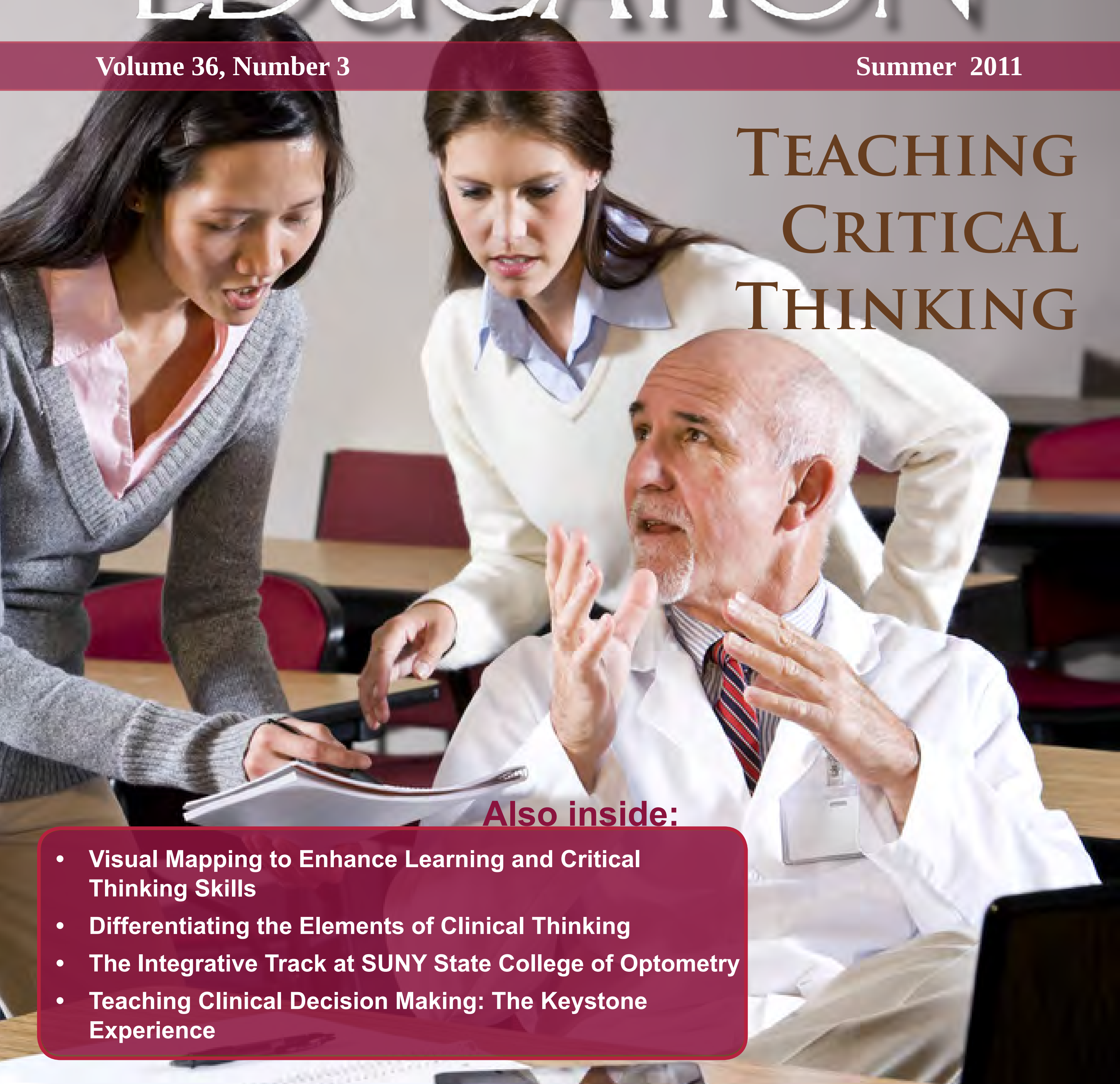
The Journal of the Association of Schools and Colleges of Optometry

OPTOMETRIC EDUCATION

Volume 36, Number 3 Summer 2011



Teaching Critical Thinking

Also inside:

- Visual Mapping to Enhance Learning and Critical Thinking Skills
- Differentiating the Elements of Clinical Thinking
- The Integrative Track at SUNY State College of Optometry
- Teaching Clinical Decision Making: The Keystone Experience

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 nonprofit, tax-exempt professional educational association with national headquarters in Rockville, MD.

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SUMMER
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Past issues of Optometric Education *are available on the ASCO Web site at http://www.opted.org/i4a/pages/index.cfm?pageid=3404. Funding for archiving was generously provided by Transitions Optical.*

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Contents (Cont'd)

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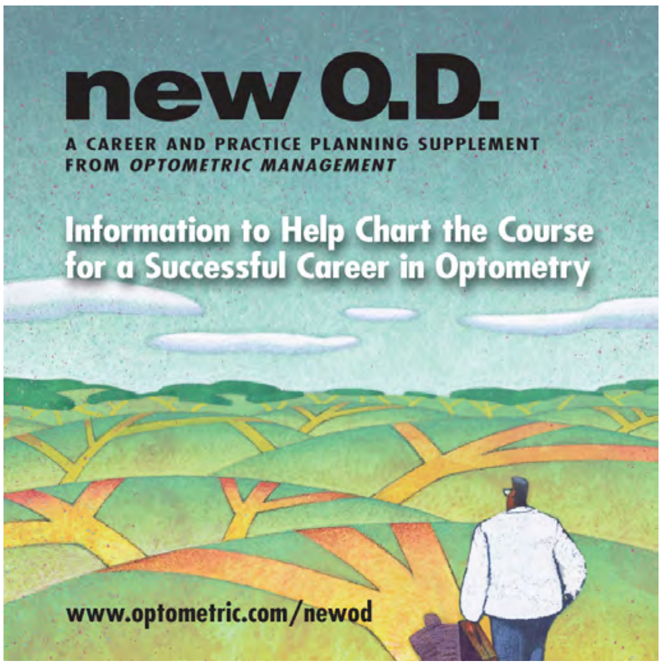

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OPHTHALMIC INDUSTRY NEWS

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)

CIBA VISION Corporation
Essilor of America
HOYA Vision Care, North America
Luxottica / EyeMed Vision Care
Walmart Stores, Inc.

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Vision Service Plan
Vistakon®, Division of Johnson & Johnson Vision Care

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Compulink Business Systems
Haag-Streit
HEINE
M & S Technologies, Inc.
Marco
Oculus, Inc.
Optos North America
Volk Optical

Contributors ($5,000 – $9,999)

CooperVision
Marchon Eyewear
Ophthonix, Inc.
Review of Optometry
Safilo Group
TLC Vision
Vision Source!

As of June 10, 2011

Multifocal Contact Lenses, Fitting Approach Debut

CooperVision Inc. launched Biofinity Multifocal, the latest addition to the Biofinity family of monthly replacement contact lenses. The new lenses combine the Biofinity Asphere and Toric lens material with the company's Balanced Progressive Technology. In clinical testing, Biofinity Multifocal lenses outperformed other brands in a range of measurements, including end-of-the-day comfort, vision quality and intent to continue with a lens, and patients rated them as superior for overall satisfaction after two weeks of wear.

CooperVision worked closely with eyecare practitioners to develop a streamlined fitting approach designed to make it easier for doctors to fit their patients and offer them an ideal combination of ease, comfort and eye health. Visit www.coopervision.com for product details.

Dr. Chudner Hired as Training Manager

Bausch + Lomb has hired Benjamin Chudner, OD, as training manager for the North America Vision Care Learning + Development Team. Dr. Chudner is expected to bring the perspective of the practicing eyecare professional (ECP) to training throughout the company's Vision Care Division. He is charged with applying his deep knowledge of the needs of ECPs to help B + L better communicate product innovations.

Benjamin Chudner, OD

Most recently, Dr. Chudner was in private practice in the Seattle area. Previously, he was president of The Eye and Contact Lens Clinic in Bremerton, Wash.

Company Names President, Bestows Scholarships

Transitions Optical Inc. awarded 15 scholarships to optometry and opticianry students through its 2011 Students of Vision Scholarship program, which is supported by the Transitions Healthy Sight for Life Fund. Students were asked to submit an entry demonstrating their multicultural vision. Six top winners received $1,000 scholarships. Top opticianry winners also received a trip to the ABO-NCLE National Education Conference in Cincinnati in September. Nine others received $500 scholarships.

Top winners were:

- Avin Kishore, Douglas College, video
- Ryan Nicholas, Western University of Health Sciences College of Optometry, interactive kiosk
- Natalie Nguyen and Nicole Pogue, University of Missouri at St. Louis College of Optometry,

video

- Yusufali Pirmohamed, Georgian College, community outreach brochure
- Mariel Ruocco, Camden County College, scrapbook
- Jermi Santos, Douglas College, video.

Submissions for the next scholarship competition, the theme of which is "leadership," are due by March 10, 2012. For more information, visit the education section of www.Transitions.com/PRO or e-mail education@transitions.com.


Dave Cole

Transitions Optical also announced that Dave Cole, who had been named chief operating officer in October 2010, has been appointed president of the company. In his expanded role, Cole will be responsible for effectively leveraging the regional and global leadership teams and business strategy development and execution while continuing to build strong strategic partnerships to drive the overall photochromic market. He joined Transitions Optical in 1990 as manager of sales and business development.

Tear Film Scan Added to Keratograph

Oculus has added tear film scanning to the capabilities of its Keratograph. Using noninvasive placido ring technology projected onto the anterior corneal surface, tear film alterations are automatically detected and tear break-up time is measured. Altered areas can be exactly located and represented using an inserted grid. Patients can be given a color representation of their personal tear film quality.

To evaluate quantity as well as quality, the Keratograph tear film scan also precisely measures the height of the tear meniscus much like it would be measured with a digital video slip lamp. For more information, visit www.oculususa.com.

Residency Awards, New Online Program Announced

The American Optometric Foundation (AOF) and Vistakon, Division of Johnson & Johnson Vision Care Inc., announced the recipients of the 2010-2011 Residency Awards. Christen Kenrick, OD, New England College of Optometry, and Lindsay A. Sicks, OD, Northeastern State University Oklahoma College of Optometry, received Dr. George W. Mertz Contact Lens Residency Awards. Michael Rebarchik, OD, Pennsylvania College of Optometry at Salus University, and Steven J. Warne, OD, University of Alabama at Birmingham School of Optometry, received Dr. Sheldon Wechsler Contact Lens Residency Awards. Jenelle L. Mallios, OD, New England College of Optometry, and Yos M. Priestley, OD, New England College of Optometry, received Dr. Terrance Ingraham Pediatric Optometry Residency Awards.

The Vistakon/AOF Residency Awards are intended to promote post-graduate optometric clinical education by supporting residents who demonstrate talent and commitment in the fields of children's vision and contact lenses. Winners receive $4,000 toward their graduate education, which includes a $750 travel fellowship to attend the annual meeting of the American Academy of Optometry.

Vistakon also announced the launch of a new online radio program, Healthy Vision with Dr. Val Jones. The program, supported by Acuvue Brand Contact Lenses, aims to close the gap between vision care attitudes and behaviors by providing consumers with timely and relevant information and helpful resources to help them manage eye health for themselves and their families. Host Val Jones, MD, is CEO of Better Health, LLC, a network of popular health bloggers.

The program can be found in the iTunes Store and at LifeMinute.TV Health, www.blogtalkradio.com/healthyvision and http://getbetter-health.com/healthy-vision. A link to the show also can be found at www.acuvue.com/healthyvision.

New Imaging Device Features Portability

The portable Pictor imager from Volk Optical captures still and video images of eye structures and is ideal for use in off-site clinics and for examining pediatric and nonambulatory patients. The Pictor weighs one pound and fits with its accessories into a small briefcase. It includes two modules. The Retinal module provides a 45-degree nonmydriatic view of the fundus. The Anterior module for imaging the


The portable Pictor imager from Volk Optical.

surface of the eye has a series of cobalt blue LEDs for fluorescent imaging.

The Pictor produces high-resolution jpeg images that easily upload to a computer and are adaptable to any patient database system. The files can be used for patient records or shared for remote diagnosis and consultation.

Heine Staff Members Take on New Roles

Ben St. Jean, president of Heine USA Ltd., recently announced the following appointments:

- Mr. Christian Berling has been promoted to Vice President of Sales and Marketing for North America. He has more than 12 years of marketing experience and more than three years of sales management experience.
- Lindsay Morgan has been promoted to Specialty Accounts Manager. She has more than five years of experience in Marketing and Business Analytics Management with Heine.


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virtually all
YOUR ASTIGMATIC PATIENTS.[1**]
NOW AVAILABLE
NEW COMPLETE PARAMETER RANGE
for ASTIGMATISM
AIR OPTIX
breathable contact lenses*
CIBA VISION
See how natural they feel.
AIR OPTIX® for ASTIGMATISM contact lenses—
Now with Round-the-Clock Coverage.
· New, wider parameter range covers 99% of astigmats![1**]
· One of the widest in-stock silicone hydrogel toric lens parameter ranges available.
PRECISION BALANCE 8|4™
· AIR OPTIX® for ASTIGMATISM contact lenses feature the breakthrough Precision Balance 8|4™ design for exceptional stability, predictability and visual acuity.
· 95% of eyes were successfully fit with the first lens![2]
Order your free trial lenses today at mycibavision.com or call 1-800-241-5999.
*AIR OPTIX® for ASTIGMATISM (lotrafilcon B) contact lenses: Dk/t = 108 @ -3.00D, -1.25D x 180. Other factors may impact eye health. **Among astigmatic patients with 0.75 to 2.75D cylinder.
AIR OPTIX® for ASTIGMATISM (lotrafilcon B) contact lenses: For daily wear or extended wear up to 6 nights for near/far-sightedness and/or astigmatism. Risk of serious eye problems (i.e., corneal ulcer) is greater for extended wear. In rare cases, loss of vision may result. Side effects like discomfort, mild burning or stinging may occur.
References: 1. Based on the prevalence of refractive errors presenting to U.S. ODs surveyed in 1999 and calculation of residual astigmatism (of=0.62D); CIBA VISION data on file, 2009. 2. In a randomized, subject-masked, multisite clinical study with over 150 patients; significance demonstrated at the 0.05 level; CIBA VISION data on file, 2005.
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EDITORIAL

Infusing Critical Thinking into the Curriculum: How Can We as Faculty Improve Student Learning?

Aurora Denial, OD, FAAO

As explained by Facione and Facione,[1] "Critical thinking and reflective problem-solving are the two common terms for the cognitive process involved in clinical reasoning." In 2000, the Association of Schools and Colleges of Optometry (ASCO) recommended that new graduates 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."[2] Critical thinking as related to clinical decision-making and patient care is now a specific outcome of the educational process.

Moving in the Right Direction

Historically, optometric educators relied on students to "naturally" acquire the clinical reasoning skills needed to go forward and provide a high level of patient care. To achieve the ASCO recommendation, many optometric institutions initiated courses dedicated to teaching critical thinking, clinical reasoning and integration of knowledge. Most of these courses support the integration of basic and clinical sciences and provide a forum for reflective problem-solving and clinical reasoning. The courses occur in small group settings and are often case-based. Theoretically, the new courses provide students with an opportunity to practice clinical reasoning and decision-making in an environment that does not include the stresses often present in the clinical setting.

Courses dedicated to teaching the cognitive process represent an acknowledgement that these skills need to be taught and practiced and that there is not necessarily a natural ability to acquire the skills while delivering patient care. Can optometric education do more? How can the educational process help students become more critically minded and intellectually autonomous thinkers? Is the teaching of critical thinking and problem-solving infused into all aspects of the curriculum as a means of supporting the acquisition and utilization of these skills?

Dr. Robert Swartz, Director of the National Center for Teaching Thinking, supports infusing thinking skills and strategies into all aspects of the curriculum to reinforce the use of these skills with the goal of developing critical thinking skills as a habit of mind.[3] Faculty are the facilitators of learning. Many faculty members may already be implementing the teaching of critical thinking strategies into their course content or clinical teaching. Faculty members should reflect as a means of identifying what is done well, what is not occurring and what could be improved. Are we incorporating thinking strategies in all of our teaching? Is thinking being taught within course content?

What is meant by course content? According to Dr. Enoch Hale, a Fellow at the Foundation and Center for Critical Thinking, "Course content is a system of interconnecting avenues. Therefore, teaching should involve the thinking strategy needed to understand and develop these interconnections. Course information needs to be turned into content; otherwise, you are not teaching content but just disseminating information. Dissemination of information without teaching explicit strategies for thinking can often lead to rote memorization of material."[4]

As we contemplate the concept of critical thinking as faculty members, we should ask ourselves whether we are disseminating information or teaching content. Do we start each lecture as a question or problem to be reasoned or solved? What are faculty doing to challenge students to develop thinking strategies and understand the connections within their course material? Heightening faculty desire and awareness of the need to teach and incorporate thinking strategies in their teaching are the first steps towards designing a curriculum that can help students learn to think better.

In This Edition of the Journal

The teaching and learning of critical thinking skills is a journey not a destination. This theme edition provides an opportunity to learn about critical thinking as well as how institutions have implemented the teaching of critical thinking.

In his paper, "Visual Mapping to Enhance Learning and Critical Thinking Skills," Dr. Hector Santiago discusses helpful tools for developing thinking strategies. "Differentiating the Elements of Clinical Thinking," written by Dr. Caroline Faucher, reviews and clarifies the various concepts related to critical thinking in health care. The implementation of courses designed to facilitate the clinical thought process is presented by Drs. Leon Nehmad and Julia Appel in "The Integrative Track at SUNY State College of Optometry" and by Drs. Gregory Good, Michael Earley and Kelly Nichols in "Teaching Clinical Decision Making: The Keystone Experience."

Also, in the Think Tank feature, Chief Academic Officers comment on how the teaching of critical thinking is implemented at their institutions and what challenges they have faced and lessons they have learned in the process.

Each of these articles is a stop on the journey to becoming more informed about critical thinking. All faculty are encouraged to assess how we can help students learn better.

References:

1. Facione NC, Facione PA. Critical thinking and clinical reasoning in the health sciences. Millbrae, CA: The California Academic Press LLC; 2008.
2. Heath D, Daum K, DiStefano A, Haine C, Schwartz S. Attributes of students graduating from schools and colleges of optometry. Optometric Education 2000 Fall;26(1):15-18.
3. Personal correspondence with Dr. Robert Swartz.
4. Personal correspondence with Dr. Enoch Hale.

ASCO Announces Recipients of First Starter Grants for Educational Research

The Association of Schools and Colleges of Optometry (ASCO) is pleased to announce the 2011 recipients of its starter grants for educational research.

- Rebecca Kammer, OD, FAAO, Southern California College of Optometry, was awarded a grant for "Does Format Matter? Engagement of First-Year Students."
- Patricia Sanchez-Diaz, DVM, PhD, University of the Incarnate Word Rosenberg School of Optometry, was awarded a grant for "Impact of Interactive Instructional Tools in Gross Anatomy for Optometry Students: a Pilot Study."

This year's educational research grants, the first to be awarded under the new program, are supported by funding from The Vision Care Institute, an affiliate of Johnson & Johnson Vision Care, Inc. The grant program serves to introduce and support the concept of the Scholarship of Teaching and Learning (SoTL). The grant proposals submitted for 2011 represented 10 institutions.

ASCO congratulates Drs. Kammer and Sanchez-Diaz and looks forward to the completion and publication of their projects.

Critical thinking as related to clinical decision-making and patient care is a specific outcome of the educational process. Many optometric institutions have initiated courses dedicated to teaching critical thinking, clinical decision-making and integration of knowledge. How is the teaching of critical thinking implemented at your institution? What challenges have you faced or what lessons have you learned in this area?

Michigan College of Optometry at Ferris State University

At the Michigan College of Optometry we attempt to integrate the development of critical thinking skills beginning with the earliest courses in the first year of optometry school. Every effort is made at this level to relate basic science to clinical application. One example is developing the relationship between cellular and human anatomy and physiology to normal and abnormal function and the types of treatments that would ameliorate abnormal function. In Geometric Optics, the students are required to maintain a journal in which they discuss one aspect of the subject matter covered that week in an insightful and unique way, thereby solidifying their understanding of those concepts and principles.

Beginning in the second year and continuing into the third year, we have implemented three courses we have named Clinical Problem Solving. In these courses, cases are presented and the students take home PAM-style cases, which are discussed in the next class meeting. The students return to class with diagnoses, treatment strategies and coding and billing plans and answer questions regarding anatomy, physiology and the rationale for their responses. A great number of our courses also include cases designed to illustrate the use of proper history, specific testing and the appropriate thought process to arrive at a correct diagnosis and management plan for the presented case. Some faculty members utilize small groups in which students analyze cases and explain their findings to their classmates. Classmates are able to edit the findings of the group presenting the case, if need be, in a safe environment that facilitates better understanding of the case and condition(s) presented.

Testing is also employed to assist faculty in evaluating how well students are able to use their knowledge in the practical application of concepts and principles through careful test construction.Cases may be evaluated by students making use of multiple choice, short answer or essay questions.

In our clinics, our didactic faculty also precept in the clinic, which facilitates the application of concepts and principles taught in the classroom to actual patient encounters. In clinic, faculty members encourage students to provide their input on the synthesis and analysis of examination findings and to develop and defend the proposed diagnosis and management of a given patient. This provides continuity between the classroom and the clinic, enhancing the ability of our students to employ critical thinking skills in actual patient care, which is the ultimate goal of optometric education.

The overriding challenge in developing critical thinking skills in our students has been overcoming the learning techniques students had utilized in undergraduate education. There, students have survived well in an environment which, for the most part, required only the memorization of facts and in turn repeating them in a testing situation. Given this background, teaching critical thinking skills may be somewhat agonizing for both the students and faculty at the outset. However, almost invariably, as the students progress through the program, great strides can be seen to have been made with regard to the development of the critical thinking skills, which are so imperative in becoming a successful optometrist.

