, application, and understanding of knowledge necessary to pass the tests. However, these components play an even larger role in establishing the skills necessary for our students to become lifelong learners.

The Teacher

The first integral part of this process is the teacher. In higher education, this role has traditionally been one of dispenser of knowledge. Historically, college students have looked for the teacher to provide the content of the discipline through well-defined classroom lectures. Ironically, teachers have also followed the same line of reasoning. With due diligence, we have prepared our lectures based on the text material and supplemental readings. We have even incorporated technology and provided extensive PowerPoint lectures to our students, complete with detailed lecture notes. We have gone so far as to eliminate the need for active note-taking by the students. We have been sure to provide adequate definitions for terms and been proficient in "covering" the most important material to be included on our own exams. In fact, we have contributed to the very passive style of learning evident in many college classrooms today.

With respect to identifying the body of knowledge our students should acquire, teachers are responsible for establishing course content. We are, in fact, hired because of our expertise in the discipline. We are responsible for deciding what to cover in a given semester. However, we must make sure the information will be useful to students, who are sure to face some form of competency exam. However, with knowledge doubling every five years, this task has become daunting.[4] With each new textbook edition, the expanse of information that we could cover in a given term increases. The decision as to what to leave out becomes as important as what to include with respect to content. The dilemma only adds to the burden of fully engaging students with the material.

At the pace and quantity of change in the knowledge base in any given discipline, the teacher can no longer be a dispenser of information but must become the guide in helping students learn how to learn on their own. It is our responsibility to establish key concepts that will become the foundation for dialogue and skill development necessary for our students to become lifelong learners. As experts in our disciplines, we must demonstrate that expertise in the selection of content more now than ever before. At the most basic level in meeting this requirement, we must maintain a current knowledge base in our discipline by keeping abreast of new findings. In addition, we must be aware of the prerequisite thinking skills necessary for students to engage in a meaningful way with the content we select. If for no other reason than there is too much information to memorize in one term, our interactions with students need to shift from telling to skill-building using the content as our platform. In so doing, we must also develop ways to evaluate the learning process or measures of student learning.

The Student

The second part of the learning process focuses on the student. Students bring a rich history that includes years of attending classes that have reinforced their being passive recipients of knowledge. Those students who traditionally have been able to memorize facts and repeat back information to which they have been exposed constitute the bulk of our student population. To date, students who know how to take tests and find the correct answer have been rewarded with good grades and passing competency scores. Their educational experiences have fostered an expectation that they can attend a class and experience an absorption model of learning, as if they are sponges soaking up information to repeat later. When our students are asked to evaluate a new clinical or work procedure, they may not have the necessary thinking skills to respond effectively and efficiently. They often believe that they need only listen, memorize, and repeat to learn the material. However, when students are asked to solve problems or think "outside the box," they are often surprised when test performance indicates a more shallow level of processing, as are their instructors. This shallow level of processing should come as no surprise, when students arrive in our courses with minimal development of good thinking skills.[5] At the same time that students may bring few developed thinking skills, they do bring a good deal of past knowledge to our courses. Unfortunately, they have never developed the awareness that their own knowledge base can be useful in acquiring new knowledge and solving problems. In short, they have not learn how to learn. Although they may have completed 16 years or more of formal education, they have not learned how to actively engage in the learning process. They have not developed skillful thinking habits.

The Learning Environment

The third part of the learning process is the learning environment, which includes the daily classroom experiences. In this context, the instructor has a significant role in constructing this environment. Elements include the content base, usually from an established text, and ancillary reading materials. In addition, there are the rules for engagement in the class on a daily basis, such as participation requirements, procedures for handing in coursework, grading requirements, and so forth. Typically, the syllabus becomes the tool for informing students about this environment.

For this environment to be effective, it should also include a transparent set of thinking skills necessary to understand concepts the instructor has identified as being central to the courses. In addition, this environment should include activities designed to promote a deep level of understanding of concepts. Last, a clearly defined process for evaluation of these activities should be indicated.

Creating a Learning Environment That Promotes Skillful Thinking: What Is Skillful Thinking?

In designing and coordinating the learning process that promotes skillful thinking, we, as mentors and guides, must also take some first steps. First, we must begin the process of evaluating and improving our own thinking skills. If asked, each of us would argue that we use skillful thinking, or critical thinking, on a daily basis. However, if asked for a definition of those characteristics of skillful thinking, many of us would be hard-pressed to provide one. The development of skillful thinking in this case is much akin to the belabored topic of critical thinking. Much of the literature in the 1980s focused on the need to develop critical thinking skills in our students. However, over the past two decades and into the present one, educators have engaged in debate over a simple, agreed-on definition of *critical thinking*. For the purpose of this article, I have chosen to focus on three related areas of skillful thinking. Richard Paul and Linda Elder have a developed a model of critical thinking that stresses the importance of developing a process of thinking using elements and standards.[5] Walcott and Lynch have provided a developmental framework for understanding and promoting skillful thinking.[6] Art Costa has proposed that skillful thinking is a set of habits of mind that must be cultivated and practiced.[7] All three of these perspectives assert that students must be actively engaged in the development of thinking skills, must be given opportunity to practice them on a routine basis, and must be given appropriate feedback so as to improve their skills throughout their lifetime. An even more basic premise for all of these theorists is that, before we can guide our students in this process, we must first work to develop them in ourselves.

As a practitioner of skillful thinking, our job is to model skillful thinking for our students on a daily basis. Moreover, our course design should also model this type of thinking in the most transparent of ways. For example, Paul and Elder have argued that teachers must ask questions about their purpose, assumptions, and their own teaching/learning perspectives.[5] We must ask ourselves soul-searching questions: What do we want our students to learn? What assumptions are we making about their previous learning experiences or their existing knowledge base? What questions do we want our students to be able to answer? Why is this information important? The questions are as infinite as the answers. Not only must we ask these questions but we must do so while adhering to standards of skillful thinking, such as relevance, accuracy, clarity, breadth, and depth. In beginning to think clearly about these issues, we can help to guide our students in this process in our classrooms. In summary, we must model skillful thinking in our daily lives if we are to expect our students to develop these same skills.

As we develop these skills in thinking, Costa would argue that we must guide our students effectively by making connections between developing skillful thinking and learning content.[7] One method of accomplishing this task involves relating readings, activities, assignments, and evaluations to concepts and thinking skills in such a way that awareness of the process begins to develop. Typically, students are not aware that the major component in the learning process is the practice and application of skillful thinking to the content. By making this process transparent in relating the course activities and concepts to thinking, students can develop an awareness of a set of strategies for learning, thereby improving their meta-cognition skills. Moreover, this practice of skillful thinking can, in time, become a mental habit that results in more disciplined, productive thinking in both our and their daily lives.

Last, it is important to recognize that skillful thinking, like other life skills, may follow a developmental progression.[6] Students must be supported when engaging in skillful thinking and reinforced for actively engaging in the material, not merely memorizing it. Moreover, they must be given feedback so that they can monitor their skill development. By increasing student responsibility for learning, we are actually increasing their capacity to learn.

Several assumptions underlie the basic premise that we can build a better learning environment that emphasizes the development of skillful thinking. Wolcott and Lynch proposed that skillful thinking develops in a sequential manner and includes a set of skills necessary to be an effective problem solver and powerful thinker.[4] Moreover, it is imperative that the environment be structured to include support for the development of those skills. The environment must also include a strategy for allowing students to take responsibility for their learning and provide a mechanism for evaluation and feedback of their learning. The question then becomes, how do we, as educators who may only have students for one term, embark on this task? Where do we start?

Charting the Course: The Classroom Experience

In structuring the classroom environment we can start at a basic level. It can be helpful to provide students with aids to developing more skillful thinking. For example, bookmarks with brief definitions of the skillful-thinking standards, such as clarity, relevance, breadth, depth, accuracy, and precision, can provide students with cues for better thinking. Reinforcement of the standards can occur with each assignment. For example, it is helpful to verbalize the thinking skill that students are practicing. Thinking skills can become real for students when we provide cues for them to recognize the skill. If they are engaging in brainstorming, be sure to identify with them what it sounds like, looks like, and feels like to brainstorm. Compare and contrast that experience with one of actively listening. Give them physical cues to accompany the skills they are working on. When they are working on an activity that requires them to evaluate data, provide them with a map or template for establishing the reliability and validity of the data. Create transparency between your objectives and the students' behaviors you wish to develop.

In creating a learning environment in the classroom, we must rethink the roles and responsibilities of both our students and ourselves. As stated before, we serve as guides and mentors. Our students will be responsible for their own learning. For students to function in this type of environment as active learners, we need to prepare them with the skill set needed to critically read the content of our discipline on their own. Often, we assume students have a set of skills needed to accomplish reading and higher order tasks. For example, we may ask our students to compare and contrast two theoretical perspectives on an exam. However, they may not have the prerequisite skills of identifying similarities and differences or sequencing. It is imperative that we take a developmental approach to helping our students to develop more skillful thinking. Again, if we have skillfully thought about our assignments we will also have identified pre-requisite skills as well.

Numerous classroom activities exist which will help to ensure our students are reading and understanding the material assigned as content. One activity proposed by Paul and Elder requires students to read selected material ahead of time and then process in class with a peer. First, students are assigned selected reading material. Second, they summarize it by paraphrasing in their own words, elaborate on the information, and provide an example. Third, they illustrate it with an analogy or a metaphor. This process of summarizing, elaborating, providing an example, and illustrating is known as the SEEI method.[8]

Next, they would actively engage with the material again by participating in a think, pair and share process with their peers. Pairs of students would be asked to share their SEEI process with each other using the material they had been assigned to read. An activity such as this one requires that students be responsible for reading the material but at the same time ensures that they process it at a level that would promote deeper understanding.

A key element in ensuring students become more responsible for their own learning requires a shift in the method of acquiring knowledge and basic information. This shift in knowledge transmission moves away from traditional lecture format and towards the creation of understanding information through processing with another peer. The instructor's role is to guide and promote the sharing of information as the activity is processed in a larger group. In the larger group the instructor may use reciprocal teaching and question-response cuing as effective strategies in place of lecturing.[9] Providing students with cues for types of questions such as those requiring recall, example, or evaluation helps them engage more actively with the material and to monitor their own thinking early in the term. Starting the term with these types of activities informs students that the responsibility for reading and learning rests squarely on their shoulders. It also sets the standard for active participation during the class time. The more students are interacting with the content, the less time teachers will be lecturing. This aspect of the learning environment allows students to process information and construct their own understanding in such a way that memorization is not the sole method for storing the information.

