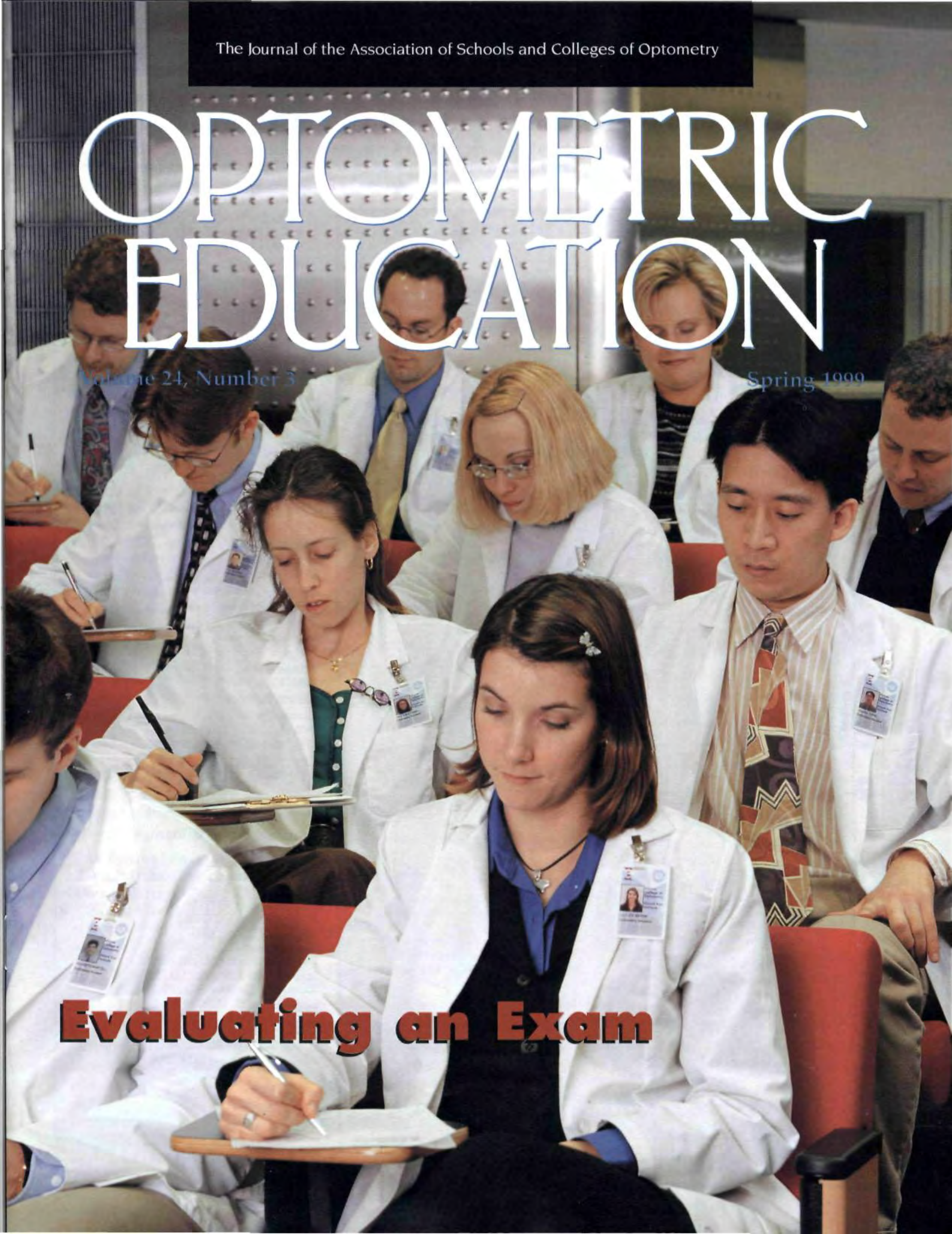
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OPTOMETRIC EDUCATION
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Evaluating an Exam

Association of Schools and Colleges of Optometry

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EDITORIAL

Professionalism - Alive and Well?

Roger Wilson, O.D.

The teaching of professionalism in the schools and colleges of optometry has recently been the subject of concern and debate. Optometry is not alone in this concern - the health professions generally are focusing on the role of the professional in today's rapidly changing healthcare environment. Medicine is clearly concerned about the impact of managed care on a physician's ability to render care within an ethical framework, and in a professional manner.[1]

But a notion of "deprofessionalism"[2] continues to gain attention. Where is it coming from and what factors may contribute to it? Is it the decay of values and principles in society? How about the impact of managed care on the care-giving process? Is role modeling outmoded - a thing of the past?

For years faculty have observed that each class has its own "personality." Surely you have shared your personal insights with your colleagues: "this year's first year class asks more questions; the second year class seems disinterested in learning; the third year class is the best group of clinicians we've ever had; I'll be glad when this fourth year class graduates - they act as if they were doing us a favor by showing up for clinic." It is easy to misjudge an entire class by the actions of a few, but do our students today really understand what it is to be a professional? And more importantly, can we teach students how to change their attitudes and thinking so that "acting" as if they are professional is replaced with "being" professional?

Dr. Wilson is associate editor of Optometric Education.

What are the motivating factors that lead to unprofessional behavior in our students? Perhaps it is permissive parents who did not set boundaries of good or appropriate behavior. Maybe it is the deterioration of the educational system and poorly qualified teachers. Could it be that college professors really have surrendered to grade inflation and the pressure from students (and their parents) to get an "A" at any cost? Is it the Internet, or maybe politicians behaving badly? Could it be the influence of managed care, cost cutting, and the emphasis on business strategies in health care today? If these or other factors have influenced the collective behavior of our students, is there anything that we can do about it? How do we transform today's students into tomorrow's professional optometrists?

Responsibility. Accountability. Integrity. Ethics. Setting the tone. Role modeling. Do these constructs sound familiar? Do we consistently promote, encourage, expect, and practice them at our schools and colleges of optometry? Are we as faculty somehow contributing to the decline of our students' professional attitudes? In an interesting and provocative article by Arnold et al.[3], medical students and residents were asked to evaluate their teachers' behaviors in an effort to develop a scale by which to measure professionalism. While excellence, honor/integrity, and altruism/respect were found to be key indicators of professionalism, there was also disturbing data about just how often teachers demonstrated what might be construed as unprofessional behavior.

Most instructors, didactic and clinical alike, will tell you that you can set the hurdle at virtually any level and, given enough information and guidance, students will rise to the challenge. We do this all the time. Yet how often do we spend time on setting the tone for professional expectations of our students? At what point in professional education are professional demeanor, professional values, and professional attitudes introduced into the lives of our students? How are they practiced and role modeled by us, and how are they measured?

Becoming a professional requires dedication, commitment, and an openness to learning. In some ways it is also a lesson in maturity (and, in many cases, humility) that enables a particular professional-in-training to reach beyond his or her own self-centered needs and replace those needs with the rendering of care to a patient, with the patient's needs becoming the more important. Caring for people is a privilege afforded to only a few members of our society, but do our students, and we, the faculty, truly understand and appreciate this privilege?

What if we approached teaching professionalism and professional attitudes differently? What if the chairpersons of the boards of trustees of our schools and colleges, our presidents, our deans, and our faculty made a commitment from the top down that teaching professional

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behavior and demeanor is just as important as the basic sciences, optics, disease, and clinical sciences? Many of the mission statements of our schools and colleges speak to the development of the professional, but how many go beyond lip service and actively seek to instill these values into their students?

Imagine that, from the point of first contact with a college of optometry, a prospective student were given information pertaining to learning professional behavior, both as a provider and as a consumer of professional education. Suppose that during the application process we became more interested in what prospective students thought about being professionals and what personal qualities they felt they possessed and could contribute to optometry, instead of the standard types of questions posed to them about why they want to become optometrists, or how they are going to pay for their education?

If all institutions were to set a tone of professionalism from the beginning of a student's educational experience and made an effort to consistently reinforce principles of professional behavior, we would improve our chances of graduating doctors who carry those professional attributes into practice.

We are headed in this general direction. An example is the Southern College of Optometry, which has moved its Optometric Oath Ceremony to the first year of the professional degree program (see story on page 75). Many medical schools also now engage in a "white coat ceremony" as part of the tradition and privilege of being selected for a seat in a school of medicine. These ceremonies are important benchmarks in the formation of a professional. But ceremony alone will not make the difference. If we truly care, we must all "talk the talk" and "walk the walk." ■

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1. Hensel WA, Dickey NW. Teaching professionalism: passing the torch. Acad Med 1998; 73:865-70.
2. Reed RR, Evans D. The deprofessionalization of medicine. JAMA 1987; 258:3279-82.
3. Arnold EL, Blank LL, Race KE, Cipparrone N. Can professionalism be measured? The development of a scale for use in the medical environment. Acad Med 1998; 73:1119-1121.

ASCO Meetings Calendar

June 11-13 **Academic Officers Meeting**
Oakbrook, Illinois

(Note: the following meetings are at the Henry B. Gonzalez Convention Center and Marriott Rivercenter, San Antonio, Texas)

June 22 **Executive Committee Breakfast**
8:00 a.m. – 11:00 a.m.
Board of Directors Meeting
1:00 p.m. – 5:00 p.m.

June 23 **Board of Directors Meeting**
8:00 a.m. – 12:00 p.m.
Annual Luncheon
12:30 p.m. – 2:30 p.m.

June 25 **Sustaining Member Advisory Committee Breakfast**
7:30 a.m. – 10:00 a.m.

For the most up-to-date information on ASCO meetings, contact ASCO's website at http://www.opted.org

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OPHTHALMIC INDUSTRY NEWS

B & L Receives FDA Approval For Pure Vision™ Lenses

Bausch & Lomb received marketing approval in the United States for the first silicone-hydrogel lens for extended wear of up to seven days. The FDA approval gives Bausch & Lomb clearance to market **PureVision™**, a new soft contact lens made of balafilcon A, with AerGel technology. According to B & L, AerGel technology's unique blending of silicone and hydrogel offers a new level of ocular health and comfort in extended wear contact lenses. The lens combines the oxygen transmissibility of silicone and the fluid transport capacity, dehydration resistance and viscoelastic properties of conventional hydrogels.

Alcon Website Offers Eyecare Information

Alcon's comprehensive site on the World Wide Web at www.alconlabs.com is an excellent basic reference for eyecare information. It has sections oriented to consumers and eye care professionals as well as an overview of the corporation. Topics covered in its professional resource, the *Alcon Journal*, include meetings and seminars, Alcon products, customer and technical services and medical publications and links. Alcon's consumer section, *Eyecare Online*, contains information regarding allergies, eye surgery and contact lens care. **Alcon Laboratories, Inc.** is the global leader in research, development, manufacture and marketing of ophthalmic products, including surgical instruments and accessory products, intraocular lenses, prescription drugs and contact lens care solutions. Alcon is a wholly owned subsidiary of Nestle S.A. Founded in Fort Worth, Texas in 1947, Alcon now employs nearly 10,000 individuals around the world. Total sales in 1997 exceeded $2 billion with products being sold in 170 markets. Over the next five years, Alcon plans to spend nearly one billion dollars on eye-related research, an amount exceeded only by the National Eye Institute, according to Mary Dulle, Alcon's director of corporate communications.

CIBA Introduces Focus®Lens Drops

CIBA Vision announced the introduction of **Focus®Lens Drops,** an addition to the Focus brand family that gives contact lens wearers a solution to dry, sticky lenses and dry eyes associated with contact lenses, while promoting better eye health. Focus Lens Drops contain Oxygentle, a proprietary ingredient that increases tearflow and allows additional oxygen to the cornea by temporarily flattening the lens. In addition, Focus Lens Drops contain Lubriclens, a lubricating ingredient that helps wash away dirt and debris from contact lenses, leaving eyes refreshed and more comfortable according to Steven T. Schuster, president of CIBA Vision North America.