Dean L. Luplow, OD
Assistant Professor

State University of New York State College of Optometry

At SUNY Optometry, one of our educational objectives is to teach students to think critically in their courses and throughout their clinical education and into practice. To improve clinical decision-making we emphasize clinical applications in the didactic courses and reinforce the relationship between the basic sciences and clinical care with our integrative seminar program. The integrative seminar program is a unique element of our curriculum that runs throughout all four years. In years one and two, as students prepare for and enter the clinic, integrative seminars emphasize the integration of didactic course concepts into the clinical examination.

In year three, the integrative seminar is actually integrated into the clinic as part of a weekly full-day primary care clinical assignment. Third-year primary care clinic at SUNY is organized into units we call "pods," where two clinical faculty are teamed with six students for eight weeks. The integrative seminar takes place during a break in the clinic assignment and offers opportunities for the faculty and students to reflect, discuss and critically analyze patient care plans while reinforcing basic science applications to their clinical experiences. In the fourth year, all students have one quarter of clinic seminar, which offers a grand rounds format for discussing cases and clinical decisions critically.

Our integrative seminar program is a new program, and the first class of students is just completing the full sequence this year. Initial assessments have been positive. The greatest challenges we've faced have been changing the clinic schedule to incorporate the pods with their integrative seminars and changing the expectations on the clinical supervisors. However, with the dedication of the clinical faculty and the cooperation of the clinical administration, the program is functioning so well it is being considered as a model for our specialty clinics and our fourth-year clinical internships.

David Troilo, PhD
Vice President and Dean for Academic Affairs

Southern California College of Optometry

The teaching of critical thinking at the Southern California College of Optometry has been embedded in coursework through the use of asynchronous discussion boards and also through in-person, small group, case-based learning. A critical component to these methods is the ability for students to challenge each other's thoughts and ideas. Some courses require justified responses through the use of peer-reviewed literature.Although critical thinking has been emphasized in many of the preclinical courses at the College, more recently a concerted effort to measure perceived learning outcomes in critical thinking has occurred.

In the fall of 2010, a pilot course designed specifically to address deeper learning through problem-based learning (PBL) strategies was incorporated into the first-year curriculum.The pilot course utilized a mixture of two hours a week of traditional lecture methods and two hours with learning groups using PBL pedagogy to teach geometric optics. The course promoted self-directed learning, problem-solving through the use of hypothesis testing, idea development and fact-finding. The purpose of the methods was to promote both independent and collaborative knowledge-building. Higher-order learning such as "meaningful processing" was heavily emphasized (e.g., connecting new learning to prior knowledge). An outcomes survey queried student engagement, critical thinking gains, satisfaction with learning and other outcomes. The results demonstrated that there was a strong relationship between engaged learning (measured with six items) and critical thinking skills improvement. Higher critical thinking scores were also related to high student satisfaction scores with the amount learned and also satisfaction with faculty.

The challenges in the course included student dissatisfaction with grading criteria and limited faculty feedback on learning topics. Another limitation was the restricted facilitator time within each group (the faculty facilitator rotated visitations through several groups at one time). A new stand-alone course utilizing a higher ratio of faculty to students with methods more closely matching problem-based learning guidelines will be launched this fall for first-year students.The purpose of the course is to foster higher-order thinking and integration of the basic sciences with clinical reasoning strategies. Outcomes will be assessed for engaged learning, critical thinking and basic science knowledge integration.

Rebecca Kammer, OD, FAAO
Associate Professor

Indiana University School of Optometry

If we accept critical thinking as being "the mental process of actively and skillfully conceptualizing, applying, analyzing, synthesizing and evaluating information to reach an answer or conclusion,"then we would hope that critical thinking would be a part of every course within our curriculum. But we know that in spite of our best hopes, students do not automatically enter into this type of thinking, even as they move into a clinical setting.

A major hindrance to critical thinking is compartmentalization. Yet out of necessity we compartmentalize our curriculum into distinct course subject areas. At the same time, we expect students to take these different pieces and automatically put them together holistically. We know that if this is not done, critical thinking doesn't occur. In an attempt to meet this challenge, the Indiana University School of Optometry has done two things worth mentioning.

First, we have incorporated problem-based learning courses, entitled "Integrative Optometry," into the first and second years of our curriculum. The first-year course is small seminars facilitated by optometry faculty. At the onset of the course, students are given a clinical case. The expectation is that students will individually search into the literature and collectively find out as much about this particular disorder as possible. There is an emphasis on relating the disorder back to basic sciences. A clinical solution is not the ultimate goal, but rather an understanding of the underlying mechanisms of the problem. Individual faculty members do not "teach" the course. Instead they facilitate discussion, as needed, andredirect the search as students delve into thetopic.

In the second year, Integrative Optometry takes the form of a "Reverse PBL." Students are organized in small groups. Each group chooses a clinical topic, constructs the case and guiding questions together with a Facilitator's Guide that is amply referenced. Again, the goal is to relate the clinical case to the underlying basic science concepts so as to provide both critical thinking skills and the understanding that clinical and basic sciences are on a continuum and not separate.

The second step we took happened approximately four years ago when we reorganized our curriculum with an eye toward grouping courses into four different tracks: Optics, Biology/Disease, Sensory & Motor and Clinical Science. Each track looked at the content and sequencing of subjects within their subset of courses. Courses and their content were reorganized with the intent of integrating subject material for efficiency and flow. At the same time this was going on, the faculty for each track were charged with timing the delivery of material to coordinate subject matter across tracks. In this way, for example, optics material related to prism would be taught shortly before prism was needed in clinical sciences.

Both of these changes were made to facilitate the integration of subject matter, getting students accustomed to conceptualizing, applying, analyzing, synthesizing and evaluating information to reach an answer or conclusion.

Clifford W. Brooks, OD
Executive Associate Dean for Academic Affairs and Student Administration

Northeastern State University Oklahoma College of Optometry

In addition to teaching critical thinking skills in all clinical rotations, the Oklahoma College of Optometry teaches a course, Differential Diagnosis, which is designed specifically to enable students to improve critical thinking skills and clinical decision-making.We also have four Case Studies courses, which are conducted in a grand rounds format. Critical thinking skills and integration of knowledge are taught across the curriculum as a portion of many different courses, including disease, optics, clinical methods, contact lenses, low vision and vision therapy. Some instructors who teach courses early in the curriculum find teaching critical thinking skills challenging, as the students do not yet have much background knowledge. We believe that our clinical program is made stronger by incorporating the teaching of critical thinking skills and integration of knowledge across the curriculum.

Kippi D Wyatt, BS, OD
Assistant Dean, Academic Affairs

The Ohio State University College of Optometry

Several years ago, The Ohio State University College of Optometry began a case-based course series to help students learn to apply their coursework knowledge to the clinical environment. Students would work in small groups on cases across a five- to seven-day period. Students took one "Keystone" course at the end of their first year of training and took a second Keystone course at the end of the second year. They learned to assimilate patient history, optometric testingand laboratory test results into a concise and meaningful summary statement called the patient illness script. Students were then tasked with comparing the patient illness script to different disease presentations they had learned in their optometric courses. First-year students completed the case studies by completing a differential diagnosis list, while second-year students also prepared a detailed assessment and plan.

The learning objective was to help students make the transition from the basic sciences to the clinical sciences and to show through sample cases how their basic science education fit into optometric clinical care. Additionally, students learned the process of how clinical decisions are made. During the course, students were constantly reminded that reaching the "correct" case diagnosis was not the goal of the course; completing each step in the examination/diagnosis process was the key. Students must develop a meaningful patient summary that includes epidemiology, temporal pattern and examination key features. Only after these elements are developed and verbalized should comparisons to different disease presentations be made. Additionally, clinical attendings and basic scientists worked side-by-side to oversee student progress on these cases to allow clinicians to revisit basic science concepts and to allow basic scientists to better understand the clinical value of their course elements.

Other than the obvious demand on teaching (12 faculty engaged in course all week long), challenges have been few. Both students and preceptors have enjoyed the case-based learning process. A frequent finding, however, is the tendency for many students to jump ahead and skip important process elements to reach premature closure. When this occurs, often an incorrect diagnosis is found, and certainly learning is always compromised.

Michael J. Earley, OD, PhD
Professor of Clinical Optometry
Chief, Binocular Vision/Pediatrics Clinic

Gregory W. Good, OD, PhD
Professor of Clinical Optometry
Assistant Dean, Clinical Services

University of Alabama at Birmingham School of Optometry

At the UAB School of Optometry there is no single, specific or successful approach to teaching critical thinking. Some of our faculty believe that we do not, in fact, teach it. Others believe that it is taught, almost "without thinking," in the clinical setting. A student in a supervised clinical setting is essentially forced to apply his or her knowledge to a real-life situation. The attending witnesses this application of critical thinking and evaluates the student, providing constructive feedback in order to improve performance with each subsequent patient the student sees. The attending is also a safety net to ensure that the patient receives quality care and that each clinical decision is appropriate.

Other instructors emphasize evidence-based decision-making. This includes lecture material as well as assigned readings of keystone significance in the field of study. The challenge is that students are overwhelmed with material and seem reluctant to overcome the daunting task of critical reading/thinking to discern the evidence and consequently lapse into previously perceived notions. The lesson learned is to limit the assigned readings to the most critical and potentially productive material.

Because most students have limited or no previous experience with our subject matter, many faculty believe the only way to engage the students and make them think is to use case examples and ask them what they would/should do in particular situations. In our Business Aspects of Optometry course, for example, the students are told that they are practicing doctors with an employee who is causing some kind of problem. Perhaps the employee has body odor that everyone notices or is constantly late or is caught stealing. The students are asked what they are going to do about it. Is there a best course? Are there legal issues if they consider dismissal? In HIPAA, the hypothetical situation is presented, which might be based on a real case, and they are asked if there is an issue and what they think the outcome should be. There really is nothing better than challenging the student with a case pertaining to the subject and making him or her practice decision-making.

Some faculty have learned that assigning students to prepare written reports really helps identify the cream of the crop. Those students who provide thoughtful answers in a well-written manner show a level of maturity in critical thinking that we attempt to identify. From there, we may encourage residencies, thinking that someone who can write well and think critically would make a great resident and possibly future faculty member.

Here is an example of the essentials of the written assignments:

- **Weekly Assignment**

  At the end of each clinic day, write down three things that you learned as a result of seeing patients that day and e-mail them to me. Also, add one question that came to mind in your patient care. This may be an answerable question that you might wish to review later, or it may be an unanswerable question that would require further research but shows your maturity in thinking.

- **Term Assignment (three per term)**

  Literature Review Instructions

  a. Briefly summarize the article, including the patient base (number of patients studied, age, major inclusion and exclusion criteria), methods and results
  b. Provide three bullet points that you will be able to use to tell your patients in real life
  c. Provide at least one bullet point that was interesting to you that was NOT in the abstract
  d. Write one question that comes to your mind after reading the study (i.e., now that you have answered the question in the paper, what other questions surface in your mind?)
  e. Cite the reference (consider PubMed via www.uab.edu/lister/tools and enter your blazer id/password to have increased electronic access to full articles)

- **Evaluation**

  1. How mature of a thinker are you?
  2. Were you able to get access to literature when indicated?
  3. Did you use the best reference to answer the question? (Asking me or another instructor for help is NOT cheating)
  4. Can you write?
  5. Did I learn something? Did you teach me at least one thing?

Jimmy D. Bartlett, OD
Chair, Department of Optometry

Nova Southeastern University College of Optometry

At Nova Southeastern University College of Optometry, we use critical thinking components in both the didactic and clinical teaching arenas. Activities to develop critical thinking skills are included in all course learning objectives because we believe these skills are crucial for making the transition from student to clinician. Only through proactive processing of information can students apply what they have learned in the classroom to the care of a patient in an exam room. Case studies and problem-based learning scenarios are used throughout clinical training. Both didactic and clinical curricula include learning objectives to stimulate critical thinking, such as:

- embedded questions to challenge students to wider fields of study
- supporting students to compile their own learning portfolio, reflecting their personal philosophy and action plans to achieve goals and to detail successful learning guidelines
- using technology to augment study guides, encouraging students to develop enhanced versions of an area of study, engaging in meaningful, active, constructive learning, such as identifying causal relationships
- promoting collaborative strategies to achieve a community service goal
- including measurement metrics of progress, such as pre-post tests, checklists or the creation of an "expert" lecture by the learner.

Critical thinking by definition is an action term used to describe the proactive processing of information, a useful ability to guide behavior and decision-making. This is precisely the skill that is needed during the critical transition to clinical care. At NOVA, we characterize our teaching objectives as providing the framework for students to learn the skills necessary to go beyond the acquisition and retention of information. Our teaching objectives are to ultimately produce outstanding optometric physicians who are committed to lifelong learning and growth.

Josephine Shallo-Hoffmann PhD, FAAO
Associate Dean for Academic Affairs

Michael Bacigalupi OD, MBA, FAAO
Assistant Dean for Student Affairs

Southern College of Optometry

At Southern College of Optometry we have attempted to give our students multiple guided experiences in critical thinking with didactic courses prior to entering the clinical curriculum. For example:

- The most profound change in the way we model and develop critical thinking in our students is in the manner of presentation of our optics course sequence in the first year. Under the leadership of Dr. John Mark Jackson, this course has been transformed into a team-based learning (TBL) experience in which students work together to look at problems and use what they have already learned to arrive at new solutions. For students who often come out of undergraduate science education that is largely driven by memorization and multiple choice examinations, there can be significant challenges to looking at a situation that does not have a "right answer" and coming to the best possible solution for all the parties involved. This course has been exceptionally well-received by our students and aspects of TBL are being adopted in several other courses.
- Dr. Betty Harville teaches the Clinical Communication & Patient Care course in the fall of second year and Clinical Internship Introduction the following spring. In this course series, students have to work their way through complicated case histories and basic optometric procedures while Dr. Harville challenges them individually by personally acting out patients presenting with various conditions or states of mind. Students are graded with a rubric that assesses their ability to adjust their techniques to the needs of the patient. These sessions are videotaped and reviewed by the entire lab group, with feedback and discussion, allowing all the students in that group to benefit from the experience.
- We have just added a course to the second year, Evidence-Based Medicine, taught by Dr. Sharon Tabachnick. This course requires students to use health sciences literature to research various questions about ocular and visual conditions and critically assess the literature available. As with any valuable growth experience, there have been growing pains. We have learned that requiring the students to be responsible for extensive investigation beyond the classroom requires careful communication about the purpose, expectations and benefits in order to engage the students in deriving solid learning outcomes.

Lewis Reich, OD, PhD
Vice President for Academic Affairs

David A. Damari, OD
Professor
Chair, Department of Assessment

Western University of Health Sciences College of Optometry

Instruction in critical thinking at the Western University of Health Sciences College of Optometry is embedded within the curriculum through didactic and clinical experiences, including group projects, facilitated lessons, clinical case studies and supervised patient interactions. The College of Optometry administers both the California Critical Thinking Skills Test and the Health Sciences Reasoning Test to students at the beginning of their first year and again at the end of their final year. This approach will enable us to measure the extent to which critical thinking skills are being cultivated in students. If increases in scores from year one to year four are not sufficient to indicate that critical thinking skills are meeting the expected entry level competence of new graduates in optometry, we expect to initiate strategies that include, but are not limited to, coursework that explicitly attempts to teach the art and science of critical thinking.

Miki Carpenter, PhD
Director of Assessment

Daniel Kurtz, PhD, OD
Professor
Associate Dean of Academic Affairs

Send Us Your Comments

Do you have any thoughts or insights related to teaching critical thinking? Send your comments to Dr. Aurora Denial at deniala@neco.edu, and we will publish them in a future edition of the journal.

A Personal Retrospective

Ellen Gilman, MEd, OD

Remembering my best day in optometric education brings tears to my eyes. My friends know I am emotional, but if you don't know me, let me introduce myself. I am a graduate of The New England College of Optometry, a second-generation optometrist and a late bloomer (I was 35 when I graduated in 1978), who has been adjunct faculty at NECO for 33 years. While my primary professional career has been in my own practice, and while that employment has been overwhelmingly rewarding, some of my best days ever have come from teaching at the College. As I contemplate retirement from both clinic and academia, I'm having fun looking back on those days and deciding which might have been the very best.

Chronologically, my first best day in optometric education had to be the day, when I was about 10, when my dad put an ophthalmoscope in my hand to let me look into my brother's eyes. Yes, my dad was my first optometry educator, and I was the one being educated, but I sensed his excitement as he explained that the red lines I saw were blood vessels and that the eye was the only place in the body where blood vessels could be seen without cutting into the skin(!). While my dad was always a model for me of caring, thoroughness and ethics in practice, some of the rewards of teaching became obvious to me that day. It was a day of not one, but two, "aha! moments."

The day I got my first student reviews was another best day for me. I love teaching for its own sake, but feedback from students is precious. When it's positive, it rewards us for our hard work and preparation, but, more importantly, feedback motivates us to improve on our strengths and minimize our weaknesses as teachers. While words like "great," "helpful," and "effective" are flattering, the ones I was able to use most were specifics, like "organized," "attentive" and "mentor." My students' evaluations have made me more knowledgeable, a better communicator, and an ever more effective clinical role model.

For optometric educators, an additional best day occurs many times in clinical settings. In labs, clinics and clerkships, it's been thrilling each time I've seen that aha! look on the face of a student. Finding exactly the condition (or its location) that the student was expecting from a thorough case history, or actually observing the relationship between the power, base curve and lacrimal lens when a contact lens is put on an eye is a powerful learning experience. And we clinical instructors get to see the aha! of recognition that accompanies that experience.

Once students recognize the value of material learned in the classroom, they begin to evolve in their clinical reasoning ability. I have been involved in the Clinical Reasoning track at NECO and, before that, in the Problem-Based Learning courses. Another of my best days would have had to be the day I first heard a student say to him/herself, "What else could it be? How can I confirm this diagnosis? What treatment would work best for this particular patient?" Critical clinical thinking is an important and difficult skill to teach, and this issue of *Optometric Education* is dedicated to helping us in this endeavor. We work hard at it, and the teaching paradigm changes and improves constantly, but what excitement we experience when we observe our students maturing in their clinical thinking!

Other educators have expressed in this column the sentiment that graduation day is their best day in optometric education. Pride and happiness are certainly part of that day, but for me, a fifth, and probably very best, day comes after graduation. I have had the sheer, unadulterated pleasure of observing some of my former students working as clinicians, administrators and educators themselves. A day when I see an intelligent, successful, happy person enthusiastically using the education I have so enjoyed helping her/him achieve is truly the best day I can imagine. It almost makes me cry.

Dr. Gilman recently retired from her position as an Adjunct Assistant Professor of Optometry at The New England College of Optometry.

The High Road or the Highway: An Essay on the Ethical Responsibility of the Primary Care Optometrist

ASCO Student Award in Clinical Ethics

Becky Ramos

Introduction

Every so often a headline such as the following appears in the newspaper, "An 80-year-old woman caused three accidents while driving down the highway in the wrong direction." Stories such as this continue to spark national debate about the aging population and the appropriate measures to prevent such tragedies from being repeated. This essay will examine the ethical role of the primary care optometrist when faced with the decision to report a patient, as required by law, for not meeting the legal driving requirement of the state in which he or she is licensed.

Case History and Presentation

A 76-year-old female reports to the optometry clinic in Philadelphia, Pa., with a chief complaint of blurry vision in both eyes. The patient reports glare and difficulties driving. She reports that she can no longer read road signs. She also states that she tries to drive during the day because when she drives at night she feels that she cannot see the road and feels disoriented if she is on an unfamiliar road.

Examination Results

Systemic history was remarkable for hypertension, hyperlipidemia and arthritis. Ocular history was remarkable for dry eye syndrome and bifocal spectacle correction. Uncorrected visual acuities were 20/80 OD and 20/100 OS. Pinhole testing did not show improvement. Best-corrected visual acuities were 20/70 OD, 20/80 OS and 20/70+ OU. Slit lamp examination revealed dense cataracts OU and moderate tear film insufficiency. Views of the retina were hazy but appeared unremarkable.

Patient Education

I educated the patient about cataracts and explained that her cataracts were the primary cause of her vision loss. I also discussed cataract surgery as an option to improve her vision. Furthermore, I advised the patient that her existing vision did not meet the legal requirement in Pennsylvania for evening driving privileges. The patient did not agree and felt that she could see well enough for evening driving if she was familiar with the road. After a lengthy discussion about the dangers involved, it became apparent that the patient was not willing to stop driving in the evening.