In addition to creating an active environment for students to process information, we need to build into our course multiple ways of engaging students with the material both in and outside of the classroom. In addition to the think, pair, and share with a partner, small-group assignments are also of value. Working collaboratively in groups is another skill that students seem to be lacking. As mentors, we can help to define this skill for students by establishing clear roles, responsibilities, and outcomes for group work. When students are working in groups, it is imperative that the purpose of the group be clearly defined. In addition, procedures for discussion and workload sharing, as well as clearly defined evaluation methods, need to be established prior to group work. Outside of the classroom, students who engage in journaling and practice self-reflection regarding the content have been shown to process information at a deeper level. A number of additional activities and suggestions to promote active and cooperative learning can be found in a miniature guide created by Hiler and Paul.[10]

In summary, several strategies can be used to aid the student and the instructor in creating an active learning environment. These include the following:

- Provide concrete aids
- Verbalize thinking
- Provide a map or template for data evaluation
- Encourage self-directed learning and reflection on the learning process
- Identify prerequisite thinking skills needed for assignments
- Summarize, elaborate, provide an example, and illustrate (SEEI)
- Engage students with material in and outside of the classroom.

Creating a Map: The Syllabus

As stated earlier, this process should begin by first improving our own thinking skills and modeling skillful thinking for our students. To that end, our interactions with our students will be modified as well. Given that we will always be working on our own thinking, a more pressing question becomes, "What do we do in our classrooms?" or "How can we structure our courses to promote skillful thinking?"

One practical, first step is to develop a comprehensive syllabus that includes a description of the thinking skills that are required to do well in the course. In refining your syllabus for teaching skillful thinking, it is useful to consider the following questions:

- What are some of the functions the syllabus plays in my courses?
- What is my first step in building my syllabus?
- At what stage in syllabus development do I choose the course content?
- What is the most important information students need from my syllabus?
- What is the most important information I need to have in my syllabus?
- How can I make sure my students and I agree on the most important information in my syllabus?

The answers to these questions may be surprising to some. Many of us prepare our syllabus the way our instructors prepared theirs. We think back to a syllabus format we liked as a student and often adopt that format. Or, as a new faculty member, we may rely on models of syllabi from our colleagues who teach a similar course. In either case, rarely do we take the time to skillfully think about and examine the purpose of our syllabus.

The traditional model for composing a syllabus is shown in Figure 1.

As instructors, we often fail to engage in skillful thinking at the basic level of evaluating the purpose of the course and the concepts or content before we design our syllabus. A thinking-based model for syllabus development is depicted in Figure 2.

In the process of developing our syllabus, we naturally exercise our expertise in identifying the key concepts. We might begin by making clear the major concepts students would need to understand to allow them to think skillfully in our discipline. For example, in a class on visual development, the concepts central to understanding the content in this course might include anatomy and physiology of the visual system, development of the brain, link between the nervous system and vision, and visual development under abnormal conditions. These concepts would constitute the bulk of the content for the course. A set of key questions would be developed around these concepts. Next, objective learning outcomes would be developed. The expectation of previously acquired knowledge would be identified (i.e., what knowledge the students entering the class should have acquired). All assignments and activities would be designed to provide students with a clear understanding of each of these concepts and how they interact with each other. The text itself and material in the text would then need to be selected for its value in adding to the understanding of these concepts. Clear evaluation and feedback measures would be identified and attached to the syllabus.

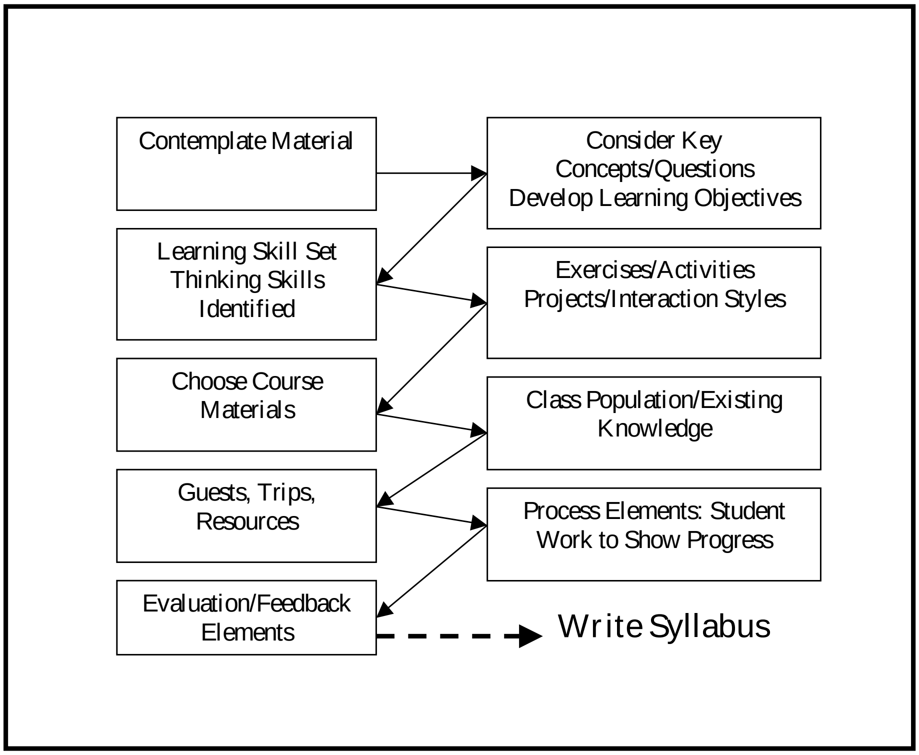
Assessment and Evaluation: How Do We Measure Progress?

When we choose to have a learning-centered classroom, anxiety often arises regarding the amount of material covered in a term and the assessment of mastery for our students. Basic questions, such as, "How will I cover everything?" and "How can I guarantee the students will be prepared for my exam let alone those tests beyond my classroom?," are certain to be raised. The answers are not simple. At best, we can hope that we have used our expertise in designing the classroom experience to fully cover the material needed for our course. If we have practiced skillful thinking in preparing our course and guiding our students, a positive outcome is probable. However, we still must evaluate the student learning that has occurred.

For each assignment created, feedback and evaluation procedures

Figure 1. Traditional Model for Syllabus Development

Figure 2. Thinking-Based-Learning Syllabus Development



should be clearly defined at conception. By asking clear questions about the purpose of an assignment or activity, we can also begin to devise clear methods of assessment. It is imperative that students be informed of the assessment methods prior to completing any task or assignment. When students are aware of evaluation or assessment guidelines for any given activity, their thinking process will also be modified. Prequizzing of the material is another way to motivate students to come to your class prepared for active engagement. Prequizzes of basic material allow students to engage in meaningful discussion with the instructor instead of passively listening to a lecture. Scores on prequizzes can be used to monitor factual understanding and free up time for engaging in more conceptual processing.

Creating rubrics for grading and evaluation also provide a clear map for students to follow in assessing their own thinking. Evaluation rubrics are useful in clarifying objectives, providing feedback, inspiring students, improving self-awareness, and improving communication between the instructor and the student. Moreover, they can also serve as tools for motivating curriculum improvement if used beyond the classroom, as we evaluate our choice and delivery of course material. A good understanding of developmentally based rubrics for assessing thinking in the classroom can be found at www.wolcotlynch.com.[11] Generic templates are available on the Web site for designing rubrics for assessing thinking for any subject. In summary, the instructor should clearly define the evaluation procedure, inform students of the assessment method prior to giving the task or assignment, give a prequiz, and create a rubric.

Conclusion

Making the shift from content-based instruction to teaching for thinking is not an easy process. It requires a leap of faith in believing that students can and should be responsible for their own learning process. It also requires instructors to modify traditional classroom strategies and establish a norm of collaborative learning in the classroom. The traditional focus on mastery of content must shift to include a focus on the development of skillful thinking as a mental habit. When instructors and students demonstrate the habit of skillful thinking, all learning and performance on measures of learning are certain to improve.

References

1. Howell C. Facilitating responsibility for learning in adult community college students. ERIC Digest. Accessed April 2007. Available from: http://www.ericdigests.org/2001-4/adult.html
2. Morse J. Is that your final answer? 2000, June, accessed December 3, 2007. Available from: http://www.time.com/time/magazine/article/0,9171,47123,00.html
3. Sacks P. Standardized minds: the high price of America's testing culture and what we can do to change it. Cambridge, MA: DaCapp Press; 2000, pp. 1-16.
4. Grunwald N, Schott D. Challenges in revolutionizing mathematical teaching in engineering under complicated societal conditions. Global J Eng Educ. 2000; 4:235-43.
5. Paul R. Why students don't reason well. 2006. Accessed December 3, 2007. Available from: http://www.criticalthinking.org
6. Wolcott SK, Lynch CL. Critical thinking in the accounting classroom: a reflective judgment developmental process perspective. Account Educ: J Theory, Pract Res. 1997;2:59-78.
7. Costa A. Habits of mind book 1: discovering and exploring habits of mind (ch.1-3). Alexandria, VA: Association for Supervision and Curriculum Development; 2000.
8. Paul R, Elder L. How to read a paragraph. Dillon Beach, CA: Foundation for Critical Thinking; 2003, pp. 18-9. Available from: www.criticalthinking.org
9. Piercy TD, Piercy W. Chaos in the classroom: the new science applied to instructional practice. In D Fasko (Ed), Critical thinking and reasoning: current research theory and practice. Cresskill, NJ: Hampton Press; 2003, pp. 187-206.
10. Paul R, Hiler W. The miniature guide: practical ways to promote active and cooperative learning. Dillon Beach, CA: Foundation for Critical Thinking; 2002. Available from: www.criticalthinking.org
11. Wolcott S. Developmental rubrics for assessing. Accessed April, 2007. Available from: http://www.wolcottlynch.com/EducatorResources.html

Critical Thinking and Clinical Judgment

Noreen C. Facione and Peter A. Facione

This material is reprinted from: Noreen C. Facione and Peter A. Facione, "Critical Thinking and Clinical Judgment," from *Critical Thinking and Clinical Reasoning in the Health Sciences: A Teaching Anthology*, 2008. Published by Insight Assessment/The California Academic Press: Millbrae CA. pp. 1-13. (c) 2008 NC Facione & PA Facione, Hermosa Beach, CA. URL: www.insightassessment.com

Lives depend on competent clinical reasoning. Thus it is a moral imperative for health care providers to strive to monitor and improve their clinical reasoning and care related judgments. Knowing that this is the agreement owed to the public trust, agencies responsible for the accreditation of professional training programs and for the oversight of health care delivery have mandated the need to demonstrate competence in clinical reasoning in health care clinicians and students. This focus on competent reasoning and problem solving is not unique to health care. Sparked by a meeting of the United States Governors in the late 1980's, educational mandates to teach and assess thinking and problem-solving have become increasingly pervasive. In this effort, the health sciences and military science have led the way. Nearly all performance based credentialing programs and performance based funding initiatives require thinking and problem solving as one of the educational outcomes worthy of assessment (Ackerman, Rinchuse, & Rinchuse, 2006). This focus on assessing competence in reasoning and problem-solving is also becoming a standard in the workplace.

