Teresa Van Deven · Kathryn M. Hibbert
Rethy K. Chhem *Editors*

The Practice of Radiology Education

Challenges and Trends

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Foreword

The practice of radiology education: challenges and trends will provide truly helpful guidance for those of you involved in teaching and training in radiology. The goal of this book is ultimately to improve patient care. As a companion piece to the first book *radiology education: the scholarship of teaching and learning*, this book focuses on applying the concepts at a practical level that can be applied flexibly within educational programs for radiology residents and fellows in any medical imaging learning environment. This book focuses on the application of scholarship in terms of the "dissemination of useful, testable and reproducible information to others." It links educational theory with practice and for those of you who wish to explore educational practice further, a number of chapters suggest additional readings and resources.

The publication is timely and congruent with one of the most important twenty-first century trends in medical education: the move from amateurism to professionalism in teaching. In the past, medical schools and other health professions' training institutions have been criticized for their resistance to the adoption of the science of medical education. Very few of us learned how to teach as medical students and most of us have our teaching responsibilities thrust on us with little preparation. The award of a basic medical degree was assumed to carry with it basic teaching expertise, unfortunately an unwarranted assumption in some cases. At last, the realization is spreading that even a short introduction to teaching and learning can make a marked impact on our students' learning and the quality of their educational experience. We can make learning more efficient and effective with the application of a few rudimentary principles and provide a coherent and cohesive educational program for our students.

Another important aspect of this unique publication is that it is customized specifically for radiology. For too long, doctors as individuals have had to translate what happened in primary and secondary classrooms to clinical training at undergraduate and postgraduate levels. It is now recognized that the application of tried and trusted educational principles to clinical practice within medical disciplines is a specialism in itself. Expertise in teaching and learning within medical disciplines has grown and developed over the years and it is the individuals with this expertise in radiology who have contributed to this scholarly work. What you read in this book is what is relevant for radiology teaching.

Contributors to the publication come from Canada and institutions across the world. The range of international contributors is one of the strengths of the book and ensures that experts in the field provide you with cutting edge and up-to-date advice. I hope it will help to prevent obstacles for those of you new to teaching and to bolster your confidence as teachers. For those of you with several years of teaching experience, wishing to further improve your teaching expertise, it will provide thoughtful pointers for further development of your skills, always with a sound educational basis.

Everyone involved in this publication has gone to great lengths to ensure a readable and up-to-date publication designed to help you with your lifetime teaching journey within radiology.

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Acknowledgements

We thank all those who have championed this educational endeavour. Those champions include the chair of our department, Dr. Andrea Lum, our Program Director, Dr. Justin Amann, and the faculty and residents of the Department of Medical Imaging, Schulich School of Medicine and Dentistry, University of Western Ontario. These are the ones who have taken those first steps by inviting us into their everyday practices and by sharing their stories. We thank our deans for their continued enthusiastic support: Dr. Carol Herbert, Dean of the Schulich School of Medicine & Dentistry, University of Western Ontario; and Dr. Julia O'Sullivan, Dean of the Faculty of Education, University of Western Ontario. We also thank our research assistants for their scholarly and collaborative vision: Lisa Boyko, Monica Caldeira, Kyra Harris, Mark Hunter, and Liem Ngo. We thank Holly Ellinor, a valuable member of our team who has been significantly instrumental in the creation of both of our books and whose expertise in so many areas keeps the Centre for Education in Medical Imaging running so smoothly.

Teresa Van Deven

> *Vision is not enough; it must be combined with venture. It is not enough to stare up to the step; we must step up the stairs.*
>
> Vaclav Havel

To my sister, Kimberly Joan: It is she, through her years in medicine within the emergency department, critical care unit, the hyperbaric unit and the northern communities in British Columbia, Canada, who has shared her stories and struggles and who has consistently shown me how to move beyond mere vision towards venture.

An avid sailor, Kim has explored the seas aboard her ship, the *Warrior's Way,* and through our journeys together, has taught me that even in the most violent of seas, we can face the challenges, defy the odds, and venture forth.

To our team: Dr. Kathy Hibbert, Dr. Rethy Chhem and Ms. Holly Ellinor. What an honour to be part of this collaborative team as we venture up those stairs together.

Kathy (Shackleton) Hibbert

Much of this second book has focused on the notion of crossing borders, taking risks and venturing into the *wild*. As Sir Ernest Henry Shackleton wrote in *The Heart of the Antarctic,* people

> go into the void spaces of the world for various reasons. Some are actuated simply by a love of adventure, some have the keen thirst for scientific knowledge, and others again are drawn away from the trodden paths by the 'lure of the little voices' the mysterious fascination of the unknown.

This second journey into the "unknown" has proved to be as illuminating as the first. My colleagues, Dr. Rethy Chhem and Dr. Teresa Van Deven, have been wonderful shipmates along the way and I always enjoy where our discussions take us. A passage from St. John Wellas Lucas, "The Ship of Fools" captures our collaboration:

> We were the fools who could not rest
> In the dull earth we left behind,
> And burned with passion for the south
> And drank strange frenzy from its wind.
> The world where wise men sit at ease
> Fades from our unregretful eyes,
> And thus across uncharted seas,
> We stagger on our enterprise.

I dedicate this book to my parents: Lorraine Audrey Shackleton and Jackson Wayne Shackleton. As my first teachers, they provided models of grace, courage and insatiable curiosity. The serious illnesses that they both faced brought us in close contact with the medical community, its services, its strengths and its limitations. Throughout it all, they continued to go about the task of "living" their lives. To quote Shackleton again, "Difficulties are just things to overcome, after all."

Rethy Chhem

In memory of my first teachers and mentors:

My mother, Nhiek Bophal
My father, Chhem Kieth

Disclaimer

The opinion of the authors does not necessarily reflect that of the editors.

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Abbreviations

ABR	Board of Radiology
ACA	Anterior cerebral artery
ACGME	Accreditation Council for Graduate Medical Education
ACR	American College of Radiology
AFIP	Armed Forces Institute of Pathology
AIP	American Institute of Physics
AIT	Applied imaging technology
AMA	American Medical Association
AMA/FREIDA	American Medical Association/Fellowship and Residency Electronic Interactive Database Access System
AMC	Australian Medical Council
AMSER	Alliance of Medical School Educators in Radiology
AUC	Area under the curve
AVM	Arteriovenous malformation
BEO	Branch education officers
BSS	Basic safety standard
CAC	Curriculum Advisory Committee
CAGE	Acronym identifying 4 questions: Have you ever felt you should *cut down* on your drinking? Have people *annoyed you* by criticizing your drinking? Have you ever felt bad or *guilty* about your drinking? Have you ever had a drink first thing in the morning to steady your nerves or get rid of a hangover (*eye opener*)?
CAMRT	Canadian Association of Medical Radiation Technologists
CanMEDS	Canadian Medical Education Directives for Specialists
CaPS	Curriculum and pedagogy support
CaRMS	Canadian resident matching service
CBL	Case based learning
CMA	Canadian Medical Association
CME	Continuing medical education
CMRTO	College of Medical Radiation Technologists of Ontario
CORA	Centre of Radiological Anatomy

CPD	Continuing professional development
CRPs	Coordinated Research Projects
CT	Computed tomography
DAT	Distance assisted training
DATOL	Distance assisted training on-line
DEC	Departmental education coordinator
DMI	Department of medical imaging
DOPs	Directly observed procedures
DOT	Directors of training
EBR	Evidence based radiology
EFSUMB	European Federation of Societies for Ultrasound in Medicine and Biology
EHRs	Electronic health records
ENT	Ear, nose & throat
EPAPS	Electronic physics auxiliary publication service
ERB	Evaluation Review Board
ESR	European Society of Radiology
ESSR	European Society of Musculoskeletal Radiology
EU	European Union
EULAR	European League Against Rheumatism
FREIDA	Fellowship and residency electronic interactive database access system
HCC	Hepatocellular carcinoma
HGH	Hamilton General Hospital
HHS	Hamilton Health Sciences
HOD	Heads of department
IAEA	International Atomic Energy Agency
ILO	International Labor Organization
IPX	Individual patient examination
ISI	Institute for Scientific Information
ITERs	In-training evaluation reports
JoVE	Journal of visualized experiments
LID	London imaging discovery
LOE	Levels of evidence
MCA	Middle cerebral artery
MCQ	Multiple-choice question
MDCT	Multi-detector computed tomography
MF	Medical Foundations
MIIRC@M/MIIRCAM	Medical Imaging Informatics Research Centre at McMaster University
MRI	Magnetic resonance imaging
MRT	Medical radiation technologist
MSF	Multi-source feedback
MSK	Musculoskeletal
MSK US	Musculoskeletal ultrasound