Paragon Announces Staff Changes

Paragon Vision Sciences, a U.S.-based global leader in the production of innovative oxygen permeable contact lens materials and specialty soft contact lenses, announced the promotion of David Moreira to vice president of worldwide marketing. In his new role, Moreira will be responsible for practitioner marketing for North America in addition to his current international marketing responsibilities. Paragon president, Joe Sicar, also announced additional staff changes. Kathy Shafer has been named director of North American practitioner marketing and Peter Fox has been named director of customer marketing.

Marchon and Nautica Launch New Eyewear Collections

Marchon Eyewear has joined with design powerhouse Nautica on a new collection. The licensing agreement will give Marchon the worldwide license for both the sun and ophthalmic eyewear collections. Globally, Nautica is heralded as a leader in men's wear and a growing force in women's, children's and home products. "With Marchon's expertise in manufacturing, marketing and distribution behind the Nautica name, the new eyewear line will make a strong showing in the year to come," said David Chu, Nautica's CEO, founder and designer. "The business potential for Nautica is tremendous," noted Marchon co-president Al Berg, "in that it is inclusive rather than exclusive. Almost everyone owns Nautica or knows someone who does."

VICA Takes Bus on *Road to Better Vision*

VICA, the **Vision Council of America,** announced its *Great American Sight-Seeing Tour* as the centerpiece of its 1999 public relations campaign, *Eye-99: VICA's Road to Better Vision.* Immediately after International Vision Expo/East '99, the bus left the Javits Center in New York City and is winding its way across the country spreading eyewear and eyecare messages. The tour will stop in 10 cities in five weeks with a final appearance at International Vision Expo/West '99 in Las Vegas this September. Highlights of the tour will include vision screenings for children and adults, eyewear makeovers for local VIPs, Envision Yourself seminars for eyecare professionals and optical laboratories, receptions for ophthalmic and industry professionals and local and national media efforts. The tour will also have a presence at the Opticians Association of America and the American Optometric Association shows in June, and at the Optical Laboratories Association show in November. For more information, contact Bill Wilson (ext. 230) or Kate Achelpohl (ext. 229), VICA (703) 243-1508.

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*The Optometric Oath**

With full deliberation I freely and solemnly pledge that:

I will practice the art and science of optometry faithfully and conscientiously, and to the fullest scope of my competence.

I will uphold and honorably promote by example and action the highest standard, ethics and ideals of my chosen profession and the honor of the degree, Doctor of Optometry, which has been granted me.

I will provide professional care for those who seek my services, with concern, with compassion and with due regard for their human rights and dignity.

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.

I will hold as privileged and inviolable all information entrusted to me in confidence by my patients.

I will advise my patients fully and honestly of all which may serve to restore, maintain or enhance their vision and general health.

I will strive continuously to broaden my knowledge and skills so that my patients may benefit from all new and efficacious means to enhance the care of human vision.

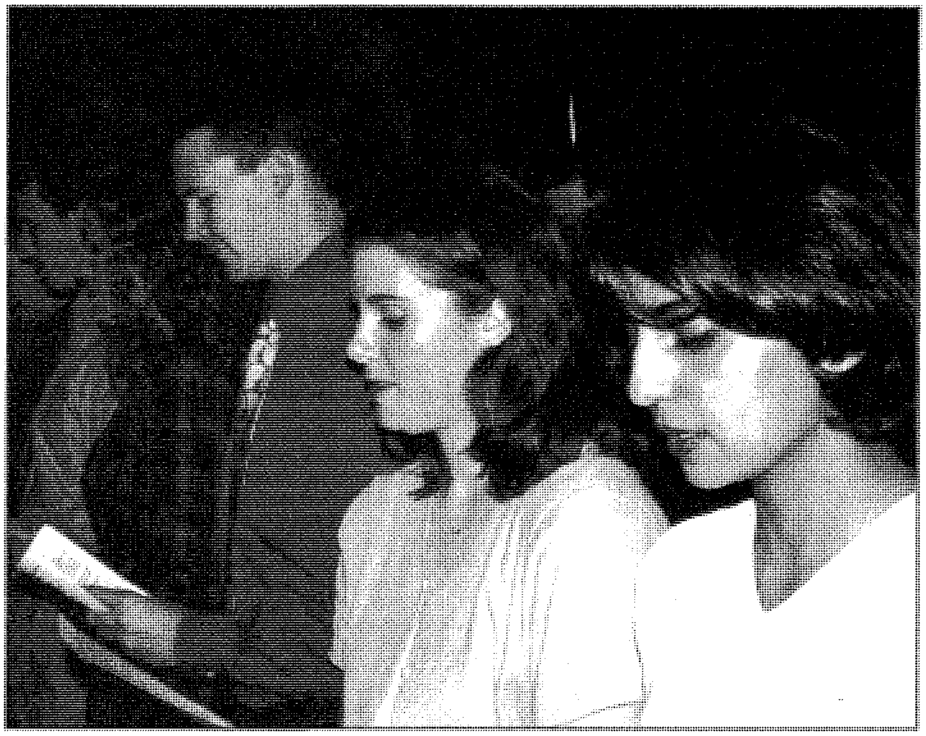
I will share information cordially and unselfishly with my fellow optometrists and other professionals for the benefit of patients and the advancement of human knowledge and welfare.

I will do my utmost to serve my community, my country and humankind as a citizen as well as an optometrist.

I hereby commit myself to be steadfast in the performance of this my solemn oath and obligation.

*The oath was adopted in 1986 by AOA's House of Delegates and by ASCO's Board of Directors.

First Year Students Pledge Professionalism During Oath Ceremony



First year students at Southern College of Optometry (SCO) pledged professionalism, high ethical standards and commitment to optometry during an Optometric Oath Ceremony held in fall 1998 at a church adjacent to the college.

Last year was the first time in SCO's history that students pledged their commitment so early in their professional training. Previously, SCO students had taken the Optometric Oath during graduation ceremonies immediately before entering practice.

Second year student Kayla Strain, who participated in last year's historic occasion, said, "Being a part of the Optometric Oath ceremony at the beginning of my first year challenged me to refocus my goals. The undergraduate mind set that all I needed to do was make good grades could no longer exist. I was here for a much bigger reason – to truly learn how to care for the needs of my patients. Their well-being had to become the top priority of my education."

Vice president for institutional advancement, Lisa R. Wade, O.D., M.P.A., who conceived the idea for the ceremony, stated, "The college feels that a continued emphasis must be placed on ethics and professionalism to prepare today's student for practice in a rapidly changing health care environment. The traditional doctor/patient relationship has been eroded by a healthcare system that frequently puts profits ahead of patients. We feel it is critical to the viability of our profession that the welfare of the patient always remains foremost in the optometrist's mind....[the ceremony] establishes early on in their professional education their roles and responsibilities as primary health care providers in the community at large."

As part of the ceremony, first year students also received their first "white coat" to symbolize their entrance into the optometric profession. Marchon Eyewear, Inc., a leading distributor and manufacturer of eyewear, sunwear and optical software, and an ASCO sustaining member, generously supported the project by funding the lab coats for the entire class of 121 students.

SCO president William E. Cochran, O.D., administered the oath, and vice president of clinical programs, Frank S. Gibson, O.D., spoke with the students on what being an optometrist means to him.

Moving the oath ceremony to the beginning of the student's training is only one of many steps SCO is undertaking to foster a greater awareness of ethical and professional behavior in its students. Other initiatives include: first year students undertaking formal instruction in ethical decision-making; faculty undergoing training sessions on mentoring students in the development of professional and personal ethics and the college instituting ethical "grand rounds" to sensitize students to the complexity of decision-making in today's health care environment. ■

A Comprehensive Approach to Critically Evaluate An Examination

Ruth A. Trachimowicz, Ph.D., O.D.
David Y. Lee, O.D., Ph.D., F.A.A.O

ABSTRACT

At the Illinois College of Optometry a peer review committee was formed to evaluate the exams of both basic science and clinical courses. Its purpose is to provide an objective means of evaluating a faculty member's teaching ability in addition to reviewing the course syllabus, lecture notes, lab manuals and student evaluations, which can be very subjective. This paper describes how five different aspects of an exam (exam content, exam construction, statistical analysis, adjusted questions and instructor's rationale) are evaluated to determine the overall quality and effectiveness of an exam as a whole as well as that of the individual test items. The use of the information obtained by this evaluation method by both the faculty and the administration is also discussed.

Key Words: *discrimination index, exam construction, exam content, instructor's rationale, statistically flawed items, exam mean*

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Dr. Lee is a professor of physiological optics at the Illinois College of Optometry.

Introduction

When instructors evaluate their exams, the focus is typically on the exam mean and the percent correct (PC) for each test item. They may also consider the discrimination index (DI) for each item, if it is available. For example, if an item has a low PC and/or the DI value is low, they may look at that individual item more closely to determine whether it is flawed in some way and should be removed or adjusted. While this type of analysis provides information about individual items, it does not take into consideration other factors that would allow instructors to evaluate the quality of their exams as a whole. Questions instructors could ask themselves to help determine the overall quality of the exam might include:

- Does the exam, as a whole, challenge the students intellectually?
- Are there so many easy questions on the exam that even the poor students can pass with a few lucky guesses?
- Are the questions written in an ambiguous manner so that the exam is testing students' test-taking skills rather than their level of knowledge?
- Do the students' and instructor's expectations match?
- Does the exam contain a representative sample of important concepts?
- Does the instructor test what he or she teaches?
- How does the instructor deal with bad questions?
- Is the exam so difficult that it discourages even the best students?

To try to answer these questions and improve faculty test writing skills, we developed a new system to evaluate exams as a whole. Five areas of the examination are evaluated: **exam content, exam construction, statistical analysis, adjusted questions and instructor's rationale.**

Our evaluation method is comprehensive, quick, easy and addresses many of the factors described above. In this way we can evaluate the overall quality of the exam in addition to the quality of the individual test items. With our system the instructor can determine, at a quick glance, how difficult the exam actually is irrespective of the mean, as well as spotting the very difficult and very easy items. Our method takes into account the instructor's rationale concerning construction of the exam, the level of proficiency required by the course, the exam content and construction, and establishes criteria to define the characteristics of flawed items. Our evaluation method has been implemented to review exams of both basic science and clinical courses at the Illinois College of Optometry by a peer review committee, the Committee to Review Exams (CRE). The CRE consists of a chairperson and five committee members all appointed by the Dean and includes both junior and senior faculty members. The goals of this evaluation process are twofold: (1) to provide a means of objectively evaluating the quality of a faculty member's teaching ability in addition to traditional student evaluations and (2) to provide the faculty with detailed, constructive input on how to improve the quality of their exams.

In the paragraphs that follow, each of the five areas (exam content, exam construction, statistical analysis, adjusted questions and instructor's rationale) are described with examples of how each area is evaluated by the CRE reviewer and how an instructor can use the information to help determine the quality of his or her exam.

(1) Exam Content — "How Come Dr. X Never Tests What He Teaches?"

One common complaint by students, especially those who did poorly, is that the exam content did not reflect the course material. There are many reasons why this could happen. For example, if the students did not read the assigned readings they would not be able to answer questions regarding them. At other times many of the questions could test difficult topics that students decided to ignore. On the other hand, an easy topic that a student felt prepared for may not be tested because the instructor was aware that students already knew these areas well and decided to test other more challenging topics. Or the complaint could simply be an excuse or misperception by students who performed poorly on the exam. While it may not be possible to know every reason for the difference in expectations between the instructor and the students, we feel that this disparity could easily be evaluated and investigated by examining the course content outline. The content outline should be sufficiently detailed and be regarded as a "contract" between the course instructor and both the students and the administration. The test items selected should be a representative sample of the course content being measured (for a more detailed discussion refer to Ebel and Frisbie[1]).

After the exam is given, the course instructor is asked to identify each test question on the content outline. If a question covers more than one topic on the outline, the item number is placed by each topic on the outline. The reviewer then assesses if the test questions were well distributed over the course content outline. The reviewer may comment if there is a significant over- or under-emphasis of some areas on the exam; however, we do recognize that the instructor should have the discretion to emphasize certain lecture topics on an exam. For example, the instructor might ask more questions on a certain topic either because of the complexity of the subject matter or because more lecture time was spent on that subject. This seems reasonable as long as the students are warned in advance that the exam will have greater emphasis in specific areas.