The Language of Thinking

Critical thinking and reflective problem-solving are two common terms for the cognitive processes involved in clinical reasoning. Excellence in professional judgment is the result of the sound use of critical thinking skills and the reliable and strong disposition to use those critical thinking skills. The alternative (acting without adequate analysis of the problem, repeating a previous care delivery behavior unreflectively, or continuing to carry out a care delivery behavior without evaluating its effect) is not a standard of practice any of us would uphold. The discussion below outlines what has been learned to date about how humans engage high risk problems and arrive at competent judgments about what to believe and what to do. It also explores the challenge we face as researchers and educators to facilitate improvements in clinical reasoning for ourselves, our students and our peers.

There are many prior accounts of the development of a consensus description of critical thinking, research carried out as a Delphi Study in the late 1980's (American Philosophical Association, 1990). and replicated by an independent study at Penn State University (Jones & Ratcliff, 1993). We recommend that those unfamiliar with this literature seek out any of these previous papers (Facione & Facione, 1996a; 2006; Facione, Facione & Giancarlo, 2000). All of our work in instrument development and in the theoretical and practical study of human reasoning stems from this seminal study focused on the importance of everyday competence in reasoned judgment. Here we offer a brief overview integrating our research on defining and measuring evidence of everyday reasoning and judgment with the emerging consensus of research attempting to explain human reasoning processes. The result is informative for training critical thinking and clinical reasoning.

We begin with a definition of critical thinking derived from a consensus of disciplines, and used widely to ground teaching and assessment of critical thinking:

> "Critical thinking is the process of purposeful, self-regulatory judgment. This process gives reasoned consideration to evidence, contexts, conceptualizations, methods, and criteria." (American Philosophical Association Delphi Report, 1990).

In other words, critical thinking is a judgment process. Its goal is to decide what to believe and/or what to do in a given context, in relation to the available evidence, using appropriate conceptualizations and methods, and evaluated by the appropriate criteria. One way of describing how critical thinking relates to clinical judgment would be: *Critical thinking is the process we use to make a judgment about what to believe and what to do about the symptoms our patient is presenting for diagnosis and treatment*. This language is discipline free, because it refers to cognitive capabilities that can be generalized to all problem frames and all situational contexts. Here our interest is applying this terminology to the health sciences. To arrive at a judgment about what to believe and what to do, a clinician should consider the unique character of the symptoms (evidence) in view of the patient's current health and life circumstances (context), using the knowledge and skills acquired over the course of their health sciences training and practice (methods, conceptualizations), anticipate the likely effects of a chosen treatment action (consideration of evidence and criteria), and finally monitor the eventual consequences of delivered care (evidence and criteria).

Adequate Time to Think

Newell (1990) provided us with some concrete data on how long it actually takes to process a novel observation or a novel problem demanding of a response. When humans are queried on a novel issue or problem they require eleven to sixteen seconds to interpret the situation at hand and formulate even the most rudimentary reflective response. With forewarning they can summon relevant memories and content knowledge to inform their response, but otherwise processing time is required. Humans also frequently rely on heuristic maneuvers in an attempt to optimally address high stakes issues. Heuristic reasoning is believed to be most prevalent in time limited situations that do not admit of more reflective thinking, and in uncertain contexts when reflective thought fails to resolve ambiguities in the direction of a seemingly certain judgment (Gilovic, Griffin & Kahneman, 2002). More on this topic in the section below entitled 'Two systems of reasoning' but for now we return to the issue of 'time to think.'

Sixteen seconds is far longer than we are accustomed to waiting for a response after we pose an important question to a clinician, or even a student who is supposed to be prepared for the clinic. Both may feel the desire to respond thoughtfully and provide the optimal opinion, but far more often they first feel the pressure to respond quickly. So, what is forthcoming usually begins as only half-thought-out, with late breaking insights and necessary edits coming later as additional ideas are formulated. If the problem we pose is novel, and the clinician values accuracy and comprehensiveness as a component of the response, we may hear, "Now let me think about that for a moment." Hearing this response should engender confidence, but often instead it engenders doubt.

Learning to 'think aloud,' supplying evidence of the process of one's thinking and subsequent judgment (the assumptions made, the evidence base applied, the logical framing) offers a way for the listener to both evaluate the quality of the judgment and to learn to reason better themselves, This is demonstrated in discussions of think aloud exercises in some of the chapters to follow.

The accuracy of Newell's findings (the need for time to think) can be readily observed by asking anyone a novel question that requires reflective thought, and recording the time to a response. This is true regardless of expertise level, when the question or problem is truly novel. The physiological realities of human thinking make it important for educators to control the tempo of teaching and learning sessions if they are to effectively lead to improved clinical reasoning. Those who answer too quickly may have not thought well.

Clinical Reasoning and Expertise

When clinical problems are familiar we can rely on externally developed protocols and internal 'mental scripts' to assist us in deciding what to believe and what to do about the problem. The externally developed protocols are elaborate and rise to the status of standards when the consequences of error are high and society is concerned with safety. There is still need for reflective thought when using protocols to assure that they are remain appropriate to the case and that expected results occur.

Internally developed 'mental scripts' are a function of expertise. The Dreyfus and Dreyfus model of expertise, which has been adapted by Benner for Nursing, (Benner 1994, 2004) is a phenomenological model that provides a description of the increasing sense of ease experienced over time by the clinician, moving from novice practice to more expert practice. Most models of expertise describe the novice who encounters a problem as attending indiscriminately to data in an attempt to recognize key relationships that will then allow the application of knowledge they believe to be relevant. The expert, in contrast, recognizes most problems by pattern, and resolves them without a significant awareness of reflective thinking. An expert does this through the retrieval of similar cases examples stored in episodic memory, a larger array of relevant knowledge stored in semantic memory, and the use of other heuristic thinking processes.

Benner's work describing the 'lived experience' of clinical reasoning notes the seeming inability to reflect on the thinking process that occurs in the expert clinician, describing it as 'intuiting.' In contrast, other cognitive science models of human reasoning explain this lack of conscious reflection as a function of several cognitive processes: heuristic reasoning (thinking maneuvers and shortcuts discussed below), automatic thought (the ability to accomplish an array of tasks without conscious attention), and the absence of perception of meta-cognition (listening to or thinking about your thinking). In the case of automatic thinking, familiarity with the tasks required frees cognitive resources to focused more specifically on only the unique aspects of the situation or perhaps even a different problem altogether. Recall the experience of driving home from work rehearsing approaches to resolving an interpersonal issue. Possibly you exit the car realizing that you really didn't 'see' the road and the other drivers for the majority of the thirty-minute drive. We even have language for this, 'running on autopilot.' But clearly some cognitive process, outside of your awareness, was monitoring your driving, making lane changes, braking, using turn signals, seeing the other cars. It is not known how often the autopilot function impacts clinical reasoning, nor what percentage of those impacts are negative.

Models of expertise help us to understand how different groups of clinicians are likely to approach clinical problems. A high level of expertise does not assure flawless reasoning in the clinician, any more than we can be sure frequent errors will be made by the novice. Novices are known to be slower to come to a judgment because they require more time for reflective thought and additional data searching. Novices err through problem misidentification and uncertainty about knowledge application. But experts also err due to problem misidentification, and they are more prone to being inattentive to those differences in the problem which make it the odd exception to the pattern and which render the modal responses inappropriate.

Understanding the cognitive effort entailed by the novice or expert state suggests several things about the training of clinical reasoning. Feelings of comfort when working on familiar problems in familiar contexts should not be confused with genuine clinical expertise. A person may be comfortable doing roughly the same thing over and over again, as demanding as that may be, but not have the expertise to be able to resolve new problems, to adapt old ways to new situations, or even to recognize limitations or shortcomings in the way he or she has always gone about doing those familiar things.

Expert clinicians are never beyond the need to actively monitor the soundness of their clinical reasoning. While we might allow ourselves to fold the laundry or cut the grass automatically, we can't allow this type of disconnect when the life or health of others is at stake. Hence, we need to continuously build the cognitive skills and habits of mind inherent in critical thinking as the preferred tools of the clinical judgment process, the conscious reflection about what to believe and what to do in the clinical context. Novice clinicians will have far more novel problems to address, but those who have stronger critical thinking skills will progress toward higher levels of competence and expertise.

Two Systems of Reasoning

Newer research in human reasoning finds evidence of the function of two interconnected 'systems' of reasoning. 'System 1' is conceptualized as reactive, instinctive, quick, and holistic. System 1 often relies on highly expeditious heuristic maneuvers which can yield useful response to perceived problems without recourse to reflection. By contrast, 'System 2' is described in the cognitive science literature as more deliberative, reflective, analytical, and procedural. System 2 is generally associated with reflective problem-solving and critical thinking. In its decision making processes System 2 also uses some heuristic maneuvers. We offer a fuller discussion in *Thinking and Reasoning in Human Decision Making: The Method of Argument and Heuristic Analysis*, (Facione & Facione, 2007) but will recap key elements here.

In humans these two systems never function completely independently. One is not naturally "better" than the other; in fact there are situations where each offers something of a corrective effect on the other. Because both systems rely on cognitive heuristics and because these maneuvers are known to have the potential to introduce error and biases into human reasoning, knowing something about heuristic reasoning is important to those who are attempting to train or to measure clinical reasoning. There is a growing literature on this research but reading several of the foundational books and papers will provide the needed insight into how we believe humans actually think and make clinical judgments (Gilovic, Griffin & Kahneman, 2002; Kahneman , Slovic & Tversky, 1982; Montgomery 1998). Here we provide only the briefest overview.

Some hypothesize that lacking claws, fangs, skeletal armor, protective fur, poisonous secretions, natural camouflage, strength, or speed, the human species survived, because of some other evolutionary advantage. One factor was the fast, efficient, and effective problem-solving made possible by heuristic reasoning. When used well, heuristic thinking helps us survive, but misuse of this type of reasoning, when not overridden by reflective thought (System 2), leads to predictable error. For example, consider the influence on behavior of the affect heuristic. This heuristic might function well pre-consciously like this: "unprotected needle –> BAD! (stop)" Twenty years after the AIDS epidemic, no reflective argument should be needed for a trained clinician to recognize the immediate danger presented by an unshielded needle. A misuse of this heuristic might be "comfort food –> GOOD," depending on how much one is trying to lose weight. Favoring choices that avoid loss, recognizing similarities, guessing about future events by playing a movie in your head of what will happen, and assuming one is able to control all threats, are examples of heuristic maneuvers that are typically below the level of conscious thought. This system 1 thought has a powerful effect on behavior as documented in these references here and others the end of this chapter. (Montgomery, 1998; Tversky & Kahneman, 1973; Kahneman, Slovic & Tversky, 1982; Weinstein, 1982).