MSUS	Musculoskeletal ultrasound
MUMC	McMaster University Medical Center
OA	Osteoarthritis
OBOs	Open biomedical ontologies
OSCE	Objective structured clinical examination
PACS	Picture archiving and communication system
PBL	Problem based learning
PET	Positron emission tomography
PGE	Postgraduate education
PGY	Post-graduate year
PPI	Personal progress index
QOL	Quality of life
RadLex	Radiology lexicon
RANZCR	Royal Australian and New Zealand College of Radiologists
RCA	Regional Cooperative Agreement
RCPSC	Royal College of Physicians and Surgeons of Canada
RCR	Royal College of Radiologists (UK)
RCRT	The Royal College of Radiologists of Thailand
RF	Radiology foundations
RHPA	Regulated Health Professions Act
R-ITI	Radiology–integrated training initiative
ROC	Receiver operating characteristic
RPGs	Role playing games
RSNA	Radiological Society of North America
RST	Radiological Society of Thailand
RTC	Residency Training Committee
RTCs	Regional training courses
RTMR	Registered technologist, magnetic resonance
RTNM	Registered technologist, nuclear medicine
RTR	Registered technologist, radiological technology
RTT	Registered radiation therapy technologist
SJHH	St. Joseph’s Healthcare Hamilton
SSMD	Schulich School of Medicine & Dentistry
TAI	Traumatic aortic injury
TC	Technical co-operations
TCP	Technical Cooperation Program
THES	Times higher education supplement
TPAC	Training Program Assessment Committee
US	Ultrasound
WBS	Whole-body screening
WHO	World Health Organisation

Introduction

Carol P. Herbert

The first book of this series, *Radiology education: the scholarship of teaching and learning,* was written as a way to begin a dialog about possibilities for bringing educational scholarship, in the broad sense, into the realm of the medical imaging world. It included a range of discussions that honored the multiple ways in which Ernest Boyer has defined scholarship; i.e., scholarship of discovery, scholarship of teaching, scholarship of integration, and scholarship of application. It included the voices of scholars and practitioners from around that world who have begun to think about their practice in new ways, and who offered glimpses into the "everyday world," so that we might all begin to better understand how to come together as a community of radiology educators and reconsider the structures and practices that are currently in place, and where we might begin to envision what we might do better in our overall goal of improved patient care.

This second volume from the Centre for Education, Department of Medical Imaging at the University of Western Ontario is a compilation of the experiences and reflections of radiologists, physicists, and educators whose common aim is to produce high-quality imaging practitioners who are well-prepared to serve patients and to reflect critically on their practice over the course of their careers so as to ensure continuous quality improvement. It is noteworthy that, during the course of the production of the first book, the name of the department of diagnostic radiology and nuclear medicine within the Schulich School of Medicine & Dentistry was changed to the department of medical imaging, to reflect better the range of imaging modalities that are being and will be taught to our learners who will become the radiologists and nuclear medicine physicians of the future.

In this second book, *the practice of radiology education: challenges and trends,* the authors have responded to calls from the community to bring the dialog even further into the "everyday world" by engaging with practitioners in ways that lay out current practice to make it visible. This is an act of courage. A number of the authors who contributed to this book are not accustomed to academic writing and by making visible the practices that are currently in place, we necessarily invite scrutiny. The theme of partnership and

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shared experience comes through clearly in this book, whether the partnership is between an educator-scholar and a clinical radiologist, between training programs in different countries, between medical radiation technologist and physician, or between physicist and radiologist. A partnership which we are particularly proud is the relationship between the two University of Western Ontario faculties of medicine & dentistry and education, which is manifested in the work of the Centre for Education in Medical Imaging.

This volume builds on the first by offering a practical guide, from a primarily Canadian perspective, to assist colleagues around the world design educational programs. Part I of this volume is focused on curriculum. It includes a chapter on designing a radiology curriculum for medical students to ensure core skills and to attract some students into a career in imaging, but the emphasis is on postgraduate medical education, i.e., residents in medical imaging, with experience shared around curriculum, rounds, and academic afternoons. There is specific advice regarding teaching modules in clinical inquiry and case review. There is attention to training of team members, notably medical radiation technologists.

Part II focuses on programs and trainees, with chapters that examine resident workload and productivity, how residents carry out case reviews, and how to ensure that residents' learning is complete and systematic in the face of the randomness of cases presented in practice. Resident logs, for instance, are suggested as a means to ensure sufficient experience with procedures to assure competency. There are international contributions from Australia/New Zealand, Austria, and Thailand, which shine additional light on what works in educational practice. Specific attention is paid to building scientific capacity in PET/CT and in Medical Physics, particularly in developing countries.

Part III examines leadership and resources. Chapters on fostering leadership, developing the academic mission in a department, selecting residents and chief residents, and managing learners with difficulty provide practical guidance, grounded in sound theory and principles.

Thinking critically about one's own practice can be a difficult intellectual, moral, and professional work. For radiologists unaccustomed to reading educational research (particularly those aimed at a research community), it can be difficult to contextualize the theories to their personal professional practice. It is here that the value of a collaborative endeavor between medicine and education becomes most evident. The struggles that are described by the radiologists in this volume are familiar to educators, but until those struggles can be articulated, the challenge remains "where do we begin?" By taking these first tentative steps and demonstrating the courage it takes to lay out their practice in writing, the authors have provided a fertile ground for educational dialog.

We recognize that radiology practices, like most professional practices, are situational and that what is offered here is a work in progress. Education is a process, not an event. This book represents an opportunity to engage more deliberately in the educational process and serves as a beginning from which we can begin to learn with and from each other as we work toward improving what it is that we do and value so highly. This book is produced by practitioners for practitioners, having fully integrated the concept of "reflective practice" that allows them to enhance not only their own practice but also benefits colleagues who may face similar challenges elsewhere. The ultimate outcome is that our patients and community will benefit.

If we are to advance the academic mission in departments of medical imaging, it is important to attend to fostering resident research in general, as well as, more specifically, translational research. It is our fond hope that the chapter that describes the role of scholarship in the establishment of our centre for education in medical imaging will encourage other departments to engage in the scholarship of teaching and learning, so that the next generation of imaging practitioners and their teachers will utilize curricula and educational tools that have been rigorously evaluated. The overarching goal of our centre is that all practitioners will have the opportunity for evidence-based learner-centered education to enable collaborative patient-centered care and reflective practice.

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1 Transcending the Barriers of Interprofessional Collaboration: Our Continuing Journey as Educators in Medical Imaging

Teresa Van Deven and Kathryn M. Hibbert

1.1 Introduction

It has been a little over 1 year since the publication of our first book, *Radiology Education: The Scholarship of Teaching and Learning* (2008). As we review the past year and continue our dialogue with professional educators not only in medical imaging, but across medicine and the health sciences, we continue to draw wisdom, knowledge, and support from those areas where our professional and personal lives intersect with a variety of sources: the academic, (the philosophical, psychological, sociological, anthropological, and educational research) and the practical (participation in medical imaging rounds and academic half days as both learners and teachers, participation in the field as teachers). These experiences are necessarily informed by all that has affected us at a very human level including patients, caregivers, family members or friends accessing the medical system we work within. From the complex richness of these experiences, we have had to pause to consider those issues that may support and impede interprofessional collaborative practice. In this chapter, we shall focus on first indentifying the barriers, for, naming them allows us to seek ways to work through them, and second, we document a "way through" and offer some thoughts about how we have experienced the transition.

1.2 A View of the Teaching Profession

> He who can, does. He who cannot, teaches.
>
> George Bernard Shaw, *Man and Superman*

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George Bernard Shaw's aphorism has plagued the education profession for nearly a century. The power of this quote reinforces the fact that fiction is not ideologically neutral and that in many cases fiction both reflects and conveys a set of sociocultural values, beliefs, and attitudes of society. The implication of this particular view of the teaching profession not only contributes to an impoverished status of teaching but also cultivates a belief that no formal training is needed to teach in any discipline.