Discussion

The scenario presented above demonstrates the dilemma that many optometrists face when it comes to care of a patient with decreased vision who wishes to retain a license to drive. In 2007, there were 31 million licensed drivers aged 65 and older in the United States. Motor vehicle crash deaths per capita among males and females begin to increase markedly starting at ages 70-74.[5] Age-related declines in vision and cognitive functioning, as well as physical changes, may affect some older adults' driving abilities.[8]

The Pennsylvania Vehicle Code requires that all physicians and other providers authorized to treat disorders and disabilities must report to the Pennsylvania Department of Transportation any patient 15 years of age or older who has been diagnosed as having a condition that could impair his/her ability to safely operate a motor vehicle. Approximately 22% of reported cases have medical impairments significant enough to merit recall of driving privileges. The Health Insurance Portability and Accountability Act does not restrict healthcare personnel from disclosing protected health information when disclosure to a state agency is required by law. Therefore, no individual consent to release of health information is necessary in these cases.[2]

Providers are immune from any civil or criminal liability if they report the suspected impaired ability to safely operate motor vehicles. However, failure to report may subject the provider to civil and criminal liability if one is held responsible as a proximate cause of a vehicle accident.[2]

The state of Pennsylvania requires that driver's license applicants meet a 20/40 acuity standard. If they fail to meet the requirement, they are required to have an eye examination by a licensed professional and must wear corrective lenses to meet the standard. If certain conditions are met, an individual with visual acuity that is poorer than 20/40 with both eyes may drive with a daylight-only restriction. In the state of Pennsylvania, the patient in this case is able to drive with a daylight-only restriction because her combined vision is less than 20/60 but at least 20/70, as long as a recommendation is obtained by a licensed optometrist or physician who has the equipment to properly evaluate visual acuity.[1]

Ethical Dilemma

On one hand, as stated in the American Optometric Association Code of Ethics, the optometrist has an obligation to the patient to maintain confidentiality and "to hold in professional confidence all information concerning a patient and to use such data only for the benefit of the patient." Additionally, the Optometric Oath states that the optometrist also has the responsibility to "hold as privileged and inviolable all information entrusted to me in confidence by my patients." [3]

On the other hand, the Oath contends that the optometrist has a responsibility "to serve my community … as a citizen as well as an optometrist." As a good citizen, an optometrist must strive not only to do what is best for his or her patients but must also take into account the safety of the public. Many states have laws that require healthcare practitioners to provide information about persons at risk for injuring themselves or others when operating a motor vehicle. It is not the intent of these laws to place the healthcare practitioner in a position to stop the patient from driving or to decide who should be permitted to drive.[3]

As healthcare providers, we are bound to protect all information placed by our patient in our trust. Conflict may arise when our patient's wishes are in opposition to our recommendations. The optometrist must accept that protecting the patient may result in the patient feeling displeased about being reported. Mandatory reporting requirements place the practitioner in the position of serving as both the agent of individual patients and as an agent to society.[7] To protect the relationship with these patients, optometrists should inform patients that reporting is required by law, that their case is being reported, and that they will have a chance to demonstrate their ability to drive. The optometrist's decision on how to proceed must recognize his or her moral obligation to both patient and society, together with an assessment of the relative risk of harm from breaching confidentiality vs. the harm of maintaining it.[3] In this patient's case, I felt conflicted as to whether we should report the patient given her resistance to discontinue driving at night. Ultimately, the attending optometrist opted not to report the case. We referred the patient for a cataract surgery consult and documented in her record that it was advised that she refrain from driving at night until vision met the required acuity.

The Optometric Oath also states, "I will place the treatment of those who seek my care above personal gain and strive to see that none shall lack for proper care."[4] Optometrists are ethically and morally bound to place the patient's needs above their own personal gain. That may include taking the chance of losing a patient if he or she becomes angry about being reported.

The ethical principle of respect for autonomy requires a practitioner to respect the choices and decisions that a patient makes about his or her own health.[3] In order to provide patients with the respect and care they deserve, an important part of the patient education process is listening. It is a natural reaction for a person of any age to feel multiple emotions upon hearing that they are no longer able to drive. They may feel frustrated, isolated and/or depressed. Give patients an opportunity to voice their concerns and frustration. Discuss the issues of health and safety. Place yourself in your patient's position. How would you feel if you were told you would no longer be able to drive? How would you get to work, to social engagements or to the grocery store? How would you feel if this were a member of your family or a close friend? [6] The patient may now be reliant upon family, friends and public transportation to travel. In some cases, patients will listen to the recommendation of the optometrist and their family and cease driving. However, in cases such as the one discussed here, patients may be resistant to the loss of their independence in the form of their driver's license, posing an ethical dilemma for the optometrist.

Conclusion

As healthcare providers, optometrists must balance patients' decisions about their own health with their duty to the community and legal obligations to the state they are practicing in. If I fail to report a patient with poor vision, I am subsequently placing him or her and the community at risk. Aside from my legal obligations, I feel that ethically I would have failed to protect my patient if I opened up the newspaper one day and realized that my patient was in an accident after my failure to report her inability to drive safely.

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Dr. Ramos, a 2011 graduate of the Pennsylvania College of Optometry at Salus University, is the winner of the 2011 ASCO Student Award in Clinical Ethics. The award, which is funded by Ciba Vision, was begun by ASCO's Ethics Educators Special Interest Group to develop greater interest in ethics among optometry students.

Invitation to Participate
Upcoming Theme Edition

Scholarship

Scholarly contributions by faculty are a critical component of faculty development, promotion/tenure and delivery of optometric education. Most optometric faculty have minimal formal training in professional writing, research and publication. Scholarly contributions move education forward and can significantly impact the profession. *Optometric Education* is announcing a future theme edition, which will focus on scholarship. The theme edition is scheduled for publication in 2012. Deadline for submissions is Jan. 1, 2012. We invite all educators and administrators to participate.

For additional information on the scholarship theme edition, contact Aurora Denial, OD, FAAO, at deniala@neco.edu.

Information Technology Literacy: The Fourth R

Geoffrey Goodfellow, OD, FAAO
Dominick M. Maino, OD, MEd, FAAO, FCOVD-A

The traditional foundation of most basic skills-oriented educational programs consists of Reading, wRiting and aRithmetic. However, information technology appears to be vying as an additional leg to this three-legged stool. Those of us who teach professional school are already keenly aware of the new and overwhelming digital resources that are available to ourselves and our students.

The Millennials who now grace our classes have been described by Marc Prensky as "Digital Natives," individuals who have "spent their entire lives surrounded by and using computers, videogames, digital music players, video cams, cell phones, and all the other toys and tools of the digital age."[1] It is mind-boggling to consider that today's college students spend 9.5 hours per day interacting with technology like MP3 players, gaming devices and computers.That doesn't include the 2.5 hours of daily TV.[2] Prensky estimates that today's average college grads have spent less than 5,000 hours of their lives reading and nearly 20,000 hours watching television.[1]

One might instantly assume that because students use all this technology in their personal lives, they would prefer its use in their classrooms as well. Ironically, many of the technology studies have shown that high levels of use and skill do not necessarily translate into preferences for more use of technology in the lecture hall.[3,4] Perhaps you've experienced students who still want that paper handout from you in addition to the electronic version. Even faculty who provide only electronic documents via a Learning Management System are often surprised when students print off these documents and bring the paper to class. Students often prefer to have paper in hand for note-taking.

Although a wide variety of tablet-type devices have entered the market, they still have limitations in the classroom. There is something about writing little notes in the margins and highlighting in a dozen colors that appeals to students. Although there is tablet and stylus technology available to duplicate a similar experience, students have been slow to adopt these. Nonetheless, we are starting to see more of these devices in our classes. Electronic versions of documents allow one to cut-and-paste and to directly hypertext to other documents, videos and other educational resources.

One thing is clear, out of all the things changing in optometric education, technology is leading the pack. Quite literally, each new day brings innovativetools to our faculty and students. E-mail, which was the quintessential student communication tool for students, has been replaced quickly with text messaging. A survey of more than 2,000 students at the University of Melbourne showed that 80% of students text daily with their cell phone.[5] However, the same 2008 report also goes on to say that 67.8% of students have not used their mobile phone to access Web-based information and services. What a difference three years makes in the world of technology! In 2011, who among us has not seen the vast majority of our students attached to the Internet via their smartphones? (Now that we mention it, who among us has not seen the vast majority of our faculty attached to their smartphones?)

What Students Really Need to Know

Despite all of this new technology and explosion of information in our palms, we usually do not spend an adequate amount of time showing students how to find information. The days of "knowing everything" are long gone, and we should be replacing the memorization of facts with an efficient ability to lookup those facts. Clearly, some things in optometry are so fundamental that they need to be committed to memory. However, for many others, it would be best to teach our students where to retrieve the required information and how to evaluate its relevance to evidenced-based optometric practice.

Dr. Goodfellow is Assistant Dean for Curriculum and Assessment and an Associate Professor at the Illinois College of Optometry. Dr. Maino is a Professor of Pediatrics and Binocular Vision at the Illinois College of Optometry. They invite your feedback and suggestions for future columns. E-mail them at dmaino@ico.edu or ggoodfel@ico.edu. You can also visit www.MainosMemos.blogspot.com.

Google and Wikipedia can be amazing tools, but students have trouble realizing that the information retrieved is not always correct. Lemley and Burnham, in their paper "Web 2.0 Tools in Medical and Nursing School Curricula,"note that the most common digital tools used in the curricula of medical and nursing schools include blogs, wikis, videocasts and podcasts.[6] These may not be the best tools to use to find accurate, up to date and scientifically sound information on various medical topics and research.

Online resources that might be better suited for students' needs include:

1. The Directory of Open Access Journals(http://www.doaj.org/doaj?func=subject&cpid=40&uiLanguage=en). Here you can find several outstanding journals, such as:
    - BMC Ophthalmology
    - Clinical Ophthalmology
    - Clinical Optometry
    - Digital Journal of Ophthalmology
    - Eye and Brain
    - Journal of Optometry
    - Journal of Vision
    - Optometric Education
    - Optometry & Vision Development
    - Journal of Behavioral Optometry
2. Medscape (http://www.medscape.com/ophthalmology)
3. Digital Atlas of Ophthalmology (http://www.nyee.edu/page_deliv.html?page_no=50)
4. The Neuro-Ophthalmology Virtual Education Library (http://novel.utah.edu/)
5. SECO International (http://www.secointernational.com/eposters/index.cfm).

Students and faculty alike should also consult past ASCOTech columns and this journal for the latest information on technology and optometric education.[7,8]

It is generally accepted that practicing optometrists underutilize the eyecare literature. To some extent this is likely due to our lack of teaching this skill in optometry school. After all, why search on my own for the information if Dr. Smith will tell me what I need to know, right? However, instilling those lifelong learning skills should be an important component to any health profession's program. It is said that it may take as long as one or two decades for original research to be used in routine clinical primary care practice.[9] With the advent of the resources noted above, this should no longer be true if we teach our students how to access and use these digital resources now.

Barnard et al. explain that information literacy translates into lifelong learning that can be initiated, extended and sustained through abilities that use technologies but are independent of them.[10] They posit that the development of information literacy facilitates engagement with effective decision-making, problem-solving and research. Although undergraduate students appear to develop a sound background of information literacy skills, professional school educators may be lagging behind in using these skills to develop critical thinking skills.[10]

Rising to the Challenge

Technology will continue to challenge the best of faculty members. Whether it is Electronic Health Records in our clinics, the newest XYZ retinal scanner in our clinical diagnostic battery, optometric vision therapy treatment tool or new Learning Management System software, there is always something new to learn. We should embrace each of these advancements as an opportunity to teach our students in new and different ways. By fully engaging in all of today's tools, we can instill information technology literacy that will prepare our students for a solid future of optometric practice. Our expectations for students should be lifetime learning, not just as a great catch phrase, but as a reality put into practice every day.

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Correction:

In the Winter-Spring 2011 issue of Optometric Education, Dominick M. Maino, OD, MEd, FAAO, FCOVD-A, should have been listed as the lead author of the ASCOTech feature.

Visual Mapping to Enhance Learning and Critical Thinking Skills

Héctor C. Santiago, OD, PhD, FAAO

Abstract

Visual mapping allows the learner to explicitly explore, analyze, synthesize and share ideas. This paper reviews mapping tools suited for brainstorming and picturing the thinking process (mind mapping), exploring the structure of knowledge (concept mapping), developing premises, counter arguments and conclusions around a contention (argument maps), exploring the learner's own thinking process (®Thinking Maps), seeking the inter-relation among variables (general systems thinking) and developing simulation models (system dynamics). The paper also presents the evidence on the effectiveness of these tools in promoting recall, comprehension and general critical thinking skills.

Key Words: *critical thinking, recall, comprehension, visual map, mind map, concept map, thinking map, systems thinking, system dynamics*

Dr. Santiago is a Professor at the Inter American University of Puerto Rico School of Optometry.

Background

Critical thinking dates back more than 2,000 years at the birth of Western civilization. Socrates' dictum "The unexamined life is not worth living" subsumes the ultimate value of critical thinking in human life. Plato's Dialogues epitomizes not only a method but also a way of living that is still relevant to our time.[1] Critical thinking skills involve the processing of information through analysis, synthesis, interpretation, explanation, evaluation, generalization, abstraction, application, comparison and contrast.[2] Critical thinking skills are, like common sense, not very common. Studies indicate that 70% of high school graduates are deficient and only 28% of four-year college graduates possess excellent skills. Yet, it is considered to be the most important asset sought by human resource professionals.[3]

Across the globe, many university educators use the lecture format assisted with PowerPoint slides as the main delivery method. More than a generation of students has suffered "death by PowerPoint,"a term describing the use of slides cluttered with text, often with irrelevant embellishments, leading to student boredom and little meaningful learning[4,5]. Although these presentations can be improved, there is an inherent limitation to these traditional methods. Lectures and text slides are inevitably linear representations that hide the rich inter-relations among the concepts. As Davies explains: "This paradoxically usually results in less meaningful learning, not more. It results in linearity rather than connectivity out of which genuine understanding arises … It also fosters a lack of engagement critical to the development of meaningful understanding … To meet assessment demands, students begin to rely on memorization techniques and cramming, not meaningful activities to ensure engagement and learning, and ultimately — via a transformative learning cycle — expertise."[6]

David Ausubel, an educational psychologist, saw the primary responsibility of the educator as the presentation of learning materials in a meaningful form, not as a list of facts. He indicated that educators must find procedures allowing the learners to tie new knowledge into their prior cognitive structure. He proposed visual mapping as a tool par excellence to promote meaningful learning.[7] His view on meaningful learning has been supported by research on the organization of knowledge by experts as compared to novices: "Studies in areas such as physics, mathematics, and history also demonstrate that experts first seek to develop an understanding of problems, and this often involves thinking in terms of core concepts or big ideas such as Newton's second law in physics. Novices' knowledge is much less likely to be organized around big ideas; they are more likely to approach problems by searching for correct formulas and pat answers that fit their everyday intuitions."[8]

Marzano completed a meta-analysis of research on instruction and strategies that significantly affect student achievement. Nonlinguistic representations, questions, cues and advanced graphical organizers were among those that were correlated with effective learning.[9] Prince reported that activities that promote student engagement like thinking about their own learning (metacognition) and explicit instruction in problem-solving enhance student learning outcomes.[10]

This paper reviews visual tools that can potentially increase students'comprehension, meaningful learning and critical thinking skills. Although most tools have received experimental corroboration of their effectiveness in schools, undergraduate, graduate and medical education, there is still very limited use in optometric education.[11] It is hoped that this paper will stimulate further study, experimentation and implementation in our schools and colleges of optometry.

Picturing the Thinking Process: Mind Maps

Mind mapping is the graphical representation of text content. It has been proposed as a technique to brainstorm and summarize information as well as a study method. The originator and main proponent of mind mapping is Tony Buzan.[12] He argued that typical note-taking is linear, while thinking involves an interlinked network. Furthermore, note-taking emphasizes the verbal component (a left-brain process) while ignoring imagery (a right-brain process). He concluded that mind maps tap into the natural nonlinear thinking process. He also concluded that mind maps potentiate learning by using both left and right brain capacities.

McClain proposed the use of mind maps in optometric education. In particular, she recommended that students be given a skeletal map (with blank terms) at the beginning of the lecture. Students would be required to fill the blanks as they listened to the lecture. She indicated that mind maps would allow teachers to stay on task, allow students to add their personal ideas to the topic, and increase comprehension.[11]

Paykoc et al. described the successful use of mind maps by faculty members in the process of brainstorming curricular changes. The map was projected to the group and the progress of the discussion was reflected in the mind map.[13]

The construction of mind maps follows specific guidelines.[12] The map itself has an organic appearance, similar to a tree with a trunk, branches around the trunk and smaller branches outgrowing from the main branches. **(Figure 1)** The map is started with an image at the center of the page (landscape mode) representing the core idea. Branches are drawn, beginning at the top right of the page and following a clockwise direction. The branches contain keywords that are subheadings of the main topic. Out of these bigger branches grow smaller branches detailing the information. Each branch line should contain only one keyword. Ideally, lines closer to the center should be thicker than those far from the center. The use of images tagged to the branches is encouraged. The use of color, especially for grouping and encoding is also recommended.

Although mind maps can be produced using paper and color pens or pencils, several companies have developed mind-mapping software that facilitates drawing and allows saving of the maps. The original organic version of mind maps is ©IMindMap. Mind Map is a registered trademark of the Buzan Organization Limited 1990 (www.thinkbuzan.com). An alternative and less organic version of mind maps allowing for multiple words and phrases have been developed by ©MindJet (www.mindjet.com). Free versions of mind maps software include ©SciPlore (http://www.sciplore.org/software/sciplore_mindmapping/) and ©FreeMind (http://freemind.sourceforge.net/wiki/index.php/Download). These programs permit the attachment of documents, images and Internet links to the branches of the maps.

Figure 1 is an organic mind map (©IMindMap) based on an optometric case scenario.[14] The case was a 9-year-old student who came with his mother complaining about poor academic achievement that started in the third grade. Diagnostic hypotheses included a visual problem (related to refractive error, binocular or accommodative dysfunction), a developmental (information-process-

Figure 1

A Buzan organic mind map (®IMindMap Software, www.ThinkBuzan.com) of an optometric case scenario of a third-grade boy failing in school. The map is read clockwise, starting at the top right. It shows the hypotheses derived from the case history, diagnoses corroborated or ruled-out through testing, one additional diagnosis and the final management of the case. Software-derived map used with permission.

ing) disorder and learning disability. Case history showed that the boy started having problems in the third grade, had no word recognition problems, and had good handwriting, ruling out both the information-processing disorder and the learning disability. He claimed that his eyes got tired frequently, he did not have double vision, had headaches in the afternoon and reported having passed a recent vision screening (distant visual acuity test). Tests revealed a low refractive error requiring no correction, convergence insufficiency, as well as accommodative insufficiency and infacility. Additional tests revealed a saccadic (oculomotor) dysfunction). The boy was scheduled for vision therapy.

The map illustrates an obvious issue of traditional organic mind maps: They are typically difficult to interpret by an outsider without proper help from the developer.

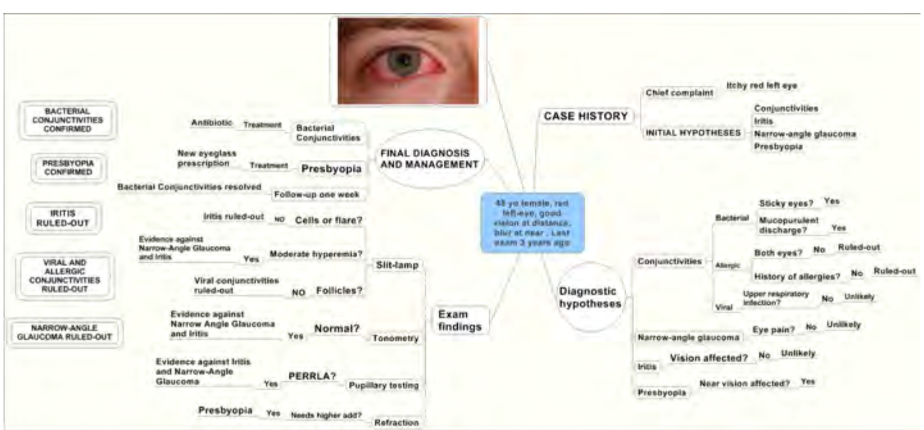
Figure 2 shows a second modified mind map, using ©Mind Manager Software, of a clinical case scenario of a patient visiting an optometrist with a red and itching left eye.[14] The map depicts the clinician's thinking process, including the generation of hypotheses during the case history, the evaluation of the hypotheses during the examination, and the final diagnosis and management of the case. The look of the map is less organic, but it depicts phrases (rather than just a single word) at the branches, allowing for clearer and easier map interpretation. Faculty and students can develop these mind maps from case scenarios to share their clinical decision-making process.

Evidence for the Effectiveness of Mind Mapping to Enhance Learning

Farrand et al. conducted a study on the efficacy of mind mapping to enhance performance in a fact-recall test by medical students. As an additional variable they asked students to self-rate their motivation. In the study, a control group used their preferred study technique (keywords, re-reading the text or underlining keywords). The experimental group was instructed to use mind mapping. Both groups were immediately tested with a 15-question factual test. They were also tested a week after the initial exposure. In general, students allowed to use their own study techniques were more motivated than those told to use mind mapping. However, the mind mappers had better performance than non-mappers on the immediate recall test (13% more) and in the long-term recall test (24% more) when results were adjusted for motivation.[15]

Figure 2

A modified mind map using ©Mind Manager Software accompanying an optometric case scenario showing the case history findings, the initial diagnostic hypotheses developed during the case history, the examination findings confirming or ruling out the diagnoses, and the treatment and management of the case. It summarizes the clinical decision process during the optometric examination. Used with permission.



A study showing no advantage of mind mapping in college students was completed by Shuttleworth using a within-subjects design. Initially, subjects studied a text using their preferred study technique. They completed a multiple-choice and fill-in-the-blank factual test. Then, they were trained in mindmapping study technique and used it while studying a second equivalent text. They completed a second factual test. Test results were not significantly different for the mind mapping technique compared with their preferred study technique. No motivational differences were found in this study. However, some participants found that the 20-minute study period was too short for the mind mapping procedure.[16]

Abi-El-Mona and Adb-El-Khalick compared the performance of two groups of eighth-grade students on a multiple-choice test based on national standards. The experimental group spent one month in mind mapping techniques while the control group spent a month in a note summarization technique. The mind mapping group scores were significantly higher than the note summarization group. This was true for students independently of their previous scholastic achievement. The experimenters also compared mind maps developed at the beginning of their training to those at the end of the training. Students with higher conceptual understanding displayed more accurate links, more colors and more links to minor concepts than other students. This study had two significant differences to the previous two studies. First, participants had a significantly greater mind mapping training period (one month). Second, the experimenters required participants in the control group to use a particular technique (note summarization) rather than their own preferred study technique. This study shows that mindmapping has an advantage over note summarization when participants have significant (one month) experience with the techniques.[17]

An issue related to mind mapping is the development of rubrics with good construct validity and inter-rater reliability to evaluate mind maps. D'Antoni, Zipp and Olson developed the mind map assessment rubric (MMAR) using weighted scores that include concept-links, cross-links, hierarchies, examples, invalid components, pictures and colors. In their study, first-year medical students received a 30-minute presentation on mind mapping techniques. Immediately after the training, they were allowed 30 minutes to read a text passage from the Graduate Record Examination. They were also asked to draw mind maps of the passage. Three different examiners evaluated the maps using the MMAR. The results showed high and significant inter-rater reliabilities for pictures (0.86), colors (0.73) and total score (0.86). The inter-rater reliabilities were moderate and significant for cross-links (0.58) and examples (0.53). The inter-rater reliabilities for concept-links and hierarchies were not significant.This study indicates that the MMAR is an inter-rater reliable rubric for mind maps. Furthermore, the rubric can also be applied to concept maps[18].