(2) Exam Construction -"Why Can't Dr. X Be Straightforward Like Dr. Y?"

This is a complaint we often hear from students after a difficult exam. Typically it is the students who did poorly on the exam who complain, since the students who did well took pride in their ability to perform well on a difficult exam. An exam might not be straightforward for different reasons. One reason could be that an exam contains questions written to test different cognitive skills, where skill level 1 represents the ability to recall previously learned facts and principles, level 2 represents the ability to calculate and interpret data and level 3 represents the ability to resolve a problem or evaluate a clinical situation[2]. Since skill levels 2 and 3 measure a student's ability to apply previously learned knowledge in a clinical context, rather than simple recall, the students often consider these types of questions difficult or tricky. However these types of questions have been found to most readily measure professional competency or readiness[2]. It would therefore be appropriate to have a certain percentage of skill level 2 and 3 questions on exams, even though students may consider them less straightforward.

Another reason test items may not be straightforward is that the questions were not well constructed. An exam should test the students' level of knowledge, not their ability to fumble through awkwardly worded sentences. Ambiguities, technical flaws or multiple correct answers can lead to misreading and misinterpretation by the students[3]. Clearly worded exams are especially important in first year optometry courses, where the students may be unfamiliar with the strategy of taking a multiple choice exam or for whom English is a second language. This is also true for second year optometry students who are now taking clinical courses from instructors who write clinical case questions.

To assess if an exam is well constructed, we developed a checklist which includes the following guidelines:

- Use concise wording in the stem that is free of ambiguity.
- Avoid the use of double negatives.
- Avoid the use of the true-false format because it typically tests the ability to recall previously learned facts (skill level 1). Students have a 50% probability of getting the item correct by chance alone.
- Avoid writing questions on trivialized knowledge that will just be a free point for the entire class.
- Correct all grammatical and typographical errors before the exam is sent to the printer (since it is disruptive to make corrections during the exam).

The reviewer reads each test question to see if any of these guidelines are disregarded and, if so, notes the number of the test question by the appropriate guideline on the checklist. At the same time the reviewer can rank each question as skill level 1, 2 or 3 and note it on the evaluation form. The reviewer will recommend that the instructor rewrite those questions that do not follow the guidelines. As concerns the skill levels, if there is a preponderance of skill level 1 questions, the reviewer will recommend that the faculty member attempt to rewrite at least some of them so that they test higher skill levels.

Equally important is the development of effective distractors. Although the number of plausible choices will vary with each question, 3–5 choices should be provided.[2] Ideally all the incorrect choices should be good distractors. Good distractors should bear a rational, though incorrect logic. For example, it may be an incorrect response students might supply if multiple choices were not provided.[2] Presumably a good distractor will be chosen by more of the students who performed poorly on the exam than by the students who did well on the exam. Conversely, bad distractors are choices that were not selected by any students. A bad distractor increases the probability of successful guessing and therefore is not desirable. The instructor is encouraged to discard or rewrite the bad distractors before the questions are used on future exams.

(3) Statistical Analysis - "The Not Very Meaningful Mean"

The overall effectiveness of an exam can be analyzed by looking at the percent correct (PC) and the discrimination index (DI) of each item. The PC measures the item's level of difficulty; the larger the numerical value, the easier the question. The DI measures the ability of the question to distinguish between students who performed well on the exam and students who performed poorly on the exam. There are several different methods to calculate the discrimination index. These include: point biserial correlation coefficient (PBCC)[1,4,5], biserial correlation[1] and the upper-lower difference index[1], also known as the item discrimination ratio.[4] We chose to use the item discrimination ratio to calculate the DI for several reasons. As pointed out by Ebel and Frisbie[1], it is easier to compute and easier to explain to others compared to the PBCC and biserial correlations. Other methods of evaluating DI values require more complex formulas which usually need item analysis by computer programs. (For a more detailed discussion of how the DI can be calculated, refer to references 1 and 5). The item discrimination ratio looks at the difference in the proportion of correct responses between the upper and lower 27% of the class[1]. This can be easily calculated by subtracting the percent of students in the lower 27% of the class who got the question correct from the percent of students in the upper 27% of the class who got the question correct.

A profile of the exam, condensed into two easy-to-read histograms, can be obtained in less than five minutes by plotting the frequency of the PC and DI. We did this by placing the number of each test item in the appropriate cell of the histogram as shown in Figure 1. By looking at the histograms we were able to gain insight into the exam and draw conclusions at a glance.

Why a Mean by Itself Can Be Misleading

The one exam statistic that is quoted most often is the mean. The mean, however, can be very misleading. To illustrate this point we will show you the histograms for PC and DI values from 3 different exams, all with approximately the same mean (78-80%). (See Figure 1).

Example 1:

This exam has a mean of 80% and would be considered a "typical" exam. The PC histogram has a unimodal distribution that peaks at the 80-89% range. Only 4 out of 48 questions (8.3%) would be defined as "easy" (95-100% of the class got the questions correct) and the questions are well distributed over all percentage values. The DI values are also well distributed, with an average DI = 0.22.

Example 2:

While the mean of this exam (77.9%) is about the same as the previous one, this exam is more challenging because a larger number of test questions have DI values in the 0.30-0.40 range. The average DI value is therefore higher (DI = 0.32).

Example 3:

Once again, this exam has an overall average of 79.6%. Based solely on the mean, it does not appear to be any different from the first two exams. But the histograms paint a much different picture of the exam. First, the PC histogram has a trimodal distribution with peaks in the 95-100%, 80-89% and <50% correct range. Second, 16 of the 50 questions (32%) lie in the 95-100% correct range. At first glance, one would guess by the appearance of the histogram that the exam mean is closer to 85%. Several questions, however, are clustered in the <50% correct range and that drags the mean down. Third, the DI values are clustered in the <0.00 to <0.20 range with an average DI = 0.16, indicating that a majority of the questions (31/50= 62%) did not discriminate the students who did well on the exam from those that did poorly on the exam. The presence of a multimodal distribution, as in this case, could be due to several factors. For example, the instructor may have written many easy questions and then added a few harder questions in order to lower the class mean. On the other hand, the exam might have included several different types of questions: some testing recall material and others testing new, never previously tested material. In the latter case, the recall questions probably fell in the 95-100% correct range, while the new items might have been more challenging and fell in the 80-89% and <50% correct ranges. In this instance, where old and new material is being tested, a multimodal distribution might be appropriate.

Another interesting point to bring up about multimodal exams is that sometimes the average students would consider them "easy" exams because all they want is to pass with a "C" and the easy questions helped raise their grade. On the other hand, the top students would come away saying they were "difficult exams" because they wanted to pass with an "A" but the harder questions probably lowered their score. In any case the instructor's rationale would need to be reviewed to determine if his/her strategy in constructing the exam was logical and reasonable.

To further evaluate the degree of difficulty of the third exam, one may tabulate the number of easy questions on the exam (e.g. 16 of the 50 questions (32%) fell in the 95-100% correct range). Assuming each question has 4 choices, a student should get a score of 25% correct by pure chance guessing. If this is coupled with the fact that 32% of the questions in example 3 lie in the ≥95% correct range, (assuming that the ≥95% questions are such easy items that a student does not have to know much at all to get them correct), then the student's chance score will now increase from 25% to 49% because 16 of the 50 questions (32%) are easy and 25% of the remaining 34 questions can be gotten purely by chance:

$$32\% + 0.25\,((50\text{-}16)/50) = 32\% + 17\% = 49\%.$$

Therefore, a student would be able to get a score of 49% on the exam in example 3 simply by a combination of very easy questions and pure luck. Consequently, this exam would be considered an "easy" exam, rather than a "typical" exam like examples 1 and 2 even though its mean is similar to the means of the exams in examples 1 and 2. That is why, by itself, the mean may be misleading. To avoid this problem the instructor should not use too many easy questions and then balance the mean by adding a few difficult ones, because it may encourage the students to have only a superficial understanding of the material and not even attempt to master the more difficult concepts.

The CRE reviewer will calculate the exam's "easiness" using the formula shown above. If its value approaches the passing grade of the course, the reviewer will recommend that more challenging questions (e.g. questions that test higher skill levels or have better distractors) be used on future exams. The instructor will also be reminded that this level of easiness is discouraged unless the lecture material warrants it (see section on Instructor Rationale).

The "Relative" Nature of the DI

Assuming the typical pedagogical philosophy that a learning environment should properly challenge the students, higher discrimination indices would be more desirable. But how high is high enough? Could a value for the average DI be established as a reference? This is a difficult question to

Figure 1

Percent correct and DI histograms for 3 different exams that have approximately the same mean. Each cell of the histograms contains the number of 1 or 2 exam items that had the corresponding percent correct or DI value listed on the x-axis. Note that the test mean and the average of all the individual items' DI values for that exam, called the "Average DI," are shown at the top of each histogram.

Example 1 :

Test Mean: 80.17%

Number of Items	≥95%	≥90%	≥80%	≥70%	≥60%	≥50%	<50%	Thrown out
20								
18								
16			39, 43					
14			37, 38					
12			32,35	47				
10		91	25, 26	44, 46				
8		30, 31	22, 23	36, 40				
6		24, 28	15, 19	29,34	45			
4	20, 33	7, 11	10, 13	9, 16	41, 42			
2	14, 17	3, 6	4, 5	1, 2	18, 21	8	12, 27	

% Correct for test item

Average DI: 0.22

Number of Items	<0.00	≥0.00	≥0.10	≥0.20	≥0.30	≥0.40	≥0.50	≥0.60
20								
18								
16			42, 13					
14			33, 36					
12			31, 32	38, 40				
10			25, 28	29, 34				
8		21, 30	23, 24	22, 27				
6		19, 20	12, 15	13, 18	43, 44			
4		14, 17	7, 11	8, 10	37, 39	46, 47		
2		3, 9	1, 6	4, 5	2, 35	26, 45	16, 41	

Discrimination Index for test item

Example 2 :

Test Mean: 77.90%

Number of Items	≥95%	≥90%	≥80%	≥70%	≥60%	≥50%	<50%	Thrown out
20								
18								
16								
14								
12								
10								
8								
6								
4		17, 18	9, 10	12, 14	16			
2	13	6, 11	1, 8	2, 4	7, 15	3, 5		

% Correct for test item

Average DI: 0.31

Number of Items	<0.00	≥0.00	≥0.10	≥0.20	≥0.30	≥0.40	≥0.50	≥0.60
20								
18								
16								
14								
12								
10								
8				14, 18				
6				10, 11				
4				8, 9			7	
2		13	6, 17	1, 5	4	12, 16	2, 3	15

Discrimination Index for test item

Example 3 :

Test Mean: 79.60%

Number of Items	≥95%	≥90%	≥80%	≥70%	≥60%	≥50%	<50%	Thrown out
20								
18								
16	34, 49							
14	32, 33							
12	28, 31		47					
10	24, 26		29, 36					
8	15, 22		25, 27					
6	13, 14	48,50	16, 20	44	42		41, 46	
4	5, 12	30, 45	9, 11	39, 43	38, 40		17, 18	
2	1, 4	3, 21	2, 6	23, 35	8, 37	19	7, 10	

% Correct for test item

Average DI: 0.16

Number of Items	<0.00	≥0.00	≥0.10	≥0.20	≥0.30	≥0.40	≥0.50	≥0.60
20								
18		50						
16		45, 49						
14		33, 34	48					
12		31, 32	43, 47					
10		28, 30	35, 38	44				
8		22, 26	25, 29	37, 42				
6		14, 17	20, 24	27, 36				
4		12, 13	6, 16	21, 23	19, 39	41, 46		
2	10, 15	4, 5	1, 3	2, 11	9, 18	7, 8	40	

Discrimination Index for test item

answer because other factors can affect the DI. First, the DI values could be significantly different depending upon which method was chosen to calculate the DI (e.g. item discrimination ratio, PBCC or biserial correlation coefficient)[1]. Even within a chosen method, such as the item discrimination ratio, the DI can vary depending upon the percentages of the upper and lower portions of the class used (e.g. 27% vs. 33%).[1] Therefore all of these parameters must be specified if an average or reference DI is to be established. Second, the content of the course material may warrant a lower DI value. We will more fully explain this last point in the section on Instructor's Rationale. Third, differences in DI values may exist among the different academic years. DI values may be higher initially for first year courses. As the weak students are lost in the first year for academic reasons, the DI values may be expected to decrease. Conversely, DI values may be higher for second and third year courses as the instructors write more questions requiring higher skill levels. Our preliminary data suggests that the class composition may become more homogeneous by the third academic year. This increased homogeneity may be due to the loss of academically weaker students in the first 2 years.

