

An Opportunity for Radiology: Recommendations from the Educational Summit

William R. Hendee PhD

Introduction

In my perspective article entitled An Opportunity for Radiology, published in the February 2006 issue of Radiology (Ref), I suggest that radiologists have three principal attributes (clinical acumen, mastery of technology, and dedication to safety and quality) that characterize the practice of their discipline, and that serve as a barrier to intrusion into the practice by other medical specialties. I also suggested that the first and third of these attributes, clinical acumen and dedication to safety and quality, are derivatives of the second attribute, mastery of technology. I then make the case that the technology of radiology cannot be mastered without a firm grasp of the physics principles and applications underlying the technology. Finally, in the article I explore the divergence between the expanding complexity of technology in radiology, and the diminished time and effort radiologists in training devote to understanding physics and its integration into the technologies so important to the practice of radiology. This divergence exposes radiology to the risk of usurpation of radiological procedures (at least those that provide a positive net income) by other specialists who control the patients needing the procedures. The Radiology paper ends with a proposal to revamp the education and certification of radiologists in order to reverse the divergence between physics education in radiology and the complexity of technologies used in the practice of radiology. This proposal is intended to convert divergence into convergence, so that radiologists entering the profession would be able to exert mastery over the technologies they employ in the service of patients.

In the Radiology article, I mention that a 3-day educational summit on physics education in the radiological specialties, sponsored by the American Association of Physicists in Medicine, would be held on January 20-22 in Atlanta, Georgia. This summit has been conducted, and the first day was devoted entirely to the physics education of radiologists (Day 2 was devoted to the physics education of medical physicists, and Day 3 was devoted to the physics education of radiation oncologists). Organizations sending one or more representatives for the first-day discussion included the Accreditation Council for Graduate Medical Education – Radiology Residency Review Committee [ACGME-RRC]; American Association of Physicists in Medicine [AAPM]; American Board of Radiology [ABR]; American College of Radiology [ACR]; American Roentgen Ray Society [ARRS]; Association of University Radiologists [AUR]; Association of Coordinators of Training Programs in Radiology [ACTP]; American Association of Academic Chief Residents in Radiology [A^3CR^2]; American Board of Medical Physics [ABMP]; American College of Medical Physics [ACMP]; Association of Program Coordinators in Radiology [APCR]; Canadian Organization of Medical Physics [COMP]; Canadian College of Physicists in Medicine [CCPM]; Council on Accreditation of Medical Physics Educational Programs [CAMPEP]; European Federation of Organizations of Medical Physics [EFOMP]; Institute for Theoretical Physics [ITP]; and the Radiological Society of North America [RSNA].

This article describes the discussions, conclusions and recommendations of this first day of the educational forum and, with the earlier Radiology article, identifies the challenges and opportunities to improve the physics education of radiologists, and through this education permitting them to gain an enhanced mastery of the complex technology of radiological imaging.

Process

The summit was designed to facilitate discussion and interaction. Participants were seated at one of six round tables of 6 or so individuals, with one person selected as a discussion facilitator. Four periods for discussion among round-table participants were scheduled during the day. Questions to stimulate discussion were prepared for each round-table discussion, but the participants were not required to follow the sequence of questions, or to use them at all if they wished to pursue a different line of reasoning. Facilitators remained at their assigned round table for all discussions, while other participants rotated from one table to the next for each roundtable discussion. In this manner each attendee had opportunities to interact with many other attendees, and physicists, radiologists, and administrators were all included in the discussions.

After each roundtable discussion, the facilitator reported to the assembly on the conclusions and recommendations of his/her particular round table. There was substantial discussion by all the participants after the round-table reports, leading to more suggestions and recommendations. Overall, the day was highly interactive, and the participants concluded the day with a strong feeling of collegiality among radiologists, physicists and administrators, a sense that the physics education of radiologists must be substantially improved, and several ideas on how this improvement could be achieved.

The first day of the summit began with my 20-minute keynote address on the purpose and objectives of the one-day discussion, following the theme and concerns laid out in the article *An Opportunity for Radiology*. This address was followed by a brief presentation by Richard Massoth PhD on the curriculum for physics education of radiologists developed by the AAPM (Ref). This presentation provided examples of the breadth and depth of physics that the AAPM committee believes to be appropriate in the education of radiologists. Following this presentation, a round-table and open discussion identified several potential improvements in the curriculum, including more attention to molecular biology, greater emphasis on image reconstruction and processing, using images to teach physics concepts, starting with imaging applications and moving to principles, focusing on high-dose procedures and the challenge of radiation dose in pediatrics, making physics teaching articles such as those published in *Radiographics* readily available, providing physics educational modules on the world-wide web, etc. One intriguing issue revealed during the discussion is that although approximately 50% of medical students are female, only about 25% of radiology residents are women. The reason for this discrepancy is unclear, especially since the practice of radiology is more conducive to family life for women than some other specialties may be. Some female participants in the discussion suggested that the low percent of women radiologists may reflect an aversion to the quantitative aspects of the discipline.