Within the medical field, there has been a long-held consensus that the broader competencies of medical proficiency are not easy to learn from someone untrained in educational methods. Yet herein lies the tension; as early as the 1800s, renowned medical educators like Flexner and Billroth recognized that the pressures and time constraints on academic physicians were compounded by the lack of recognition assigned to teaching as an important professional activity. They understood experientially, the important role of professional educators in medicine and the need for understanding and applying educational research to curriculum development, faculty pedagogical support and assessment and evaluation. The anthropological view suggests that there are those within the medical world who take issue with Shaw's comment on "teaching." Pioneering medical educators throughout the world have shared their stories, struggles, and successes. However, despite this, the partnership between medicine and education remains, for many institutions, either nonexistent, or at the pioneering stage.

1.3 Establishing a Partnership

In our case, the department of medical imaging had recognized the need for support, but was unable to identify specifically what that support would look like. As they were working through this issue, they appointed a new chair to their department who brought the unique qualification of having also completed a PhD in education. With a Chair situated in the Medical Imaging world but with a solid understanding of what education had to offer, the first bridge was built, and our conversations began.

We would be remiss if we did not acknowledge the importance of the support from Senior Administration at this stage. We drafted a proposed partnership with the Dean of Education, and submitted it to the Dean of the Schulich School of Medicine and Dentistry. Were it not for the willingness of both Deans to initiate and navigate the lengthy process of paperwork, the partnership may never have gone any further. First, it was necessary to make the faculty appointment a "cross-appointment" between the two faculties. There had never been a nonclinical appointment in the Schulich School, so appointing two educators necessitated understanding old practices in new ways, and demonstrating an ability to think in innovative ways. Our "home" institution is listed as education, even though one appointment functions exclusively within the Schulich School. Our department has also experienced changes in leadership with the new Chair of Medical Imaging bringing fresh ideas and insights to develop and expand the Centre for Education in Medical Imaging – and, so, the conversations continue!

1.4 Crossing Borders

It is helpful when planning to participate in interdisciplinary collaboration to understand a little about the process of engaging with scholars and practitioners beyond traditional boundaries. Studies of "border crossing" have described the process as slow, complicated, and perplexing (Derry et al. 1997; Naiman 1999; Wear 1999). According to a sociocultural perspective, learning is both social and contextual; it comprises our interactions with others as we participate in both familiar and unfamiliar contexts (Lave and Wenger 1991). Perhaps, the most significant reason for engaging in scholarship across borders is its potential to reveal insights not previously seen through traditional disciplinary lenses – what some call a cross-pollination of ideas.

To develop partnerships that capitalize on the collaborative skills of both professional educators and in our case, medical imaging specialists (radiologists, nuclear medicine faculty, physicists), it is necessary to first collapse the walls of "professional silos." An early impression that we frequently encounter is a prevailing belief that diverse professional groups do not have sufficient disciplinary knowledge about each others' domains in order to work effectively together. However, sound educational pedagogy transcends disciplines. While the content taught may vary, depending on the department or focus of the health institution, strong pedagogical principles can be universally applied. Our first task was to find opportunities to spend time together – to first explore each others' worlds in order that we may learn to work together in meaningful ways to strengthen medical pedagogy. Opportunities for dialogue are necessary to "foster doubt, to facilitate discovery and to nourish change" (Miller 1980).

1.4.1 The First Step

Building an awareness of "who we are" and gaining access to an array of teaching and learning contexts required the help of innovative and enthusiastic champions within the department of medical imaging. Champions within the departments or the field are needed to offer the insider perspective, to suggest ways to stimulate change in the individual context, and to generate interest and commitment across of variety of stakeholders (Clark 2002). Champions contribute to conducting a "needs assessment" within the organization, and can orient educational partners to the physical site, the departmental organizational structure, and facilitate communication "on the inside." They have both the access and the credibility required to bring newcomers into their working world and ultimately, having champions of a collaborative venture enhances the chances for sustainability (Barker et al. 2005). "Champions" are often those that will take the first step, open their classroom door or their rounds for visits, invite newcomers into their everyday practice, and share their sites of struggle. In doing so, champions light the way for professional educators to see ways in which their skills and abilities can be put to use in new ways.

1.4 What Are Some of the Barriers?

1.4.1 Different Cognitive Values

All professionals, to some extent, develop particular cognitive patterns (ways of thinking and acting in their role) and values (beliefs). While these patterns and values may contribute to their ability to successfully participate in their professional practice, they can hinder the capacity to collaborate. For most professionals, however, these patterns and beliefs are so embedded in everyday practice that they have become implicit. To address this, we must first be able to articulate current patterns in the cognitive and value maps of the various professionals involved in collaboration.

To do this, we draw on the work of Donald Schon (1983) and the process he has described for becoming “reflective practitioners.” Schon’s work offers professionals a means to lead examined lives. By asking professional practitioners to first become proficient in articulating what it is that they do, he provides a process to then go back and look closely at that practice from multiple perspectives through thinking deeply about our work, something he calls *reflection-on-action*. As we do this, we open up opportunities to explore the *theories-in-use* that are applied, allowing us to relate to one another in new ways. We began to attend or participate in any and all teaching and learning contexts available to the medical student, the PG Resident, and Faculty. For example, we attended, reviewed, or participated in;

- Undergraduate lectures, clinical simulations, web-based courses and curriculum materials
- Postgraduate rounds, academic half days, RTC, Journal Club
- Faculty rounds, city wide rounds, RSNA, academic journals, faculty development series (UWO), Medical Education certification (Harvard)

It is important to keep in mind that within our own domains, professionals develop strong professional identities. To participate in collaborative work, we must be mindful of those identities, and practice an intellectual openness that allows us to respect the differences in our individual cognitive maps and values, rather than resisting what is not familiar. It is a process that demands a way of listening and speaking that embodies the meaning of partnership and positions collaborators as colleagues, each having something to learn from the other. Participating in the various teaching and learning contexts offered us a glimpse into current understandings and practices and allowed us to form clear ideas about where to begin our collaborative work.

1.4.1.1 What Role Does Culture Play?

The culture of an institution plays a key role in collaborative and interdisciplinary partnerships. For collaboration to occur, the institutional culture must be one that desires, supports, and encourages risk and change. Ginsburg and Tregunno (2005) have noted that “process changes are easier than cultural.” Introducing interdisciplinary collaboration is risky business; to introduce a “new player,” the existing team must be prepared to examine and challenge their own underlying practices, assumptions, beliefs, and values. Recognizing the structures within which a particular institution operates, allows us to learn about the ways in which those structures may have shaped or been shaped by a particular culture. This knowledge can then contribute to looking for ways to work together effectively rather than being paralyzed by incorrect or preconceived notions. It is a process that can allow organizations to take a critical look at whether the practices, often initiated at a different time and place based on now out-of-date knowledge, resources, and contexts, continue to be relevant or efficient. Interdisciplinary collaboration offers the opportunity for each group to review the “way things have always been” and question “what is taken for granted” in practice. Explaining to the “other” why we do things the way we do, can open up spaces for considering change. Once there is a shared understanding of the culture, we can begin to introduce new policies, curriculum, and practices that will enhance professional educational practices.

In order to reshape a culture, we had to first help the members of the culture, in this case, the Medical Imaging department, to recognize the need for change. It was important to take a look together at the processes, programs, and policies in place, and begin the difficult work of rethinking or re-visioning what was possible. To do this, we offered participatory educational sessions designed to provoke thinking and discussion about current practices around the topics of, for example, curriculum development, assessment and evaluation, mentoring, differentiated instruction, and pedagogical strategies and techniques. The discussions were always fruitful and have led to collaborative projects that have included developing curriculum objectives for a fellowship program, revising policies and practices for assessing and evaluating residents, organizing the integration of CanMEDS competencies into the curriculum, and support for research.