Despite the varying nature of the DI, it is still very useful in many ways. For example, an instructor can use it to monitor his/her improvement on a yearly basis or to improve the discrimination ability of an item by rewriting the poor distractors. In addition, the department chairperson may use the average DI (of all questions of an examination) to compare different courses or instructors. In some cases, more higher skill level questions, which typically yield higher DI values, should be included on an exam. If an instructor's average DI is consistently lower than the average DI of other instructors, it is imperative to determine the reason for the low DI values and review the instructor's rationale.

(4) Adjusted Questions - "To Curve or Not to Curve, That Is the Question!"

Consider the following scenario: You give an exam, anticipate the class will do reasonably well and they perform very poorly. One common way people handle this situation is by curving the exam (e.g. by adding 5% to everyone's score). But a more appropriate alternative would be to look at the statistics of each question, especially the statistically flawed items, to determine what adjustments need to be made.

Using our system of evaluation, questions were classified as statistically flawed if they had either a negative DI value or if they had a difficulty level that was less than 50% along with a DI value >0.20. (It should be noted that the NBEO automatically "flags" new questions for review if less than 40% of the students get them correct [personal communication LJ Gross, March 7, 1997]). In our evaluation, we ask the instructor to provide a list of adjusted questions and include both why and how each question was adjusted. The reviewer will record all statistically flawed questions on the evaluation form and compare them to the instructor's list of adjusted questions. The reviewer will comment on the method of adjustment if it appears inappropriate or if the rationale behind it is questionable. If statistically flawed questions are not adjusted the instructor is encouraged to re-evaluate these flawed items and make appropriate adjustments if necessary.

There are several different ways a question can be adjusted. For example, if the students present valid arguments as to why they chose a different answer than the one keyed as the correct answer the instructor may chose to accept more than one answer. If there is no correct answer, they may omit the question by either giving the whole class credit for the question or removing the question from the computer so that no one gets credit for the question. If a small percentage of students get the question correct but the item has a high DI value, the instructor may chose to reduce the total number of questions possible on the exam by one but not rescore the exam. In this case the small percentage of students who got the question correct (presumably due to their better understanding of the material, as indicated by the high DI value) would not be penalized.

There are also times when students say that an instructor writes "tricky" questions. What is a "tricky" question and should allegedly "tricky" questions be adjusted? We defined a tricky question as one that does not test the students' knowledge base and the responses of students in the upper and lower portions of the class are not different. All the students are "tricked" equally to select the incorrect answer, resulting in a statistically flawed question with a low PC and a low DI value. It should be noted that not all statistically flawed questions have a "tricky" component. Sometimes a question is so difficult (e.g. never taught or never included in assigned readings) that no one, including the top students, have any clue as to what the correct answer should be. These questions need to be looked at carefully and perhaps eliminated.

(5) Instructor's Rationale (Is "Easy" Always Bad?)

In certain courses, the nature of the material presented may warrant that the questions have a low degree of difficulty. We have observed that exams for such courses consistently have high means each year. A first year introductory course that reviews basic material that two-thirds of the class had in undergraduate school, such as the pharmacochemistry course taught to our first year students, would be one example of such a course. For this course, the instructor's goal is to get everyone to the same basic level of knowledge in preparation for another related course, biochemistry, which will be taught the next quarter.

Likewise, a high mean or high number of 95 -100% correct questions would be expected for courses that contain material that would have serious consequences if the material was not known well by the students (e.g. ocular emergencies and CPR). In such cases the instructor might even raise the expected passing grade above the usual ≥65%. Knowing the instructor's expectations of the difficulty level of the exam and his/her particular approach to the exam's content helps to better understand and interpret the exam's PC and DI histograms and prevents inappropriately labeling an exam as too easy or not particularly challenging given the subject matter tested. Therefore, in our evaluation system, rationale forms are sent to all instructors whose exams are to be reviewed. And while the appropriateness of the instructor's strategy depends on the pedagogical rationale of the course, it should be remembered that the use of too many easy questions does not encourage students to master the subject matter in depth.

The CRE Forms

In addition to completing the detailed CRE evaluation form, a separate summary sheet is used to outline any major strengths and weaknesses noted in the five major areas described above (exam content, exam construction, statistical analysis, adjusted questions and instructor's rationale). Both the department chairperson and the faculty member receive a copy of these forms. Faculty members are encouraged to speak with the primary reviewer when they have questions or concerns. In our experience, when weaknesses have been noted, faculty members have responded by soliciting additional input from the CRE.

Advantages of This Evaluation Method

Our method of evaluating an examination is easy and quick. It provides the instructor with a more global view of the whole exam in addition to information about individual items. By looking at the percent correct (PC) and discrimination index (DI) histograms, the items that do not discriminate well and the very easy items can be spotted immediately. The non-discriminating items can then be further evaluated to decide if adjustments need to be made and/or if the items need to be rewritten before using them on future exams. The instructor can also determine at a quick glance how difficult the exam actually is irrespective of the mean.

The additional advantage of our system is that the two indices (PC and DI) allow an easy comparison of the quality of the instructor's exams over several years to see if it has been improving. Based on this information, the administration could also make comparisons among different courses and instructors. If significant differences are found among faculty, exam writing workshops may be one good way to help improve the quality of the poor exams. Another advantage of the CRE evaluation is that the junior faculty that serve on the committee quickly gain insight into the essential features of a good exam and hopefully apply what they have learned when writing their own exams.

At the Illinois College of Optometry, the CRE evaluations are used in conjunction with teaching portfolios and student evaluations to assess a faculty member's overall teaching performance. The CRE evaluations assess the quality of an instructor's exams. Teaching portfolios are used to evaluate instructor rationale, teaching innovations and updates to lectures and/or laboratories. Student evaluations are used to assess the clarity of lecture presentations and the instructor's level of enthusiasm. We feel that this combined approach provides a more comprehensive evaluation of teaching ability. ■

NOTE: Although we could not include the actual CRE evaluation form in the paper, we will gladly send a copy of the form to anyone who is interested. Contact: rtrachim@eyeball.ico.edu

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Industry News

Continued from page 73

Wesley Jessen Resumes Promotion of Precision UV™

Wesley Jessen will resume promotion of its **Precision UV™ disposable lenses,** following the FDA's evaluation of extensive evidence provided by Wesley Jessen that substantiates UV protection claims for the product and approval of a PMA supplement applicable to such claims. "Wesley Jessen believes that incorporating UV blockers into soft lenses advances public health by providing additional protection against exposure to harmful UV radiation," said Dwight H. Akerman, O.D., F.A.A.O., director of professional services. "We are pleased that the FDA will now allow Wesley Jessen to inform patients and practitioners through labeling and advertising that the Precision UV contact lens offers protection from harmful UV radiation, and that exposure to UV radiation is one of the risk factors associated with cataract formation."

Companies Jointly Support IACLE Exam Program

ASCO Sustaining Members **Bausch & Lomb, Johnson & Johnson Vision Products, CIBA Vision, Wesley Jessen/PBH** and **Alcon Laboratories** are the sponsors of an International Association of Contact Lens Educators (IACLE) program that developed an international qualifying examination for educators. The IACLE Accreditation Examination is now available free to members to enable them to assess their own knowledge as well as providing feedback to IACLE on global needs. "Quality control in contact lens teaching is best served by all educators throughout the world meeting the standards of knowledge and skill implied in the Accreditation Examination," said Professor Brien Holden, president of IACLE. ■

Effects of Optometry School Recruitment Efforts on Urban and Suburban High School Students

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ABSTRACT

Optometry schools must develop strategic recruitment plans if they are to mitigate the chronic under-representation of certain minorities in the profession and remain competitive with other health care fields in attracting the best degree candidates. In two Oakland, CA high schools (one urban, one suburban), we conducted an audiovisual presentation designed to enhance students' interest in optometry as a potential career. The effects of the presentation were assessed through a multiple-choice questionnaire. The results suggest that few high school students are considering pursuing an O.D. degree, but that an on-site presentation of this nature can be effective in stimulating interest in optometry as a career, especially among urban minorities.

Key Words: *optometry recruitment, high school, minority students, questionnaire, career planning*

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Introduction

In recent years, optometry schools in the United States have reported steadily increasing numbers of applicants. However, the number of applicants of African American, Hispanic, and Native American ethnicities, who have traditionally been under-represented in the health care professions[1,2,3], has not increased to any significant degree. The 1993 National Health Interview Survey reported that among first year optometry school enrollments for 1991-92, only 6.7% were of ethnicities other than Caucasian or Asian American[4]. In 1995, the School of Optometry at the ethnically-diverse University of California at Berkeley reported that only 9.4% of its first-year enrollments were from these minority groups (down from 13.6% in 1992)[5], compared to a university-wide 28% enrollment of these minorities[6].

In order to attract the best possible candidates for graduate study in optometry, and to reverse the chronic under-representation of some minorities in the profession, schools of optometry must invest in the development and evaluation of strategic recruitment plans. In this paper, we describe a recruitment presentation administered to two socioeconomically distinct groups of high school students, and report the results of a survey administered to the students after the presentation.

Methods

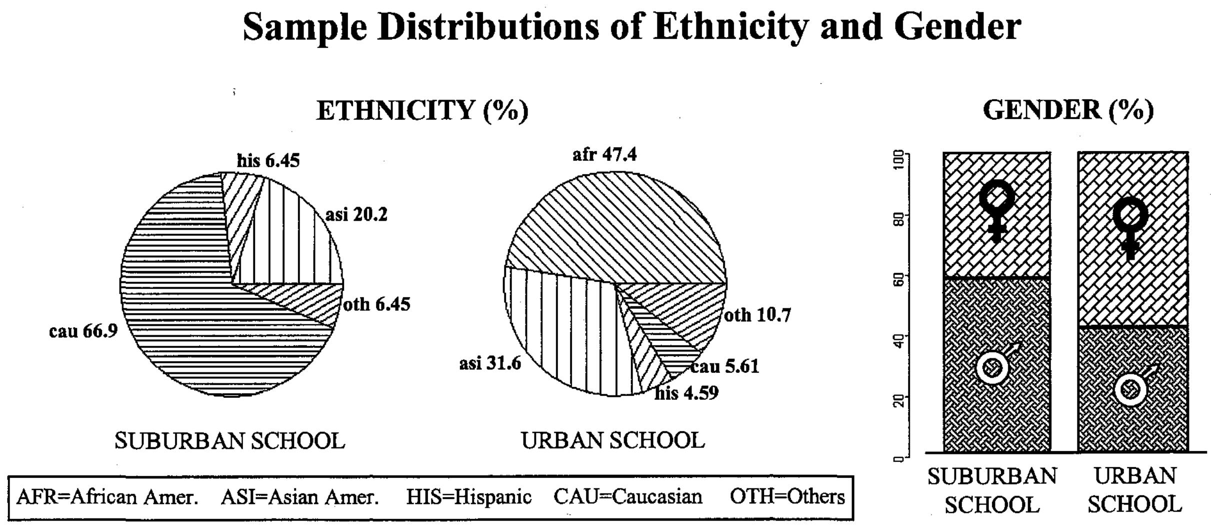
In two Oakland, CA high schools (one urban, one suburban), we conducted an audio-visual presentation, followed by a question-and-answer session, designed to enhance students' interest in optometry as a potential career. The presentation lasted approximately 20 minutes, and consisted of 45 slides presented in four sections. The first section exposed the students to the field of optometry, and demonstrated how basic techniques and ideas they learn in their science and math classes are extended to the optometric discipline. The second section described the anatomy and physiology of the eye, and highlighted the complexity of the eye and the visual system. The third section introduced the clinical practice of optometry and the role of the optometrist as the primary eye care specialist in the larger team of vision health professionals. The final section emphasized the benefits of choosing a career in optometry, and provided advice on how to plan an academic path culminating in an O.D. degree. A multiple-choice questionnaire was administered to the students after the presentation, to collect demographic information, to gauge the status of their career planning, and to assess the effects of the presentation on their interest in optometry.