After the open discussion, Daniel Bednarek PhD described the written physics examination of radiologists conducted by the American Board of Radiology. Dr Bednarek disclosed the topics on the examination and how each topic is weighted among the 130 questions on the written physics examination (Ref). The assembly strongly recommended that this information should be accessible on the ABR website. Dr. Bednarek revealed that for several years the performance of radiologists on the written examination has not reached the level of performance identified by quantitative measures for performance validation such as the Angoff procedure (Ref). Further, the performance of radiologists declined noticeably in 1999 when the written examination in physics was made available to radiologists-in-training as early as their second year of residency. The most recent (fall, 2005) physics written examination for radiologists was graded with a slightly higher cut score (the cut score is the lowest numerical grade that a candidate can attain and still pass the examination), resulting in a drop in the percentage of candidates passing the examination from the low 90s to 89. In some programs several candidates failed the examination, reflecting an inadequate learning process, and possibly a deficient teaching process, in those programs. Representatives of the ABR stated during the discussion that the cut score will be examined carefully in future years in an effort to achieve greater concurrence with the score indicated as reasonable by the Angoff procedure.

A second round-table discussion focused on the ABR physics examination process for radiologists. Suggestions included: teach physics of a particular technology when the resident is rotating through services that utilize the technology; the physics that is taught and that is tested on the certification examination should be consistent and should emphasize applications leading to fundamentals, and not just fundamentals isolated from applications; the physics examination for radiologists should be separated into 2 parts – a fundamentals part taken early in residency, and an applications part taken after most clinical rotations have been completed; and physics educational programs should be examined as part of the ACGME-sponsored reviews of residency programs in radiology.

Following lunch, Herbert Mower PhD addressed the assembly with the objective of helping participants focus on the afternoon session dedicated to finding solutions and making recommendations to improve the physics education of radiologists. After this introduction, the afternoon was divided between two additional periods of round-table discussions, each followed by report-backs from each table and general discussion among the assembly. The afternoon concluded with my wrap-up of the major findings and recommendations of the day's efforts. This wrap-up forms the foundation for the remainder of this paper.

Findings:

A rather straightforward theme emerged from the day's efforts focused on improving the physics education of radiologists. This theme identifies 5 needs: 1.) Determine through consensus the physics knowledge needed by radiologists; 2.) Teach and learn this needed knowledge, and validate these requirements through the residency accreditation process; 3.) Ensure that the knowledge taught and learned satisfies regulatory requirements of federal agencies (eg the Nuclear Regulatory Commission); 4.) Examine radiologists on

the taught knowledge as part of the ABR certification process; and 5.) Sustain and update needed knowledge over the careers of radiologists. The need to articulate these straightforward needs suggests that greater integration of curriculum efforts, residency evaluations and certification examinations needs to occur, and that this integration requires improved communication among professional organizations such as the AAPM, RSNA, ACMP and ACR, the ACGME Residency Review Committee, and the ABR. It is only through improved communication and integration that what is taught, what is evaluated and what is examined can be brought into coherence. All of the organizations present at the meeting agreed that this conclusion expresses an urgent need in the physics education of radiologists.

Participants in the summit agreed on the following strategies to address the need for greater coherence in the physics education of radiologists. First, physicists should work with radiologists in the generation of a curriculum in physics, so that the physics that is taught to radiologists reflects an appropriate balance between fundamentals and applications, and that the presentation expresses physics within the context of the education, experience and interests of radiologists. The physics curriculum developed by the AAPM would be an excellent starting-point for this ecumenical review by physicists and radiologists working together to identify what needs to be taught to, and understood by, radiologists. Included in this effort should be one or more radiologists who have recently passed the ABR certification examination.

Second, the ACGME Radiology Review Committee should acknowledge the key importance of physics to the education of radiologists, and its evaluation of residency educational programs in radiology should include an analysis of the depth and breadth of physics education for radiologists. A comment during the discussion that inquiries into the physics education program are almost never made during residency review visits by the ACGMC-RRC elicited the response that such inquiries should, and hopefully, will be made in the future.

Third, the educational curriculum in physics agreed upon by physicists and radiologists should be tightly linked to the certification examination in physics administered by the ABR. Both the curriculum and the examination should be clinically relevant and transparent, so that certification candidates are guided in their study of topics thought to be important and tested on the examination. A blueprint for the written physics certification examination should be accessible on the ABR website to improve the transparency of the examination process.

Fourth, input into the certification process should be elicited from one or more radiologists who have recently acquired certification. These individuals could comment on both the content of the certification examination and on the way it is administered. Further, they would be an effective voice for the ABR in communicating with residents who will take the examination in the future.