In summary, the evidence indicates that mind maps are potentially useful techniques that can enhance learning. Well-motivated students with significant mind mapping practice are the most likely candidates to benefit from its use.

Exploring the Structure of Knowledge: Concept Maps

Concept maps are the brainchildren of Joseph Novak, a noted American educator. Originally, he developed them as a tool to document the changes in the cognitive structure of children taking basic science lessons. Novak was a disciple of David Ausubel, who argued: "If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly."[19]

Concept maps allow explicit recording of what the learner knows and how this knowledge evolves through time. **Figure 3** is a concept map of classical optics.

A concept can be an object, idea or event. It is usually represented by a noun such as "chair," "disease" or "optics." Concepts are related to one another through links, which are usually verbs. Two or more concepts related through links become propositions. For example, in Figure 3, one proposition is "geometric optics implies light as a ray." Concept mapping is the systematic development of the structure of knowledge related to a main concept, tying themain concept to subsidiary concepts via links.

There are two main characteristics that differentiate concept maps from mind maps:

1. **Hierarchical:** Concept maps are hierarchical with the most important concept shown first, usually at the top of the map. Subsidiary concepts are placed below the main concept. Tertiary concepts derived from secondary concepts are placed below secondary ones. This process continues as needed. In mind mapping, the main idea is placed at the center of the map and all other ideas are outgrowths of the main idea with no obvious hierarchy.
2. **Explicit naming of links:** Concept mapping requires that the links between concepts are named explicitly through verbs such as "includes," "is part of," etc. Naming of the links allows for an easier and more accurate interpretation of the map. Mind maps do not name the links and the nature of the relationship is implicit.

While mind maps do not impose constraints on the order of ideas, concept maps require more rigorous thinking, analysis and implementation.

Novak and Gowin describe a well-defined process to build concept maps as follows:

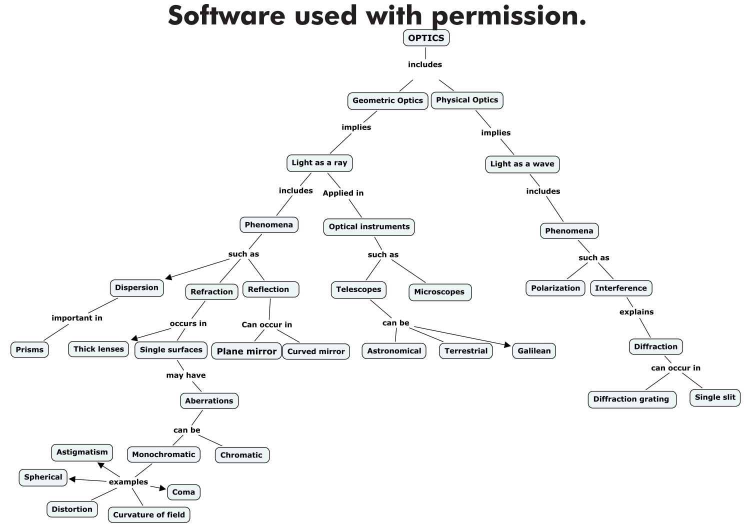
1. Find a focus question or concept. Identify 10-20 concepts that relate to the main concept and place it around the main concept.
2. Arrange the concepts so that the broader ones occupy the top of the map.
3. Continue and add concepts as needed.
4. Connect concepts by line links. Name the links to define the relationship between the two linked concepts.
5. Modify the structure of the map as you add, delete or modify concepts or links and as you gain insights.[20]

The Institute for Human and Machine Cognition, affiliated with the Florida University System, developed specific software for concept mapping, ®IHM-CCMap Tools, a free Web-based program. Students can develop their concept maps, work collaboratively, and share them. The program allows mappers to attach documents, images and Web site links to their maps (http://cmap.ihmc.us).

An excellent and sophisticated group of concept maps was developed by the NASA Ames Research Center. The maps are related to the exploration, geology and climate of Mars.[21] The elements of the maps provide links to documents, photographs, diagrams and films related to the topic at hand.

Figure 3

A concept map related to optics using IHMC ®CMap Tools software. Software used with permission.



These concept maps convey the power of Web-based concept maps to display scientific information.[22]

Although the basic knowledge about the construction of concept maps can be explained in minutes, mastery requires significant practice. Daley et al. described the development of concept mapping proficiency of nursing students, finding significantly better maps at the end of a semester of a clinical course.[23] Rendas, Fonseca and Rosado-Pinto used computer-generated concept maps as a problem-based learning tool for medical students. The main strategy was the presentation of clinical cases along with incomplete mind maps, where students had to provide the missing concepts. They reported better quality maps at the end of their problem-based training.[24]

Evidence for Concept Mapping Effectiveness in Enhancing Learning and Critical Thinking Skills

Vacek considers concept mapping a fundamental tool in developing critical thinking in nursing education.[25] Many (but not all) studies show that concept mapping enhances problem-solving skills or course achievement of students. Esiobu and Soyibo found that Nigerian secondary school students trained in concept mapping and a technique called Veediagramming outperformed students in a conventional environment (lecturing without concept mapping) when tested using multiple-choice achievement tests. The difference was quite robust, five standard deviations (SD).[26] Bascones and Novak reported a study of secondary school physics students in Venezuela where students trained in concept mapping outperformed students without concept mapping training in tests measuring problem-solving skills. In another study, high school physics students in the United States showed significant advantages in achievement tests when using concept mapping throughout a course as opposed to using single-shot concept mapping at the end of the course.[27] However, even students using concept mapping at the end of the course had significantly better achievement than those who did not use concept mapping at all.[28] Similar results were shown in an elementary physical science course by students who were trained in concept mapping.[29] University chemistry students who had significant concept mapping training outperformed control groups in their ability to form concepts and relationships during structured interviews.[30] Zittle found that, for a population of college students, concept mapping is more effective, but only when the learner has to actively construct the maps, rather than examining pre-built one.[31] Chang, Sung and Chen had an opposite conclusion for elementary school children: Students who were required to develop full-fledged maps performed worse than students who were required to correct a map provided by the experimenters.[32] This result suggests that active concept map construction only benefits the learning performance of students who have achieved a significant level of mastery. Coleman found that requiring students to use higher level learning strategies (such as evaluating, comparing and contrasting) enhances their concept mapping advantage even further.[33]

There is also evidence that concept mapping enhances free recall by college students when the material is presented in a concept map versus ordinary text.[34] This is especially true of propositions at the top of the map, i.e., superordinate concepts.[35]

Gonzalez et al. trained a group of medical students in concept mapping. They practiced their skills with the help of a mediator during case presentation sessions. A control group of medical students followed the traditional case discussion sessions. All students took multiple-choice examinations and problem-solving exams (based on clinical scenarios). The students receiving concept mapping training performed significantly better than the traditional students in the problem-based exam but not in the multiple-choice exams. This was particularly true for lower-achieving students.[36] West et al. trained medical residents in concept mapping techniques and immediately after asked them to develop a concept map on the topic of seizures. The residents completed three one-hour education sessions on the same topic and were asked to develop a concept map again. Using their rubric, they found that the second maps had significantly better quality. However, the mapping scores were not significantly correlated to residents' in-training board exams.[37]

On the other hand, a smaller number of studies shows limited or no advantage of concept mapping over other procedures. For example, Schmid and Telaro divided high school Canadian students of low, medium and high academic ability into a treatment group (concept mapping) and a control group (no concept mapping). Students' performance was determined using achievement tests. The post-test also included a test measuring the ability of students to use cross-linking. They found that concept mapping was only significantly better in the low academic ability group and only in the concept-linking test.[38] Spaulding obtained a similar result, mainly that concept mapping only benefitted lower ability science high school students.[39] No advantage of concept mapping over outlining on a high school biology course was found by Lehman, Carter and Kahle.[40] Rewey et al. found that concept mapping improved free-recall performance only in low ability students using a cooperative learning situation.[41]

Like mind mapping, one subsidiary issue is the development of reliable rubrics for the assessment of concept maps. Novak and Gowin proposed the first rubric based on the valid relationships, hierarchy, cross-links and examples.[20] West et al. obtained inter-rater reliabilities ranging from 0.51 to 0.88.[37] Srinivasan et al. reported a study involving internal medicine residents, pediatric residents and fourth-year medical students. They produced concept maps related to diabetes (using 61 concepts) and asthma (using 56 concepts). The authors concluded that good reliability required 4-5 repetitions of the maps. This study is unique due to the high number of concepts used by the participants and that the participants were constrained to use the concepts provided by the experimenters rather than their own.[42]

In general, these studies seem to indicate that concept mapping may enhance learning, recall and problem-solving skills, most especially with students with lower abilities. They also suggest that learners should achieve a significant level of mastery in the construction of concept maps to reap their full benefits. Finally, they indicate that concept maps can be evaluated and graded reliably.

Visual Organizers for Metacognition: Thinking Maps

One of the goals of critical thinking is learners' awareness of their own thinking process (metacognition). One of the most powerful tools for developing metacognition are the ©Thinking Maps, a brainchild of David Hyerle.[43,44]

The method is based on eight map templates that purportedly represent distinct thinking skills: defining, describing, comparing and contrasting, classifying, dividing into parts, sequencing, establishing cause/effect and determining relationships. **(Figure 4)** As generic templates, they can be applied across disciplines and grades.[45] Rubrics for teachers and students have been developed.[44,46] These tools have been implemented in more than 5,000 schools in the United States, New Zealand, England and Singapore.[47] The process can be done as paper and pencil tasks or with the help of specifically designed software (www.thinkingmaps.com).

Figure 4
®Thinking Maps (Thinking Maps, Inc.) are a powerful set of metacognitive visual organizers developed by Dr. David Hyerle. Used with permission.

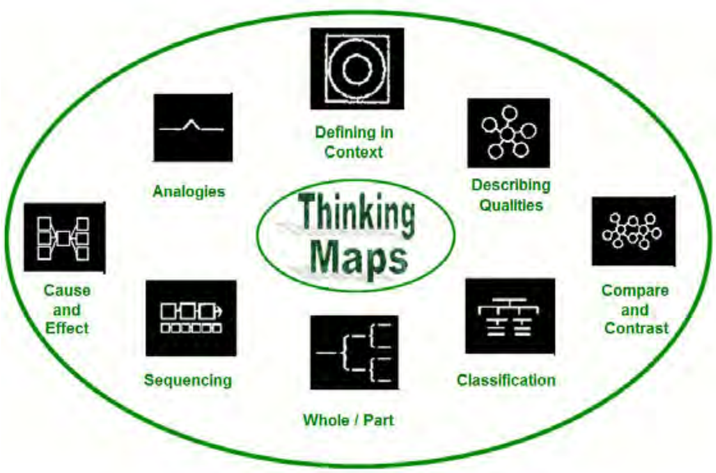


Figure 5
The compare and contrast visual organizer used for the concepts of myopia and hyperopia.

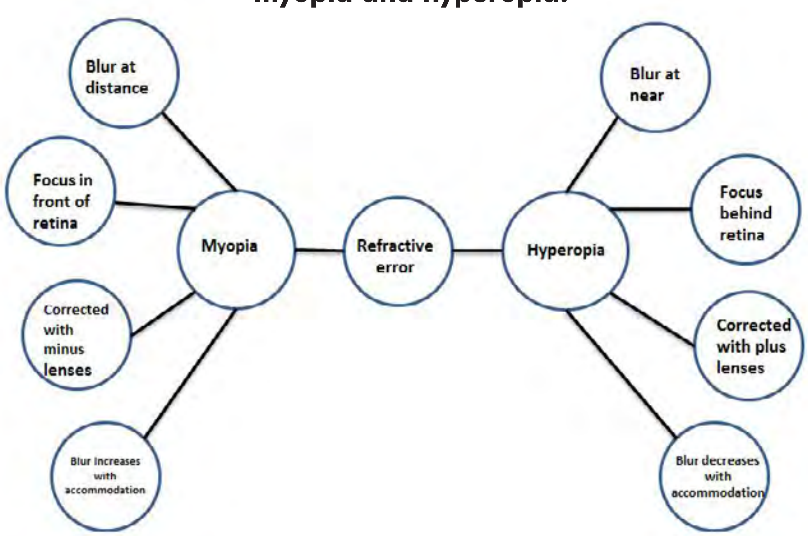


Figure 5 shows an optometric example of a double-bubble map where two refractive errors (myopia and hyperopia) are compared. The central bubble identifies them as concepts related to refractive error (common characteristic). The peripheral bubbles show the unique, contrasting characteristics of each one. The construction of this simple map requires a sound knowledge of the concepts. The details can be modified as the learner gains sophistication.

It is not difficult to imagine other uses of the double-bubble map, such as comparing and contrasting the signs and symptoms of two ocular diseases. Other maps can also be applied to optometric subjects. For example, the multi-flow map can be used to depict the risks (antecedents) and the consequences of a particular disease.

Spiegel indicates that one of the benefits of the practice of thinking maps is that students may become teachers, as they share their maps with their classmates, creating a sense of empowerment.[48]

Evidence for the Effectiveness of Thinking Maps in the Improvement of Learning

The research literature on thinking maps is mostly related to school children in the area of reading and language skills. For example, Blount tested a group of 17 fourth-grade students, all below grade level in reading performance. During the first two weeks they had a typical teaching unit. After finishing a teaching unit, they completed a multiple-choice test. They also wrote an essay related to the unit. During the second two weeks, they had a different teaching unit. Students were familiarized with the flow, bubble and double bubble maps. They were requested to apply these maps to the material taught in the teaching unit. At the end, like in the previous unit, they completed a multiple-choice exam and wrote an essay related to the new teaching unit. There were increases in the performance on the second test as compared to the first test in main ideas, details, sequencing and inferences.[49] Unfortunately no statistical tests were conducted to verify if the differences were significant. Manning describes the experience of a school for learning-disabled children in Massachusetts. The thinking map tools were applied in all school subjects and all grades in this school. Students were required to take the Massachusetts Comprehensive Assessment System Retest, which includes Language Arts and Mathematics. Within a year, the passing rates in English Language Arts increased from 17.3% before introduction of the thinking mapping tools to 68.3% after their introduction. Mathematics passing scores increased from 11.5% to 45.6% during the same period.[45]

Worsham and Austin conducted a study with 139 high school students with low Scholastic Aptitude Test (SAT) verbal scores. The control group (52 students) received no mapping training while the experimental group (87 students) spent 20% of their English class developing their mapping skills. The experimental group had significantly higher achievement in all verbal measures of the SAT (vocabulary, reading comprehension and total score).[50]

Ball conducted a study on the effects of the use of thinking maps visual tools on performance in a standardized reading test. The subjects were college students taking a reading course. All groups received training in thinking skills such as descriptors, contrasting, comparisons, analogies, cause/effect and classification. The experimental group also received training in the use and application of the visual mapping tools while the control groups did not receive this second training. All students were tested with the Stanford Diagnostic Reading Test Form G at the beginning of the course and with the Form H at the end of the course. This test provides data on reading comprehension, vocabulary, fast reading, phonetic analysis, structural analysis, word parts and skimming/ scanning performance. The experimental group (using the maps) had significantly better performance than the control group (no map use). Further analysis revealed better performance in all areas except phonics and scanning.[51]

A study in England in a school system using these visual tools found that 77% of teachers and 62% of students agree or strongly agree that these tools help students learn. Sixty-six percent of teachers and students agree or strongly agree that the tools are easy to use. Interestingly, administrators had lower opinions of their effectiveness in facilitating learning (58%) or ease of use (42%).[52]

In general, the literature indicates that these tools are effective, particularly with students having lower achievement. They help organize the learners' thinking, providing a platform for better comprehension. Most importantly, learners enhance their own appreciation of their thinking processes (metacognition).

Facilitating Judgments: Argument Mapping

Argument mapping is a graphical representation of a contention where arguments can be explicitly presented for and against the contention. Argument mapping is especially useful in the discussion of complex and sometimes controversial issues such as those presented in an ethics course.

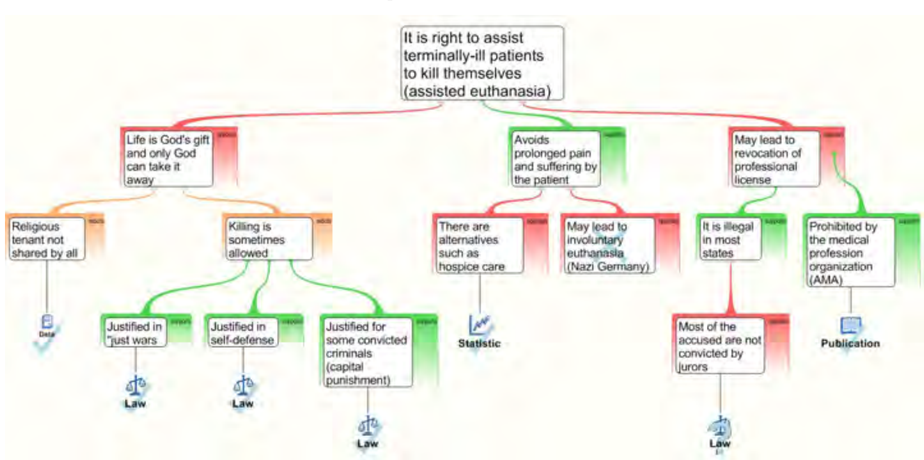
An argument map starts with a contention. The rest of the argument map strives to answer why the contention should be accepted or rejected. A reason is a statement supporting a contention. An objection refutes a contention, a reason or another objection (rebuttal). The evidence basis for the reasons and objections can be added to the argument map. Evidence basis may be data from experiments, publications, a known statistic, personal experience, the law, expert opinions and examples among others. Finally, the reasons, objections and evidence basis should be evaluated (accepted, rejected or in some difficult cases undecided). At the end, the evaluator must decide, if in light of all the evidence, the primary contention should be accepted, rejected or left unresolved until better evidence is obtained.[53]

As an example, **Figure 6** depicts an argument map on the ethics of assisted euthanasia using ©Rationale software. This contention was considered to be the most important ethical issue during the second half of the 20th century.[54] Reasons based on religious values, compassion, professionalism and the laws are presented on the argument map. As the map is developed, the student must research questions such as:

- What do religions have to say about assisted euthanasia?
- What does the professional organization (American Medical Association) consider ethical?
- Is assisted euthanasia legal?
- What are the personal and professional consequences of assisted euthanasia?
- Are there reasonable alternatives to assisted euthanasia?

These questions require that students conduct a thorough search on the historical context of the issue, the impact of religious beliefs, the professional stand of the medical profession, the ap-

Figure 6
Argument map regarding assisted euthanasia developed in an ethics course with ®Rationale software. Software used with permission.



plicable federal and state laws, the availability of alternatives such as hospice care, and current outcomes in states that allow assisted euthanasia among others.

Weinstein proposed a useful model for resolving ethical dilemmas.[55] The four steps of his model are:

1. Obtain the objective facts about the situation.
2. Identify the values (personal and societal) involved in the situation.
3. Describe the options to the dilemma.
4. Based on the values, make a judgment of the best option.

In this model, the best option is the one that satisfies the most important values. The method can be best applied using an argument map.

Halpern has described a set of skills necessary for the construction of argument maps:[56]

1. identification of the premises (reasons), counter arguments and conclusion
2. developing strong arguments that show good thinking and communication skills
3. judging the credibility of the information, including knowing the source of the information and its validity
4. understanding the difference among opinions, reasoned judgments and facts.

Kee and Bickle provide an example of argument mapping applied to epidemiology.[57] While argument mapping is best suited for issues related to the issue of validity or truthfulness of a contention, clinical decision-making is best assisted through similar methods, such as hypotheses mapping or analysis of competing hypotheses.[58,59]

Argument mapping and decision-making can be facilitated by the use of software. ©Rationale is a commercial product that provides useful tutoring support for students and educational guidelines for educators (http://rationale.austhink.com/). Compendium is a free argument mapping tool useful for group deliberations (http://compendium.open.ac.uk/institute/). There are also online collaborative argument tools for debate such as TruthMapping (www.truthmapping.com).

Evidence of Argument Mapping to Improve Recall and Critical Thinking Skills

Dwyer et al. have argued that argument maps decrease the cognitive burden by combining the text (reading) and structure of the argument. They hypothesized that argument mapping would significantly increase comprehension and memorization of an argument compared to a pure text reading. In an experiment, they presented written (text only) arguments compared to arguments maps to groups of university students. Students' reasoning ability was initially assessed with the Differential Aptitude Test. Six experimental groups were tested using a multifactorial design with two levels of complexity (arguments with 30 propositions and 50 propositions) and three conditions (text only, black-and-white maps, and color maps). Subjects were tested for comprehension by being asked whether a subset of the propositions supported or denied the main argument claim. Each subject also received a fill-in-blank memory test.