The urban school sample was taken from Oakland Technical High School. In this sample (Figure 1), 5.6% of students were Caucasian, 94.4% were of other ethnicities (47.4% African American), 62.2% reported having at least one parent who attended college, and 58.0% had parents receiving Aid to Families with Dependent Children (AFDC). The suburban school sample was taken from Piedmont High School. In this sample, 66.9% of students were Caucasian, 33.1% were of other ethnicities (0.0% African American), 94.4% reported having at least one parent who attended college, and <1.0% had parents receiving AFDC. The proportions of urban and suburban school students reporting that they were likely to attend college (96.4% and 97.6%, respectively) did not differ significantly ($p=0.746$) [7,a].

Using standard sample size calculations[8], we determined that 95 stu-

Figure 1

The two high schools sampled differed with respect to ethnic composition and male-to-female ratio.



dents in each school had to be surveyed in order to detect a difference in proportions of questionnaire responses of 20% or greater, at the $\alpha=0.05$ level, with 80% power. We were able to survey 196 students from the urban school, and 124 students from the suburban school, thereby gaining statistical power.

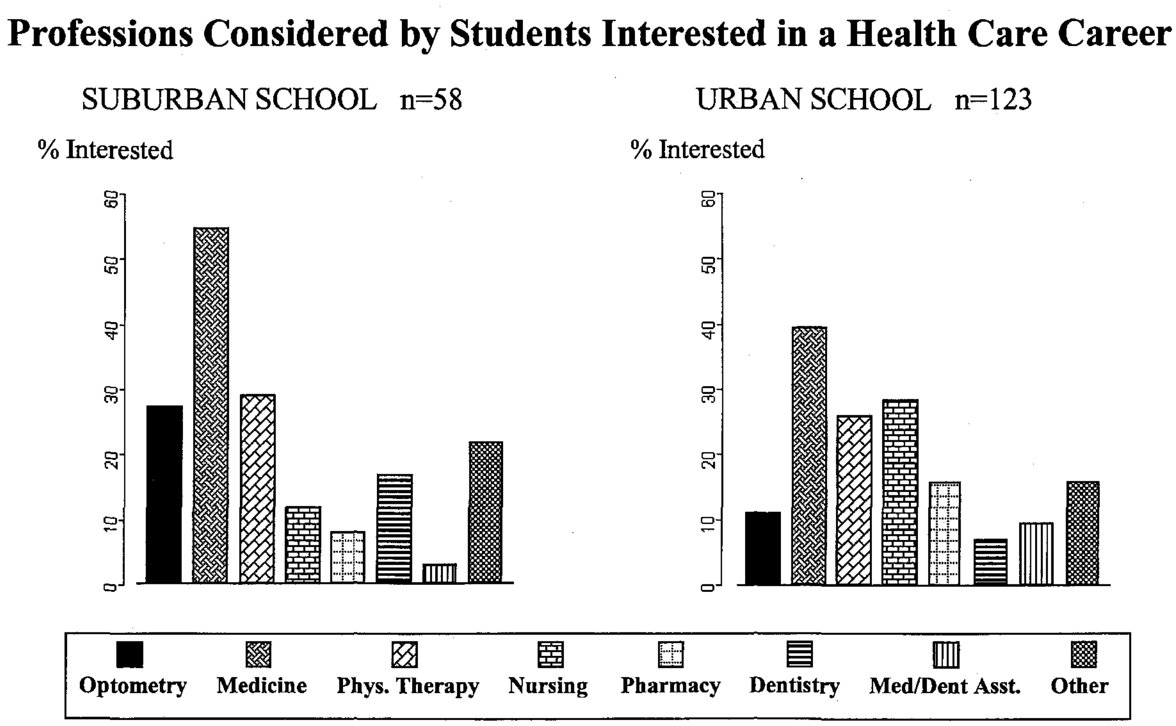
Results

Interest in the Optometric Profession

Among those being surveyed, 68.6% of students in the urban school and 47.6% in the suburban school expressed some interest in health care as a profession. Among those expressing such interest, 16.6% reported that they had considered a career in optometry (11.4% in the urban school, and 27.6% in the suburban school) prior to the presentation. In both schools, more students reported considering careers in physical therapy and medicine than in optometry, while in the urban school, optometry

Figure 2

More students are considering careers in medicine and physical therapy than in optometry. In the urban school setting, optometry also falls behind nursing and pharmacy.



also fell behind nursing and pharmacy (Figure 2).

Effects of the Presentation

Overall, 50.5% of students reported that their interest in optometry as a potential career increased because of the presentation. While the proportions of positive responses in both the urban school (57.1%) and the suburban school (40.2%) suggest that a presentation of this nature is effective in increasing interest in optometry in both populations, the proportion in the urban school was significantly greater ($p=0.004$)[8,b].

A standard measure of association between a binary outcome (e.g., a positive or non-positive response to the presentation) and some other potentially explanatory factor (e.g., belonging to the urban, as opposed to the suburban school) is the *odds ratio* (OR)[8]. Choosing (arbitrarily) the suburban school as a baseline, we computed an OR of 1.980 (approximate 95% confidence interval [95%CI]: 1.565 to 2.506), which tells us that the odds of a positive response in the urban school were 1.98 times greater than in the suburban school.

We identified two variables as potential confounders in the analysis. There were significant differences between the two school samples in the relative proportions of genders ($p=0.006$)[b], and in the relative distributions of ages ($p=0.001$)[c]. Upon examination, it did not appear that gender was confounding the relationship between school type and response to the presentation ($OR_{MH} = 2.067$)[8,d], nor was there evidence of statistical interaction ($p=0.918$)[9,e].

Because adjusting for age in the analysis was problematic, due to the extremely low frequency of responses at the extremes of the age distribution, we used high school grade level as a proxy. Adjusting for grade, rather than age, eliminated the need for small sample size adjustments, and allowed a more natural interpretation of the results, since any recruitment efforts that take age into account will, in practice, be directed at particular grade levels. The two samples did differ significantly in the relative distributions of students in the various grades ($p=0.001$)[c], and while there was little evidence of interaction ($p=0.092$)[e], it did appear that the confounding effect of grade ($OR_{MH} = 1.630$)[d] had to be taken into account in

Table 1
Effect of the Presentation in the Suburban and Urban Schools, Adjusted for Grade

Model:

$$\text{log-odds(positive response)} = -0.7516 + 0.5711(\text{school}) + 0.2504(\text{grade})$$

(SCHOOL Coded: Suburban=0, Urban=1)

Model Fit:

Parameter	Estimate	Std. Error	χ^2 P-value	Estim. OR
Intercept	-0.7516	0.2617	0.0041	.
School	0.5711	0.2430	0.0188	1.770
Grade	0.2504	0.1285	0.0513	1.285

Likelihood Ratio Tests:

	Δ(-2LogL)	df	χ^2 P-value
This model vs. Intercept-only model	12.394	2	0.002
This model vs. model without Grade	3.841	1	0.050

Table 2
Percentage of Students with Definitive Career Plans Prior to the Presentation

Grade Level	Suburban % (N)	Urban % (N)	Overall % (N)
9	27.27 (22)	33.33 (6)	28.57 (28)
10	22.73 (44)	40.68 (59)	33.01 (103)
11	13.04 (23)	48.65 (74)	40.21 (97)
12	18.18 (22)	52.17 (46)	41.18 (68)
Totals:	**20.72 (111)**	**46.49 (185)**	**36.82 (296)**

Table 3
Percentage of Students for Whom Earlier Exposure to Optometry Would Have Made a Difference in Career Plans

Grade Level	Suburban % (N)	Urban % (N)	Overall % (N)
9	0 (6)	50.00 (2)	12.50 (8)
10	0 (10)	33.33 (24)	23.53 (34)
11	0 (3)	33.33 (36)	30.77 (39)
12	0 (4)	29.17 (24)	25.00 (28)
Totals:	**0 (23)**	**32.56 (86)**	**25.69 (109)**

the analysis. We therefore fit the linear logistic regression model, *(log-odds (positive response to presentation) = - 0.7516 + 0.5711(school) + 0.2504(grade)* (Table 1), which provided an estimated OR of 1.770 for school type, adjusted for grade level[9]. While adjusting for the effect of grade level reduced our previous estimate of the OR from 1.980 to 1.770, it is still clear that the odds of a positive response are much greater in the urban school (95%CI: 1.294 to 2.246) than in the suburban school.

Status of Career Plans

In the urban school, 46.5% of students reported that they had already decided on a career, and were very sure about their choice. This figure is significantly greater ($p<0.0001$)[b] than that in the suburban school (20.7%). Again using the suburban school as a baseline, the OR for having made a definitive career choice is 3.324 (95%CI: 1.956 to 5.647).

We found that gender did not significantly confound the OR ($OR_{MH}=3.318$)[d], nor was there evidence of interaction ($p=0.920$)[e]. While intuitively one would expect the unequal distributions of students at the various grade levels to confound the relationship between school type and students' career decision status (Table 2), it turned out that the OR adjusted for grade level ($OR_{MH}=3.397$, 95%CI: 1.926 to 5.989) revealed a negligible confounding effect. There was no evidence of statistical interaction ($p=0.410$)[e].

Among the urban students who had already made definitive career choices, 57.0% expressed increased interest in optometry after the presentation, and 32.6% responded that having learned about optometry earlier in their education would have made a difference in their career choice. Interestingly, among the 23 suburban school students who had already made definitive career plans, none reported that earlier exposure to optometry would have made a difference (Table 3).

Discussion

It appears that among high school students who have some interest in a health care profession, far fewer are considering optometry than other fields like medicine and physical therapy. Among socioeconomically disadvantaged minority students in particular, optometry is rarely considered as a potential career. These results clearly indicate the need for optometry schools to develop recruitment strategies, in order to compete effectively with other health care professions for the best degree candidates, and to mitigate the lack of African American, Hispanic, and other minority optometrists.

Audio-visual presentations combined with question-and-answer sessions are commonly used as a recruitment tool in the medical and dental fields. Our study shows that recruitment presentations of this nature are effective in enhancing high school students' interest in the optometric discipline as well. Our recruitment presentation was especially effective among economically disadvantaged urban minorities, where the odds of a positive response were 1.77 times that observed in the predominantly affluent Caucasian suburban school.

Our study also found that the urban school students made definitive career choices at an earlier age, and that many of them would have considered optometry as a potential career if they had been exposed to it earlier in their education. Presentations at the high school level appear to be effective motivators in both types of schools, but in order to actually increase minority recruitment, urban minority students must be targeted at an earlier stage - in middle school, or perhaps even in elementary school. There was no evidence that earlier exposure to optometry would have made a difference in the career choices of the suburban students.

While our study shows that this type of presentation is highly effective in stimulating interest in the optometric profession, it is relatively labor-intensive. Further study is therefore needed to assess its actual impact on recruitment and retention. Before investing heavily in recruitment through on-site presentations, optometric educators need to know whether stimulating high school students' interest in this manner actually generates more applicants, and whether the young students targeted by the recruitment efforts tend to become scholars of sufficient caliber to actually achieve an O.D. degree. Future studies should address these questions, if today's optometric educators are to attract the best and brightest future health care professionals who will offer the profession adequate racial diversity in its pool of eye care specialists, role models, and future educators. ■

Footnotes

Statistical Methods

a. Fisher's Exact Test
b. Z Test for Difference in Proportions
c. χ_2 Test of Association
d. Mantel-Haenzel Adjusted Odds Ratio
e. Breslow-Day Test for Homogeneity of Odds Ratios

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Standardization of Residency Titles

Douglas J. Hoffman, O.D., F.A.A.O.