1.4.1.2 Institutional Support

We have all heard the saying, “money talks.” The work of collaboration requires institutional support for the practical needs of doing the work, to legitimate the work and communicate that the institution values the work that is being done. Without dedicated resources and funding, collaborative work is left to linger at the periphery; its survival dependent upon the goodwill and interests of the few, working from snippets of time stolen away from their “real work.” To develop a meaningful collaborative partnership then, it is necessary to ensure that protected budget allocations and administrative supports are in place. The budget needs to be sufficient to sustain the partnership and attract scholars competing for comparable positions in the academic market. An administrative officer with “strong financial management skills with the ability to ensure that efficient and effective use of resources and the ability to prioritize the department’s needs and align these needs with the vision and mission of educational scholarship” (Matheson 2008) is vital to realizing a collaborative vision because interdisciplinary work takes time. It must be sustainable and stable. A meaningful partnership is not about simply filling the gaps in service; it is essential for collaborators to meet frequently and dialogue often in order to be effective. Navigating the schedules of busy medical imaging professionals across four hospitals and a university requires administrative support. Collaborating on projects that include scholarship of discovery, teaching, integration, and application requires time.

Collaborative partnerships require reciprocity because “we are enriched by our reciprocate differences” (Vallery). Building a culture of interdisciplinary work between educators and medical imaging faculty requires that there is an environment of learning together with the intended goal of promoting collaboration. By learning and working together, we are able to generate new knowledge that ultimately serves the interests of patients, families, and communities. A culture of reciprocity encourages educators to come into the partnership *not* to create educational orthodoxies about curriculum, but to strengthen existing practices, to introduce techniques which meet the needs of more learners, and to point out principles and practices that have not yet found their way into the institution (Miller 1980).

1.5 Recognizing the Limitations

At the time of this publication, our world has been thrust into the worst global economic crisis to date. We recognize that in such a climate, finding resources for existing programs, let alone new ones, can be a challenge. It is also a time in which increased scrutiny has been leveled at the medical profession for “botched” pathological reports and radiology exams (CBC 2008; Purdy 2009). An expected response to such serious flaws in the system is increased oversight. What are the processes in place (curriculum development) to ensure that residents will participate in the learning experiences necessary to fully develop the skills and abilities of the role? How do we assess them in ongoing ways to develop confidence in these abilities broadly – not solely for the performance of a single licensing examination? These questions beg the participation of experienced professional educators – but “if inter-professional education is to become a permanent structure for future practice, we need to ask, who gains? who pays? who gives the time? who assesses the relevance? And who ultimately measures the outputs and outcomes?” (Gilbert 2005)

These are not easy questions to answer, and each institution will need to grapple with the complexities of their own economic and governance contexts. As we have communicated with health care centres around the world, we have heard that “doing nothing” is not an option. Globalization has intensified the economic need for universities to pay attention to the educational cache of their institutions in unprecedented ways. Working in interdisciplinary spaces poses challenges to funding bodies and publishers who express desire for interdisciplinary work, but struggle with a peer review process steeped in traditional ideology and discipline specific practices. We have had encouragement from our major funding agencies on more than one occasion, only to have those charged with reviewing the application suggest we send it to a different body.

1.6 Final Thoughts

Billroth shares the story of the gifted masters of German music, Mozart and Beethoven, who were "taught by men who, themselves devoid of any trace of genius, were purely pedants in the theory and technique of music" (Billroth 1924). When we first stepped into medical education, it was easy to feel devoid of any trace of genius; the content matter we were discussing included physics and safety in radiation therapies and diagnoses of diseases and conditions unfamiliar to us. In time, we began to see connections – connections to the pedagogy that we had studied as educationalists and embodied in more than 25 years of professional practice. The collaborative process, for us, has stimulated new conversations around our own understandings of scholarship and pedagogy. It has pushed us back into the realm of reflection more vigorously; as we articulate our own "wisdom of practice," we have found that the process has served to disrupt familiar patterns, raised new questions to challenge our beliefs and assumptions about what it means to move educational theories into the medical setting, and has, as a result, opened up new channels to explore new alternative best practices. To George Bernard Shaw, we respond with the words of Jacques Barzum "Teaching is not a lost art, but the regard for it has become a lost tradition." As challenging as interdisciplinary collaborative work can be, our experience has been both fruitful and enlightening. Initial responses of politeness mixed with curiosity and uncertainty – or even dread as we entered the room: "Oh oh! Here comes Double Trouble!" – have given way over the years to invitations and open arms. Over time, our colleagues in medical imaging have let us know that our work together has perhaps recovered some of that regard for *what education has to offer*.

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2 Curriculum Matters! Designing Curriculum for Radiology Resident Rotations

Andrea Lum and Witek Zaleski

2.1 The Evolution

To understand the overall challenges and interest in curriculum development, it is important to first understand the changes in medical training over the past two decades.

In the past, medical students would select a year of internship that usually involved circulating through multiple clinical rotations prior to entering a 4-year radiology residency program. There was no CaRMS match, and the number of applicants for the few residency positions in radiology was low. Residents were referred to by their training year; R1–4 to reflect their 4-year training program.

From the 1970s up to early 1980s, most radiology programs did not have separate rotations during the first year and residents were based at a single hospital rotation for 6–12 months performing general radiology. With the advances in cross-sectional imaging and the introduction of ultrasound and computed tomography in the 1980s, radiology programs introduced core rotations based on monthly changes with some rotations taking up to 2–4 months. The introduction of magnetic resonance imaging and more invasive technology with angiography/interventional radiology contributed to the expansion of the rotations. As a result, many of the early rotations were so-called modality-based, concentrating on training of a single technology for the month.

By the late 1980s and 1990s, with the change to postgraduate training for all physicians including family medicine, the traditional internship year became part of the radiology residency program and residency programs were now considered to be for 5 years (including the internship year as a residency year). Residents are now designated as PGY 1–5 (PGY: post graduate year). Although by itself, this did not really change the number of total years an individual physician participates in training, the change did result in medical students having to make their decision to apply for residency training during their fourth year of medical

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school. This placed more backward pressure on the medical school curriculum to provide sufficient exposure to inform medical students' choices among innumerable clinical specialties. In addition, rapid advances in computer technology have reshaped current practices in imaging. As each modality attained a level of "maturity," radiology rotations reflected the multimodality of the advances and many became "organ system" or "program based."

2.2 Components of Radiology Teaching

Radiology programs have utilized three basic core approaches for teaching residents both the clinical and academic aspects of radiology: Rotations, Rounds or Small Group Case Based Learning, and Academic Afternoons.

2.2.1 Rotations

> If a student hasn't learnt, the teacher has not taught
>
> Lum, Yun-Foo

Even before the introduction of CanMEDS competencies (Frank 2005) and the shift toward outcomes-based curriculum development, the importance of identifying a set of criteria identifying the requisite knowledge, skills, and attitudes desired for radiology residents was recognized. At the time, there was no research focused on radiology core curriculum development for either undergraduate medical school teaching or radiology residency programs.

In every specialty there are core imaging specialties that each resident needs to know. With modality-based rotations such as fluoroscopy (Gastrointestinal studies), the apprenticeship model of teaching was appropriate as many of the techniques were taught by demonstration. With the integrated program or "organ system" approach to rotations and multiple modalities, the need for a more structured curriculum grew to ensure that all areas are addressed.

Radiology uses a version of PBL (problem based learning) called case based learning (CBL). Residents are presented with imaging studies for independent viewing and then reviewed with the attending radiologist, repeating this process throughout the day. This process has many benefits as it allows the resident to have time to review the findings on the examination in an undisturbed and calm manner; to formulate his/her own diagnosis, to research, if needed, potential questions, and to record any unresolved questions for further discussion with the attending radiologist. The advent of electronic medical records and PACs on each patient also allows the resident to review previous imaging, if available, as well as historical and current medical laboratory data including clinical consultations and pathology which are now easily accessible on-line.

Radiology residency review of cases in most centers is customized, with dedicated individual review time spent with each resident rather than the more team-oriented larger medical or surgical services. This provides radiology residents with a greater opportunity for learning, given the significant amount of feedback and interaction they are afforded with staff radiologists daily. In order to integrate the radiology training with other services, group rounds are held to allow residents from various specialties to congregate and review cases collectively.

2.2.1.1 Rotation Objectives

Rotation objectives are important for both the supervisor(s) and the resident to ensure that the resident has well-defined learning outcomes. It is instructive when the individual rotations incorporate the overall CanMEDS' roles as well as identify specific expectations for the resident to guide their progress through the rotations. All are listed under the appropriate CanMEDS' competency headings in the objectives for the rotation, which are distributed to all residents at the beginning of each academic year. As rotation objectives also differ based on the level of residency training, residents have customized daily rotations. (see for example, Appendix – an excerpt from the Abdominal/Body Imaging Rotations offered at our center.) The residents spend a minimum of 4–6 months if additional elective time is either required or requested in the PGY 5 year.