Fifth, the certification examination schedule should be evaluated to determine if there are more effective ways to administer it. As mentioned in An Opportunity for Radiology

(ref), it may be wise to restructure the written examination so that it is given, as now, at the beginning of the second year, but focused on the principles of physics and not on clinical applications. The physics associated with clinical applications then would be covered during rotation of residents through specific imaging applications and modalities, and physics questions about these applications and modalities would be asked as part of the written and oral certification examinations in clinical radiology at the end of the residency. There may be other options for the examination schedule that may be preferable to this suggestion, and which would emerge during evaluation of the examination schedule.

Sixth, self-assessment education modules (SAMS) should be developed on the physics of imaging methods and applications. These modules would be web-based, peer-reviewed, and accessible on an as-desired basis while residents are rotating through the clinical specialties. Their availability would avoid the scheduling conflicts now encountered when physics classes are offered to residents who are busy in the clinic. The physics SAMS would also be useful to radiologists engaged in the Maintenance-of-Certification (MOC) process, especially if a few questions related to the physics of new imaging procedures appeared on MOC examinations for radiologists.

Seventh, communication must be improved concerning the depth and breadth of physics knowledge expected of radiologists, evaluated during residency review, and tested for on the ABR certification examination. This improvement demands a more effective conduit for information flow among the ABR, ACGME-RRC, AAPM, ACR, ACMP and other organizations concerned about the physics education of radiologists. Careful planning and effective communication are key to the success of any effort to improve the physics education of radiologists.

Not all of the challenges to improving the physics education of radiologists are directed to radiologists and organizations. There are substantial challenges directed to physicists as well. These challenges can be characterized in a series of questions that must be addressed by the physics community. The questions are: 1.) Do physicists have the knowledge to teach effectively?; 2.) Can they teach?; 3.) Can they be taught to teach?; 4.) Do they have the time to teach?; 5.) Are there incentives for physicists to teach?; 6.) Can they teach at the “teachable moment” in the clinic?; 7.) and can supplemental materials, including web-based modules, improve the teaching effectiveness of physicists? These questions pose challenges for the physics community that must be addressed if the physics education of radiologists is to be improved. They are part of the agenda for change mapped out during the second day of the educational summit during which the physics education of medical physicists was discussed (ref).

Several challenges to effective physics teaching of radiologists can also be directed to radiology program directors and departmental chairs. Any one of these challenges can seriously inhibit the physics education of radiologists if a solution is not identified in individual radiology educational programs. First, the importance of physics in the education of radiologists must be emphasized by the program director, the departmental chair, and other role models for residents in the department. A role model who

encourages the acquisition and application of physics knowledge can greatly influence the desire of residents to acquire the knowledge. Equally influential, but in the opposite direction, can be a role model who dismisses physics as non-essential knowledge, or who in other ways trivializes the importance of physics education.

Second, physics teaching requires the time and effort of physicists, and this time and effort must be paid for by the department. It is unrealistic to require physicists to generate their support from research and clinical service, and then to expect these individuals to devote substantial time and effort to physics teaching. Physics teaching is a necessary expense of offering a radiology residency, and the department must be prepared to cover this expense.

Third, time for physics teaching must be accommodated in the departmental schedule, and this time must be protected by the departmental administration. Scheduling physics classes at 7am before the workday begins, or at 5 pm or later after the regular workday ends, not only introduces physics at a time when many residents are unreceptive to learning, but also makes a statement about the importance of physics compared with activities scheduled during the regular workday. In some programs, residents are distributed among several hospitals that may be several miles apart, and it may be impossible for them to participate in physics classes during the regular workday. In that case, before- or after-hours teaching may be necessary. But its disadvantages should be readily acknowledged, and the scheduling of physics classes should be recognized as a product of the nature of the residency program and not as a commentary on the importance of physics education.

Fourth, residents should be encouraged if not required to actively participate in the physics instructional process. The learning process should be interactive, with questions and discussion rather than dry lectures that encourage passive somnolence rather than active acquisition of knowledge. Attendance and participation should be monitored informally, or formally if preferred, by the residency program director and departmental chair. These individuals should make their expectations about active participation and learning clear both to the residents and to the physicists and others who are teaching physics.

Fifth, a mixture of principles and applications helps make physics relevant to new residents who may be unfamiliar with the technologies and procedures they will encounter later during their rotations through various modalities and applications. Often this mixture can be explicated best by a tag-team of a physicist and a radiologist teaching the class together. Where there is interest from radiologists, tag-team teaching can be a very effective way of teaching physics principles within the applications of physics to specific modalities and body regions.