ABSTRACT

A new nomenclature system for optometric residencies was adopted by the Association of Schools and Colleges of Optometry (ASCO) in spring 1998. This system is intended to reduce confusion and ambiguity fostered by the existing program titles and is based on the content and emphasis of each program's curriculum. Nine residency titles were designated along with a system for implementation. A system for naming new programs was devised. The new system is to be implemented by the start of the 1999 residency year and will be formally re-evaluated in 2001.

Key Words: optometric residencies — family practice optometry, primary eye care, cornea and contact lenses, geriatric optometry, pediatric optometry, vision enhancement and rehabilitation, low vision rehabilitation, ocular disease and refractive and ocular surgery

Dr. Hoffman is director of residencies at The New England College of Optometry.

Background

The number and types of optometric residency programs have grown dramatically over the past twenty-five years. There are now over 100 residency programs accredited by the Council on Optometric Education (COE). Each has its own mission, goals and objectives. Since there have been no rules for residency nomenclature, new programs were named arbitrarily and in many cases without appropriate rationale. It became apparent that the existing residency titles tended to confuse student candidates, optometric educators and residency directors and supervisors.

These concerns led to a review of the 1996 ASCO Residency Directory by the ASCO Residency Affairs Committee. This review revealed that there are actually fewer than ten types of programs, but each type was associated with as many as ten different titles. The ASCO Residency Affairs Committee (Table 1) appointed a task force to evaluate the existing residency titles in order to determine the merit and feasibility of a structured procedure and system for the naming of residency programs. The Titles Task Force members represented a diversity of expertise in residency education. Dr. Bernard Dolan is an experienced Department of Veterans Affairs optometrist and UC Berkeley School of Optometry affiliated educator. Drs. Irwin Suchoff and Douglas Hoffman are longtime directors of residencies at SUNY College of Optometry and The New England College of Optometry respectively and members of the ASCO Residency Affairs Committee. Dr. David Sullins is a former president of The American Optometric Association and currently chair of the Council on Optometric Education, and Dr. John Schoessler is dean, The Ohio State University College of Optometry and a former member of the ASCO Residency Affairs Committee.

Table 1
ASCO Residency Affairs Committee 1997-98

Dr. Larry Clausen, NEWENCO, Chair
Dr. Gwenn Amos, PCO
Dr. Douglas Hoffman, NEWENCO
Dr. Timothy Messer, VA
Dr. John Nishimoto, SCCO
Dr. Kimberly Reed, NOVA
Dr. Irwin Suchoff, SUNY

Over the next several months, the Task Force examined the residency titles of optometry, dentistry and podiatry. In addition to numerous conference calls and internal sharing of information, it sampled a large number of practicing optometrists, current and former residents, residency supervisors, educators and others in order to maximize the input. In October 1997, Dr. Larry Clausen, Residency Affairs Committee Chair, presented to the ASCO Executive Committee a draft of the tentative recommendations. He requested comments and suggestions not only from the ASCO Executive Committee but also from their faculties. Some Executive Committee members later received additional input, which they transmitted to Dr. Clausen. At the American Academy of Optometry Annual Meeting in San Antonio in December 1997, Dr. Douglas Hoffman presented the Task Force's tentative recommendations at the Residency Educators SIG Breakfast and received useful input from several attendees. The overall process resulted in a proposal by the Task Force to the ASCO Residency Affairs Committee, which consisted of a system for residency nomenclature based on a residency's clinical curriculum and main emphasis. Rules were proposed for selecting, changing and monitoring the names of optometric residencies.

The Residency Affairs Committee accepted the Task Force's recommendations but felt broader input would strengthen the outcome. Additional input from optometric educators, residency directors and other interested individuals was solicited and received. The Committee's final recommendations were then presented to the ASCO Executive Board and Board of Directors at its March 1998 meeting in Houston, where the measure was adopted. It was agreed that the proposal would be implemented in 1999. A retrospective analysis would be conducted two years later to ascertain the strengths and weaknesses of the system.

Rules of Nomenclature

The following Rules of Nomenclature are to be implemented by the 1999-2000 residency year:

- A residency title must reflect the program's mission and the main emphasis of the program's curriculum.
- The title must convey the nature of the resident's activities as determined by the program's curriculum.
- The title **Family Practice** will be applied to a program in which the clinical and didactic curricula are devoted to topics and practice involving the broad diversity of optometric care.
- All other program titles will reflect the main clinical area emphasized in the majority of the curriculum.
- In the event that a program's curriculum consists of two areas of **equal emphasis** (e.g. 50% Low Vision Rehabilitation and 50% Primary Eye Care), the program's title will include both names.
- Nine residency titles have been selected (Table 2).
- The title of any new program that contains new content will be determined by applying the **same criteria** which are used for current programs and must reflect the main emphasis of the program's curriculum.

The Process

1. The nomenclature document that ASCO adopted has been distributed to the COE and to all the Directors of Residencies.
2. The directors have been asked to distribute the information to each Residency Supervisor. They will collaborate on title selection.
3. After evaluating each program's mission and curriculum, each program will be given **no more than two of the nine existing titles** (see equal emphasis rule above). The new titles should be in place for the 1999-2000 residency year.
4. If it is determined that a program requires a new title, the Director of Residencies and Program Supervisor will apply the rules of title selection to identify and select a new title.
5. The Director of Residencies will then submit to the ASCO Residency

Table 2
Optometric Residency Titles and Descriptions

The curricula of all optometric residency programs must be devoted to beyond entry-level didactic and clinical components. The following is a list with descriptions of the types of programs:

1. **Family Practice Optometry:** The didactic and clinical curricula will be devoted to topics and practice broadly represented in general optometric care. The patient population will be community based and include an age range from pediatric to geriatric.
2. **Primary Eye Care:** The majority of the didactic and clinical curricula will be devoted to topics and practice relevant to the program's unique patient population. This patient population may be evident in the title, e.g. Primary Eye Care-Dept. of Veteran Affairs, Primary Eye Care-Indian Health Services.
3. **Cornea and Contact Lenses:** The majority of the didactic and clinical curricula will be devoted to topics and practice prevalent in the cornea and contact lens population.
4. **Geriatric Optometry:** The majority of the didactic and clinical curricula will be devoted to topics and practice prevalent in the geriatric population.
5. **Pediatric Optometry:** The majority of the didactic and clinical curricula will be devoted to topics and practice prevalent in the pediatric population.
6. **Vision Enhancement and Rehabilitation:** The majority of the didactic and clinical curricula will be devoted to topics and practice relevant to dysfunctions of the eye movement, accommodative, binocular and perceptual systems. The patient population will include the age range from pediatric to geriatric.
7. **Low Vision Rehabilitation:** The majority of the didactic and clinical curricula will be devoted to topics and practice relevant to low vision patients.
8. **Ocular Disease:** The majority of the didactic and clinical curricula will be devoted to topics and practice relevant to the diagnosis, management and treatment of ocular disease.
9. **Refractive and Ocular Surgery:** The majority of the didactic and clinical curricula will be devoted to topics and practice relevant to refractive and ocular surgery.

Affairs Committee a New Title Application containing the details of the program's mission, curriculum and weekly schedule as well as other supplemental information. The program will use the title provisionally until the Residency Affairs Committee can make a final determination.

6. The Residency Affairs Committee will review and act on the application at its next scheduled meeting or conference call.
7. The Committee will either approve the New Title Application or it will assign one of the existing titles to the new program.
8. The Committee will then notify the Director of Residencies of its decision. The Director of Residencies will be given the opportunity to appeal the decision to the Committee.
9. The Residency Affairs Committee will conduct a thorough review of the rules of nomenclature and the naming process two years after implementation.

Conclusion

The Association of Schools and Colleges of Optometry has adopted a strategy and procedure for the naming of optometric residency programs, both present and future. This standard nomenclature system was the result of substantial input from the optometric community. The process, to be implemented by each school and college of optometry by July 1999, will both simplify and greatly improve the task of naming optometric residency programs. The ASCO Residency Affairs Committee will conduct a thorough analysis of the implementation and outcomes two years after titles standardization takes effect. This formal review will allow the Committee to evaluate and further refine the guidelines and process. ■

RESOURCES IN REVIEW

Getting Tenure. Whicker ML, Kronenfeld JJ, Strickland RA. SAGE Publications. Newbury Park, CA, 1993, 147 pages, $35.00 hard cover, $15.95 soft cover.

The SAGE Publications Survival Skills for Scholars series includes several books that discuss everything from how to work with the media to developing a consultative practice and confronting diversity issues on campus. Volume eight, *Getting Tenure*, has nine chapters.

Tenure is always a "hot" topic, as was noted during the 1998 American Academy of Optometry Optometric Education Section Symposium, "Explosive Topics in Optometric Education." This book may make "getting tenure" a little less explosive. Chapter one notes that "Tenure is a powerful force. A desire for tenure at times grips people as strongly as a desire for romantic love. The outcomes of both tenure and love shape and mold one's self-image and self esteem." It is no wonder that the understanding of tenure and what it takes to become a "tenured faculty member" is a vital undertaking for most of us.

Chapter two discusses the "politics" of tenure, while the third chapter reviews academic career gateposts. These gateposts include completing your degree, finding a tenure-track position, marking time on the "tenure clock" (e.g. up or out after seven years), and learning the rules. Other chapters review the tenure process and meeting the research/publication, teaching and public service criteria. The final two chapters consider various paths leading to tenure and the following Ten Commandments of Tenure Success:

1) Publish, publish, publish

2) View tenure as a political process

3) Find out tenure norms

4) Document everything

5) Rely on your record, not on promises of protection

6) Reinforce research with teaching and service

7) Do not run your department or university until after tenure

8) Be a good department citizen

9) Manage your own professional image

10) Develop a marketable record.

This text is a very good place to start for all new faculty who are on the tenure path. I highly recommend that you: 1) read the book and 2) follow all the commandments. ■

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Illinois Eye Institute
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The Perfect Eye — A Novel Model for Teaching the Theory of Refraction

Daniel Kurtz, O.D., Ph.D., F.A.A.O.

ABSTRACT

BACKGROUND. Optometry students often have difficulty understanding the interactions among lenses, objects, accommodation, and ametropia.

METHODS. The Perfect Eye model facilitates student comprehension of these interactions by defining all the components in the unit of the diopter. The model derives its name from its premise: that inside every healthy eye is a "perfect" or emmetropic eye. Physiological eyes are combinations of a perfect eye with a discrepancy lens (the difference between the power that the eye has and the power that it needs to achieve focus on the retina).

RESULTS. The model simplifies solutions to a wide variety of problems by applying the Summation Principle, namely, the algebraic sum of all of the optical elements equals the defocus blur.

CONCLUSION. The Perfect Eye model is a powerful aid to students learning about the theory of refraction.

Key Words: *refraction, education, ametropia, emmetropia, myopia, hyperopia, astigmatism*

Dr. Kurtz is professor of optometry at The New England College of Optometry. This paper was originally presented at the American Academy of Optometry meeting in December 1997, in San Antonio, Texas.

Introduction

Early in their training, optometry students often struggle with how ametropia, lenses, accommodation and the object of regard combine to produce the range of clear vision. This difficulty is due in part to the fact that the ametropias are defined in terms of the location of the focal plane of the unaccommodated eye or the location of the far point of the eye[1], and objects are defined by their physical location with respect to the eye, whereas lenses and accommodation are defined in a different unit, that of the diopter (see also references 2 to 5, whose publication dates span over 100 years). How is the student to combine distances, focal planes or far points, and diopters?

The Novel Model

Students at The New England College of Optometry are taught an alternative model of the theory of refraction during their first year. This model uses a modification of the conventional definitions for the purpose of facilitating students' comprehension of how the ametropias relate to accommodation, lenses, and objects at various locations.