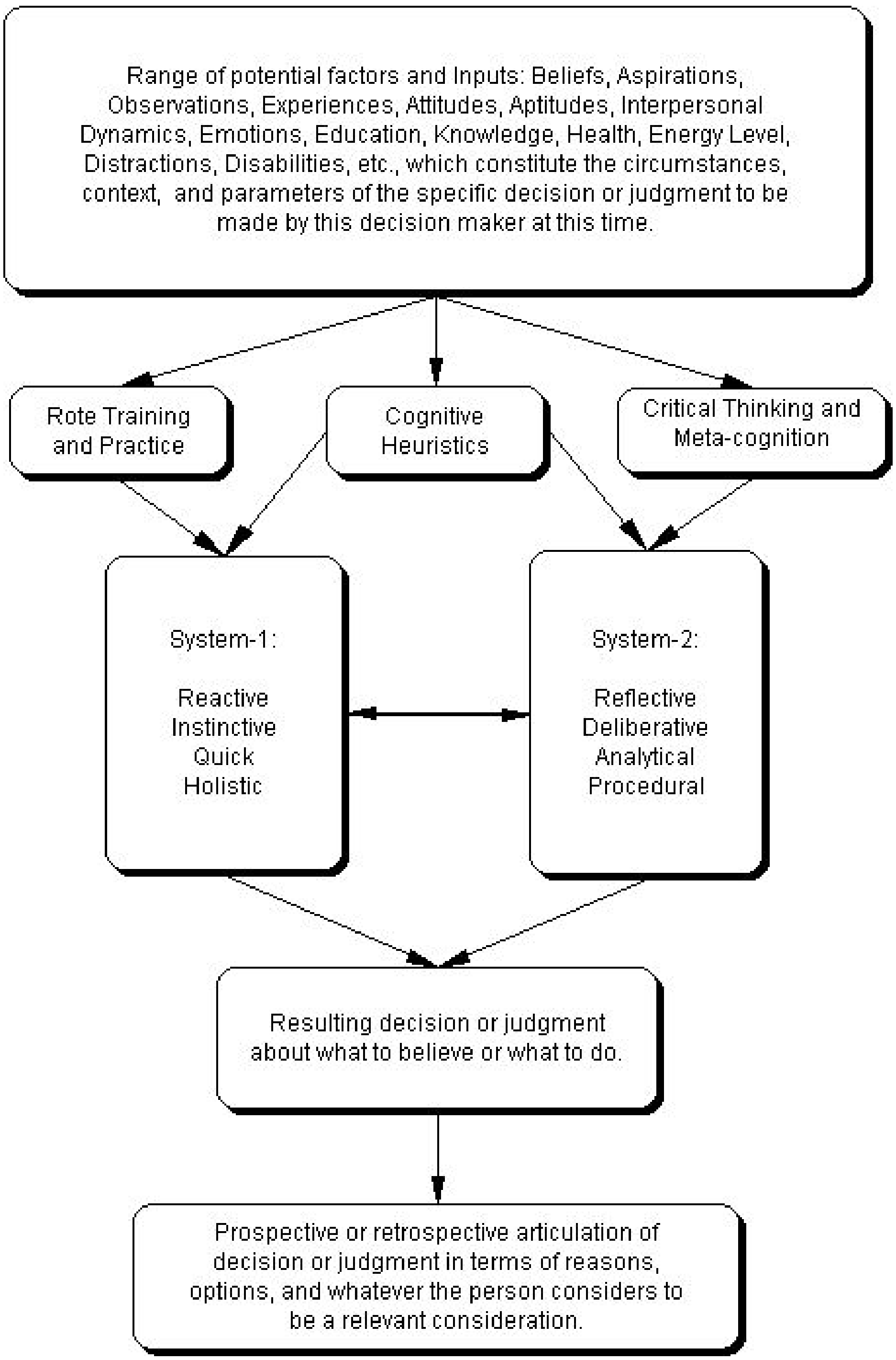
Perhaps the current preoccupation with heuristic reasoning results from being relatively unaware of it in the past. While cognitive and social psychology has been working to impact the understanding of human reasoning, many have been holding to early descriptions by Plato and Aristotle of humans as always striving to be deliberative, reflective, and logical. Not true. Even when we are making high stakes clinical judgments, this is not true. The current conceptualization of two interacting and complementary systems better explains the evolutionary success of our species. A new method of argument analysis has emerged that includes an examination of the entire decision-making process, both System 1 and System 2 and the influences of cognitive heuristics along with argument making on decision outcomes (Facione & Facione, 2007). It's likely that this method of decision analysis will bring new insights about how some common clinical errors occur. The important thing to realize is that although you may not as yet have heard much about this in the past, this is how we think. Effectively mixing System 1 and System 2 cognitive maneuvers to identify and resolve clinical problems is the normal form of mental processes involved in sound, expert, clinical reasoning. Misusing heuristic reasoning maneuvers, in the context of poor logic and misinformation is a description of poor clinical reasoning. Figure 1 below is a diagram locating the thinking processes we have been discussing. Even good thinkers make both System 1 and 2 errors from time to time. We misinterpret things, overestimate or underestimate our chances of succeeding, rely on mistaken analogies, reject options out of hand, rely too heavily on feelings and hunches, judge things credible when they are not, etc. And there is one more strategy humans use to become confident about their decisions which needs to be factored in before the story of clinical reasoning is fully told.

Dominance Structuring

Richly considered judgments about what to believe or do are typically structured around one dominant conclusion. In the case of a clinical judgment made under risky and uncertain conditions, that judgment emerges as a function of eliminating possible choices based on the evidence available. Subsequently, even when new evidence becomes available that changes the value of the chosen alternative, it proves difficult to override one's original conclusion. This remains true, even when new information renders the supporting reasons for the initial decision questionable at best. Creation of a 'dominance structure' (Montgomery, 1989) around one's choice of action (or inaction) can sustain confidence in the judgment even when the negative consequences of error are extremely high.

We all do this. We need to do this, actually, to attain significant confidence to act under uncertain conditions. Otherwise we would be more likely to delay a needed judgment or fail to maintain our resolve, thus making errors of omission. This would constitute a breech in the trust placed in us as health care providers. But there are dangers here. We can all think of situations where an ineffective plan of care was continued too long to be optimal, and was even harmful for a given individual. If we add the realities surrounding the interpersonal power structure necessary for the function of a medical team, there is an added pressure of responsibility on team leaders to be aware of dominance structures around particular diagnostic or treatment decisions which they may be sustaining long past their utility for improving the health of individual patients. The same situation could be described in relationship to the retention of policies and practices well beyond their appropriate application, or negative judgments against coworkers because initial negative impressions are wrongly sustained.

Figure 1:
The Argument and Heuristic Analysis Model of Decision-Making



Problem Parameters

When we interpret presenting symptoms, we explore their characteristics (frequency, severity, persistence, duration...), knowing that these characteristics modify the symptoms' meaning. So it is with the characteristics of clinical problems, or all of life's problems for that matter. A problem's attributes pose differing challenges for the thinking skills and habits of mind required for successful problem resolution. We have already mentioned above that new, or novel, problems and situations are approached differently than familiar ones. Other key characteristics of problem situations are the associated risk, the problem's complexity, the spontaneity of its occurrence, accompanying time constraints, and the need for specialized knowledge or collaboration required to address a response. Reflect on the likely characteristics of the typical problems presented in clinical practice and recall your own initial clinical experiences as a student. When you were a health science student yourself, many of the problems you encountered in the clinical setting appeared to you to be: 1) novel, 2) complex, 3) high stakes, 4) time constrained, 5) spontaneous, and 6) requiring of more specialized knowledge than you had at your fingertips. Finally, in spite of being a trainee, often you probably felt you had to resolve problems individually rather than relying on collaboration. Your responses to those same problems now will depend in part on the nature of your current practice and the expertise you have developed. The perceived risk attached may be similar, as most clinical judgments are high stakes for you as well as your patients. But there are probably a higher proportion of those problems which are now, for you, highly familiar, less complex, more anticipatable, more within your knowledge base, where time to think is less of an issue, and you can rely on collaboration with other members of the health care team.

Training clinical judgment across all of these possible problem parameters requires a careful pedagogical approach. We need to remember to provide time for trainees to think. Scaffolding the complexity of problems presented to students and novice staff will improve their ability to think well. Debriefing case outcomes as to the embedded clinical reasoning (surfacing assumptions, preliminary diagnoses, suspected interacting factors) externalizes the reasoning process so that it can be critiqued or praised. In the end, training health professionals to think well in clinical practice is a delicate dance, balancing the need to function in swiftly evolving real world cases with the need to allow every promising student time to develop their critical thinking skills.

The emphasis here is on 'promising.' One thing we have learned in the course of our work in critical thinking measurement is that many students admitted to health science programs do not have the requisite thinking skills to become great or even competent diagnosticians. We know this by examining thousands of critical thinking test scores from students across the health science disciplines (Facione & Facione, 1997; Chirema, 2006) and from the research that has been done to link critical thinking test scores with success on licensure examinations in the health sciences (Williams, Schmidt, Tilliss *et. al.*, 2006).

Taking a critical thinking approach to clinical practice entails two linked goals: accurate problem identification and optimal problem resolution. The first is essential. Taking action to solve the wrong problem may work occasionally in politics, but will not work for the sick and dying. The second is also essential. What are the consequences of not taking a critical thinking approach to developing a clinical treatment plan? If clinicians or our health science students do not have the possibility to think reflectively about clinical situations, they will use other methods for problem resolution. Some alternatives to critical thinking are: 1) to ask someone else what to do; 2) to do nothing; 3) to keep on doing something which is failing to achieve our desired outcome; or 4) to do something, anything, new just because it has not been tried yet. The first three are a recipe for mediocrity or failure through omission. The fourth is perhaps most dangerous if the presumed diagnosis is mistaken or if the chanced upon trial treatment turns out to be not simply ineffectual but actually harmful.

At its best, a focus on reflective thinking, and some attempt to metacognitively monitor our use of heuristic thinking, allows one to be thoughtful about intellectual honesty, analytically anticipating what happens next, demanding the wisdom of making decisions in a fair-minded and timely manner, and the attempt to eliminate personal biases. These habits of mind have been identified as those of the ideal critical thinker (Facione, Facione & Sanchez, 1994; American Philosophical Association, 1990).