2.2.1.2 Learning

Radiology learning involves three fundamental components:

- Perception – ability of the resident to see the abnormality
- Interpretation – ability of the resident to understand the significant finding
- Diagnosis – ability of the resident to arrive at either a definitive diagnosis or give a differential list of diagnostic possibilities

As the curriculum is enacted, through CBL at rounds, through daily interactions with attending radiologists and through conversations with medical professionals from various specialties (referring or consulting), opportunities for developing and improving the three components will be at the forefront. Recent research has demonstrated the role reflection plays in goal setting, internal analysis, and as a means to enhance the learning experience (Toy et al. 2009).

2.2.1.3 Reporting

In the business world, customers are referred to as clients. In medicine, the referring physician has traditionally been the "client" as reports are generated for the referring physician. However, as a more patient-centered philosophy has evolved, the patient is also viewed as a client, presenting radiologists with the dual responsibility of serving both the referring physician and the patient. This increased responsibility has become more apparent in recent years as shared clinical and imaging practices with nonradiologist imagers and the promotion of screening programs (e.g., breast screening where the patient self-refers) become more prevalent.

While verbal preliminary reports can satisfy urgent requests (e.g., where a stat report needs to be communicated for patient care and safety) following up with written documentation of what was communicated in the form of a final written report is critical. The need for documentation must not be minimized, as it is often the case that a patient has involvement across multiple medical/surgical teams making accurate and focused information vitally important. Negative patient outcomes or complications can never be entirely avoided, but it is noteworthy that legal consequences are often a result of poor documentation rather than lack of competency.

There are many styles of reporting and they are well-described in the Radiology literature (Stolberg 2002). What is of utmost importance is the need to summarize and include the interpretation of imaging studies at the conclusion of the report, making recommendations where appropriate.

2.2.2 Rounds or Small Group Case Based Learning

2.2.2.1 Rounds by Radiologists

Formal Radiology teaching has primarily occurred through a tradition of "rounds," which are often held at specific times daily, ranging from one to three times per day. These sessions both model and foster a team approach, while bringing residents together for about an hour of undisturbed, focused interaction. Generally, rounds include the participation of a few subspecialty staff radiologists who bring expertise in various topics.

Radiologists encounter interesting cases on a daily basis, and it is the compilation of these cases which will easily facilitate teaching. There are many systems to categorize teaching file cases, and in the current electronic environment, rapid and accessible files with user-friendly programs are integral to the smooth operation of an academic center.

It is important to note that residents are assessed, as part of their rotation, on their contributions to rounds. The milieu of rounds allows each resident to demonstrate, in a communal setting, their evolving abilities to problem solve since the format for the majority of rounds utilizes a CBL framework with explicit instruction or didactic lectures used to address specific information. The conditions of the learning environment contribute greatly to the success (or lack of success) that takes place during rounds. Staff Radiologists leading rounds need to:

- Recognize the importance of modeling how to present and communicate effectively
- Point out common errors that are made and demonstrate the critical thinking processes that are used to arrive at a differential diagnosis

- Understand that residents learn information in different ways and provide multiple avenues to instruct and support learners
- Recognize that creating an environment which views mistakes as "sites for learning" can be a valuable instructive opportunity in a setting with low risk
- Understand the difference between poor communication skills and a lack of knowledge, and be able to support the development of both
- Understand deeply the importance of meaningful feedback that clarifies, corrects, extends, supports, or confirms the residents' evolving understanding, with clear direction in the instructional "next steps"
- Be aware that rounds may be experienced as highly stressful (in particular by junior residents) and that appropriate supports may be required to develop confidence in their abilities as they hone their skills in preparation for examinations

The teaching/learning relationship is a reciprocal one. In addition to the responsibilities outlined above for faculty, residents share in the responsibility for their learning. Sometimes, the PGYs present challenges and obstacles that residents have never faced in their previous academic experiences and it can be somewhat overwhelming. It is important for residents then to:

- Complete the necessary reading in advance of rounds in order to be prepared and to participate fully in the discussions of the teaching files presented
- Learn to ask questions where clarification or information is needed, and ask for information about additional resources if needed
- Recognize the central role that strong communication skills (verbal and written) play in the professional life of the radiologist, and work to strengthen those skills
- Learn to accept constructive criticism as a mechanism to improve
- Recognize that the "stress" associated with rounds and presenting an opinion on a case with a diagnosis simulates "real-life" consultations with clinicians and to a lesser extent Royal College exams

2.2.2.2 Rounds by Residents

In partial fulfillment of developing the CanMEDS competency of communication, residents are offered opportunities to present imaging findings at other clinical rounds, allowing them to develop their skills in public presentation, demonstrate their expertise and teaching abilities, as well as promoting collaboration and consultation with other clinical services.

Residents are also given the opportunity to present a set of rounds to their peers during their rotation and are encouraged to explore innovative ways of presenting. Some choose a familiar format such as the case-based presentation or a didactic lecture, while others have adopted an interactive game show method such as "Jeopardy," introducing competition, enjoyment, and imagination into their learning.

2.2.3 Academic Afternoons

The curriculum in radiology education is not unlike other specialties and is primarily addressed in half-day sessions of academic teaching known as Academic Afternoons. The structure of the academic afternoons varies greatly from those that are very structured to those that are unstructured, depending upon the topic and the instructor. One of the ways in which educationalists work within a radiology department is to work with faculty to ensure that the structure selected is purposeful. The radiologist, with a focus on their subspecialty content, can work with the educationalist to develop a plan that acknowledges the foundations of teaching and learning; creating an environment for learning, selecting appropriate and relevant content, choosing the teaching and learning strategies, devising suitable assessment and evaluation practices, and ensuring that all align with the objectives established by the Royal College of Physicians and Surgeons of Canada (RCPSC) per specialty.

2.3 Components of Radiology Assessment and Evaluation

Assessment and evaluation are two terms that are often conflated or used interchangeably but they are really quite distinct. They are used differently across subject area disciplines with variable criteria attached to them. For the purposes of this chapter, they are defined as follows.

Educational assessment is a process of gathering information from multiple and diverse sources in an ongoing way, in order to learn what students know, understand, and can do with their knowledge both prior to, and as a result of their educational experiences. The information is used initially to help the instructor develop curricula and prioritize goals around learning. Once teaching begins, the information is gathered to inform the instructor and the resident about the resident's progress and to help the instructor make decisions about instructional next steps (Weimer 2002). Assessment is typically formative, ongoing, and used to guide future actions.

Evaluation on the other hand, is typically summative in nature, and is used to determine the merit of the resident's performance in relation to set standards and criteria. At the point of evaluation, it is essential that the resident has already received ongoing assessment and feedback throughout the teaching–learning cycle in order to identify and address any problems in a timely manner. The evaluation serves to document the achievement for accountability and progression requirements.

2.3.1 Resident Assessment and Evaluation

As previously noted, "assessment and evaluation have proven to be two of the more contested and challenging areas to work through" (Chhem et al. 2008). This statement certainly underpins ongoing challenges for radiologists despite the advent of many tools including electronic on-line programs to facilitate this process. The process of assessment in residency needs to be a combination of formative and summative. Formative assessments leverage ongoing reviews and observations during a rotation and are very important because radiologists providing meaningful and timely feedback is the first step to identifying instructional next steps or resources that guide the resident in his/her development of the required professional knowledge and competencies. It also serves as a model for providing feedback which is integral in the radiologist's practice and addresses the CanMEDS communication competency. Summative assessments will optimally occur at the end of a rotation, with summative evaluation occurring semi-annually and annually to ensure that the resident has achieved the required physician competencies.

Like most teachers, radiologists are caught in the dichotomy of having to prepare residents both for a final examination set by the RCPSC, and also to be patient-focused, caring imagers who provide consultancy and expertise in imaging. These two purposes should be complementary but often appear incompatible as residents, during their final years, may focus narrowly on the details of the final credentialing examination to the near exclusion of engaging in a plethora of clinical cases that could enhance their experience.

All residents need appropriate and timely assessments throughout their rotations, as well as meaningful evaluation at the end of their rotations (Adusumilli et al. 2000). On-line assessment and evaluation tools are now in place which integrate the CanMEDS competencies and facilitate the process for radiologists. As the RCPSC moves toward more specific rotation objectives, it will be important for rotations to have appropriate assessments in place that align with those objectives.