The results indicated that there was no difference in the comprehension level across all experimental groups. However memory performance was better for the smaller (30 proposition) complexity in the text-only, black-and-white map and the color map conditions. Also, both the black-and-white and color map conditions were superior to the text-only condition. No difference was found between the black-and-white and the color map condition. In short, argument maps produced better recall than text-only arguments. Subjects in this experiment were only allowed a 10-minute presentation of the maps. It is possible that longer presentations by subjects experienced in argument mapping techniques may lead to better comprehension.[60]

Butchart et al. used computer-assisted mapping software in a 12-week undergraduate course. The course included a one-hour lecture and a two-hour tutorial session per week. Participating students took one version of the California Critical Thinking Skills Test at the beginning of the course and a second version at the end of the course. The test itself has 34 items for testing the student's skill in analyzing, evaluating, drawing inferences, deducting and using inductive arguments. The difference between the post-test and the pre-test was an indication of the critical thinking skills gains. Results showed that students had the equivalent of 0.45 SD improvement in these skills.This result compared favorably with gains of 0.19 SD with a standard course (without the use of the mapping software).[61]

Van Gelder et al. used an argument mapping software in a one-semester undergraduate critical thinking course. They hypothesized that students would have significant gains in their critical thinking scores as measured by the California Critical Thinking Skills Test (CCTST). They also hypothesized that the gains would be significantly correlated to deliberate practice measured objectively and subjectively. For example, one objective measure of deliberate practice was the actual (measured) number of hours using the software. An example of a subjective measure would be a self-reported estimate of number of completed practice exercises. The results showed a gain of 0.8 SD in critical thinking skills as determined by the difference between the pre-training and post-training scores on the CCTST. The gain of 0.8 SD through the one-semester software-assisted course was equal or better than the gain achieved by students after three years of college undergraduate education. The gains were significantly correlated to the actual number of hours spent using the software and the number of activities related to the use of the software. The correlations were moderate (0.31 and 0.27 respectively). Gains were also significantly correlated with the self-reported amount of effort spent on the subject (0.19).[62]

Guzetti et al. performed a meta-analysis of experimental studies and found that student argumentation had the greatest effect on correcting misconceptions, a 0.80 SD effect compared to student discussion, 0.51 SD, or simple activation of prior knowledge, 0.08 SD.[63]

Alvarez-Ortiz completed a meta-analysis of the impact of philosophy, critical thinking education and argument mapping on performance on critical thinking tests. Students in the control groups had a gain of 0.12 SD within a semester without any specific training. In comparison, philosophy students without argument mapping training had a gain of 0.26 SD while philosophy students with significant argument mapping training had a gain of 0.78 SD.[64]

In conclusion, argument mapping increases critical thinking skills and argument recall when compared with standard procedures.

Seeking Inter-Relationships: General Systems Thinking

The most powerful of all visual mapping tools derives from general systems thinking. General systems thinking was promoted by Peter Senge as one of the characteristics of the effective learning organization.[65] It hypothesizes that in most situations we are aware of single events, the tip of the iceberg, which are occurrences manifesting deeper realities. As we study the sequence of events in time, we discover patterns of behavior just under the surface. These patterns reflect the hidden structure of the system: the beliefs, mental models and culture of the organization.[66] Effective problem-solving requires that we dig below the surface (events) and discover the structure that perpetuates the patterns of behavior and the events we discern from the outside. **(Figure 7)**

While cause/effect analysis is usually linear and unidirectional, systems thinking analysis is based on feedback loops. In **Figure 8**, stress leads to consumption of beer, the plus sign signifying that an increase in the level of stress increases consumption of beer. (Also a decrease in the level of stress decreases consumption of beer.) This is a typical unidirectional relation that does not portray the whole story. However, consumption of beer itself produces changes in the levels of stress. The minus sign implies that increasing levels of beer consumption leads to decreases in the level of stress. This is also a unidirectional relationship. A feedback loop, as shown, portrays the whole relationship more accurately.

Feedback loops can be reinforcing, where there is continuous growth or decline in a variable. Feedback loops can also be balancing (like the one in Figure 8) where an explicit or implicit goal (level of stress) is maintained. Some effects may take significant time to be seen, and this is depicted by a delay in the feedback loop.

System thinkers have found that many situations can be explained through generic templates called, appropriately, "system archetypes." These archetypes are a combination of feedback loops that can be applied across many fields, such as economics, psychology, science and sociology. As an example, **Figure 9** (left) depicts the "shifting the burden" archetype. A symptom creates a need for a short-term, symptomatic solution.

Figure 7

Systems Thinking allows recognition of the patterns below unique events. It also promotes the examination of the mental models, beliefs and culture that support the systems behavior.

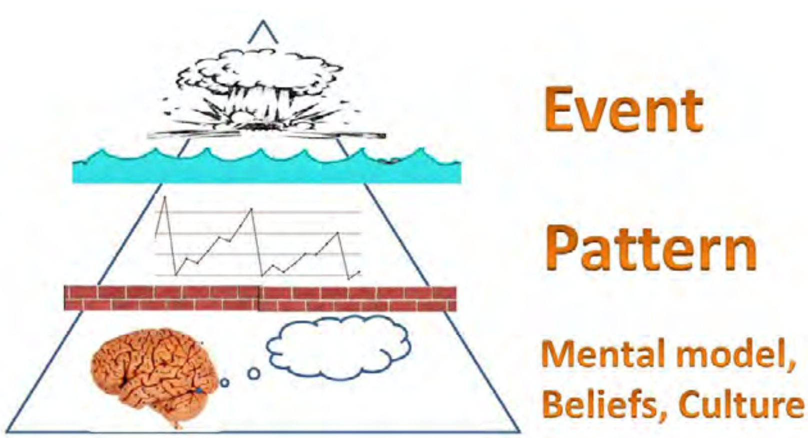
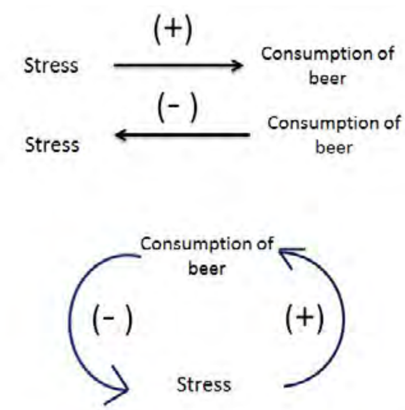


Figure 8

Top: Two typical unidirectional relationships. Stress level affects consumption of beer, while consumption of beer affects stress levels. Bottom: A feedback loop is a more accurate representation of the inter-relationship.



A better, fundamental solution is available, but this solution requires more effort and time (delay). In the meantime, reliance on the symptomatic solution has unintended and undesirable effects. Consider the following two scenarios as applications of this archetype.

Scenario 1 (Figure 9, middle)

Paul is a freshman optometry student. He is having serious difficulties keeping up with his classes and his grades are poor. As he ponders his future, he is very tense and stressed-out. He knows that he can have counseling and tutorial help through the Office of Student Affairs. However, he believes that this would detract from his study time and his busy schedule. On weekends, he can relax and enjoy drinking beer with his friends. He discovers that drinking beer on weekdays helps him to cope with the stress. His drinking habit increases every week. Soon, his grades plummet and he fails the semester. Paul's symptoms (stress) led him to a symptomatic solution (drinking). This led to a temporary reduction of his symptoms. A more effective solution was available through counseling and tutoring (fundamental solution), but this solution would take more time to achieve (delay). Unfortunately, the symptomatic solution (drinking) led to alcohol addiction (unintended consequences) which decreased the perceived need for the fundamental solution.

Scenario 2: (Figure 9, right)

Dr. Rogers has a healthy optometric practice and the number of examinations has been steadily increasing during the past few years. However, the number of patients buying optical devices (eyeglasses and contact lenses) from her optical dispensary has been slowly but steadily decreasing. Dr. Rogers may hire another optician and send the current dispensing technician for additional training. However, this would take significant investment and time. She decides to hire an advertising agency and spend money on a campaign with an emphasis on her dispensing services. Initially she sees an increase in the number of sales in the dispensary, but after a few months the sales drop to old levels. She decides to invest additional funds on a stronger marketing campaign. Again, sales increase for several weeks, and then drop again. In this second scenario, the problem was the drop of sales at the dispensary. The symptomatic solution was the hiring of an agency to launch an advertising campaign. The fundamental solution was to increase the quality of services at the dispensary by hiring additional staff and training her current staff. However, this solution would take more time to take effect (delay). The advertising campaign worked temporarily creating the perception that there was no need to apply the fundamental solution. It led to a dependence on an intervenor (outside advertising agency) and erosion in the capacity of her staff to resolve the problem.

In both scenarios, the best strategy would have been the application of the fundamental solution. If the symptomatic solution is ever applied, it should be used only once or for a very short time. The power of systems thinking is the explanatory ability of the archetype, allowing exploration of the variables and feedback loops in the systems. It gives useful insights into optimal ways to apply leverage so that the problems at stake are resolved satisfactorily.[65]

Other examples of archetypes:

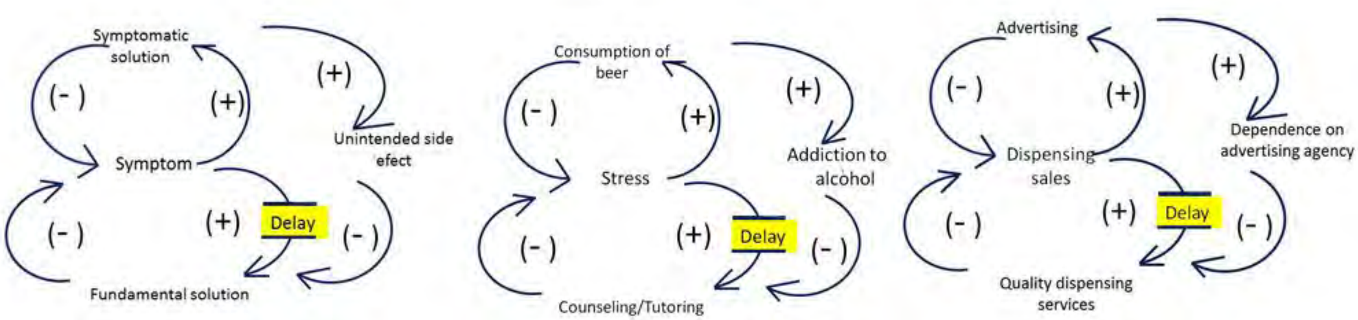
- **Limits to growth (limits to success):** A process starts with a period of increasing growth. After some time, the growth slows down or reverses due to a limiting condition.
- **Success to the successful:** Two processes or activities compete for finite resources. The more successful process gains an increasingly bigger share of the resources and eventually obliterates the weaker one.
- **Tragedy of the commons:** Units within an organization share common finite resources or assets. The more they use these assets, the bigger the rewards as they develop more activities. Soon, the return on the use of resources decreases, forcing them to request additional resources. Eventually, the resources diminish dramatically or are exhausted.
- **Eroding goals:** A version of a shifting the burden archetype, where a fundamental goal of an institution is sacrificed in order to fulfill a short-term gain.

Simulation Models: System Dynamics

System dynamics applies general systems thinking via mathematical simulation models. These models allow the exploration of different scenarios based on the changes of the variables of the model. This allows students to design experiments and answer specific questions on their model: "The move from a static model in an inert medium, like a drawing, to dynamic models in interactive media that provide visualization and analytic tools is profoundly changing the nature of inquiry… Students can visualize alternative interpretations as they build models… in ways that introduce different perspectives on the problems. These changes affect the kinds of phenomena that can be considered and the nature of argumentation and acceptable evidence."[8]

System dynamics uses three basic graphical units: stocks, flows and converters.[67] Stocks are the nouns of system dynamics and are symbolized by a rectangle. They represent variables that accumulate through time. Examples are number of patients, clinic income, knowledge, population and gasoline in car tank. Flows are the verbs of system dynamics and they are symbolized by a pipe, flow regulator and a spigot. The direction of the actual flow is shown by an arrow at the end of the pipe. Typically, a flow can move toward a stock, increasing its accumulation, or move away from a stock, decreasing its accumulation. Examples are births, deaths, patients to clinic, patients leaving, expenses and hiring. Converters are the adverbs of the system and are symbolized by a circle. They represent variables

Figure 9
The "shifting the burden" archetype (left) and two examples of its application in psychology (center) and optometric practice management (right).



that do not accumulate through time. Examples are birth rate, dispensing rate, new patients per year and consumption per capita.

Consider the following example, close to the colleges and schools of optometry. One of the main challenges of optometric institutions is to maximize the income of their clinics while maintaining the breadth and quality of the education. This helps maintain tuition costs as low as possible. A systems model allow us to critically examine the variables that impact clinic income and experiment with scenarios as the values of the variables change through time. These "experiments" allow us to determine the best strategies for maximizing income. **(Figure 10)**

The model of Figure 10, using iseesystems inc.'s ©Stella Software (available at www.iseesystems.com), depicts two main stocks: clinic income and number of patients. As shown at the bottom of the model, the "number of patients" at the clinic increases by the flow "patients to clinic" and decreases by the flow "patients leaving." The flow "patients to clinic" depends on two converters: new patients per year and thereturn patient fraction (the fraction of all patients at the clinic who return for an examination within a year). As the model shows, because the income of the clinic is directly affected by the number of patients seen at the clinic, the "number of patients" stock at the bottom feeds into the "producing income" flow that increases the "clinic income"stock. The income flow is affected by the "exam income per patient" (cost of the eye exam per patient), the "dispensing rate" (fraction of patients who acquire eyeglasses, contact lenses, low vision devices and other optical devices) and the "dispensing income per patient"(gross income from the sales of optical devices). This last variable depends on the "dispensing mark-up" (a number indicating the multiplying factor for the cost of optical devices to the patient) and the "dispensing cost per patient." On the other hand, the "clinic expenses" flow is affected by the "cost of utilities," "staff salaries," "faculty salaries," "dispensing cost," and "interest expense" (assuming the institution is paying off a loan for the facility). In the depicted model, "faculty salaries" are affected by the mixture of "faculty days for third year" and "faculty days for fourth year." This is a fairly complex model that incorporates many of the main variables that affect clinic income. The model can be adjusted to add or delete variables or represent them in alternative ways.

The model allows us to experiment with changes in the values of the input variables and determine how they affect stocks such as clinic income and number of patients through time. The first set of inputs is the initial values of the stocks (clinic income and number of patients). The second set of inputs representsthe values of the converters. The values of the converters can be set through sliders **(Figure 11)**. The values on the sliders can be changed into a virtually infinite number of positions within a range.

Figure 10
System dynamics model of a college optometry clinic developed with ©Stella Software. Used with permission.

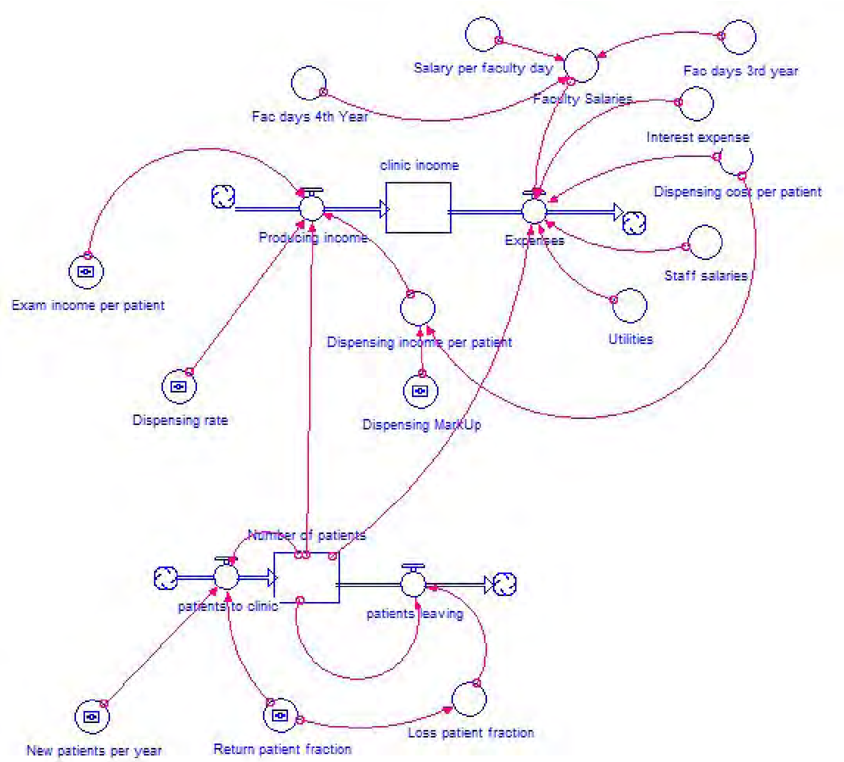


Figure 11
Sliders allow a continuous variation of the system parameters within limits for a college optometric clinic. Simulation allows us to determine which combination of parameters maximizes a critical variable such as clinic income. Diagrams developed with ©Stella software. Used with permission.

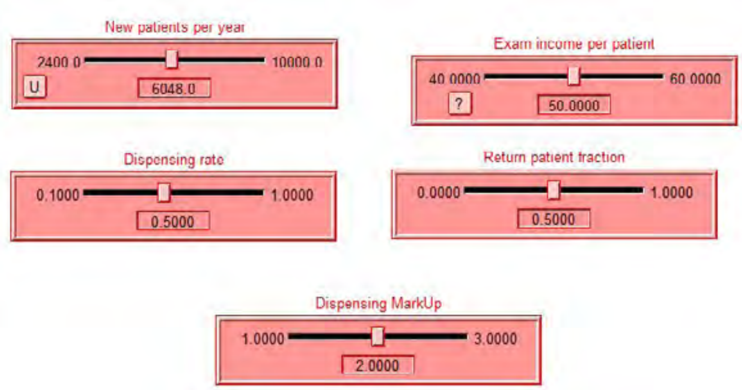


Figure 12 shows the effects of changing dispensing rate from 0.3 to 0.6 on clinic income during the first 25 years of operation. The values of the other converters are maintained constant. For example, exam fee at $50, new patients per year at 6,000, return patient fraction at 0.5, and dispensing markup (multiplying factor of sale vs. cost of dispensed devices) at 2.0. The graph shows that a dispensing rate of 0.3 (30% of patients acquiring optical devices at the clinic) will lead to increasing losses throughout the years (if everything else remains equal). A dispensing rate of 0.6 will lead to a net cumulative gain at the beginning of the seventh year. Strategically, one can increase the dispensing rate by training the dispensing staff, providing better frame and lens options to patients and counseling of patients by the optometrist. Besides the graphs, the program can produce detailed tables by year of operation.

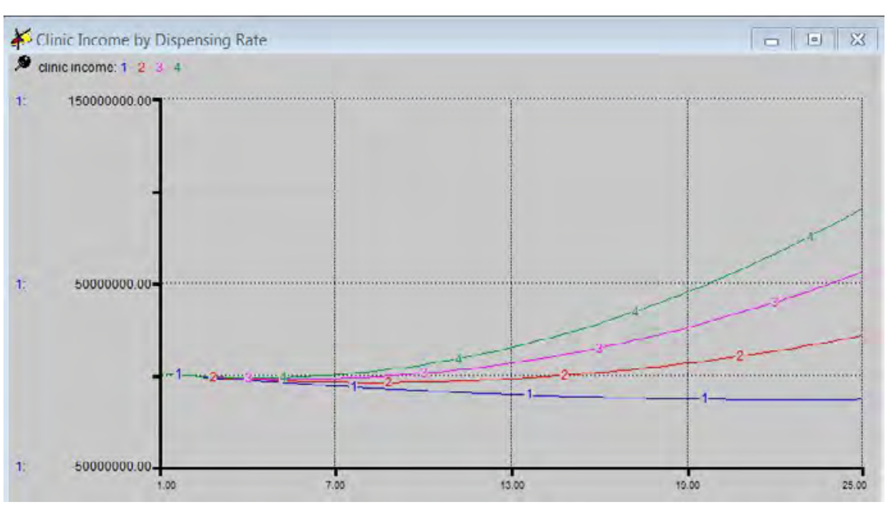
The above exercises brought into practice management would allow students to make rational decisions about strategies to increase their practice success. It is a high level, sophisticated environment that may be used to simulate their own future practices.

System dynamics is not limited to business modeling. It can also be applied to simple and complex modeling of scientific and social issues. For example, it can be used to model the dynamics of glucose regulation in physiology, population dynamics, predator-prey systems, impact of policies on drug trafficking, and epidemiology, among others.[67]

Evidence of Improvement of Decision-Making Skills through Systems Thinking and System Dynamics

There are studies that indicate that systems thinking may enhance decision-making abilities, especially those related to complex situations. For example, Dhawan, O'Connor and Borman completed a study on 26 business school graduate students to determine if systems thinking and system dynamics training could improve the quality of their analysis of a business scenario. The scenario involved an information technology company with revenue oscillations through time. They completed a pre-test and a post-test after 10 hours of systems thinking training. A second post-test was completed after an additional period of 13 hours of system dynamics training (computer simulation). The tests were designed to ascertain their ability to identify stocks and flows, propose a cause for the oscillations, suggest solutions and predict the workforce of the company. The first two tasks are of low or medium complexity, while the last two tasks have high complexity. The researchers found that systems thinking training improved performance in the first two tasks but not the last two. System dynamics (computer simulation) training improved the ability of participants in the last two, high-complexity, tasks. The results suggest that full-fledged benefits are obtained through training on both systems thinking and system dynamics (computer simulation).[68]

Figure 12
Clinic income by year of operation for four dispensing rates: Curve 1= 0.3, Curve 2 = 0.4, Curve 3 = 0.5 and Curve 4 = 0.6. Graphs developed with ©Stella Software. Used with permission.



Maani and Maharaj were interested in the variables related to decision-making performance and the sequence of systems thinking that would lead to better performance. Ten business school graduate students, versed in system thinking and system dynamics, participated in a computer simulation model of a company. Their objective was to maximize revenues, profits and market share by manipulating variables such as total workforce and spending on marketing. The results showed that better performers had higher levels of understanding as shown by their models.[69]

Plate completed two studies assessing the effectiveness of systems thinking in the ability of students to develop causal maps. The first study included 23 undergraduate college students on a topic within a political science course. Post-test maps (at the end of the course) were compared to pre-test maps (at the beginning of the course). At the end of the course the maps had more concepts, more link densities, more complex causal loops and were more similar to expert maps. A second study compared middle school children trained in systems thinking to children without such training. The group trained in systems thinking had maps with higher link densities, more complex causal loops and that were more similar to expert maps.[70]

LaVigne completed a meta-analysis of studies relating systems thinking and dynamic modeling to students' learning. She reported trends indicating that this training enhances the connections between curriculum and real-life experiences, clearer exploration of thoughts and mental models, and increased motivation and engagement.[71]

Systems thinking and system dynamics are promising tools in optometric education. System dynamics is the most sophisticated tool in our armamentarium. Several companies offer commercially available software for dynamic modeling, training and specialized books:

- Isee Systems (http://www.iseesystems.com)
- Ventana Systems: (http://www.vensim.com)
- Pegasus Communications(http://www.pegasuscom.com)
- The Waters Foundation, which promotes systems thinking education in schools, offers via its Web site free modeling tutorial lessons as well as detailed lesson plans that can be adapted to college-level courses(www.watersfoundation.org).