Multiple Measurement Modalities

The assessment of critical thinking lends itself to the full array of measurement methods. Here as in all areas of measurement, multiple measures allow the assessment of critical thinking in the many clinical practice contexts. Multiple choice (Facione & Facione, 2006; Facione, 2000; Watson & Glaser, 1980; Ennis, Millman & Tomko, 1985) or short answer essay tests (Ennis & Weir, 1985), can be used to take one measure of critical thinking skill. These are particularly useful as diagnostic tests for reasoning competence for newly hired clinicians, health science students, and even health care clients who are not cognitively impaired. Some of these instruments use multiple choice questions requiring test-takers to apply critical thinking skills not only to solve a problem but to evaluate the quality of the solution and provide the evidence for that quality. Likert-style attitudinal measures can gauge critical thinking habits of mind (Facione & Facione 1992; Giancarlo 1998). Others have reported the utility of the multiple choice format to test reasoning process when the items are written well (Leung, Mok & Wong, 2007). Rubrics can be constructed to assess particular critical thinking skills or to obtain a holistic ratings of critical thinking skills and disposition. When care is taken to train rater and assure their valid and reliable observation of critical thinking as it presents in real time, these rubrics can be used to assess critical thinking exhibited by clinicians or students in routine case conferences, planned classroom presentations, written assignments, or immediately after addressing a spontaneous bedside situation (Facione & Facione 1996b; Facione & Facione, 1994).

Each assessment device has different potential for assessing critical thinking in relation to more or less authentic clinical judgment situations. Any test of critical thinking must call forth evidence of critical thinking itself and not merely evidence of content knowledge if they are to assess an individual's ability to think well. Psychological measures of critical thinking disposition can provide a barometer for whether a given individual is disposed to use their critical thinking skills rather than to rely on some other way of dealing with problems. These test an individual's willingness to try to think well. We need clinicians who are both willing and able to think well.

Summary

The focus on the need to training clinical judgment per se is rather new. At every level from novice to expert, clinical judgment regarding diagnosis, treatment, and on-going evaluation of patient outcomes is a fundamentally complex reasoning process which is applied to problems characterized by a multiplicity of potentially varying parameters, and which consumes cognitive resources including time to think as it relies upon core critical thinking skills and habits of mind, integrating our two systems of decision-making, susceptible to the benefits and shortcomings of cognitive dominance structuring. How clinical reasoning is experience, even d by the expert, is not a reliable measure of either the complexity or the quality of reasoning process. We would make an analogy to the practiced use of customized software on a computer. The apparent ease of the experience belies the cognitive, physiological and mechanical processes at work. We cannot make this point strongly enough, because the potential implications of overconfidence in one's expertise in clinical reasoning could not be more grave for the sick and dying. Previously we were overly confident that students and novice clinicians would somehow "naturally" advance in their clinical reasoning as they were introduced to typical clinical case scenarios. But we have learned that without a direct focus on the critical thinking processes used to interpret, analyze, infer, evaluate, and explain what is going on, progress in clinical reasoning is an uncertain outcome. True, this progress may come entirely from the learners own awareness of how she or he needs to go about internalizing and growing their clinical reasoning expertise. But when wise instructors and mentors facilitate reflective problem-solving by prompting meta-analysis and evaluation of clinical reasoning through their course assignments and pedagogical approaches, the progress is more certain. Changes in health science curricula to case-based pedagogies and problem based learning are relatively recent, but we are already seeing evidence of improved outcomes as educational researchers report that their pedagogical efforts to improve clinical reasoning skills and dispositions have been demonstrated in a variety of health science disciplines and contexts (Jenicek 2006; McAllister 2005; Tiwari, Lai, So & Yuen, 2006, Shin, Jung, Shin, & Kim, 2006; Torre, Daley, Stark-Schweitzer, Siddhartha, et al., 2007; Ozturk, Muslu & Dicle, 2007; Suliman, 2006; Velde & Wittman, 2006). Expanding our knowledge of how to do this well will surely follow.

References

Ackerman, M., Rinchuse D. & Rinchuse D. (2006). ABO certification in the age of evidence and enhancement. *American Journal of Orthodontics, Dentofacial, and Orthotics*. Vol. 130 (2), 133-140.

American Philosophical Association [APA] (1990). *Critical Thinking: A Statement of Expert Consensus for Purposes of Educational Assessment and Instruction, Recommendations Prepared for the Committee on Pre-College Philosophy*. ERIC Doc. No. ED 315-423.

Benner, P. *From Novice to Expert: Excellence and Power in Clinical Practice*. Menlo Park, CA: Addison Wesley., 1984.

Benner, P. (2004). Using the Dreyfus Model of Skill Acquisition to Describe and Interpret Skill Acquisition and Clinical Judgment in Nursing Practice and Education, *Bulletin of Science, Technology & Society,* Vol. 24, No. 3, 188-199.

Chirema, K. (2006). The use of reflective journals in the promotion of reflection and learning in post-registration nursing students. *Nursing Education Today,* 27,192-202.

Ennis, R. Millman, J. & Tomko, T. *The Cornell CT Test (Levels X and Z).* Pacific Grove, CA: Midwest Publications, 1985.

Ennis, R & Weir, E. *The Ennis-Weir CT Essay Test: An Instrument for Testing and Teaching*. Pacific Grove, CA: Midwest Publications, 1985.

Facione, N. & Facione, P. (1996a). Externalizing the critical thinking in knowledge development and clinical judgment. *Nursing Outlook* , 44, 129-136.

Facione, N. & Facione P. *Critical Thinking Assessment in Nursing Education Programs: An Aggregate Data Analysis*. Millbrae, CA: California Academic Press, 1997.

Facione, N. & Facione, P. (2006) The cognitive structuring of patient delay. *Social Science & Medicine*, Vol. 63, pp. 3137-3149.

Facione, N. & Facione P. *The Health Sciences Reasoning Test (HSRT*). Millbrae, CA: California Academic Press, 2006.

Facione, N, Facione, P & Sanchez, C. (1994). Critical thinking disposition as a measure of competent clinical judgment: The development of the California Critical Thinking Disposition Inventory. *Journal of Nursing Education*, 33 (8), 345-350.

Facione, P. *The California Critical Thinking Skills Test (CCTST).* Millbrae, CA: California Academic Press, 2000.

Facione, P. & Facione, N. *The California Critical Thinking Disposition Inventory (CCTDI)*. Millbrae, CA: California Academic Press, 1992.

Facione, P. & Facione, N. *The Professional Judgment Rating Form: Novice/Intern Level*. Millbrae, CA: California Academic Press, 1996b.

Facione, P. & Facione, N. *Thinking and Reasoning in Human Decision Making: The Method of Argument and Heuristic Analysis*. Millbrae, CA: The California Academic Press, 2007.

Facione, P, Facione, N, & Giancarlo, C, (2000). The Disposition toward critical thinking: Its character, measurement, and relationship to critical thinking skill. *Informal Logic,* Vol. 20 (1), 61-84.

Giancarlo, C, (1998). *The California Measure of Mental Motivation (CM3*). Millbrae, CA: California Academic Press. 1998.

Gilovic T, Griffin D, & Kahneman D, *Heuristics and biases: The psychology of intuitive judgment.* Cambridge, UK: Cambridge University Press, 2002.

Jenicek, M. (2006). How to read, understand, and write 'Discussion' sections in medical articles. An exercise in critical thinking. *Medical Science Monitor*. 12(6): SR28-36. Epub 2006, May 29.

Jones, B. & Ratcliff, J. National Center on Post Secondary Teaching. (1993). Learning and Assessment, The Pennsylvania State University. US Department of Education's Office of Educational Research and Improvement (OERI) Grant No.: R117610037, CFDA No.:84.117G.

Kahneman, D. Slovic, P. & Tversky, A. *Judgment under Uncertainty: Heuristics and Biases*. Cambridge, UK: Cambridge University Press, 1982.

Leung, S.F., Mok, E. & Wong, D. (2007). The impact of assessment methods on the learning of nursing students. *Nursing Education Today*, Epub ahead of print at the time of this printing.

McAllister, M. (2005). Transformative teaching in nursing education: leading by example. *Collegian*, Vol. 12 (2), 11-6.

Montgomery, H. From cognition to action: The search for dominance in decision making. In, *Process and Structure in Human Decision-Making*, (pp 23-49). John Wiley & Sons Chichester, UK, 1989.

Newell, A. *Toward Unified Theories of Cognition*. Cambridge, MA. Harvard University Press, 1990.

Ozturk, C., Muslu, G.K., Dicle, A. (2007, Dec 1). A comparison of problem based and traditional education on nursing students' critical thinking dispositions. *Nursing Education Today* (epub ahead of print at this printing).

Shin, K, Jung, D, Shin, S, & Kim, M. (2006). Critical thinking dispositions and skills of senior nursing students in associate, baccalaureate, and RN to BSN programs. *Journal of Nursing Education*, Vol. 45 (6), 233-7.

Suliman, W. (2006). Critical thinking and learning styles of students in conventional and accelerated programs. *International Nursing Review*, Vol. 53, 73-79.

Tiwari, A., Lai, P. So, M., & Yuen, F. (2006). A comparison of the effects of problem-based learning and lecturing on the development of students' critical thinking, *Medical Education*, 40, 547-554.

Torre, DM., Daley, B., Stark-Schweitzer, T., Siddhartha, S., Petkova, J., & Ziebert, M. (2007). A qualitative evaluation of Medical student learning with concept mapping. *Medical Teaching*, 29(9), 949-955.

Tversky, A. & Kahneman D, (1973). Availability: A Heuristic for Judging Frequency and Probability. *Cognitive Psychology*. Vol. 5: pp. 207-232.

Velde, B. Wittman, P. & Vos, P. (2006). Development of critical thinking in occupational therapy students. *Occupational Therapy International*. Vol. 13 (1), 49-60.

Watson, G. & Glaser, E. *Watson-Glaser Critical Thinking Appraisal*, *Forms A and B*. New York: Psychological Corporation, 1980.

Weinstein, N. (1982). Unrealistic optimism about susceptibility to health problems. *Journal of Behavioral Medicine*. Vol. 5. pp. 441-460.

Williams, K, Schmidt, C, Tilliss, T, Wilkins, K, & Glasnapp, D. (2006). Predictive validity of critical thinking skills and disposition for the national board dental hygiene examination: a preliminary investigation. *Journal of Dental Education*. 70(5), 536-44.

Association of Critical Thinking Skills With Clinical Performance in Fourth-Year Optometry Students

Aurora Denial, OD, FAAO

Abstract

The goal of optometric education is to produce a clinician who exhibits entry-level competencies in knowledge base, skills, and attitudes by the time of graduation. The purpose of this study was to address the following research question: Is there an association between critical thinking scores, as measured by a standardized test, and evaluations of clinical performance in fourth-year optometry students?