Although faculty appreciate the importance of resident assessments and evaluations, most programs still experience low rates of resident evaluation returns despite emphasis and encouragement by the Residency Program Director and Chairperson. One study on Psychiatry Faculty studied the change in return rate of resident rotation evaluations by utilizing a survey and open discussion as methods of intervention to improve faculty rates of evaluation return (Shah et al. 2007). What has emerged is an understanding that support, guidance, and strategies are needed to help faculty learn how to offer constructive feedback to residents who are struggling or underachieving. Offering positive feedback is easy but often does not help the student understand ways to improve or identify areas to work on. Radiologists on a leadership track are discovering that developing critical communication skills that include constructive feedback strategies are part of today's leadership training curriculum. As leaders and future leaders in radiology departments, resident supervisors are well-positioned to help shape a culture in which constructive criticism is both expected and valued for the benefits to the department, and ultimately to patient care, that it brings. Modeling and practicing these skills will serve as powerful models for junior faculty – the supervisors of tomorrow's residents. Identifying and seeking support, education, and resources to develop these skills becomes additionally important. Although there are mechanisms within each university for resident remediation, when there is a documented failure, it is paramount that timely, meaningful, and appropriate assessment has occurred, with opportunities for remediation along the way.

Historically, residents have been evaluated against their peer group and compared to others at the same level over time incorporating both formative and summative assessments along with evaluations of their teaching assignments. The Royal College specialty requirements are becoming more explicit (as well as prescriptive), which should allow resident supervisors to assess and evaluate residents against the stated criteria that they are expected to meet, rather than "the best compared to the rest." In addition, it is anticipated that summative assessments such as OSCE examinations at the end of rotation and year end along with oral examinations, supplemented with American examinations, such as the ACR in-training examination, will increasingly become integral components of radiology curriculum.

2.3.2 Radiologist and Rotation Assessment and Evaluation by Residents

Although it is often not as well-communicated, for the educational cycle to be complete, residents also have an obligation to provide feedback on their teaching and learning experience. Like their supervisors, residents need appropriate tools and processes to ensure that their feedback offers an optimal assessment of their rotations and supervisors. At our institution, the on-line assessment/evaluation forms residents are asked to complete are often not done. The lack of feedback makes it very difficult for rotation supervisors to modify or enhance the residents' training or their own teaching practices. In addition, faculty seeking promotion need to include assessments and evaluations in their teaching dossiers, as well as for annual Royal College Continuing Professional Development records. Many universities also have Career Development Planning cycles for faculty review and development for which these evaluations are also required.

2.3.3 Reflection, Last But Not Least

Schön (1983) describes two fundamental reflective practices. The first, reflection-on-action, refers to a looking back at what one has already done, examining and critiquing the practice with the goal to improve the practice in subsequent experiences. The second, reflection-in-action, suggests a level of metacognitive awareness while one is teaching, thereby allowing for decisions to be made during the experience. Both contribute to the ability of residents and faculty to assess their own progress toward goals and work to continually improve and build on their professional knowledge and competency in their chosen career.

> the attributes of a professional … emphasize that a professional: applies technical knowledge, has completed higher levels of education, demonstrates competence in order to be admitted to and remain in the profession, is bound by a code of ethics, is a member of a professional association which supports his/her practice, and feels responsible to the public he/she serves … [and] … "are rewarded for efficiency, technical skill, and measurable results, while their concern, attentiveness, and human engagement go unnoticed within their professional organizations and institutions." ways of knowing that value care, nurturance, relationship and situated knowledge are frequently given less attention and legitimacy in professional practice. This creates a tension whereby practitioners face an implicit pressure to attend most seriously to professional ideals of objectivity and measurable results, despite

> frequently being drawn to a career … out of relational ideals and a desire to "care" for the other. (Phillips 1994; Noddings 1995; Grumet 1988; Belenky et al. 1997; Haraway 1991 as cited in Kinsella 2006)

To become professional entails going beyond the credentialing discourses of Board examinations and mandated Continual Professional Development. *Being* professional means,

- Meeting the requisite academic qualifications set by the governing body, the RCPSC
- Continually upgrading your specialized knowledge in the area of your professional practice (i.e., reading about new research in academic journals, attending rounds, conferences and professional sessions, participating in or conducting research studies to improve the knowledge in the field)
- Practicing and modeling best practices for those learning with and from you, with the ultimate goal of improving patient care
- Maintaining documentation that facilitates and motivates professional growth (e.g., teaching portfolios) and continuing the ongoing search for discrepancies between your beliefs and practices through a process of deep reflection upon your own performance
- Demonstrating an exemplary level of professional ethics in all communication, activities, and decision making

2.4 Summary

As academic faculty members, we have a responsibility to share our knowledge with the next generation. Education is lifelong learning and as we begin to understand and articulate what we do, we then open up more opportunities to recognize where we might begin to improve. Residents are here to challenge us and sometimes they are our greatest challenge. Our collective goal is to remain open to what is behind those challenges and to seek ways to learn from them and ultimately, to build the capacity of the whole department together.

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Journals

Radiology
American Journal of Roentgenology
Canadian Association of Radiologists Journal
Academic Radiology
Clinical Radiology
Investigative Radiology
British Journal of Radiology
Magnetic Resonance Imaging Clinics of North America
American College of Radiology teaching files should be used as additional resources.

Associations

American College of Radiology
Canadian Association of Radiologists

European Association of Radiology
Hong Kong College of Radiolgists
Royal Australian and New Zealand College of Radiologists

Appendix
Abdominal/Body Imaging Rotations

Adapted from: Victoria Hospital LHSC Abdominal/Body Imaging Rotation Documents

The rotation will be an integrated abdominal/body imaging rotation for radiology residents which will focus on cross-sectional abdominal/body imaging modalities CT, US, and MRI with some radiography/fluoroscopy. Some chest CT will be included where possible.

Rotation Objectives by Resident Year

By the end of the PGY2 Rotation the resident will:

- Experience 3–4 months in the department with a focus on CT, US, and fluoroscopy
- Identify and communicate imaging indications and diagnosis of trauma and acute/urgent abdominal diseases
- Demonstrate an introductory knowledge of differential diagnosis

Assessment

- Residents will be assessed daily through a review of their knowledge of abdominal anatomy in each modality and their ability to perceive and analyze imaging findings.

By the end of the PGY3/4 Rotation the resident will:

- Gain a further 2 months experience in the department with a focus on CT, US, and MRI
- Demonstrate an abdominal MRI integrating multimodality imaging
- Consolidate previous knowledge from PGY2 and begin formulating complete differential diagnosis in their daily reviews of cases
- Demonstrate supervisory skills in interactions with technologists, medical students, and other off-service residents
- Demonstrate leadership and collaboration skills in interactions with junior residents (where applicable)
- Triage, protocol, and prioritize cases

(Residents who would like further experience in biopsies can obtain additional experience if requested.)

Assessment

- Residents will be assessed daily through a review of their knowledge of abdominal anatomy in each modality and their ability to perceive and analyze imaging findings

By the end of the PGY 5 Rotation the resident will:

- Experience an additional 1 month elective CT,US, and MRI
- Demonstrate ability to identify abdominal imaging diseases with further development of differential diagnosis combining real-practice aspects with Royal College examination requirements appropriate for a PGY5 candidate
- Function as a junior consultant, taking on supervisory responsibilities and requesting staff assistance when necessary in alignment with graded responsibilities as part of developing the CanMEDS competencies

CanMEDS Rotation Objectives Pgy2–5

In accordance with RCPSC CanMEDS roles, the rotation-specific objectives are as follows:

Medical Expert

Technology

- An understanding of various technologies, recent advances, advantages vs. limitations
- An understanding of the role of technologists and expertise
- An understanding of scanning protocols, postprocessing techniques
- Knowledge of appropriate contrast utilization and techniques (IV, oral, etc.)
- Develop an understanding about the physics involved with each technique including artifacts
- Be knowledgeable about quality assurance of each modality

Anatomy

- Cross-sectional anatomy of the abdomen (GI, GU, Vascular, Lymphatics, etc.) in all modalities
- Normal variants
- Pathways of pathology spread

Skills

- Able to insert angiocatheter for venous access
- Able to apply the appropriate protocol(s) for each patient
- Able to modify scanning protocols based on variations of clinical and technical factors
- Able to supervise examinations including checking acute cases from ER, trauma
- Able to diagnose and treat complications related to intravenous injections (limitations, extravasation, reactions, etc.)