Sixth and finally, effective teaching requires educational resources and the time to find or develop them. Departments should encourage and facilitate the use of web-based educational modules, and should encourage departmental members, including physicists, to develop them in areas where they are unavailable from other sources. The

departmental library should contain physics texts and radiology journals such as Radiographics that contain articles relevant to physics education of residents, and residents preparing for certification examinations should be supported to attend physics lectures and refresher courses.

There are also challenges to radiology residents related to the effective teaching and learning of medical physics during the radiology residency. These challenges relate primarily to improvements in the receptivity of residents to learning the physics of their discipline, and to acknowledgement of its importance in competing with other specialties for the utilization of imaging technologies in the care of patients. First, radiologists and radiology residents must recognize the importance of physics to the practice of their discipline, and apply themselves to their studies in a manner consistent with this recognition. Residents should study to understand the physics of their discipline, and not just to pass the physics portion of the certification examination. Further, radiology residents should study resources in physics beyond simple question review books and questions putatively remembered by candidates of previous certification examinations. The goal should be to truly understand the physics infrastructure of radiology, and not just to pass an examination. Residents should actively engage in the physics learning experience as participants, and not behave simply as passive observers of didactic physics lectures. Finally, residents are encouraged to let others, including their physics instructors, know about what works and what does not work concerning their physics instruction and learning. Improving the knowledge of radiologists about the physics of their discipline is a shared responsibility of physicists, residents and staff radiologists in every residency program.

Conclusions:

Radiology is at a crossroads of opportunity and challenge. The technology of imaging is becoming increasingly complex, and the applications are expanding across several dimensions, from organ- and system-level imaging to imaging at the cellular and molecular levels. Imaging is being recognized increasingly as a tool for managing massive quantities of information, whether acquired directly through anatomical imaging techniques, indirectly from quantitative measurements related to biological function and biochemical composition, or even more indirectly through measurements of gene activity detected through multidimensional array analysis.

This crossroads can be traversed successfully only by sustaining radiology's attributes of clinical acumen, the mastery of technology, and a dedication to quality, safety and cost-effectiveness of radiology procedures. The sustainability of these attributes depends strongly on the ability of radiologists to understand and apply the physics underlying their discipline in the selection, performance, and interpretation of imaging studies for patients. This dependence demands a substantial improvement in the teaching and learning of physics during radiology residencies, which in turn requires a determined effort by physicists, residents and radiologists working cooperatively to improve physics instruction and physics learning.

Recommendations:

- Consider the scientific and engineering credentials of applicants to residency programs in radiology as indicative of their interest and ability to master the science and technology of their future discipline;
- Physicists and radiologists should work together under the aegis of the American Association of Physicists in Medicine (AAPM) to identify the breadth and depth of core knowledge necessary for radiologists to competently practice their discipline;
- The AAPM and the American Board of Radiology (ABR) should work with regulatory agencies such as the Nuclear Regulatory Commission to ensure that the identified core knowledge encompasses the education and training required to be recognized as a qualified expert by the agencies;
- Accreditation of residency programs by the Accreditation Council on Graduate Medical Education-Residency Review Committee (ACGME-RRC) should include examination of the quality and extent of physics education during residency;
- The physics certification examination offered by the ABR should be clinically relevant, reflect the AAPM curriculum for physics education of radiology residents identified above, emphasize problem-solving, work backwards from images to principles where possible, be transparent in terms of the core knowledge that will be tested on the examination, and include a substantial number of questions on magnetic resonance imaging, multi-array computed tomography, positron emission tomography, and other state-of-the-art imaging technologies;
- Communication among the AAPM, ABR, and ACGME-RRC should be dramatically improved so that residents and physics instructors understand what is to be taught, what is to be learned, and what is to be examined concerning the physics foundation of radiology;
- Radiologists who have recently passed the written physics examination should be invited to participate in the development of the AAPM physics curriculum for educating radiologists, and in the development of the ABR physics examination to test the core knowledge expressed in the curriculum;
- The ABR examination schedule in physics should be examined to identify the most logical time(s) and process(es) to administer the examination, probably including asking applied physics questions during the clinical written and oral examinations of radiologists;
- Physicists should recognize that too often physics is taught in an unsatisfactory manner by physicists who do not have the knowledge or incentive to be good teachers, and that this problem must be addressed in those programs where it arises if the current problems of inadequate physics instruction and knowledge of residents is to be addressed satisfactorily;
- In residency programs where there is interest, physicists and radiologists teaching physics together in a tag-team format should be explored;
- Web-based educational modules should be accessible to facilitate “just-in-time” and “point-of-care” education of residents about the physics of specific technologies as residents encounter those technologies in the clinical setting;

- The cost of preparing peer-reviewed, web-based educational modules should be covered by professional organizations such as the Radiological Society of North America and the American College of Radiology, potentially with the assistance of funds from corporate sponsors;
- Physics must be understood by radiologists, radiology residents, and medical physics as essential knowledge to the competent and compassionate use of imaging technologies in the care of patients.