Conclusion

The evidence indicates that visual tools may help our students develop better recall, comprehension and critical thinking skills. It is important that the tools be used mindfully and judiciously. Mind mapping is most useful during brainstorming, note-taking and developing clinical scenarios. Concept mapping's strength lies in forcing us to organize knowledge hierarchically. Thinking maps are powerful templates allowing the learner to develop metacognitive skills. Argument mapping is a critical thinking tool to formalize premises, counterarguments and conclusions. Systems thinking provides the ability to observe the deep structure of systems, transcend the simplistic linear cause/effect relationships and apply the language of archetypes across different disciplines. System dynamics allows us to simulate the behavior of systems and determine the effects of changes in critical variables.

Davies proposed a convergence of mapping technologies where students incorporate concept maps, mind maps and argument maps. The concept maps will be the core maps where students are able to depict their present knowledge structure. Some concepts will be linked to mind maps elaborating their associative structure. Other concepts may be tied to argument maps as needed.[6]

One of the main objectives of this paper is to promote educational research activities of optometric educators as they apply these tools in their courses. In the meantime, the available evidence supports the implementation of certain activities: [7,9,11,20,46,47]

1. Construct a concept map or mind map of your entire course and present it to your students on the first day of class. The map will be an expert, holistic representation of the knowledge structure related to your course. It will serve as an anchor throughout the quarter or semester. You may refer back to the map as you develop your topic. It will be a helpful tool as students conduct a systematic review when studying for your examinations or the optometry boards.
2. Train students in the use of mind mapping and concept mapping techniques. Initially, they may use them for note-taking during their own readings. Once proficiency is established, they can be used for note-taking during lectures.
3. Ask students to develop a concept map of their knowledge about your lesson topic before the beginning and at the end of your lesson. The beginning map will allow them to explore their own knowledge base before the lesson. The final map will allow them to explore the expanded knowledge base and how it fits into their cognitive knowledge structure. You may want to periodically review some of your student maps for accuracy and understanding.
4. Ask students to use ©Thinking Maps tools around specific course topics. For example, they may use the classification organizer to represent anterior and posterior segment diseases. The sequencing tool may be used to depict the stages of certain ophthalmic diseases such as diabetic retinopathy. The cause/effect tool may be employed to represent the risk factors and effects of diseases such as glaucoma.
5. Ask students to develop case presentations using mind mapping or concept mapping. They can use free collaborative mapping software such as ®IHCMapTools and post their maps on the Internet. Documents, drawings and Web site links can be attached to their maps.
6. Request that students develop argument maps related to professional ethical dilemmas or policy issues in public health.
7. Consider using system dynamics models for practice management. Students can develop a systems model of their own future practices and simulate scenarios to find out which strategies are more likely to maximize their success.

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Differentiating the Elements of Clinical Thinking

Caroline Faucher, OD, PhD

Abstract

Clinical judgment, clinical reasoning, clinical thinking, critical thinking and decision-making are often used concurrently or interchangeably in the literature, which can lead to confusion. This article is a succinct review, by no means an exhaustive one, of these various concepts related to clinical practice in the health professions in order to distinguish them from each other. Moreover, the need for research on these subjects for optometry is highlighted so that schools and colleges of optometry can adapt their teaching and assessment methods to the specific context of the optometric profession.

Key Words: *clinical judgment, clinical reasoning, clinical thinking, critical thinking, decision-making, optometric education*

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Introduction

Critical thinking related to clinical reasoning and decision-making in patient care is taking center stage in optometric education. However, many of those terms and others related to clinical practice are similar and interrelated. This may be confusing when it comes to understanding clinical practice, and especially to making it explicit to optometry students.

The objectives of this article are 1) to define different terms related to clinical practice in order to clarify them and distinguish between them; and 2) to underline the need for further research on these topics specifically for the optometric profession.

Untangle Concepts Related to Clinical Practice

Many terms are often used interchangeably to describe the processes necessary to resolve complex clinical problems and make the appropriate clinical decisions in the practice of health professions: decision-making, critical thinking, clinical thinking, clinical reasoning, clinical judgment, diagnostic reasoning, diagnostic thinking, etc. The use of these terms concurrently or interchangeably without defining them may lead to confusion. In order to clarify educational curricula, thereby orienting teaching, learning and assessment towards appropriate educational objectives, the concepts need to be distinguished from one another. In addition, the final goal of the optometric encounter must be kept in mind.

Patients consult their optometrist for several reasons. They seek his or her advice to resolve symptoms or to be reassured, and they want to return to a sense of well-being. Patient encounters are often described as problems to be solved with the diagnoses and treatment considered the solutions. However, as Fuks, Boudreau and Cassel[1] stipulate, "Diagnosis is neither the goal, nor the end point, of the clinical encounter." Considering this, diagnostic reasoning and diagnostic thinking may not be terms that are representative enough of the health professional's activity. They seem to address only the processes related to the diagnosis.

Decision-Making vs. Clinical Reasoning

The medical literature mostly uses the terms decision-making or clinical reasoning, the latter being increasingly frequent in recent decades. Originally issued from research on the psychology of decision-making, decision theory is a model of idealized rationality,[2] a prescriptive approach telling doctors how they should make decisions based on statistical decision theory, rather than a description of how people actually make judgments and choices. Today, decision-making is mainly used to describe choices between different alternatives, either to decide what procedures to do, to make a diagnosis or to decide what treatments to prescribe.[3] Decision-making is regularly used as a synonym of clinical reasoning even though the concepts differ from each other.

Clinical reasoning focuses on the cognitive processes involved not only in the decisions to make in clinical context, but also in all the problem-solving "demarche" leading to the understanding of the whole clinical situation. Problem-solving involves the identification of the patient problems and of data required to resolve them and make a diagnosis.[3] Problem-solving and decision-making are clearly interdependent: Problems must be solved in order to make decisions, while decision-making is required all along the problem-solving process.

Therefore, clinical reasoning implies both solving problems and making decisions. It is defined as the thinking and decision-making processes associated with clinical practice[4] and the cognitive processes that are necessary to evaluate and manage a patient's clinical problem.[5] There are various interpretations and representations of clinical reasoning, depending on the disciplines, the models of practices and the research paradigm in which it is investigated. Clinical reasoning is often categorized as analytical or nonanalytical. Hypothetico-deductive reasoning, relying on hypothesis formulation and testing,[6,7] is a widely accepted conception of analytical clinical reasoning. Depending on the patient's history, physical appearance and the results of clinical examination, the clinician formulates one or more diagnostic hypotheses that are subsequently validated or eliminated. On the contrary, nonanalytical reasoning relies on rapid, automatic and often unconscious recognition of characteristic features, based on a wide background of well-organized clinical knowledge. Pattern recognition is a well-known form of nonanalytical clinical reasoning. A simple example of pattern recognition is a patient presenting with a subconjunctival hemorrhage, a condition that is usually automatically recognized without additional data acquisition. Analytical and nonanalytical modes of clinical reasoning are usually combined in clinical practice.[8-10] For instance, recognition of a condition by the means of nonanalytical reasoning will often trigger an analytical process of hypothesis testing after more information gathering.[11-13] This is the case when, for example, a patient comes to the office wearing glasses and the eye through the right ophthalmic lens looks smaller, while the left eye looks bigger. By the means of nonanalytical reasoning, an optometrist will rapidly recognize antimetropia or anisometropia.

Along with this diagnosis, other hypotheses will be triggered: Does this patient have diplopia when reading? Does he suffer from aniseikonia? Does he have binocular vision troubles? These hypotheses will have to be tested with more data acquisition. Some of them will be rejected while others will be part of the final diagnosis. This corresponds to analytical reasoning. Thus, optometrists gradually construct a mental representation of the clinical case to be resolved, that is, in essence, an understanding of the patient's condition and of the patient as a whole.[14] This representation evolves and is refined progressively from the first contact with the patient until the end of the encounter. Following Faucher,[14] the management plan would also be elaborated throughout the examination. This makes sense because most optometrists would probably agree that they often have an idea of what kind of treatment will be prescribed early on in the examination, rather than wait until the end of the examination to be formulated.

Finally, knowledge and other resources are capital to clinical reasoning. In medicine, research has shown that knowledge acquisition and clinical reasoning development go hand in hand.[15] That makes clinical reasoning harder for first- and second-year students to learn because their knowledge is mostly limited to theoretical biological, medical and optics concepts. As they are involved in real clinical scenarios, students integrate theoretical knowledge into clinical knowledge.

Critical Thinking

What about critical thinking? It is important to clarify this concept and to distinguish it from others since the Association of Schools and Colleges of Optometry (ASCO) has included it in its report on attributes of students graduating from schools and colleges of optometry.[16] This report states that, to be professional and ethical, new optometrists must demonstrate personal attributes that include "problem-solving and critical thinking skills that integrate current knowledge, scientific advances, and the human/social dimensions of patient care to assure the highest quality of care for each patient." New optometrists should also be skilled in demonstrating "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 plans."[16]

A general definition of critical thinking is "the process of analyzing and assessing thinking with a view to improving it."[17] Although critical thinking has been largely investigated in many health sciences and particularly in nursing, there is still no consensus on its definition, teaching or learning strategies.[18] Behar-Horenstein, Schneider-Mitchell and Graff[19] recently provided a comprehensive review of critical thinking. They reported that it is "regarded as intellectually engaged, skillful, and responsible thinking that facilitates good judgment because it requires the application of assumptions, knowledge, and competence and the ability to challenge one's own thinking." Moreover, critical thinking requires self-monitoring and active argumentation, initiative, reasoning, envisioning and analyzing complex alternatives, as well as making contingency-related value judgments.[20]

Critical thinking involves some skills and attitudes necessary for the development of clinical reasoning.[21] Therefore, critical thinking can be viewed as a complement or a facilitating factor to the clinical reasoning process.

Clinical Judgment

Clinical judgment or professional judgment involves deliberate and conscious decision-making, with a particular emphasis on higher-level awareness, discrimination and evaluation in the face of complexity of professional practice. It refers to the ways in which health professionals interpret patients' problems and issues and demonstrate saliency and concern in responding to these matters.[22] Clinical judgment develops through practice, experience, knowledge and critical analysis.[23] Finally, Fish and de Cossart[24] distinguish between the professional judgment corresponding to the end product of the whole process of clinical thinking, and what they call a "personal professional judgment," that is, an ability to weigh competing elements, ideas and actions and to adjudicate between conflicting but equal priorities.

Clinical judgment is facilitated by critical thinking.[19] It also differs from clinical reasoning, but is intimately related to it. In fact, judgment is part of the clinical reasoning process and is also necessary to reflect on the product of clinical reasoning, that is, the decisions made in clinical practice.[25]

Figure 1
An Integrative Model Of Clinical Thinking

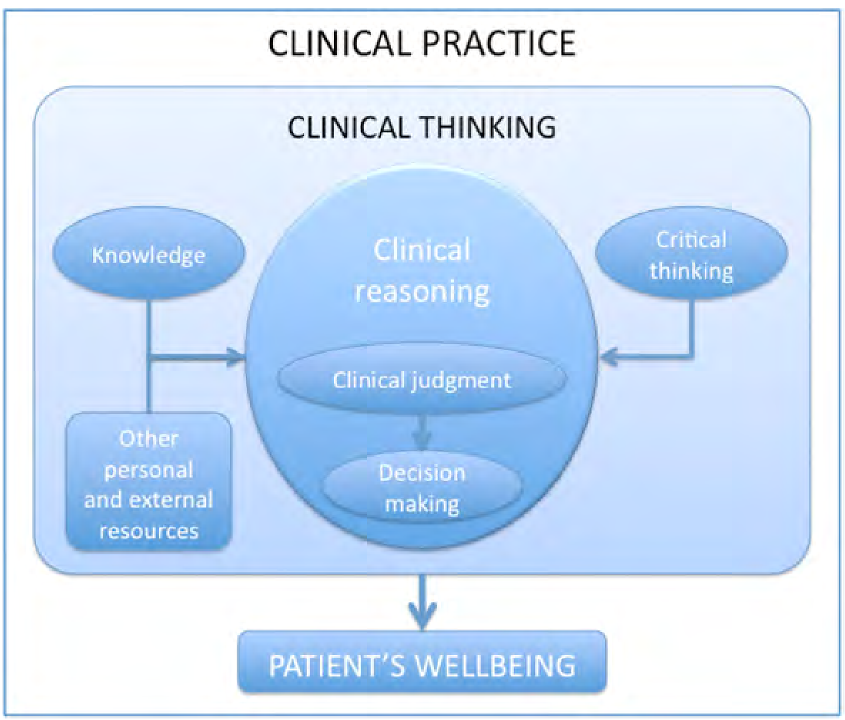

Table 1
Most Common Definitions of Terms Related to Clinical Thinking

Decision -making	Making choices between alternatives in order to decide what procedures to do, to make a diagnosis or to decide what treatments to prescribe.
Clinical reasoning	Thinking and decision-making processes associated with clinical practice. Cognitive processes required to evaluate and to manage a clinical problem.
Critical thinking	Analyzing and assessing thinking with a view to improving it. Intellectually engaged, skillful and responsible thinking that facilitates good judgment. Requires the ability to challenge one's own thinking.
Clinical judgment	Ability to weigh competing elements, ideas and actions and to adjudicate between conflicting but equal priorities. Involves a particular emphasis on higher-level awareness, discrimination and evaluation in the face of complexity of professional practice.
Clinical thinking	Cognitive processes of a health professional in the course of his or her work (larger concept that encompasses the previous ones).

Clinical Thinking: All These Concepts Intertwined in Clinical Practice

Clinical thinking seems to be a larger concept that encompasses all the others. Following Fuks et al.,[1] clinical thinking refers to the cognitive processes of a health professional in the course of his or her work. It includes clinical inquiry, clinical reasoning and clinical judgment. Fish and de Cossart[24] also include many processes in what they call the clinical thinking pathway. In their model, clinical thinking begins with a complex clinical situation that triggers the need for clinical reasoning, which involves personal and professional judgment in order to take wise action for every specific case.

Figure 1 presents an arrangement of the terms described above in a coherent schematic representing what clinicians do in clinical practice. The most common definitions of those terms are presented in Table 1.

Clinical thinking includes knowledge and other personal (abilities, values, ethic principles, etc.) and external (colleagues and assistants, reference material, instrumentation, etc.) resources, as well as critical thinking. Those are considered as input to clinical reasoning, which is the core of clinical thinking. They must be mobilized in order to resolve clinical problems, use appropriate clinical judgment, and then make the best decisions for each specific patient. The whole clinical thinking process is oriented toward the goal of maintaining, improving or recovering a patient's well-being.

Table 2 presents a simplified example of what could be the clinical thinking processes of an optometrist during a clinical consultation. Clinical practice is complex. Many elements captured by an experienced clinician may be hard to make explicit, for example, a patient's attitude, subtle corneal change, and global integration of multiple clinical data in a coherent mental representation. Therefore, it is obvious that all the mental actions of an optometrist resolving a clinical case cannot be summarized in a single table. Another optometrist faced with the same clinical case would probably have managed it differently. This example is provided to give an idea of how critical thinking, decision-making and clinical judgment differ from each other and how they are all intertwined and related.

What about in optometry?

It is essential to clearly define and distinguish the concepts described above before they are explicitly included in an educational curriculum in optometry. Moreover, many authors recommend that clinical reasoning (and its related concepts) of experts in a profession should be made explicit to the learners of that same profession.[12, 26-29] In order to do so, research studies must be conducted specifically for the optometry profession. This is important to establish the competencies to develop, their course of development through the studies, as well as to define the assessment objectives and create the appropriate assessment tools to achieve them.

The concepts defined and explained above have been largely studied in many health professions, such as medicine,[6, 7] nursing[30] and physiotherapy.[31] However, there is a paucity of research in the area of optometry. With the exception of a doctoral thesis in which the clinical reasoning processes of expert and of recently graduated optometrists were studied using a qualitative research protocol,[14] literature on clinical thinking or related concepts mostly refers to results from other professions. This is the case of Werner,[32] Corliss,[3] Ettinger and Rouse,[33] who were all inspired by the medical model. So there is clearly a need to investigate the way practicing optometrists resolve clinical problems in order to answer their patients' needs, rather than to infer optometrists' clinical reasoning and thinking from results obtained in other health professions.

Conclusion

It has been shown that there may be confusion between many terms related to a health professional's clinical practice. Many of them are often used alternatively, but it is important to distinguish between them as they usually represent different concepts. This paper also underlines the need to investigate clinical thinking and its related concepts specifically for the optometric profession. This is fundamental when

Table 2
Example of Clinical Thinking in Clinical Practice

HISTORY / FINDINGS	CLINICAL THINKING	
A 20-year-old man presents with pain and redness left eye; he is wearing sunglasses indoors	Clinical reasoning: • Mental representation of the clinical case by hypotheses generation	Pain, hyperemia, sensitivity to light Anterior uveitis? Corneal erosion? Contact lens related complication? Corneal ulcer? Other ocular health problem?
	Decision-making	Additional questions to ask Procedures to do: visual acuity, pupils and slit lamp examination (carefully examine cornea and look for cells and flare in anterior chamber)
	Clinical reasoning: •Expectations	Visual acuity probably reduced; left pupil may be smaller; limbal injection, possible corneal involvement, cells and flare may be present
	Critical thinking	Do I consider all the possibilities given the available information? What if expectations are not confirmed by clinical data?
It started suddenly upon waking 3 days ago Not a contact lens wearer No recent eye trauma but a corneal foreign body was removed from the involved eye 3 months ago Was worse when blinking until yesterday, but pain has reduced since then	Clinical reasoning: • Mental representation refinement • Hypothesis elimination	Recurrent corneal erosion? Anterior uveitis still a possible diagnosis Contact lens related complication impossible Recent corneal erosion improbable
	Critical thinking	Am I thinking and reasoning correctly? What else can I ask before starting the eye examination?
	Decision-making	Additional questions to ask before the eye examination
	Clinical reasoning: • Hypothesis refinement • Hypothesis elimination • Expectations	Recurrent corneal erosion or other corneal involvement more probable Healing process in course (re-epithelialization if corneal) Anterior uveitis improbable Cells and flare probably not present (or traces); probable corneal involvement
	Critical thinking	Am I thinking and reasoning correctly? Did I ask all pertinent questions? Is there any other plausible hypothesis?
Corrected visual acuity left eye slightly reduced Left pupil smaller Limbal and bulbar redness, central corneal erosion (deepness: anterior stroma); stromal edema, no positive fluorescein staining, small negative staining adjacent to epithelial debris No cells, no flare	Clinical reasoning: • Hypothesis elimination • Diagnosis formulation • Management plan • Patient-centeredness	Anterior uveitis and corneal ulcer eliminated Recurrent corneal erosion, re-epithelialization in course Think to prescribe hyperosmotic solution and lubricant, with topical steroids Planning follow-up and patient education
	Critical thinking	Am I sure that there is no infectious process? Did I carefully look at all the possible hypotheses? Do I understand the whole situation? Did I look carefully to make sure the epithelium is repaired? Is there any other procedure to do to confirm diagnosis? Are there alternative treatment options? What is more appropriate to this specific case?
Patient is leaving tomorrow night for one month abroad in a country with easy access to healthcare services	Clinical reasoning: • Patient-centeredness and management plan	Planning the best management plan for this specific patient, considering his own personal situation and all the available information
	Clinical judgment	Knowing that standard of care for treating corneal erosions includes cycloplegia, broad spectrum antibiotics and analgesics Considering that pain is less severe than yesterday; that the cornea has re-epithelialized, and that the patient has a recent history of corneal foreign body Considering that the patient is leaving the next day Make the following decisions:
	Decision-making following clinical judgment	Prescribe hyperosmotic agents Prescribe topical steroid Follow-up tomorrow morning Educate patient: importance of the one-day follow-up Immediately consult an eyecare specialist if worsening or recurrence Follow-up in one month when back home
	Critical thinking	What is my confidence in the diagnosis and management? Is the management plan appropriate to that specific patient, given his own personal situation? How can I learn from this clinical case?

it comes to formulating a curriculum, in order to clearly elaborate the teaching, learning and assessment goals of an optometric program, with the view of facilitating the integration of optometric evidence-based knowledge in clinical practice through a patient-centered approach.

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The Integrative Track at SUNY State College of Optometry

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Abstract

This paper discusses the theory and implementation of curricular changes at the SUNY State College of Optometry regarding the courses of the Integrative Track. In response to the changing requirements of optometric clinical education, timely integration of basic science and clinical practice are essential in order to achieve the necessary attributes of a graduating Doctor of Optometry. By beginning this process early in the student's education where expanding clinic experiences are discussed in small group settings, the interns are able to connect to the curriculum in meaningful ways. Improved critical thinking and development of independent learning styles are goals of the courses in the Integrative Track.

Key Words: *optometric curriculum, integration, critical thinking*

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Dr. Appel is an Assistant Clinical Professor at SUNY State College of Optometry. She is course Coordinator for Optometric Clinic I, II and III and the third-year Integrative Seminar course. She also serves as Clinic Track Coordinator, is an Educational Facilitator for the third-year class and works with interns in the Primary Care service. These complementary roles enable Dr. Appel to play a part in the development, implementation and assessment of clinical curricular goals.