- Senior residents should be able to perform simple biopsies including the organization of the procedure (pre, during, and post)
- Understand the various oral and rectal preparations for fluoroscopic examinations and performance of those examinations

Interpretation

- Knowledge of abdominal pathologies and the capability of the exam to evaluate the pathology
- Knowledge of the diagnostic ability of each examination including recognizing artifacts, limitations, potential contraindications, and complications
- Learn the importance of comparisons with previous examinations and correlative imaging including clinical information on the case and clinical expectation of the results
- Knowledge of additional examinations required for further diagnostic or therapeutic intervention
- Ability to recognize critical acute diagnosis
- Ability to develop appropriate differential diagnosis and suggest appropriate further imaging, therapy, or clinical action required

Communicator

- Develop communication skills with attending radiologists and radiology residents with a positive and enthusiastic attitude toward learning
- Develop communications skills with referring physicians, residents including results of examinations (preliminary and final report), notification of complications and follow-up
- Develop communications skills with patients (families) when asked about results in an ethical and appropriate manner or when dealing with a complication of an examination
- Ability to discuss and obtain informed consent from patient, parent, or legal guardian
- Communicate with support staff within the specialty, technologists, nurses, clerical booking personnel, as well as with referring support staff such as ward clerks, nurses, etc.
- Listen effectively to concerns of others and enjoy continuous learning
- Once an acute diagnosis is made, the ability to communicate urgent results by immediate communication with referring/attending physicians and documentation of the discussion
- Ability to dictate in a concise, clear manner to facilitate typing of reports by stenographers and developing an appropriate usage of the radiology lexicon
- Complete communication process by signing reports in timely manner

Collaborator

- Ability to communicate and develop an expertise related to consultation on abdominal imaging cases and an appreciation of other specialists imaging requirements
- Develop a cooperative attitude and facilitate imaging requests, working as a team with clinicians
- Assist clinicians in understanding appropriateness criteria for examinations (best test)

Manager

- Ability to triage cases based on urgency
- Ability to manage workload on a daily basis by reviewing cases at appropriate intervals and an appropriate work ethic
- Work effectively within the context of the subspecialty area

Health Advocate

- A global understanding of the determinants of health
- An understanding of cross-sectional imaging determinants which include awareness of radiation safety, contraindications to examinations (pregnancy, metals in MRI, body habitus, etc.), and alternate methods of imaging such as no radiation vs. radiation based on the understanding of the clinical requirements and the appropriateness of each examination
- Contribute to the improved health of the patients and communities by advocating the best examination and promoting appropriate access

Scholar

Learning

- Daily case review and differential diagnosis discussions with radiologists
- Develop a lifelong learning strategy
- Read core reference textbook and utilize journals/on-line resources (see references below)
- Utilize information technology (electronic patient record) or patient chart to obtain clinical information relevant to the examination
- Develop an ability to critically appraise resources of radiological information
- Participate in abdominal imaging resident and clinical rounds and be a role model for residents/students
- Contribute toward learning of other residents by submitting two teaching file cases/month of rotation in electronic format
- PGY 2: Fundamental interpretation skills of emergency imaging and trauma which include bowel diseases (perforation, obstruction, ischemia, appendicitis, other "itis," inflammatory and infection, neoplasms), renal/retroperitoneal acute diseases (renal colic, infection, neoplasm, hemorrhage, etc.), thoracic dissection, PE, pneumonia, pulmonary edema, etc.
- PGY 3/4: To consolidate differential diagnosis of diseases, patterns of spread of disease, building on previous rotation
- PGY 5: To develop into junior clinical consultant, supervising area, and developing some independence in reporting whilst reviewing key diseases and differentials in preparation for exams

Teaching

- Participate in weekly abdominal imaging rounds with abdominal radiologists which will include one presentation by resident once a month to peer group to develop teaching expertise
- Teaching off-service residents/students (formally/informally) as required by Radiology program
- Learn to teach by presenting one rounds/month to other radiology residents of interesting cases during rotation and by mentoring off-service residents or medical students
- Teach clinical staff at regular clinical service rounds (general surgery, urology, other) and be an advocate of abdominal imaging and radiology

Professional

- Deliver high-quality imaging, optimized for disease entity, clinical requirements
- Encouraged to support the imaging profession and to develop a sense of professionalism by becoming a member of professional organizations (CAR, RSNA, AJR, etc.)
- Ensure that an examination provides and contributes toward optimized patient care and appreciating that there is a person behind the images
- Practice imaging ethically consistent with the obligations of a physician which includes respect for patient privacy and confidentiality in compliance with hospital policies

Rotation Evauluation

- Evaluation will be based on all above objectives and the completed submission of two electronic teaching file cases/month
- Evaluation may include an Objective Stuctured Clinical Examination (OSCE)
- In-Training Resident Evaluation (ITRE) will consist of a composite evaluation by all supervisors at the end of rotation
- The level of expertise should increase over the course of the rotation(s) and will be evaluated based on appropriate resident year
- Expectation for residents to achieve an average or above average evaluation on ITRE for the rotation

Applying CanMEDS to Academic Afternoons

3

Karen Finlay and Linda Probyn

3.1 Theory and Principle

The CanMEDS framework of the Royal College of Physicians and Surgeons of Canada outlines comprehensive content which must be included in all residency training programs in Canada. (Frank 2005) In existence since 1996, this framework emphasizes the importance of training physicians to meet both the needs of individual patients as well as society as a whole, through the development of program curriculum specifically addressing seven physician roles. The CanMEDS Roles include: medical expert, communicator, collaborator, manager, health advocate, scholar, and professional. This competency framework mandates development of specialty-specific curriculum and inclusive resident evaluation, in order to adequately prepare residents for certification and independent practice. The roles define the essential components for physician competency and ongoing professional development, preparing learners for the demands of the specialty, societal expectations, and the challenges of future practice. The American Accreditation Council for Graduate Medical Education (ACGME) requires similar broad-based core competency training in residency education curriculum, including six general competencies: patient care, medical knowledge, practice-based learning and improvement, interpersonal and communication skills, professionalism, and systems-base practice (ACGME 2008). To address these training requirements, programs must include specialty-specific ethics topics in their radiology residency curriculum (Oljeski et al. 2004). The shift from an almost exclusive educational focus on medical expertise highlights the increasing recognition that physician training needs to specifically address more comprehensive skills and professional behaviors. Although the CanMEDS Roles are not new or particularly unique, the framework challenges programs to expand their focus and approach to formal educational training in residency, more so than has been conventionally emphasized in the past. Roles overlap, but the

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overall scheme and content to be included in program curriculum must include all seven roles.

While the Medical Expert still occupies the privileged position as "keystone" to becoming a successful professional and physician, it has become clear that medical expert in the absence of the additional competencies is insufficient. The challenge for medical educators is to first recognize and explore what each of the roles means for the physician in general and, secondly, what they mean for radiology education and the radiologist in practice. The next challenge is to integrate content and strategies that allow the development of the competencies to emerge within the context of the radiology curriculum and program. Although generic in their overall description and intent, each of the roles has specific applications in the specialty of diagnostic radiology. In the first part of this chapter, we will explore what the CanMEDS Roles mean for radiology, and how these facets of professional practice are exercised and experienced in everyday practice. In the second part of the chapter, we will outline practical solutions for including this content in your residency educational curriculum.

3.2
Challenge 1: What Are the CanMEDS Roles and What Do They Mean for Radiology?

An understanding of each CanMEDS Role is important, in order to appreciate the competency framework for all physicians – this is the first critical step. Knowledge of the application of each role to diagnostic radiology evolves from this understanding. A summary of these roles is provided in Table 3.1. Each specialty has developed specific CanMEDS objectives for their residency programs, accessible for review on the Royal College website (RCPSC 2006.)

3.2.1
Medical Expert

Definition: "As Medical Experts, physicians integrate all of the CanMEDS Roles, applying medical knowledge, clinical skills, and professional attitudes in their provision of patient-centered care. Medical Expert is the central physician Role in the CanMEDS framework" (Frank 2005).