Methods: *Thirty-six students from the New England College of Optometry were assessed at the end of their fourth year with the California Critical Thinking Skills Test (CCTST).*

Results: *An association was found between critical thinking scores after one year of full-time clinical experience and clinical performance (p=0.0057, Kruskal-Wallis Test).*

Conclusion: *After intense clinical experience of full-time patient care, students who demonstrated the lowest clinical ability demonstrated low scores in critical thinking skills. This study suggests that evaluations of clinical performance are associated with critical thinking skills as measured by a standardized test. The identification of this trend may have potential impact on promoting the teaching of critical thinking, the early identification of clinically weaker students as an assessment tool for clinical education, and in customizing specific remediation plans.*

Key words: *critical thinking, optometric education, clinical performance*

Dr. Denial is associate professor of optometry at the New England College of Optometry. She thanks Drs. Nancy Carlson and Elizabeth Hoppe for her help in editing the manuscript and Dr. Li Deng for her statistical support. E-mail: deniala@neco.edu

Introduction

The goal of optometric education is to produce a clinician who exhibits entry-level competencies in knowledge base, skills, and attitudes by the time of graduation. To help clarify this goal, the Association of Schools and Colleges of Optometry (ASCO) recommended that new graduates must acquire "the critical thinking skills needed to assess the patient's visual and physical status and to interpret and synthesize the data to formulate and execute effective management skills."[1] This recommendation has led the schools and colleges of optometry to strive to incorporate critical thinking into their curricula and into the various clinical settings where teaching and learning occur.

Critical thinking is a complex and much sought-after skill. The literature reports many definitions of critical thinking with varied emphasis. Paul and Elder's definition emphasizes the art of analysis, evaluation, and assessment of thinking.[2] Watson and Glaser emphasized an attitude of inquiry.[3] The *Delphi Report*, which represents the collective thinking of several hundred experts in a variety of disciplines, defines *critical thinking* as, "Purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based."[4] In the healthcare professions, clinical reasoning is the cognitive process that involves critical thinking and reflective problem solving.[5]

For more than three decades, researchers have been exploring the nature of clinical reasoning. Several studies in the healthcare professions have linked good critical thinking skills to good professional judgment.[6-8] In the field of optometry, previous research has demonstrated a positive association between evaluations of clinical performance and critical thinking skills in students with minimal clinical experience.[9]

The education of optometrists and other healthcare professionals requires clinical experience to fully develop clinical reasoning skills. The final year of optometric education represents intense, full-time clinical training in preparation for graduation. At the New England College of Optometry (NECO), fourth-year students, as they progress through the clinical curriculum, have a greater demand for efficient thought process because they make higher stakes decisions. They are exposed to more complex ocular and systemic patient care scenarios and are expected to exhibit independence in decision making.

Educational research is needed to evaluate the relationship between critical thinking skills and clinical abilities during optometric training. The purpose of this study was to address the following research question: Is there an association between critical thinking scores as measured by a standardized test and evaluations of clinical performance in fourth-year optometry students? This study may impact promoting the teaching of critical thinking, early identification of clinically weaker students, and customizing specific remediation plans and serve as an assessment tool for clinical education.

Methods

Thirty six students from NECO were assessed with the California Critical Thinking Skill Test (CCTST)[10] at the end of their final year of optometric education. The sample size included 25 female and 11 male students between the ages of 25 and 30 years. Participation in the study was voluntary and the participants were randomly chosen. The students were engaged in over 2,000 hours of direct, patient-specific and comprehensive care by the end of their final year of education.

The CCTST is designed to measure the skills involved with critical thinking. The CCTST is content neutral; questions are not related to science or optometric knowledge base. Therefore, it possesses the ability to measure basic critical thinking skills that are not influenced by the test-taker's knowledge base, educational background, educational emphasis, or type of professional degree program. The instrument is based on the American Philosophical Association's definition of critical thinking. [4] The items cover a variety of topics; some include concrete scenarios and some are more abstract in nature. The test contains 34 multiple-choice questions, with a 45-minute time limit. The range of scores is between 0 and 34. The test has demonstrated content validity and has been successful in detecting growth in critical thinking skills. [11] The alpha reliability of the CCTST ranges from .78 to .84.[11] The five areas tested by the CCTST are analysis, evaluation, inference, deductive reasoning, and inductive reasoning. The CCTST was administered using guidelines from Insight Assessment.[12] The tests were scored by Insight Assessment, which reported both a total score and individual subsets.

The total CT scores were compared with evaluations of clinical performance in the final year of study, grouped as follows: Group 1, any grade of remedial or fail at midterm or final; Group 3, three out of four grades of honors at the final; Group 2, all of the others (no remedial or fail and less than three grades of honors). The evaluation tool for clinical performance consisted of a nine-domain rubric validated by expert consensus. The evaluation rubric is used by all clinical instructors at NECO. The domains evaluated were technical skills, knowledge base, analytical skills, diagnostic skills, management and treatment, communication skills, efficiency, attitude, and professionalism. A nonparametric analysis of variance (ANOVA), the Kruskal-Wallis Test, was used to analyze the relationship between evaluations of clinical performance and critical thinking skills.

Results

Clinical performance was grouped into three groups representing high, medium, and low ability. An association was found between critical thinking scores after one year of full-time clinical experience and clinical performance ($p=0.0057$, Kruskal-Wallis Test). The average CCTST score for the lower performing group was 15.5; the medium group, 19.3; and the higher performing group, 22.9 (Table 1 and Figure 1).

Table 1
Average CT scores and Clinical Groups

Clinical groups	*n*	Average critical thinking score	Variance
Group 1- low performing	7	15.57143	9.619048
Group 2	16	19.375	19.18333
Group 3- high performing	13	22.92308	24.41026

Note: Group 1, any grade of remedial or fail at midterm or final; Group 3, three or more final grades of honors; Group 2, all of the others (no remedial or fail and less than 3 final grades of honors).

Discussion

Critical thinking skills have been associated with clinical reasoning skills in several health care professions.[6-8] The data from this study supported a previous study that demonstrated an association between critical thinking test scores and evaluations of critical thinking in the field of optometry.[9]

The association between critical thinking and clinical performance, along with the recommendations from ASCO, supported the teaching and acquiring of critical thinking skills in the optometric curriculum. Facione has shown that, with instruction, critical thinking skills improved in college students.[11,13] However, without specific instruction, no improvements took place. The development of critical thinking skills is essential, but implementation of teaching and fostering critical thinking in the curriculum is difficult.

Optometric faculty face the challenge of teaching extensive amounts of knowledge and techniques while developing the critical thinking skills of students. Administrators often find themselves hindered by faculty and student time limitations and financial consideration. The didactic curriculum builds a foundation of knowledge, thought process, and technical skills that are used and expanded in the clinical setting. Clinical educators face the dual role of taking care of patients and educating students. The lecture format is one of the most cost-effective ways to deliver material. However, in most cases, in the lecture format, students are left on their own to analyze, prioritize, and structure their knowledge, thus hindering the development of critical thinking skills.[14]

Although this study evaluated critical thinking skills and clinical performance, the foundation for critical thinking ability comes prior to entry into the clinical setting and must be reinforced in the preclinical didactic coursework. In the 1990s, many healthcare institutions moved away from the traditional, lecture-based, single-discipline courses to a curriculum that incorporated the integration of disciplines and small-group, problem-based or case-based learning. [15-17] Curricula that incorporate problem- or case-based learning have the opportunity to foster and develop clinic thought processes and critical thinking.[5,18]

The small-group seminar provides a safe, nonthreatening environment for students to practice clinical problem solving. [19] In addition, this setting promotes the learning of critical thinking skills by giving students immediate feedback, the opportunity to brainstorm, and the encouragement to think reflectively.

Although small-group seminars are one way to foster critical thinking, any teaching strategy that encourages active learning can be instrumental in helping students think about the skills of evaluation, assessment, and analysis. Hiler and Paul[20] have several teaching strategies that can easily be implemented in a large lecture format or in the clinical setting. They have suggested asking questions that arouse curiosity, using study questions that require thinking and application of knowledge, and being a role model by thinking out loud.

Additional suggestions from Hiller and Paul may be directly applicable to the clinical teaching environment and include the following four ways to integrate critical thought processes:[20]

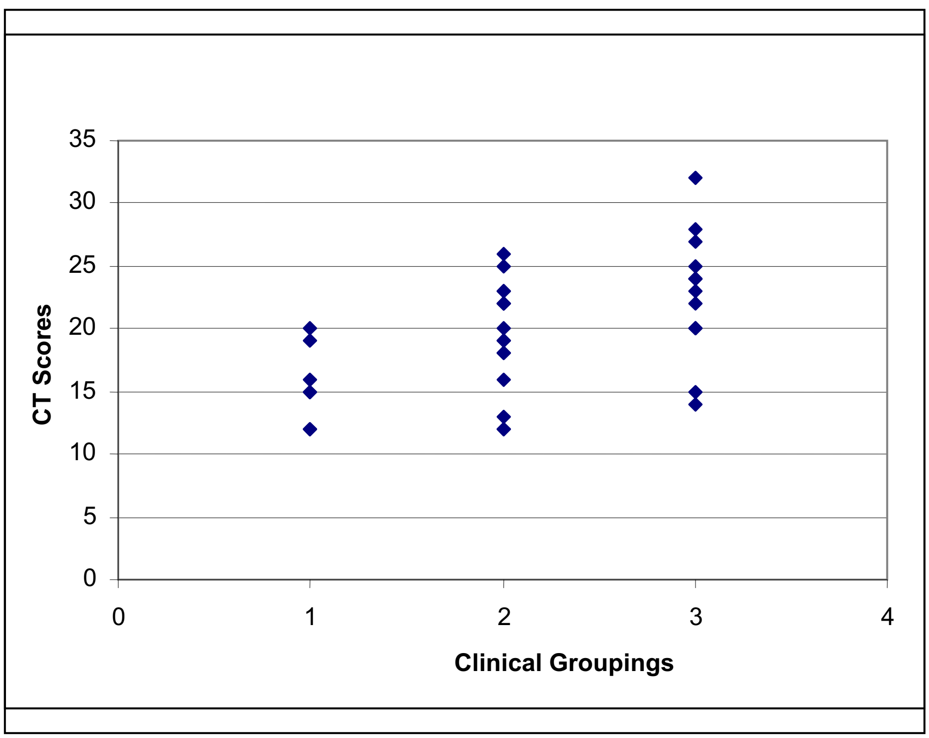
1. "Teach the principles of critical thinking along with subject material." Use the subject material as examples of analysis, evaluation, and assessment of material.
2. "Promote independent thinking, present students with a problem/diagnosis that has several possible solutions/treatment. Have students defend their proposed solution/treatment plan with logical evidence."
3. "Use Socratic questioning." What do you mean? What evidence do you have? What does that imply? How did you arrive at this conclusion?
4. "Teach for usefulness." Teach concepts as a functional tool for application in patient care. If students value the information, their learning will be deeper and better retained.