Introduction

The practice of optometry requires integration of knowledge. In performing an optometric exam, the clinician must synthesize information from the biological and vision sciences, which serve as the knowledge base and foundation necessary to provide good patient care. In addition, multiple influences from the patient's life, including general health, socioeconomic status and cultural factors impact care directly. Optometric education programs that teach and support an integrative approach can prepare students better for what will be required of them when they graduate.

The expanding scope of optometric practice together with the increased knowledge base supporting it requires fitting more material into an already crowded four-year optometric program. More relevance and efficiency in teaching is necessary to avoid overburdening students with excessive time spent in the classroom. This places an increased emphasis on programs to remove material that does not develop the optometric practitioner. One way to support the relevance of classroom learning to optometric practice as well as enhance educational efficiency is to provide a more integrative approach to teaching. This is consistent with recent changes to the National Boards, in which questions are constructed in a fashion that places basic science information within the context of clinical cases.

The Integrative Track at SUNY State College of Optometry was created to respond to these educational challenges. In this paper, we discuss the creation and implementation of the track, which takes place during the first three years of the optometric curriculum.

Prerequisites for optometric professional programs require the entering student to devote a good deal of his or her undergraduate years to studying basic sciences. In traditional optometric curricula, early courses consist of those in the biological and vision sciences, which are likely to be discipline rather than clinically based. The entering student may become frustrated, perceiving optometry school as a continuation of undergraduate education, with the direct relevance to optometric practice being difficult to discern. This may lead to superficial, rather than deep learning on the part of the student, with the importance of the material not being appreciated until it is encountered later in the curriculum.

Timely integration is vital to success. Waiting to emphasize an integrative approach until the student enters clinical internship places the student at a disadvantage. The student who was used to learning material in isolation is now called upon to think using an integrative approach. By introducing integrative teaching at the outset, students are more likely to become proficient in the manner of synthesizing information and thinking critically, both of which are attributes of a successful practitioner. Before discussing the Integrative Track in detail, we review some of the literature on integrative education in the health sciences.

Literature Review

Integration is not new to optometric or medical curricula. With the advent of changes in most healthcare curricula from a traditional model (i.e., where preclinical didactic courses are followed by exclusively clinical instruction) to one that integrates the clinical and basic sciences throughout, the inception of an integrative curriculum provides a vehicle for students to immerse themselves in integrative activities appropriate to their level of experience. As it is no longer enough to provide our interns with pure content, we must also model ways to organize this information and introduce problem-solving strategies appropriate to a healthcare profession.[1] While reviews of outcome assessment have shown that strict problem-based learning (PBL) curricula have not resulted in consistent improvements in knowledge base and clinical performance,[2] the positive contributions of PBL small group tutorials in a hybrid curriculum cannot be denied.[3] These improvements have also been evident in programs embracing horizontal and vertical integration of material,[3,4] and have been found across the healthcare professions (including medicine, dentistry and nursing) as well as other disciplines. Efforts are being made in many medical school curricula to reintroduce basic science concepts later in the clinical years to enhance relevance in light of the intern's clinical expertise,[5] while most curricula have also introduced earlier clinical exposures.

An explosion of information has necessitated the incorporation of appropriate access to and organization of material (informatics), as well as emphasizing the application of new information and use of technology to patient care in the form of an evidence-based medicine model.[6] Although most incoming professional students are comfortable with technology, they often do not possess the ability to recognize that which makes an information source "high quality," and look to their professors to feed them the "necessary" material. The independent pursuit of knowledge and active lifelong learning are goals of any integrative curriculum, and these skills must be taught and applied for the curriculum to manifest positive outcomes. The motivation to learn independently can be linked to the integration of the student into the clinical setting, and through instructors modeling the application of basic science constructs in these situations.[7] While students may respond differently to small group, problem and inquiry-based learning approaches, the goals of this type of curriculum structure (including information integration, collaborative learning and self-directed learning) are the same requirements of well-prepared healthcare providers. Assessment of success must not assume that because some don't respond positively, the curriculum is a failure. Rather, ways of reaching all students to achieve positive results or choosing those who will get the most out of the curriculum must be explored.[8] There currently exist in other successful optometric curricula courses incorporating many of the same goals of SUNY's Integrative Track using case-based learning for teaching problem-solving and integration.[9] The difference here is that much of our emphasis will be on incorporating actual patient observation and interaction into our case discussions.

In summary, small group activities that link content introduced in basic science courses to clinical observation and patient care, and which provide the opportunity to integrate both vertically and horizontally in the curriculum via modeling of reasoning, provide a strong complement to integrative didactic instruction. This is the basis for the implementation of the Integrative Track.

Integrative Track at SUNY State College of Optometry

While the integration of existing courses was a necessary part of creating a more integrated curriculum, it was felt that creating a specific Integrative Track would strengthen the goal. Recognizing the importance of starting early, and continuing throughout the professional program, a track was created, similar to other tracks (i.e., Ocular and Systemic Disease, Visual/Perceptual/Sensorimotor and the Clinical Examination), which would thread throughout the three years and be geared toward refreshing and integrating material already taught. Therefore, the Integrative Track serves as a vehicle to tie together important aspects of the curriculum, without adding new material. It is presently at the end of its third year of implementation. At the time of writing, current first-year students have completed a full year of the track, while current second-year students are completing a second year of the track. The current third-year class has completed three years of the Integrative Track.

To underscore the clinical relevance, the courses within the track, which are named Integrative Seminar (IS), heavily utilize case-based teaching. Throughout the first three years of the curriculum, each IS employs a combination of small group and clinic exposure and a lecture component in the first two years only. The intern's clinical exposure and responsibility is increased over the course of the three years. There is a Course Coordinator for each year of the Integrative Seminar and a wide variety of additional faculty involved, including those from both basic and clinical sciences. The following is a year-by-year description of the Integrative Track at SUNY State College of Optometry.

First-Year Integrative Seminar

The course runs three hours per week, comprising one hour each of lecture, seminar (small group) and clinic. A weekly topic is presented in lecture, which is then discussed in seminar and clinic. This serves to reinforce the topic in different venues. The groups consist of approximately 12 students and are led by a clinical faculty member. Lecture topics start by considering the patient as a whole before going on to evaluate the eyes and visual system. Some of the topics include: overall patient observation (including patient orientation to time, place and situation, general observations such as gait, visual behavior, dress, hygiene, communication style, etc.), patient health history, use of information technology in patient care, history of the optometric profession, visual acuity testing, clinical decision-making, clinical applications of anatomy and physiology, optics, ethics, and evidence-based patient care. In an effort to strengthen integrative learning, these topics loosely parallel those which students are currently learning in their didactic courses. Accordingly, efforts are made in didactic courses to incorporate cases to illustrate application of basic science concepts.

The first-year IS not only combines basic science material with clinical observations but also makes an effort to develop clinical reasoning by linking it early on with its basic science foundations. This new approach embraces a re-orientation in clinical education and includes improvement in teaching efficiencies by encouraging independent, student-guided use of information technology.

The clinical component of IS consists of students observing examinations for one hour in Primary Care and specialty clinics throughout the year. They are paired with interns and preceptors who reinforce weekly topics and apply them to the observed cases. In the seminars, the students share cases they find interesting that pertain to the weekly topics. Students are expected to pursue topics of interest on their own or with the help of the faculty member assigned to their group.

In the course of case-based teaching, an effort is made to employ what we refer to as a "bottom-up approach." In view of the rudimentary clinical knowledge base of a first-year optometry student, discussing cases in the more common fashion using clinical findings and terminology is apt to lose the student. Instead, we use as a starting point material that the student has previously learned in science courses and apply it to the case at hand.

For example, consider the case of a patient with Adie's pupil. A "top-down" approach to the discussion might give the diagnosis, the pupil test in light and dark, the finding of anisocoria, and the appearance of the iris in the slit lamp. Given this information, the student might be asked how a lesion in the pupillary pathway can account for these findings. However, because the student has not yet been exposed to any of this clinical information, the question is less meaningful than it would have been given later in the curriculum. In fact, the faculty member would have to explain all the terms before the student could answer the question. In using a bottom-up approach, the instructor starts by asking the student to describe the basic anatomy, which the student has already learned (horizontal integration), and works up to the clinical diagnosis. For example, the instructor might ask the student to describe the anatomy of the iris, and the neuromuscular elements that affect pupil size in light and dark. This would include a discussion of the anatomical structure of the ciliary ganglion and how it affects the pupil. Next, the instructor would ask how the pupil size would change if there were a lesion in this region. Then, given this condition, what would be the pupil's response in a light and dark environment? The discussion could then lead to what would be the effect of pharmacological interventions on this condition.

A "bottom-up" approach to discussing cases may be a less familiar method of teaching for the clinician, who is more accustomed to thinking first in terms of patient history and findings and recalling the basic science elements in order to arrive at a diagnosis. In contrast, the method employed here starts where the student is and avoids using technical terms, which the student has not yet learned. Technical terminology can be introduced at the end of the case discussion. Thus, a new way of looking at previously taught information is introduced with the intent that the student will learn about it in more detail later in the curriculum (vertical integration).

Second-Year Integrative Seminar

The course also runs for three hours per week and is divided into seminar, clinic and "half-class" sessions consisting of about 35 students. The course is structured differently from the first-year model, as students are armed with a greater knowledge base. An increased emphasis is placed on active learning. Instead of being in clinic for just one hour per week, students are assigned to clinic for a three-hour period every other week. On alternate weeks, they participate in a two-hour seminar and one-hour half-class session. This schedule gives the students the opportunity to follow a case from beginning to end, rather than having only a partial one-hour exposure to the case. The clinical experience is more hands on. Students work as scribes, performing electronic medical record (EMR) recording as well as assisting with elementary testing in concert with third- and fourth-year interns and assisting patients as they make the transition to the dispensary or to make follow-up appointments. Pairing junior and senior students in clinic fosters peer learning, which is a key component of second-year IS.

In seminar, students present cases they have seen in clinic, which are then discussed in the context of material learned in their other classes. Discussions stress clinical decision-making and critical thinking. Alternatives to the diagnosis and plan for their cases are discussed and students are asked to justify their decisions based on material they have learned in their didactic courses. Volunteer patients participate in seminars to help students learn communication skills and history-taking with actual patients. Special topics are sometimes introduced, for example, conducting a practice exam in Spanish on a Spanish-only speaking patient.

Second-year IS differs from the first-year program in that there are very few formal lectures. Rather, in half-class sessions, students address questions regarding cases for which they need to apply basic science knowledge in the formation of clinical assessments and decisions. Both basic and clinical science faculty are present to guide the discussion. Topics have included amblyopia, apoptosis, diabetes, refractive surgery evaluation and macular pathology. All of these topics are discussed with respect to didactic information that has been introduced in other tracks. Because of the increased knowledge base of a second-year student, a strictly "bottom-up" approach need not be used exclusively. Students are more familiar with clinical diagnoses, and questions can be designed with that in mind. Here is an example of a question that the students must address.

An 8-year-old boy presents for an eye exam. He has worn glasses since age 5 and his ocular history is otherwise unremarkable. The spectacle prescription is:

OD -10.75-4.25x180 20/200

OS -5.25-1.25x180 20/30+

Explain the reduction in his VA based on the normal development of his visual system and how clinical interventions might affect this development.

The students work in teams of eight or nine, and each team has to present its answer to the question. It is completely open book, and the students are allowed to bring in whatever notes or sources they have, including being able to utilize online information. This requires them to access previously learned material. Students are not given the question beforehand, only the general topic. The idea is to create a unique type of case scenario, such as the kind they would have to face in clinic. The groups then challenge each other as to who gave the best answer. Groups are graded, in part relative to one another. This helps students learn to critique one another and to respond to critiques on clinically relevant and integrative questions. As in first-year IS, there are no exams and few out of class assignments. Students are evaluated based upon how they perform during class time.

Third-Year Integrative Seminar

Implementation of the third-year IS is coinciding with a significant restructuring of the third-year clinical experience. Recommendations for improving the third-year clinical program were made by an appointed committee in which incorporating the third-year IS course into clinic was a top priority. Third-year Integrative Seminar is a mandatory weekly one-hour course given on the day the intern is in the Primary Care clinic. In addition to case discussions, the interns are challenged to think creatively regarding patient care options and applications. They are expected to reflect on and justify their patient care choices and bring to bear what they have learned didactically and via purposeful searches of the literature with an emphasis on application of evidence-based medicine. Six students meet with the same two faculty members who supervised them in clinic. This helps to integrate the clinical experience with the course, while contiguous placement with the clinical assignment allows issues that have just been experienced to be discussed. The process is supported by the availability of pertinent data from earlier didactic courses (first through third year) which can take the form of texts, articles, Web site links, or other visual aids found on Moodle (our online learning management system) and via Internet access with links from our library home page to journals, databases and image catalogs. The information that highlights fundamental points can then be used to support the intern's understanding of clinical presentations encountered in patient care. The students must justify their management using this information. Interns are required to develop and present a 10-minute case-based Power Point presentation on a topic they have encountered and list their references. This fosters a deeper understanding of a specific topic while encouraging independent, exhaustive research.

Challenges

The implementation of any new program will expose a myriad of unexpected challenges. Despite previous implementation of integrated curricula elsewhere in optometric education, each institution will encounter its own particular pitfalls. As IS courses have only recently been instituted, outcome data are still in the process of being collected. However, informal feedback has revealed some difficulties. Below are some of the challenges we have experienced so far and have attempted to address.

• **First-year IS:** A challenge for any new course designed to synthesize existing information (rather than adding new material in a tightly packed curriculum) is assuring that it does not serve as an entry point for material otherwise omitted from the curriculum. In the first year of IS, public health material was added to the course, then, in part based on student feedback, removed during the second administration and placed within the Public Health Track at a more appropriate time in the curriculum.

The first time that IS was offered, seminars were conducted in an open format to incorporate what was discussed in the one-hour lecture and with respect to student experiences in their didactic courses and patient care observations. While this format provided for flexibility in discussions, the lack of uniformity among the individual groups resulted in differing assignments and greater or lesser workloads amongst them. This led to discontent among the students as some felt overburdened by having to do more work than their peers. This has now been remedied, as assignments outside class time have largely been eliminated. Whereas a uniformity of experience cannot be achieved, a uniformity of requirements is desirable.

• **Second-Year IS:** Throughout the entire three-year Integrative Track, finding an appropriate venue for holding seminars that allows access to the clinic's EMR system and the Internet has proved to be a challenge. The large lecture halls are not designed for access to these resources, nor do they offer seating suitable for face-to-face group interaction, which is essential for seminars. Alternative locations, such as conference areas located in the library are designed more for quiet study than groups needing multimedia access. Accordingly, securing an appropriate physical location for this new course has been challenging.

Having a one-hour time slot dedicated to half-class sessions has also been problematic for second-year IS. Because these periods are devoted to presentations involving approximately 35 students, overseen by several faculty members, it has, on occasion, been difficult to limit the discussions to the one-hour time period.

• **Third-Year IS:** This course was introduced in the fall semester of 2010. An effort to incorporate IS into the clinical setting has resulted in a complex restructuring of existing patient care schedules and faculty assignments. It is a task that requires the close cooperation of the College's Clinical Administration and Academic Affairs departments. Staffing clinics, labs and first- through third-year IS has placed significant demands on faculty manpower. However, the promotion of the small group learning experience is a curricular goal, and thus efforts have been made to allocate appropriate faculty in order to achieve it.

Constraints due to patients arriving late, intern inexperience and patient complexity often results in abbreviated or late seminars leaving less time for meaningful case discussions. Changes in the schedule were piloted and implemented and are currently being assessed for improvement. While incorporating IS into clinic provides an excellent opportunity for real-time learning, it also presents logistical challenges.

Conclusion

Will the Integrative Track create students who are independent learners, provide a more holistic approach to patient care, are more developed in their critical thinking, and more adept in applying basic science principles to clinical practice? This remains to be seen. The College has developed assessment tools, such as a test similar in form to the National Board's Patient Assessment and Management (PAM). This was given to the graduates of the prior curriculum, and will be given to students who took the new curriculum (including the Integrative Track) for comparison. Traditional means of evaluation, such as National Board scores in addition to faculty and alumni surveys, will continue to be employed to assess the outcome of curricular changes. Additionally, new student course evaluations have been developed to obtain their feedback on whether IS courses are meeting the goals. This survey can be found in **Appendix 1**. As with any new curricular initiative, modifications will certainly have to be made based upon the results of these assessments.

The College's mission statement and strategic plan are devoted to developing outstanding optometrists within a professional program that employs innovative and pedagogically sound instructional strategies centered on evidence-based care, critical thinking, and promotion of lifelong learning skills. The Integrative Track is designed to be a crucial component in achieving this mission.

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Appendix 1
Course Survey (Fall 2009) Integrative Seminar

Please answer the following questions, which pertain to Group, Clinic, Lecture, or the course in general.

Indicate which group session you attended:

Tuesday ____ am ____ pm ____ eve

Wednesday ____am _____ pm _____eve

Thursday _____ am _____pm _____eve

Friday _____ am _____pm

Group

1. The group sessions were useful in integrating didactic course material with clinical care

Strongly Agree Agree Neutral Disagree Strongly Disagree NA

2. The group leader was helpful in creating a positive learning environment

Strongly Agree Agree Neutral Disagree Strongly Disagree NA

3. I was satisfied with my participation in group

Strongly Agree Agree Neutral Disagree Strongly Disagree NA

Please provide any additional comments you like regarding the group sessions

Clinic

1. Participating in clinic was beneficial to my development as an optometrist

Strongly Agree Agree Neutral Disagree Strongly Disagree NA

2. The interns were helpful to me in clinic

Strongly Agree Agree Neutral Disagree Strongly Disagree NA

3. Participating in the screenings was beneficial to my clinical development

Strongly Agree Agree Neutral Disagree Strongly Disagree NA

Please provide any additional comments you like regarding the clinic sessions or screenings

Lecture sessions

1. The lecture sessions, assignments, or suggested references were useful in integrating course material with clinic situations

Strongly Agree Agree Neutral Disagree Strongly Disagree NA

2. Working with other students was a beneficial learning tool

Strongly Agree Agree Neutral Disagree Strongly Disagree NA

Please provide whatever comments you like regarding the lecture sessions

Course in general

1. The course facilitated student attainment of goals described in the syllabus

Strongly Agree Agree Neutral Disagree Strongly Disagree NA

2. The course was helpful in developing my independent thinking

Strongly Agree Agree Neutral Disagree Strongly Disagree NA

3. The course was helpful in my getting used to working in a clinical environment

Strongly Agree Agree Neutral Disagree Strongly Disagree NA

4. As a result of this course, I was more likely to independently use outside resources

Strongly Agree Agree Neutral Disagree Strongly Disagree NA

5. The course contributed to my ability to present a case in an organized manner

Strongly Agree Agree Neutral Disagree Strongly Disagree NA

Please provide whatever comments you like regarding the course in general

Teaching Clinical Decision Making: The Keystone Experience

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Abstract

Preceptors facilitate clinical education by teaching knowledge organization skills to allow meaningful information retrieval during patient examination. The intensive patient-based Keystone Course series designed at The Ohio State University College of Optometry uses case scenarios to help students develop these skills. Students analyze individual patient data and develop a patient illness script composed of three elements: epidemiology, temporal pattern and key features. Students next compose a ranked differential diagnosis list by comparing the patient's illness script to classic disease presentations. The goal is to teach meaningful diagnostic integration and the importance of basic science principles to eye and systemic interactions.

Key Words: *clinical teaching, diagnostic reasoning, differential diagnoses, illness script*

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Introduction

Clinical educators face a daunting task of having to simultaneously provide exemplary patient care, fine-tune students' technical skills, highlight appropriate basic science principles during clinical care, and teach clinical diagnostic reasoning, all while assessing the overall patient care skills of numerous student clinicians. Students certainly face a long road to becoming efficient and accurate doctors. In order to best facilitate this journey, clinical educators must recognize the steps most students take as they travel from novice to experienced clinician. Denial[1] discussed the connection between "critical thinking" ability and clinical thinking and that more was required of educators than just teaching students the "knowledge and technical skills associated with the profession." She expressed support for the teaching of critical thinking concepts. She also demonstrated a general positive association between critical decision-making (as assessed with the California Critical Thinking Skills Test) and overall clinical performance by fourth-year optometry students.[2]

Educators can aid the development of clinical diagnostic reasoning in students by helping them mentally organize learned material to allow them to meaningfully retrieve information during a patient examination. This is a step in the teaching of "scientific thinking" recommended by Willingham[3] and reviewed by Hoppe.[4]

The intent of this paper is to describe the process used by The Ohio State University College of Optometry to teach clinical reasoning to its optometry students. A two-course series was recently developed to introduce students to the skills used by experienced clinicians for patient evaluation. Background information on clinical decision-making is presented before providing a detailed and informal assessment of the course series.

Background

Experimental studies have shown experienced individuals with "expert" knowledge in a discipline recall knowledge differently than beginners.[5] As an example, deGroot studied the chessboard memory skills of experienced vs. novice chess players. After only a five-second view of a chessboard, expert players could correctly replace more pieces than beginners, but only if the pieces were originally arranged in a recognized manner that conformed to actual game strategies. If chess pieces were originally placed in random fashion, the experts performed no better than beginners. The conclusion was that experts compartmentalize information into more easily recalled packets, which have experiential meaning.[6]

Bordage expanded on this finding to explain clinical decision-making growth for medical practitioners and put the explanation into medical terminology.[7,8] Bordage explained that experienced clinicians organize information about conditions using "semantic networks" aligned along oppositional binary axes. A grouping of these binary axes is used for different disease conditions to give better understanding and retention, and to foster improved diagnostic ability. As clinicians gain experience, the number of semantic axes associated with specific disease conditions increases. This adds specificity to a list of differential diagnoses and allows clinicians to direct case management in a more efficient manner.