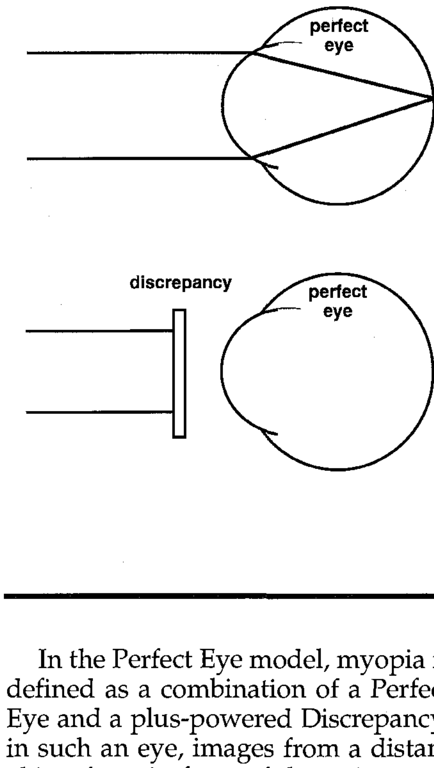
This new set of definitions is called the Perfect Eye Model. The model derives its name from its premises: (1) that within every healthy eye is an emmetropic or "Perfect Eye," in which parallel rays from a light source at optical infinity come to focus on the retina (Fig. 1, upper) and (2) in real eyes the Perfect Eye is combined with a "Discrepancy Lens" or simply the "Discrepancy" to produce ametropia. The Discrepancy Lens is defined as the difference in diopters between the power that the eye actually needs so that parallel light rays focus at the retina and the power that it actually has (equation 1 and Fig. 1, lower).

- equation 1: Discrepancy(D) = Actual Eye power (D) - power Needs (D)

The Discrepancy Lens is conceptual, not physiological, and is identified as such to students. It is a derived quantity that has no simple, physical counterpart.

Figure 1

upper: Schematic diagram of a Perfect Eye, showing the focus of parallel rays of light on the retina; lower: diagram of a real eye, shown as the combination of a Perfect Eye and a Discrepancy Lens.



In the Perfect Eye model, myopia is defined as a combination of a Perfect Eye and a plus-powered Discrepancy; in such an eye, images from a distant object form in front of the retina, and the eye's unaccommodated far point is in real space. Hyperopia is defined as a Perfect Eye combined with a minus-powered Discrepancy. Astigmatism is a Perfect Eye combined with a sphero-cylindrical or a plano-cylindrical Discrepancy Lens.

Like the Discrepancy, all other relevant components of the physiological optical system, including any and all lenses, accommodation, and the object of regard are expressed in diopters. Object diopters are equal to the reciprocal of the object distance in meters from the eye and can vary from virtually zero to some negative quantity. Accommodation can vary from zero to its amplitude and carries a plus sign, just as in conventional usage. Through the use of the device of quantifying all the elements in the same unit, the diopter, they can be added together according to what is called the "Summation Principle" to produce a sum which is equivalent to the defocus blur by a simple, linear, algebraic equation (equation 2).

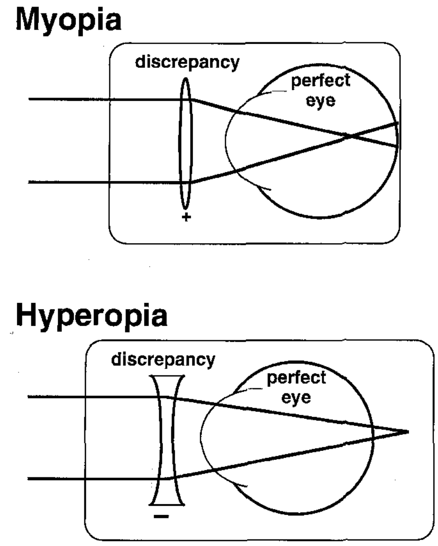
• equation 2: **defocus blur (D) = sum(D)**, where **sum(D) = object(D) + lenses(D) + accommodation(D) + Discrepancy(D)**, and where object (D) = 1/object distance in meters.

When defocus blur is zero, the image falls on the retina. Positive blur indicates that the image is coming to focus in front of the retina, and negative blur means that the image has a point of focus behind the retina. The larger the absolute value of the defocus blur, the farther is the image of the object from the retina. These generalities are true regardless of the actual numbers, as shown in the following examples.

Suppose that the eye has an actual power of +60 D (power Has), but because of the length of its vitreous chamber needs a power of only +58 D (power Needs) in order for parallel rays to focus on its retina. Such an eye has a discrepancy of +2 D (60-58) and has 2 diopters of myopia. Consequently, with no lenses and accommodation at 0, rays from an object at optical infinity (object of 0 diopters) will come to focus in front of the retina by 2.0 diopters worth (sum = defocus blur = 0+0+0+2=+2) . Note that the actual values of "power-needs" or "power-has" do not define the ametropia; rather, it is the difference between the two quantities that makes the eye non-emmetropic. Thus, an eye that has a power of +68 and needs a power of +66 has the same degree of myopia as an eye that Has +60 but Needs only +58. An eye that Has a power of +68 but also needs a power of +68 is emmetropic, even though the power of this eye differs from that of the average eye by a substantial amount, and even though it has the same power at the eye with 2 diopters of myopia in the immediately preceding example.

Figure 2

Schematic diagrams of the ametropias as defined within the Perfect Eye model.



Astigmatism

In astigmatism, the Discrepancy Lens is a sphero-cylinder or a plano-cylinder.

It should be stressed that the purpose of the Perfect Eye model is to get students up to speed quickly in solving a variety of problems that involve relationships among the ametropias and lenses, objects, and accommodation. The model does not substitute for and is not intended to replace an in-depth understanding of the actual physiological optics and anatomical basis of ametropia; it is presumed that students will acquire this deeper understanding later in their training.

In summary, the Perfect Eye model isolates the optical problem faced by the ametropic eye and identifies it as the "Discrepancy," which is measured in diopters, the same unit as all other elements in the optical system including the target of regard. Therefore, the diopters of the Discrepancy Lens can be summated with the diopters of all the other optical elements to produce a single quantity for the defocus blur.

Results and Consequences of The Perfect Eye Model

• The Perfect Eye model explains why we correct ametropias with the powers and kinds of lenses we do.

To identify the proper correction the object should be the source of 0 diopter rays (i.e., it should be located at optical infinity) and the accommodative response should be zero diopters. Under these conditions, in order to have defocus blur of 0, the compensating lens must be equal in absolute value and opposite in sign to the Discrepancy.

Since the myopic eye has a plus powered discrepancy, it requires a negative powered correction lens; since the hyperopic eye has a negative powered discrepancy, it requires a positive powered correction. Within the Perfect Eye model, correcting lenses achieve their desired results by optically canceling out the Discrepancy Lens, such that the powers of the two lenses summate to zero diopters. This condition permits parallel rays to reach the perfect eye, where such rays come to perfect focus on the retina.

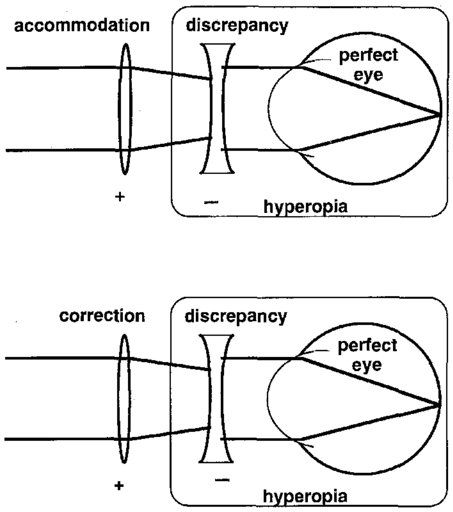
In myopia, any total minus power equal to the plus Discrepancy is consistent with clear vision. Thus, the myopic eye can see near objects clearly without a correction, provided that the negative diopters coming from the object are equal in absolute value to the plus diopters of the discrepancy lens (assuming accommodation is 0). Similarly, hyperopia, the condition in which the perfect eye is combined with a minus Discrepancy Lens, can be compensated for by any source of plus power, such as a plus lens (Fig. 3, lower), accommodation (Fig. 3, upper), or a combination of the two.

By definition the ideal correction is the one whose power is equal and opposite to the Discrepancy, so that they cancel each other out or produce a sum equal to zero with object and accommodation both at 0.

Note that the term "compensating lens" is preferable to the term "correction," since the addition of a lens to the optical system compensates for, but does not eliminate the Discrepancy. In other words, lenses do not actually make the problem go away, they merely allow the eye to see clearly despite the continued presence of the Discrepancy. Nevertheless, bowing to common usage, the Perfect Eye model continues to use the term "correction" to apply to lenses used to compensate for ametropias.

Figure 3

Schematic diagrams of hyperopic eyes compensated for either by accommodation (upper) or by a plus powered ophthalmic lens (lower), illustrating the equivalence of these two corrections.



• Locating the focal plane

The Perfect Eye model allows one easily to locate the focal point of the image with respect to the retina. As stated previously, if the sum (i.e., defocus blur) has a positive sign, then the image is in front of the retina, and if the blur has a negative sign then the image is behind the retina. This holds true regardless of the complexity of the optical system, so long as all elements, including the Discrepancy Lens, are included in the calculation of defocus blur. The absolute value of the defocus blur indicates the distance in diopters from the image to the retina, such that the larger the defocus blur, the farther is the image from the retina. Moreover, by extension, from the size of the defocus blur one can predict the visual acuity by using any algorithm that relates blur in diopters to visual acuity, such as Egger's chart[6].

• The model accounts for the ways accommodation and object distances interact with the ametropia

As stated above, in the model objects are treated as lenses with dioptric power between zero and some negative value equal to the reciprocal of their distance from the eye. When an eye looks at a near object through a lens and accommodates, light rays from the object may or may not come to focus on the retina. Nevertheless, the location of the image can be derived from the sum, or defocus blur.

For example, suppose a 4 diopter myopic eye looks through its distance correction of -4 D at an object 40 cm away and accommodates 2.5 D. The defocus blur is equal to the sum of all the elements, as shown in equation 3.

• equation 3: **defocus blur = (+4 discrepancy) + (-4 lens) + (-2.5 object) + (+2.5 accommodation) = 0.**

Since all the elements summate to zero, parallel rays of light enter the Perfect Eye, and it obtains a focused image of the object on the retina. For such a problem, the Perfect Eye model offers few advantages over the conventional point of view.However, suppose that our 4 diopter myope is looking through a -2 lens at an object 25 cm away while accommodating 2.5 D. Does the myope see the object clearly under these circumstances? To locate the image by conventional tracing techniques is cumbersome, time consuming, and is likely to produce the wrong answer in the hands of a novice. The Perfect Eye model renders this a simple problem, as shown in equation 4.

• equation 4: **defocus blur = (+4 discrepancy) + (-2 lens) + (-4 object) + (+2.5 accommodation) = +0.5.**

Thus, the myope does not see the object in focus, because all the optical elements do not summate to 0. Not only can we tell that the eye has blurry vision, we can also tell that it is fogged, because the blur is positive, and we can tell that it is fogged by half a diopter; this optical system is functionally myopic. We can also see that accommodation, which can only add plus power to the system, will provide maximum vision if set to 2.0, but will only make matters worse if it becomes more active.

The model shows clearly the relationship between myopia and accommodation. Since both are plus, either can be compensated for with a minus lens. This is why excess accommodation produces what we call "pseudomyopia" and contributes to "over-minused" refractions. Accommodative myopia is optically just like "real" myopia and contributes to defocus blur in exactly the same way, except that accommodative myopia is presumably temporary and reversible.

• Solving for an unknown value

In the examples used above, the powers of the optical elements were summed to find the amount and type of defocus blur. However, it is also easy to calculate the dioptral value of an unknown element, given the powers of the defocus blur and all the optical elements but one. For example, a 3.0 diopter hyperope is looking at an acuity chart 40 centimeters away through a +1.0 diopter lens. Under these conditions, the acuity is 20/50. How much is the hyperope accommodating? First, record all the known elements, leaving the power of accommodation blank (see equation 5A). Based on his visual acuity, blur is estimated at one diopter[6]. However, since blur can be either plus or minus, the problem does not have a unique solution. Equations 5B and 5C show that the patient is accommodating either 5.5 or 3.5 diopters to produce a blur of +1.0 or -1.0, respectively. We would make the clinical guess that the patient would accommodate the smaller amount, thus conserving biological energy, but this is not necessarily so. The Perfect Eye Model not only facilitates arriving at this answer, but shows clearly why it is so.