Critical thinking and clinical thought process should be taught and encouraged in every clinical and didactic teaching encounter. Students need to become active in their learning and develop inquisitive minds. Optometric education oversees the transition of students from a "student" to a "doctor." Acquisition of knowledge involves more than memorization of information. Sound optometric, clinical, decision making is supported by the use of knowledge and good problem-solving skills. Achieving these goals enables students to provide a high level of patient care and perform well in the clinical setting.

Most students acquire the needed skills to experience success within the clinical environment. However, each year a small percentage of students find themselves under pressure and struggling with clinical success. A review of the midterm and final clinical evaluations of the students in the lowest performing group revealed that 100% of the students obtained their grades because of a weakness in an area associated with clinical thought process. Examples of areas associated with thought process are diagnosis, management, and analysis. Future studies should include the feasibility of testing critical thinking skills before clinical rotations to enable educators to identify students at risk for weak clinical performance.

Students who are not achieving clinically hinder the efficiency of the clinical site to which they are assigned and suffer emotional stress. [20] An effective and efficient remediation program is beneficial to the student, faculty, clinical site, and ultimately to the profession. The design of remediation programs varies among institutions. In most institutions, deficiencies are identified with a valid clinical assessment and a specific plan is instituted.[22] In many cases, the plan is limited to additional clinical experience. If critical thinking is associated with clinical performance, then a well-designed clinical remediation program may need to include specific

Figure 1
Critical Thinking Scores/Clinical Groupings



course work in critical thinking/problem-solving strategies and clinical experience.

Clinical experience is an essential component of the educational process. The ability to accurately assess the quality of the clinical educational experience is vital and difficult. Variability in clinical sites, instructors, students, and patients makes evaluation of clinical education challenging. In most cases, clinical education is best assessed by multiple measures. Currently, clinical education is evaluated by several standards: students' clinical performance, students' subjective evaluations, independent site evaluations, and patient quality control. If we assume that students' clinical performance is a valid measure of clinical education, then tests that are associated with evaluations of clinical performance are also a valid measure of clinical education. This assumes that we have a motivated and capable student. The results of this study demonstrate an association between scores of critical thinking and evaluations of clinical performance. Therefore, critical thinking scores may have the potential to be used as an objective evaluative tool of clinical education. An objective evaluative tool of clinical education allows for better quality assurance, enables better student placement, and provides a basis for comparative studies.

Conclusion

After intense clinical experience (over 2,000 hours), students who demonstrated the lowest clinical ability demonstrated low scores in critical thinking skills. This study suggests that clinical performance is associated with critical thinking skills, as measured by a standardized test. This study supports previous research that reported an association between low critical thinking scores and low clinical performance after limited clinical experience.[9] The identification of this trend may have potential impact on promoting the teaching of critical thinking and the early identification of clinically weaker students as an assessment tools for clinical education and in customizing specific remediation plans. Although the results of this study are promising, we can not infer a causal relationship between critical thinking and clinical performance. Additional studies are needed to advance the knowledge of how to best facilitate and enhance the teaching of critical thinking and, ultimately, how to best apply these skills in patient care.

References

1. Heath D, Daum K, DiStefano A, Haine C, Schwartz S. Attributes of students graduating from schools and colleges of optometry. Opto Educ. 2000;26:15-8.
2. Paul R, Elder L. Critical thinking, tools for taking charge of your learning and your life. Englewood Cliffs, NJ: Pearson Prentice Hall; 2006, p. xvii.
3. Watson G, Glaser EM. Watson-Glaser critical thinking appraisal. Dallas, TX: Psychological Corporation; 1980.
4. Facione PA. Critical thinking: a statement of expert consensus for purposes of educational assessment and instruction. "The Delphi report." Milbrae, CA: California Academic Press; 1990.
5. Facione PA, Facione NC. Teaching critical thinking and clinical reasoning in the health sciences. Millbrae CA: California Academic Press; 2007.
6. Brookfield S. On impostership, cultural suicide and other dangers: how nurses learn critical thinking. J Contin Educ Nurs. 1993;24:197-205.
7. Case B. Walking around the elephant: a critical thinking strategy for decision making. J Contin Educ Nurs. 1994;25:101-9.
8. Hill T. The relationship between critical thinking and decision making in respiratory care students. Resp Care. 2002;47:571-7.
9. Denial A, Pitcher M. Optometric GPA, NBEO and clinical performance compared to critical thinking skills and dispositions. Opto Educ. 2007;32 (Spring).
10. Facione PA. The California Critical Thinking Skills Test. Insight Assessment/California Academic Press; 2000.
11. Facione PA. California Critical Thinking Skills Test technical report number 1: experimental validation and content validity. Millbrae, CA: California Academic Press; 1990.
12. Facione PA, Facione NC, Giancarlo CA. The California Critical Thinking Skills test manual. Millbrae, CA: California Academic Press; 2002.
13. Facione PA. California Critical Thinking Skills Test technical report number 2: factors predictive of CT skills. Millbrae, CA: California Academic Press; 1990.
14. Meyers C. Teaching students to thinking critically. San Francisco: Josey-Bass; 1986.
15. Schmidt H. Integrating the teaching of basic sciences, clinical sciences, and biopsychosocial issues. Acad Med(Suppl). 1998;73(9):S24-31.
16. Bruhn JG. Outcomes of problem based learning in health care professional education: a critique. Farm Comm Health. 1997;20(1):66-74.
17. Murphy J. Optometry schools raise the grade. Rev Opto. 2003;49-56.
18. Barrows H, Pickell G. Developing clinical problem solving skills: a guide to more effective diagnosis and treatment. New York: Norton; 1991.18.
19. Denial A, Zorn M. Student's assessment of an integrative seminar course. Opto Educ. 2006;32:17-22.
20. Hiler W, Paul R. Practical ways to promote active and cooperative learning. Millbrae, CA: Foundation for Critical Thinking; 2005. Available from wwwcriticalthinking.org
21. Haskivitz L, Koop E. Students struggling in clinic? A new role for the patient simulator. J Nurs Educ. 2004;43:181-4.
22. Olewszewski SC. Designing clinical remediation programs. Sum. 1989;14(4):111-113.

Changes in Critical Thinking After the Final Year of Clinical Education

Aurora Denial, OD, FAAO

Abstract

Critical thinking skills are reflective of a clinician's ability to ask relevant questions and analyze, evaluate, and assess relevant information. Critical thinking skills can be acquired through learning and practice. The final year of optometric education may provide the ideal opportunity to become more skilled at critical thinking. The purpose of this study was to evaluate changes in standardized critical thinking scores between the start and end of the final year of study.

***Methods**: Thirty-six students from the New England College of Optometry were assessed at the end of their third year of optometric education and again one year later after being engaged in full-time clinical education, using the California Critical Thinking Skills Test.*

***Results:** The results indicated that there was no significant change in critical thinking score after the final year of clinical experience (p=0.92, Wilcoxon Signed Rank Test). The mean and standard deviation of the total score change were –0.083 and 3.65 respectively.*

***Conclusion:** The cognitive skills needed to provide excellent patient care are a much sought after commodity. The results from this study raise several questions: What type, frequency, and consistency of clinical education may influence critical thinking skills? What type, frequency, and complexity of patient encounters could result in a change of critical thinking skills? Identifying where and how students acquire critical thinking skills can be valuable in determining how to teach and foster this valuable attribute.*

***Key Words:** critical thinking, clinical education, clinical thought process*

Dr. Denial is associate professor of optometry at the New England College of Optometry. *She thanks Drs. Elizabeth Hoppe and Nancy Carlson for their help in editing the manuscript and Dr Li Deng for her statistical support.* *E-mail: deniala@neco.edu*

Introduction

Critical thinking is a component of clinical thought process that is used by clinicians to determine what to believe and what to do about a patient's symptoms.[1] Critical thinking in the clinical setting involves consideration of the "unique character of the symptoms (evidence) in view of the patient's current health and life's circumstances (context), using the knowledge and skill acquired over the course of their health science training and practice (methods, conceptualization), anticipation of the likely effects of a chosen treatment action (consideration of evidence and criteria) and finally monitoring the eventual consequences of delivered care (evidence and criteria)."[1] Critical thinking skills reflect a clinician's ability to ask relevant questions and analyze, evaluate, and assess relevant information. These skills can be acquired through learning and practice.[2]

In a four-year optometric program, the final year of schooling represents intense, full-time clinical training in preparation for graduation. Fourth-year students, as they progress through the clinical curriculum, have a greater demand for efficient thought process because they make higher stakes decisions. They are exposed to more complex ocular and systemic patient care scenarios and are expected to exhibit independence in decision making. The fourth year may provide the opportunity to become more skilled at critical thinking.

Optometric clinical preceptors may use a variety of methods to assess a student's ability to think critically in the patient-care setting. Examples include the use of clinical grading rubrics, direct questioning, and chart audits. To best assess changes in critical thinking over time, it is most appropriate to use a standardized means to evaluate critical thinking skills. The California Critical Thinking Skills Test (CCTST) is a validated test of critical thinking.[3] It is content neutral; questions are not related to science or optometric knowledge base. Therefore, the test possesses the ability to measure basic critical thinking skills that are not influenced by the test-taker's knowledge base, educational background, educational emphasis, or type of professional degree program. The items cover a variety of topics some include concrete scenarios, and some are more abstract in nature.

A study of critical thinking scores, as measured by the CCTST suggests that, in optometric education, there is a moderate to high correlation among a critical thinking test score, optometric grade point average (GPA), and National Board Examination in

Optometry (NBEO; Part 1) scores.[4] Previous research has shown that critical thinking scores demonstrated an association to clinical performance.[4,5] The purpose of this study was to evaluate changes in critical thinking scores between the first year and the end of the final year of study.

Methods

Thirty-six students from the New England College of Optometry (NECO) were assessed with the CCTST at the end of their third year of optometric education and again after one year of full-time clinical experience (approximately 1,920 hours/year). The sample size included 25 female and 11 male students between the ages of 25 and 30 years. Participation in the study was voluntary and the participants were randomly chosen. By the end of the third year, students have completed the entire didactic curriculum. The fourth-year clinical experience at NECO comprises four 3-month rotations. Each student rotates through a Veterans Administration Hospital, a community health center, a site that deals with special populations (e.g., low vision, geriatrics, pediatrics), and their choice of an elective site (tertiary care, military base, private practice, or international site).