An example of this structure is illustrated with a patient complaining of a red eye. **(Table 1)** Examples of oppositional binary pairs used to sort through the case may be: onset, acute vs. chronic; injection, circumlimbal vs. diffuse; discharge, watery vs. mucopurulent; photophobia, mild vs. intense; pupil, normal reaction vs. fixed/sluggish; presence of pseudomembrane, yes or no; preauricular node involvement, yes or no; inflammation type, papillary vs. follicular; intraocular pressure, normal vs. elevated; presence of upper respiratory infection, yes vs. no; and anterior chamber angle, open vs. closed. Using information about these pairs derived from case history and/or exam room testing, the experienced clinician can quickly move from initial presentation to definitive diagnosis. Additionally, the experienced clinician has learned that individual cases may not present classically and that individual features of real patients with disease may be difficult to sort out; however, the overall features will generally match basic representations.

A first step in educating beginning students is to help them "compartmentalize" their learning into condition-specific segments to bring together elements from different parts of the curriculum. To facilitate this process, students should learn to develop "illness scripts," which describe the classic presentations of disease conditions.[9] The illness scripts should include the predisposing conditions (epidemiology) that puts patients at risk for specific conditions, the classic temporal pattern describing the disease onset and course, and the key clinical features most often seen with actual cases. For example, when students are studying acute closed angle glaucoma, they should recognize, and be able to articulate, a classic clinical appearance for the condition. The classic epidemiology is an elderly person with predisposing narrow anterior chamber angles. The temporal pattern is acute to hyperacute presentation. The key clinical features may include deep pain, pronounced circumlimbal injection, fixed mid-dilated pupil, blurred and/or hazy vision, and significantly elevated intraocular pressure. Students can then learn to develop patient illness scripts for clinical patients they examine, and determine which disease condition has an illness script that, in its entirety, best matches that for the specific patient they are examining. Students then learn to build meaningful case descriptions for individual patients through insightful history-taking and clinical testing. Students learn to evaluate the patient as a whole and not to test history elements or clinical findings as independent pieces of information.[8,9]

Clinical memory with diagnostic acumen is also enhanced as students learn to quickly translate the patient history into medical terminology and to process related findings into more descriptive, and efficient, terms.[9] For example, by transforming a patient's history of "red eye for two days in the right eye" into "acute, unilateral conjunctival injection," the clinician has medical terminology that can be matched to descriptions read in textbooks or delivered by classroom/didactic instructors.

To help students develop clinical diagnostic reasoning, a case-based, two-course series (Keystone Course series) was introduced into the curriculum at The Ohio State University College of Optometry. Students completed the initial course at the end of the first training year just as they completed their final examinations for the spring term. Students participated formally from 8 a.m. to 5 p.m. on each of six consecutive weekdays. The final examination was given on day seven. The overall design of this first course was to allow students to work in teams of eight to work through clinic cases. Two eight-student

Table 1
Red Eye
Example of Oppositional Pairs in Differential Diagnoses

	Conjunctivitis		
	Bacterial	**Viral**	**Allergic**
Discharge	mucopurulent	serous	mixed
Laterality	unilateral	unilateral progressing to bilateral	bilateral
Itching	no	variable	yes
Onset	acute	acute	chronic
Preauricular Node Involvement	no	yes	no
Inflammation Type	papillary	follicular	papillary
Exposure to Person with Red Eye	no/yes	yes	no
Respiratory Infection	no	yes	no
Systemic Allergy	no	no	yes

teams would work adjacently on a separate case. The two cases had the same overall theme, but were independent of each other. Each case was comprised of a complete case history along with full testing results for a typical clinic patient. Students would analyze each case as a team with the ultimate goal of developing a logical list of differential diagnoses.

Course Description

The Keystone Course schedule is shown in **Figure 1**. After an intense training/orientation session on day one, students began day two working up their first case within their eight-person team. Eight cases were required. Each eight-person working group would work up four cases. There were two working groups per training area. (The overall class size was 64; therefore, four independent training areas were required.) Two cases were developed for each of four chief complaint areas: 1) reduced visual acuity, 2) red eye, 3) diplopia, and 4) restricted visual field. These four general areas allowed students to review principles learned in a wide variety of basic science courses taken over their first training year. Cases were prepared from actual patient charts. Small modifications were made to the actual findings documented in charts when appropriate. As these were novice clinicians, the intent was to provide "classic" cases with few real-life inconsistencies. Cases were chosen in the appropriate categories named above that appeared to be: relevant, realistic, engaging, challenging and instructional.[10]

The requirements for completion of each case included: 1) a tiered listing of differential diagnoses that compared the degree of agreement of the patient's illness script to the different disease illness scripts, 2) a five-minute presentation describing the clinical aspects of the case, and 3) a five-minute presentation describing the important basic science principles of the case. Each working group member was required to give one presentation (either a clinical or a basic science presentation) for one of the four cases their working group completed. The presentations were given to their working group, the faculty facilitators, and the other eight students within their training area. Following the formal presentations each morning, faculty facilitators led a question and answer session for each of the two covered cases. All students were encouraged to participate by providing "expertise" in areas in which each had researched.

Figure 1
Course Schedule

	Thursday	Friday	XX	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 AM	Introduction and exemplar case	Case 1 facilitated		Present Case 1	Present Case 2	Present Case 3	Present Case 4	Work on final case
9:00 AM								
10:00 AM				Case 2 facilitated	Case 3 facilitated	Case 4 facilitated	Distribute final case	Review cases for final
11:00 AM							Discuss final / Work on final case	Written final
noon	Lunch provided	Lunch on own		Lunch on own	Seminar	Lunch on own		Wrap up
1:00 PM	Continuation of exemplar case	Group work (not facilitated)			Lunch provided			BBQ
2:00 PM				Group work (not facilitated)	Group work (not facilitated)	Group work (not facilitated)		
3:00 PM							Review cases for final	
4:00 PM								

Case work began with each working group receiving case history and clinical testing information for its patient/case. A sample case is shown in **Table 2**. Students were instructed to "work up" each case using a general sequence as follows:

1. compose a problem list from case history and clinical test information (students may need to investigate normalcy of clinical findings: for example, is 180 microns a normal macular thickness finding for the Stratus OCT?)
2. combine the related problems or those that can be defined by a single, overarching term or phrase (organize and eliminate redundancy)
3. process a problem list elements into more descriptive medical terminology **(Table 3)**
4. prepare patient illness script (epi-

demiology, temporal pattern, key elements) from case history and clinical findings **(Table 4)**

5. peruse available resource materials (hard copy and online resources) to begin composition of a tiered list of differential diagnoses.

First-year students working in the initial Keystone Course (Keystone 1) stopped case development after composing the list of differential diagnoses. Second-year students (Keystone 2) continued with case development to prepare a formal patient assessment and plan.

The list of differential diagnoses was constructed using a three-section, tiered format. The Tier I diagnosis was the nomenclature used to signify that diagnosis which the working group felt was the actual diagnosis for the case. The illness script for this diagnosis should have almost total agreement with that for the patient. An example of the format is given in **Table 5**. The Tier 1B diagnosis, if present, was a condition, that, although students felt it was not the actual diagnosis, was very important to be ruled out on an emergency basis because of the risk of potential loss of life or sight. The illness scripts for Tier II diagnoses generally fit the patient's illness script, but were different in at least one important element. The Tier III illness script agreed with the patient's illness script only in a peripheral manner and differed in several important elements.

Faculty served as facilitators for the working groups to keep students on-task and to help students from pursuing nonconstructive research paths. Facilitators were not to provide students with specific information relative to each case, but more to guide general avenues of research. Three faculty members would serve as facilitators for each of the two student group working areas. Typically, the three facilitators would be a basic science instructor for a course from the first-year curriculum, a faculty member with both didactic and clinical teaching responsibilities, and an auxiliary faculty member who teaches full-time in the clinic. The facilitators were provided with case scripts with key learning principles to ensure consistent experiences among the various groups.

Table 2
Sample Keystone Case

History	Vision Examination
CC: Patient (58 yo white male) reports that he seems to have lost his lower peripheral field. Vision History: First noticed difficulty with lower field vision getting out of bed 2 weeks ago. Is having difficulty walking down stairs. Also noticing that vision in left eye has been getting gradually blurry at both distance and near since his last exam. He has no history of eye trauma or surgery and has not noticed any double vision. PMHx: Suffered a stroke in 2004 (6 years ago) – difficulty walking ("like I was drunk" – unsteady and staggering), lost balance a lot – returned to normal after only 2 to 3 weeks. States that his carotid arteries are "partially blocked." He has diabetes, high blood pressure and had a couple of heart attacks. Medications: Gemfibrozil 600mg twice a day. Glipizide 10mg twice a day. Aspirin 325mg daily. Dipyridamole 200 mg daily. Insulin NPH 22 units daily, Insulin Reg (based on blood sugar). Lisinopril 10mg daily. Metformin 1000mg daily. metoprolol succinate 50 mg daily. Pentoxifylline 400 mg three times a day. Simvastatin 80mg daily. Allergies: Penicillin and ampicillin FOHx: No significant history FMHx: No significant history SHx: Married. 3 older kids. Retired/on disability. Quit smoking in 2007. Doesn't drink.	Visual Examination: Present Rx/Visual Acuity: OD +1.25DS +1.75 add 20/20 D and 20/30 N OS +2.25 DS +1.75 add 20/40 D and 20/30 N Pinhole Visual Acuity (over present glasses): OD 20/20 OS 20/30 Binocularlity/Eye Mvmts: CT (w/ Rx) 6 m ortho 40 cm 10 XP Motility: smooth and full, no overactions or restrictions Manifest Refraction: OD +1.25 -0.25 x 070 +2.25 20/20 D and N OS +1.50 –0.25 x 060 +2.25 20/30 D and N Pupils: ERRL (-) APD External/SLE: L/L/A: wnl OU Conj: wnl OU Cornea: wnl OU AC: deep and quiet OU, No cells / flare Iris: Flat and intact, No NVI OU Lens: NS OU Grade 1 OD, grade 2 OS Vit: wnl IOP: OD 20 mmHg and OS 20 mmHg @ 2:23 PM Internal/DFE: ON: C/D = 0.30/0.30 OD and OS, disk margins distinct, normal color, no NVD Macula: normal OU Vessels: AV ratio 1/3 AV nicking and moderate tortuosity OU Periphery: OU Intact 360°, no rips, holes, tears OCT RNFL: OD 96.97 and OS 92.67 (both WNL) Macular scan: 181 OD and 177 OS Visual Fields: Confrontations constriction inferior OD and OS HFA attached. Bilateral inferior altitudinal defect Vital signs: BP: 128/78, HR:73 HW: 74" and 292 lbs. General: Alert, clear speech, able to cooperate with ocular examination. Lab Tests: HbA1c 12.5; ESR 13 mm/hr; CRP <0.2; PT and PTT normal
ROS (review of systems): **ENT: normal** **CV: + HTN since 2004; +CAD (2 MIs in 2004); + CVA 2004; 50% to 79% carotid stenosis** ***noted 3/28/2007** **Pulmonary: normal** **Dermatological: normal** **GI: high cholesterol** **UG: normal** **Endo: + DM since 2004 blood sugar runs btw 200 and 400** **Musculoskeletal: normal** **Neurophyc: normal , denies TIAs**	Vessels: AV ratio 1/3 AV nicking and moderate tortuosity OU Periphery: OU Intact 360°, no rips, holes, tears OCT RNFL: OD 96.97 and OS 92.67 (both WNL) Macular scan: 181 OD and 177 OS Visual Fields: Confrontations constriction inferior OD and OS HFA attached. Bilateral inferior altitudinal defect Vital signs: BP: 128/78, HR:73 HW: 74" and 292 lbs. General: Alert, clear speech, able to cooperate with ocular examination. Lab Tests: HbA1c 12.5; ESR 13 mm/hr; CRP <0.2; PT and PTT normal

Working group activities for the afternoon sessions were accomplished without faculty facilitators. Students worked without supervision to finalize their list of differential diagnoses and to compose and rehearse their presentations to be given the following morning.

Each new day would begin with the selected students giving their five-minute presentations (clinical or basic science) from the previous day's cases. Considering the richness of each case, students were often challenged to limit their comments to only five minutes. In addition to saving time for the new day's activities, limiting presentations to five minutes forced students to concentrate on the important, relevant issues of each case. These novice clinicians were forced to act like more experienced, clinically savvy optometrists that can succinctly describe case findings using semantic qualifiers that illustrate strong clinical reasoning.[5] Peer review and facilitator review were part of the grading process.

Each case concluded with approximately 45 minutes of discussion of the case's clinical and basic science aspects. Faculty facilitators led the discussion with both small groups participating (i.e., the group that worked on the specific case and the group that worked on the other case with the same chief complaint). By involving both groups, the important points that differentiated the two cases, and led to different differential diagnoses, where reinforced. Because of the overlap gained from the previous research of the common theme (e.g., red eye), both groups were able to actively participate in discussion of both cases. Non-presenter group members were encouraged to participate, especially in subject areas each had individually researched. Additionally, by assembling faculty facilitator teams that included a basic scientist, a full-time clinician, and an optometrist from the lecturing faculty, each case was discussed from a wide range of perspectives.

Keystone week concluded with students required to work up the final case individually (i.e., submit a processed problem list, illness script and tiered list of differential diagnoses) and to complete a final examination. The final examination was a comprehensive examination that included information from the first-year curriculum and that had been included within at least one of the nine course cases.

Table 3
Processing of Problem List

Unprocessed Grouped Problem List	Processed Problem List
"Lost lower peripheral field" Difficulty walking down stairs Constricted fields inferiorly OD and OS on confrontations and automated fields	Homonymous congruous inferior altitudinal field defect
Left eye gradually blurry distance and near BCVA 20/30 distance and near for OS Grade 2 nuclear sclerosis cataract left eye Old Rx +2.25 for OS New Rx +1.50 for OS	Grade 2 NS cataract with slight myopic shift and reduced BCVA OS
Stroke in 2004, symptoms lasted 2 to 3 weeks Staggering like drunk Lost balance a lot	Past transient neurological deficit with cerebellar/vestibular involvement
Carotids partially blocked bilaterally 50% to 70% blockage on carotid doppler	Carotid stenosis
Couple heart attacks	Coronary artery disease with previous MI x2 Rx: anticoagulants and OTC aspirin
High blood pressure since 2004 BP 128/78 AV nicking and moderate tortuosity AV ratio 1:3	Moderately controlled hypertension with grade 2 hypertensive retinopathy Rx: ACE inhibitor and beta blocker
Diabetes HbA1c: 12.5	Uncontrolled Type 2 diabetes Rx: Insulin, biguanide and sulfonylurea
High cholesterol	Hypercholesteremia Rx: fibrate and statin
Previous smoker	Previous smoker (nonsmoker for 3 years)
6'2" and 292 lbs	Obesity

Table 4
Patient Illness Script

Epidemiology: 58 yo obese white male with uncontrolled diabetes and history of previous stroke and MI

Temporal pattern: Acute onset lower field loss OU with chronic loss of vision OS

Syndrome statement: Homonymous congruous inferior altitudinal field loss

Other problems: hypertension, hypercholesteremia, history of CVA, nuclear sclerotic cataract, carotid stenosis

Discussion

The Keystone Course series has been an intensive, and worthwhile, curricular undertaking for our College. It has proven to be extremely faculty intensive both in preparation and application (e.g., three faculty dedicated to each working group of students), yet has provided extra benefits in ways that were unforeseen during initial course implementation.

The primary intent for implementing the course was to explicitly model clinical decision-making to our students prior to their beginning clinical rotations. During preparation for course development, it became apparent, however, that even our most experienced clinicians had difficulty articulating the mental processes they each used to make clinical decisions. Experience appeared to be the great teacher as clinicians processed case findings into meaningful, related concepts. During patient examination, clinicians were building their own versions of patient illness scripts without knowing the proper nomenclature and were unable to fully describe the process to students.

The Keystone Course did provide students with a structure with which to organize clinic information. An important process in the growth of a clinician is to recognize the associations among the various signs and symptoms of conditions. The importance of these associations was demonstrated to these first-year optometry students (i.e., novice clinicians) through the Keystone process. Students processed the initial problem list by combining related terms, removing redundancies of information, and translating "patient speak" into medical terminology. They learned that expert clinicians not only know more, but they access what they know differently than novice clinicians.

Students next composed a patient illness script that included concepts related to epidemiology, temporal pattern and key features of each case.[9] Epidemiological doctrine was reinforced, i.e., disease does not strike at random, but rather, the patient's conditions, situations and activities all modify risk. The temporal pattern and key features also provided students a patient-oriented context to aid memory concerning their cases for future clinical management.[5]

Construction of the tiered list of differential diagnoses reinforced the concept of the illness scripts and the degree to which real patient presentations agree with the classic presentations learned in the classroom setting. Students learned that there is not always a single right diagnosis (which after years of multiple choice tests they expect to find) and the ranking of diagnoses depends on the degree of matching between the patient's illness script and the myriad of disease illness scripts they learn in school and in practice.

Faculty facilitators for the course were chosen from across the entire faculty. Basic science faculty, lecturing faculty optometrists and clinical auxiliary faculty all participated. The benefits of this faculty mix were many.

Faculty facilitators were instructed not to "spoon feed" information to students during the facilitated working group discussions. Instead, facilitators could gently "push" students in the proper direction as they researched diseases and conditions, and, importantly, help keep students from using large amounts of valuable time on minor points unrelated to case disposition. In this role, all facilitators benefited from hearing the students' discourse and their sometimes improper interpretation of important case concepts. Often, facilitators would have long episodes of anxiety as

Table 5
Tiered Differential Diagnoses

Tier	Diagnosis	Analysis
I	Bilateral occipital lobe cuneus damage (likely vascular infarct to posterior cerebral arteries)	Epidemiology: fits well, older vasculopath, very high risk for second CVA, previous basilar/vertebral artery involvement Time course: fits well with acute onset Syndrome: explains field loss well (bilateral, congruous)
IB	Suprachiasmic brain tumor	Epidemiology: fits well; older Time course: doesn't fit; usually more indolent, chronic Syndrome: explains bilateral inferior hemianopic field loss, but not supported by lack of nerve pallor, or signs of increased intracranial pressure
II	Bilateral AION (nonarteritic) (Arteritic not supported by patient's lower ESR)	Epidemiology: fits well (older, vasculopathy) Time course: fits with acute onset with morning onset Syndrome: fits field loss in each eye but not supported by field congruity and normal ESR, or optic nerve appearance
III	Bilateral retinal detachment	Epidemiology: doesn't fit (no high myopia, trauma) Time course: fits for acute onset Syndrome: not consistent with retinal findings or congruous field loss

Table 6
Student Evaluation of Instruction
Five-Point Scale

1	2	3	4	5
Strongly Disagree		Neutral		Strongly Agree

The Keystone Course Teaching Objectives:	Mean Score*
provides for a cognitive transition from basic science to clinical science	4.57
helps foster integration of basic science knowledge through knowledge reorganization	4.39
explicitly models and help develops clinical reasoning skills	4.40
promotes lifelong learning skills	4.35
allows students to identify and correct knowledge deficits	4.12
helps develop interpersonal and communication skills	4.39
Overall, the Keystone Course was a valuable learning experience	4.54

**(Mean scores for total of 127 students, classes of 2012 and 2013)* students incorrectly remembered concepts "learned" in a facilitator's earlier course, before a working group member would "save the day" by consulting course notes or hitting upon the proper memory cue. This often provided excellent feedback to faculty concerning what students "learned" concerning the material that instructors "taught."

The expertise of faculty was most often revealed to students during the discussions that followed case presentations. In this forum, faculty facilitators were free to express their thoughts concerning the cases. This process was especially useful for basic science faculty. This allowed basic science faculty to reinforce to students the importance of many basic science concepts on actual clinic cases. These discussions were also beneficial to clinical faculty that may have forgotten the underlying basic science principles that set the stage for all clinical conditions. The interactions among faculty in this forum were also useful to help modify didactic course materials to make taught information as clinically relevant as possible.

The structure and content of the course theoretically provided our students with a strategy to increase the accuracy and efficiency of their examinations. Understanding the illness script concept and structure should help novice clinicians develop meaningful follow-up questions during patient interviews and proper test selection during patient examinations. It has been our observation from working with student clinicians that by learning to present cases using the patient illness script format, these novice clinicians can quickly learn to present cases to their clinical preceptors using a succinct and structured format. Student clinicians should ultimately be less likely to ramble concerning case findings, but rather present patient history and test findings in a more efficient and clinically relevant manner to more quickly and accurately arrive at the proper patient management. Selected clinical faculty have commented on the change in student behavior since the course implementation. The chief of our ocular disease service has noted: "After experiencing Keystone, students have increased their abilities to present cases in Grand Rounds. Students are concise in presenting illness scripts for their patients and provide the case analysis in a straightforward and logical sequence."

The Student Evaluation of Instruction results have also been very positive. **Table 6** shows the mean results for the first two years of course administration using a five-point grading scale. All course objectives received mean scores above the agree level (score of 4), although "allows students to identify and correct knowledge deficits" was noticeably lower than the rest. Overall, however, students graded the course highly (4.54).

The Keystone Course also provided a detailed structure and nomenclature for our faculty to use to teach eye examination and clinical decision-making skills. This structure is now being implemented into the clinical education of interns and residents at several affiliated VA Optometry programs. The course also provided a forum for students to give case presentations before beginning their clinic rotations, introduced the concept of self-education to foster lifelong learning skills, and illustrated the need for healthcare personnel to work as a team to foster cooperation in today's healthcare environment.

While the Keystone Course has been widely accepted by faculty and students, we have yet to see a cohort of students matriculate through the entire series and be evaluated through the extern program. Additionally, objective, independent evaluation of the Keystone Course series through comparison of present student performance to that of previous students (who had no Keystone experience) has been complicated by other simultaneous enhancements made to the overall curriculum and to changes made to the instruments used for evaluation of student clinical performance. However, assessment of the value of the program will be monitored over the upcoming years using evaluations of student clinical performance by extern preceptors, with feedback by students comparing results from pre- and post-course evaluations, and with more general feedback from clinical faculty.

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