• equation 5A: **(1 blur)= (-3 discrepancy)+(+1 lens)+(-2.5 object)+(? accommodation)**

• 5B: **(+1 blur)=(-3 discrepancy)+ (+1 lens)+ (-2.5 object)+(+5.5 accommodation)**

• 5C: **(-1 blur)=(-3 discrepancy)+ (+1 lens)+ (-2.5 object)+(+3.5 accommodation)**

A second example further illustrates the use of the model to solve for unknown values. Given: a patient looks through a +2.0 lens at an acuity chart 1 meter away while accommodating 1.0 diopter. Under these conditions, the visual acuity is 20/50. What is the patient's ametropia? Again, after entering all of the given values, one can easily solve for the Discrepancy, as shown in equation 6A, B and C. The Perfect Eye model shows that the patient is either a 1 diopter hyperope or a 3 diopter hyperope.

• equation 6A: **(1 blur)=(? discrepancy)+ (+2 lens)+(-1 object)+(+1 accommodation)**

• 6B: **(+1 blur)=(-1 discrepancy)+(+2 lens)+ (-1 object)+(+1 accommodation)**

• 6C: **(-1 blur)=(-3 discrepancy)+(+2 lens)+ (-1 object)+(+1 accommodation)**

Solving for the near point or the far point is also easy but requires an additional step. Unless it is otherwise specified, in problems such as these we assume defocus blur is zero. Then, one enters all the given values, solves for the object in diopters, and in the final step converts the dioptral value of the object to its distance from the eye, keeping in mind that only objects with zero or negative diopters exist in real space, while those with plus diopters are virtual.

• The Perfect Eye model in astigmatism

The summation principle holds for astigmatic eyes as well as those with spherical ametropias. In astigmatism, however, one performs three summations, not just one. Thus, we calculate defocus blur or solve for unknown values in each of the two principal meridians as well as for the circle of least confusion. To perform such calculations one must keep in mind that the location of the circle of least confusion is determined by the power of the spherical equivalent, or mean, of the total optical system and that the locations of the line foci falling at each end of the resultant conoid are determined by the powers of the principal meridians perpendicular to them.

For example, an eye views a grid made up of horizontal and vertical lines (such as the target used during the fused cross cylinder test) at a distance of 40 cm through a Jackson Cross Cylinder lens of ±0.37 diopters with the minus cylinder axis vertical. In addition, although the spherical ametropia is corrected, the eye has 1.50 diopters of uncorrected against the rule astigmatism. Finally, the eye is accommodating 3.0 diopters. Where will the images of the lines fall relative to the retina, and which line in the target will appear clearer? The problem is solved by inserting all of the known values into the Perfect Eye model and solving for the defocus blur in each of the principal meridians (see equations 7A, B, and C). Notice that we do not need to specify the values of the spherical Discrepancy or compensating lens in this particular example, as we are told that they cancel each other out and thus sum to zero. Also, note that the astigmatism is given in plus cylinder form, to conform to the standard in optometry of writing corrections in minus cylinder form; a Discrepancy of the type illustrated here (plus cylinder axis 90) requires a minus cylinder correction with axis 90, and is thus an against the rule astigmatism.

• equation 7A: **defocus blur (vertical meridian) = (-2.5 object)+(+0.37 JCC)+(0 spherical discrepancy and compensation)+(0 AR astigmatism)+(+3 accommodation) = +0.87**

• equation 7B: **defocus blur (horizontal meridian) = (-2.5 object)+(-0.37 JCC)+(0 spherical discrepancy and compensation)+(+1.5 AR astigmatism)+(+3 accommodation) = +1.62**

• equation 7C: **defocus blur (spherical equivalent) = the arithmetic mean of the defocus blur of the principal meridians = (+0.87+1.62)/2 = +2.50/2 = +1.25**

Summation in the vertical meridian yields blur of +0.87; the images of the horizontal lines in the grid fall 0.87 D worth in front of the retina. Summation in the horizontal meridian yields a defocus blur of +1.62; the images of the vertical lines also fall in front of the retina, but at a greater distance than the horizontal images. Thus, the horizontal lines in the grid target will appear clearer to the patient. The circle of least confusion will fall in front of the retina by 1.25 D worth. This problem is relatively simple to solve using the Perfect Eye model. In solving problems that involve astigmatism it is often useful to draw the optical crosses of the relevant elements, as shown for the above example in Fig. 4.

• Why certain physiological and physical changes in the eye induce certain kinds of refractive changes

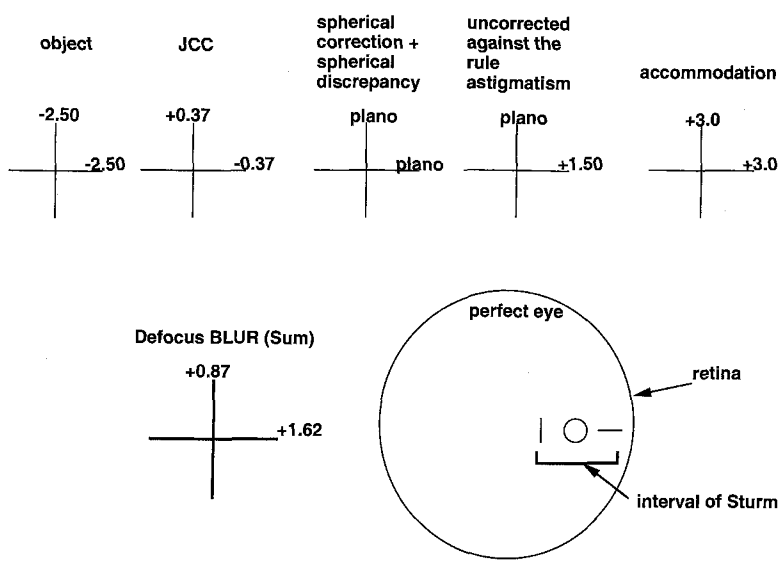
Schematic analyses of the eye (e.g., Gullstrand, referenced in 2) identify the contributions of various parts of the eye to the eye's total refracting power. When specific parts of the eye undergo changes in shape or refractive index, these changes alter the power that the eye Has without altering the power that it Needs; consequently, they modify the Discrepancy Lens. The Perfect Eye model, including the understanding that myopia is too much plus and that hyperopia is too much minus, rationalizes why certain kinds of change produce their characteristic kinds of refractive changes. For example, the nucleus of the lens acts as a plus lens within the eye; when its index of refraction increases during aging, the eye itself becomes more plus, which we recognize clinically as the myopic shift of "second sight." In contrast, the interface between the posterior corneal surface and the aqueous humor acts like a minus lens within the eye; if the cornea takes on too much water and its index of refraction declines toward that of the aqueous, then this interface has less minus power, which we recognize clinically as a shift in the Discrepancy in the plus, or myopic, direction.

Discussion

The Perfect Eye model disregards some of the details of physiological optics. Thus, it treats all optical elements as thin lenses, which are all located at the same point in space, most easily regarded as being either at the principal plane of the eye or at the

Figure 4

Illustration of the use of the Summation Principle in an astigmatic optical system.



front surface of the cornea, although the model does not require that the location be specified. For this reason the model ignores the influences of lens effectivity and the thicknesses of lenses; in general this will introduce errors greater than 0.25 only for lenses or ametropias greater than 4.0 diopters. The model also ignores such facts of life as depth of field, depth of focus, and the lead or lag of accommodation. However, these considerations do not contradict the overall model, even when ignored.

Moreover, one can achieve a greater degree of precision by taking these factors into account when solving problems. For example: the lag of accommodation could be treated as a lens with a small negative value; the values of high-powered and thick lenses can be adjusted depending on their thickness and vertex distance. Therefore, these realities do not contradict the model, but can be added as refinements when the degree of precision or accuracy demands it.

The major value of the Perfect Eye model is as a teaching tool. It provides students with a quick understanding of the ametropias in a context that allows accurate and rapid solutions to a wide variety of problems. By expressing the ametropia and the object location in diopters, they can be easily combined with accommodation and lenses (also expressed in diopters) to elucidate the interactions of ametropia, lenses, objects, and accommodation. The model facilitates calculations of defocus blur, the range of vision, visual acuity, and can be used to calculate any unknown element when the others are known.

This exposition of the Perfect Eye model has carefully avoided the term "refractive error," although it is widely used among those dealing with refraction. This avoidance is by design. In its common usage, "refractive error" refers to the optical correction; thus, one often encounters expressions such as, "The patient is a minus 3 myope." However, as it is commonly used in English, the term "error" suggests something that is wrong, i.e., a discrepancy, rather than a means to overcome a problem, i.e., the correction. This conflict between the optometric and the lay usage of the term "error" is potentially confusing to students. Therefore, the term is avoided in the Perfect Eye model, which employs the clearer terms, "discrepancy" and "correction."

Hurdles to Acceptance of the Model

• Tradition, Tradition, Tradition

All of us, even those not schooled in the Perfect Eye model, eventually reach an understanding of the ametropias, and most practitioners and educators can solve many problems involving combinations of ametropia, lenses, accommodation, and so on. Therefore, many people question the need for this novel approach. In addition, I have experienced great resistance to the idea that myopia has a plus value rather than a minus value. I believe that the primary source of this resistance is nothing more than the tradition of identifying refractive problems with their correcting lens, rather than treating the correction as separate from the actual problem. In addition, sometimes those who are comfortable solving problems in the time-honored way are bothered by the fact that the Discrepancy Lens is a derived quantity that is purely conceptual and lacks a physical or physiological counterpart. On the other hand, researchers manipulating eye growth in animal models have long realized that to create an artificial myopia, one places a plus lens before the eye. Minus lenses artificially induce the problem of hyperopia, not myopia. Without calling it by name, they are applying a Discrepancy to influence eye growth.

• Tracing Rather Than Interpreting

Even as a teaching tool the Perfect Eye model encounters one major difficulty when placed in the hands of students. Because the Discrepancy Lens and the defocus blur come out in conventional dioptral units, students sometimes cannot resist the urge to apply conventional ray tracing techniques to them. Thus, they may accurately calculate the defocus blur (e.g., +1.0), but then expect the image to be located one meter behind the cornea, rather than its actual location of 1.0 diopter's worth in front of the retina. Consequently, students must be repeatedly reminded that the defocus blur which they calculate by the Summation Principle is to be "interpreted," not ray-traced through using the principles of geometric optics. This mental error may stem from some students' seemingly irresistible urge to believe in the physical reality of the Discrepancy Lens, even though they are explicitly and repeatedly instructed that it is only conceptual.

Educational Benefits of the Model

Conversations with numerous students over more than a decade of teaching the Perfect Eye model at The New England College of Optometry indicate that the model makes it easy for them to solve innumerable, otherwise challenging problems, including many on the National Board exams. Even first year students can solve problems that are difficult if approached using the traditional methods and definitions.

Thus, the Perfect Eye model, when properly applied and interpreted, allows students to solve a wide range and variety of problems efficiently, accurately, and infallibly. Therefore, the model has heuristic value and is a powerful aid to the student learning about the ametropias and their relationships with accommodation, objects in space, and lenses. ■

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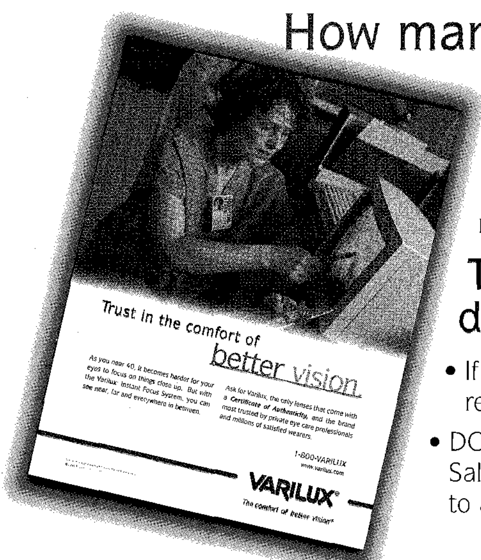

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