The CCTST was administered using the recommended guidelines from Insight Assessment (Millbrae, CA).[6] The CCTST is a standardized psychological test, designed to measure the skills involved with critical thinking. The test consists of 34 multiple-choice questions to be answered in a 45-minute timeframe. The five areas tested by the CCTST are analysis, evaluation, inference, deductive reasoning, and inductive reasoning. The meanings of each domain are defined by the Insight Assessment Interpretation Document and are in Table 1.

The CCTSTs were scored by Insight Assessment, which reported both a total score and individual subsets. The inductive and deductive scales overlap with the analysis, inference, and evaluation scales.[6] Analysis, inference, and evaluation add up to the CCTST total score.[6] Induction and deduction also sum to the CCTST total score.[6] The total scores and subsets for critical thinking skills were compared before and after one year of full-time clinical experience; the Wilcoxon Signed Rank Test was used to analyze the data for changes in critical thinking over time. The level of significance was set at $p<0.05$. This study was reviewed by the Institutional Review Board at the New England College of Optometry. Participants were given an informed consent document.

Results

All 36 students completed the test in the allotted time frame. The results indicated that there was no significant change in critical thinking score after the clinical experience ($p=0.92$, Wilcoxon Signed Rank Test). The mean and standard deviation of the total score change were –0.083 and 3.65, respectively. Table 2 shows total score and each subsection's data.

Discussion

It seems that the clinical characteristics of the fourth-year experience should provide the ideal environment to become more skilled at critical thinking. However, the results of this study suggest that the critical thinking skills of the fourth-year students did not change. Several potential explanations are discussed below in

Table 1
Types of Critical Thinking

Analysis	Analysis as used on the CCTST means to comprehend and express the meaning or significance of a wide variety of experiences, situations, data, events, judgments, conventions, beliefs, rules, procedures, or criteria, and to identify the intended and actual inferential relationships among statements, questions, concepts, descriptions, or other forms of representation intended to express beliefs, judgments, experiences, reasons, information, or opinions.
Evaluation	Evaluation as used on the CCTST means to assess the credibility of statements or other representations and "to state the results of one's reasoning; to justify that reasoning in terms of the evidential, conceptual, methodological, criteriological and contextual considerations upon which one's results were based; and to present one's reasoning in the form of cogent arguments."
Inference	Inference as used on the CCTST means to identify and secure elements needed to draw reasonable conclusions, to form conjectures and hypotheses, to consider relevant information and to deduce the consequences flowing from data, statements, principles, evidence, judgments, beliefs, opinions, concepts, descriptions, questions, or other forms of representation.
Deductive reasoning	Deductive Reasoning as used in the CCTST sub-scale means the assumed truth of the premises purportedly necessitates the truth of conclusion
Inductive reasoning	Inductive reasoning as used in the CCTST subscale means an argument's conclusion is purportedly warranted, but not necessitated, by the assumed truth of its premises.

an attempt to explain this potentially contradictory result. The discussion includes the nature of the clinical experience, composition of the patient encounters, the development of critical thinking skills, assessment tool, sample size, and student motivation.

Nature of the Clinical Experience

The clinical experience may have given the students the opportunity to use critical thinking skills but did not provide the intervention needed to change the skills. Studies have shown that, with instruction, critical thinking skills can improve.[8-11] However, without specific instruction designed to improve critical thinking skills, no improvements took place.[8,9]

What type of instruction is common in the clinical setting? Socratic questioning, role modeling with explanation of thought process, and formal case presentation are three methods commonly used to teach clinical thought process in the optometric clinical setting.[12] In addition to these methods, case studies, clinical simulations, clinical patient rounds, and small-group discussions are strategies used by healthcare educators to teach clinical and critical thought processes in the clinical setting.[13] Future studies need to explore the optimal frequency, complexity, and consistency of instruction and material needed to produce the best environment that is conducive to increasing clinical and critical thinking skills.

Patient Composition

In addition to optimizing the clinical instructional environment, the composition of the patient encounter needs to be evaluated to determine the complexity, diversity, and frequency of patient-care encounters that would enhance critical thinking. Enhancing critical thinking skills requires perceiving, remembering, thinking, and decision making.[14] Applying these cognitive processes to a diverse and complex group of patients would give students the opportunity to advance their critical thinking skills. If students are providing care to a homogeneous group of patients, they may not be challenged to change their critical thinking skills. Even with a heterogeneous group of patients, the act of taking care of patients alone may not be sufficient to change critical thinking skills. The growth of critical thinking may need in-depth self-reflection, discussion, and analysis of thought process.

Development of Critical Thinking Skills in the Didactic Environment

Another explanation for why critical thinking skills did not appear to change during the year of full-time clinical education is that students' critical thinking skills are most influenced by the didactic education that takes place prior to the final year. It may be that students experience the most rapid growth in critical thinking ability during the first 3 years of the educational program and that further improvements are negligible. Future studies need to address the changes in critical thinking over the first 3 years of optometric education.

Assessment Tool

The lack of change seen in this study may indicate a lack of correlation with the assessment tool, CCTST, and clinical decision making. Critical thinking is one component of clinical thought process. Clinical thought process also involves a combination of experience and knowledge base. The final year of optometry school may provide an increase in experience and knowledge base, which leads to overall improved clinical thought process but not necessarily better critical thinking skills. The CCTST is a knowledge-neutral test of problem-solving skills. Several other disciplines have also used a knowledge-neutral test of critical thinking to evaluate or predict clinical decision-making skills.[13-16]

Sample Size

This study was limited by a relatively small sample size. The number of students recruited was large enough to detect a change in critical thinking ability scores. With a sample size of 36, the study was sufficiently powered to detect a change of two points on the total score. Insight Assessment advised that, after a non-specific intervention, a change of 2–3 points is a reasonable expectation.[17] Future studies should include a larger sample size to capture smaller changes.

Motivation Level

The motivation level of the students may have played a role in the outcome of the study. The CCTST was first administered at the end of third year. At this point, students have completed their didactic course requirements and have limited clinical experience. The students are anticipating their first full-time clinical rotation with both excitement and stress. By the end of the fourth year, the students are awaiting graduation and are anxious to move on with their lives and careers. Even though the students were chosen randomly and participation was voluntary, by the end of the fourth year, the students may have been less attentive while taking the CCTST.

Discussing possible explanations for the lack of change in critical think-

Table 2
Total Mean Critical Thinking (CT) and Subset Scores Before Clinical Experience (3rd Year) and After Clinical Experience (4th Year)

Point type	3rd year	4th year	p-value
Total CT score	20.00	19.91	0.89
Analytical	4.77	4.72	0.79
Inference	9.94	9.94	1.00
Evaluation	5.27	5.25	0.94
Induction	10.80	10.61	0.61
Deduction	9.19	9.30	0.80

ing scores provides insight for the teaching of clinical reasoning. However, it does not necessarily indicate a lack of adequate critical thinking skills. Do students have adequate critical thinking skills to provide patient care by the time they graduate? Most students experience success within the clinical environment. Therefore, it is a reasonable assumption that their critical thinking skills are adequate to provide entry-level patient care. However, each year, a small percentage of students find themselves under pressure and struggling with clinical success. In prior studies, weak clinical performance has been associated with lower critical thinking skills.[4,5] Clinical optometric educators are often faced with the challenge of finding efficient and effective remediation strategies for weaker students. As educators, we should strive to produce clinicians who provide the highest level of patient care. Therefore, our goals should be to maximize the clinical thought process of all students. However for weaker students, increasing critical thinking skills may be vital to their success in the clinical system and, ultimately, in their professional careers.

An effective and efficient remediation program is beneficial to the student, faculty, and clinical sites .The designs of remediation programs vary among institutions. In most institutions, deficiencies are identified with a valid clinical assessment, and a specific plan is instituted. A well-designed remediation program may need to include specific coursework in critical thinking/problem-solving strategies and clinical experience.

Conclusion

The results of this study indicated that there was no significant change in critical thinking score after one year of clinical experience. This study may cause optometric educators to question when and how students develop critical thinking skills. It may also provide information that is helpful for the design of remedial programs for students who are weaker clinically. The results raise several questions: What type, frequency, and consistency of clinical education may influence critical thinking skills? What type, frequency, and complexity of patient encounters could result in a change of critical thinking skills? The cognitive skills needed to provide excellent patient care are much sought-after commodities. Additional educational research is needed to learn how to best facilitate, teach, and enhance these skills.

References

1. Facione PA, Facione NC. Teaching critical thinking and clinical reasoning in the health science. Chapter 1 (p. 2). Millbrae: California Academic Press; 2007.
2. Browne MN, Keeley S. Asking the right questions. A guide to critical thinking. Englewood Cliffs (NJ): Prentice Hall; 1990.
3. Soukup F. Assessment of critical thinking skills in associate degree nursing students. presented at the graduate college of the University of Wisconsin—Stout; May 1999.
4. Denial A, Pitcher M. Optometric GPA, NBEO and clinical performance compared to critical thinking skills and dispositions. Opto Educ. 2007;32 (Spring).
5. Denial A. Association of critical thinking skills with clinical performance in fourth-year optometry students. Opto Educ. 2008;33.
6. Facione PA, Facione NC, Giancarlo CA. The California Critical Thinking Skills Test manual. Millbrae: California Academic Press; 2002.
7. Insight Assessment. Insight Assessment interpretation document. Millbrae, CA: Insight Assessment. Available from: www.insightassessment.com
8. Facione PA. California Critical Thinking Skills Test technical report number 1: Experimental validation and content validity. Millbrae: California Academic Press; 1990.
9 . Facione PA. California Critical Thinking Skills Test technical report number 1: Experimental validation and content validity. Millbrae: California Academic Press; 1990.
10. McMillian JH. Enhancing college students' critical thinking: a review of studies. Res Higher Educ. 1987;26:3-29.
11. Pascarella ET. The development of critical thinking: does college make a difference. J College Student Devel. 1989;30:19-26.
12. Denial A. Teaching clinical thought process in the classroom and clinical setting. Paper presented at the 16th Annual New England College of Optometry's Preceptors Conference, Boston; April 21, 2006.
13. Hill T. The relationship between critical thinking and decision making in respiratory care students. Resp Care. 2002;47:571-7.
14. Scott JN. Critical thinking: Change during medical school and relationship to performance in clinical clerkships. Med Educ. 1998;32:14-8.
15. Williams KB, Glasnapp DR, Tilliss TS, et al. Predictive validity of critical thinking skills for initial clinical dental hygiene performance. J Dent Educ. 2003;67;1180-92.
16. Williams KB, Schmidt C, Tilliss TS, et al. Predictive validity of critical thinking skills and disposition for the National Board Dental Hygiene Examination: a preliminary investigation. J Dent Educ. 2006;70:536-44.
17. Personal Correspondence, Insight Assessment, Millbrae, CA. November 2006.