This competency involves the integration of all of the other CanMEDS Roles and is easy to understand. Central to this role is the specialty-specific body of knowledge, patient assessment, and clinical skills, diagnostic decision-making, manual and procedural skills, patient management, and consultancy skills necessary for practice. For the radiologist, knowledge of basic science, physics, radiation, anatomy, disease processes, clinical radiology, pharmacology, and contrast media are all included. The radiology Medical Expert Role also encompasses the fundamentals of quality assurance, epidemiology, and biostatistics, as well as maintenance of competency.

Table 3.1 CanMEDS Roles for radiology (Frank 2005)

CanMEDS role	Role descriptors
Medical Expert	Medical knowledge of clinical radiology, anatomy, physics, pharmacology and contrast, quality assurance, biostatistics, and epidemiology
	Diagnostic reasoning, clinical judgment and decision-making, consultancy skills
	Manual and procedural skills competency
Communicator	Communication skills during clinical encounters: patients, families/significant others, team members
	Establishing rapport, trust, empathy, compassion
	Verbal and nonverbal communication awareness
	Written documentation of clinical encounters (e.g., reports, consultations)
Collaborator	Effective healthcare team functioning and collaborative decision-making (e.g., nurses, technologists, support staff, referring clinical services)
	Team skills of delegation, awareness of team dynamics, constructive negotiation, conflict resolution, management and prevention
	Interprofessionalism, respect for others
Manager	Resource allocation and decision making (e.g., care prioritization, protocoling)
	Skills and knowledge required for sustainable practice: technical, computer, organization, office management
	Leadership and administrative roles
	Personal time management, work/life balance
Health Advocate	Advocacy for individual, patients, communities
	Recognition of determinants of health and public interest health issues (e.g., screening programs)
	Patient safety (e.g., radiation)
Scholar	Skills for lifelong learning: continuing professional development, critical appraisal, research literacy, journal clubs, translating knowledge in to practice
	Teaching (students, residents, fellows, technologists, clinical colleagues, laypersons), assessing learners and giving feedback
	Role modeling, mentoring
Professional	Concepts of ethical practice: integrity, honesty, compassion, respect
	Adherence to professional regulatory standards, peer review processes, medical-legal frameworks
	Awareness of personal health and professional behaviors of self and others

3.2.2 Communicator

Definition: “As Communicators, physicians effectively facilitate the doctor-patient relationship and the dynamic exchanges that occur before, during, and after the medical encounter” (Frank 2005).

The Communicator Role includes skills in therapeutic, patient-centered communication with patients, families and care-givers, as well as other health-care professionals or individuals involved in patient care. The role requires effective listening, establishment of rapport and trust, as well as skills at conveying diagnoses and important information in a manner that is compassionate, effective, and accurate. For radiology, this includes instances where interaction with patients and families is direct (for example, obtaining consent), interactions during diagnostic or therapeutic tests and procedures, as well as indirect communication of test or procedure results. Communication also includes interaction with other healthcare team members and synthesis of information in a manner which is timely, appropriate, and effective in both written and verbal formats. The formulation of an effective radiology report is a common and frequent daily component of the radiologist's communicator Role.

3.2.3 Collaborator

Definition: "As Collaborators, physicians effectively work within a healthcare team to achieve optimal patient care" (Frank 2005).

The Collaborator Role allows the physician to function optimally in a multidisciplinary and multiprofessional environment, respecting the input and expertise of all. This role necessitates skills in conflict management and knowledge of team dynamics. Radiology-specific teams involve support staff, nursing, technologists, physicists, department managers, other subspecialty colleagues and hospital administrators. Radiologists participate on many clinical multidisciplinary teams for surgical and medical subspecialty interests, interventional referrals and procedures, as well as hospital and educational committees. These collaborator-role skills are important for effective team operations and as a result, optimal patient care.

3.2.4 Manager

Definition: "As Managers, physicians are integral participants in healthcare organizations, organizing sustainable practices, making decisions about allocating resources, and contributing to the effectiveness of the healthcare system" (Frank 2005).

The Manager Role encompasses the important organizational challenges of the healthcare system in modern-day practice. It addresses human and physical resource availability, utilization, and financial considerations of medical practice. In radiology, these skills are important for effective team operations and optimized healthcare delivery. Resource management encompasses local hospital or community healthcare settings, as well as regional and national levels and standards. To operate effectively, decisions and policies regarding test appropriateness, case prioritization and finite resource allocation are critical to providing equitable care to all members of the community. Radiology resource and equipment allocations, manpower needs, budgeting, and financial considerations are all intimate with this role. Simple tasks of protocoling or accepting requisitions, to larger projects lobbying governmental bodies for appropriate budget and equipment resources represent the spectrum of the Manager Role for the radiologist. A second important facet is personal time management, effective use of computer and healthcare technology, and efficient practice organization. Included in this role is managing the balance between work and personal life demands. This is a challenge for both the radiology trainee and the practicing radiologist.

3.2.5 Health Advocate

Definition: "As Health Advocate, physicians responsibly use their expertise and influence to advance the health and well-being of individual patients, communities, and populations" (Frank 2005).

As Health Advocate, the physician must identify the important determinants affecting the health of patients and communities, responding to issues where health advocacy is appropriate. In radiology, the importance of considering the risk and benefits of various tests, interventional treatments and therapies is critical. Central to the task of the radiologist as Health Advocate is minimizing or limiting radiation exposure, as this is the largest patient safety issue in our practice. A large part of this role entails education of referring clinicians and patients regarding the appropriateness of radiological imaging, advising on best practice, and working with industry to minimize risks. The advocacy of effective screening programs also encompasses the Health advocate role for radiology, as these programs address important health promotion and early detection for individual patients, as well as the community at large.

3.2.6 Scholar

Definition: "As Scholars, physicians demonstrate a lifelong commitment to reflective learning, as well as the creation, dissemination, application and translation of medical knowledge" (Frank 2005).

Central to the Role of Scholar are the principles of lifelong learning, development and maintenance of a continuing personal education plan, as well as skills in critical thinking and critical appraisal. This role addresses the challenges of acquiring, maintaining, improving, and sharing knowledge and expertise in everyday practice. The importance of research, teaching, mentoring capacities, and critical thinking are easily translatable to everyday radiology practice. From the beginning of our education, effective learning strategies, monitoring, and revision of personal learning plans, as well as translation of our developing knowledge base to practice are key factors in the professional practice of the radiologist. Radiology residents teach medical students, fellow residents and colleagues, technologists, and lay persons. This necessitates developing various skills, including the ability to give an effective presentation, objectively assess, evaluate, and provide feedback to others. Teaching skills are an important facet of the physician scholar role.

3.2.7 Professional

Definition: "As *Professionals*, physicians are committed to the health and well-being of individuals and society through ethical practice, profession-led regulation, and high personal standards of behavior" (Frank 2005).

As a Professional, the physician must deliver the highest quality of care, exhibiting altruism, compassion, and integrity. The Professional Role applies uniformly to all medical subspecialties, including radiology. Adherence to an acceptable code of ethics and demonstration of appropriate personal and interpersonal professional behaviors are pivotal to this role. Responsibilities include commitment to professional standards and accountability to regulating bodies. The Professional must respect the diversity of others, along with recognition and appropriate response to ethical issues in practice. Professional issues on a personal level entail balancing personal and work responsibilities, awareness of personal strengths, weaknesses, and limitations. The radiologist as a Professional must be aware of their personal health and behaviors, as well as those of others, in order to foster a sustainable practice.

3.3 Challenge 2: How Do I Implement the CanMEDS Framework into Formal Radiology Curriculum?

Academic half-days are an opportune time for introducing and highlighting formal educational curriculum in the CanMEDS competencies. In order to best communicate the importance of CanMEDS content, the information needs to be interesting and specialty-specific, in order to engage the residents and effectively communicate their importance and relevance. If the resident can translate the content to their everyday experiences in residency, then the message of CanMEDS competencies beyond the Medical Expert Role "hits home." This is the challenge: to develop CanMEDS content that is interesting, specialty-specific, and can be easily incorporated into an already demanding and time-restricted educational curriculum.

3.4 Practical Implementation

In this section we outline some topics and clear examples of how to design and implement radiology-specific CanMEDS curriculum, using two different approaches. The first is a resident-centered group presentation in a workshop or small group exercise format; the second involves the development of a half- or whole-day CanMEDS topic retreats. Finally, we will provide some "tips" for explicitly identifying and labeling CanMEDS competencies in residency experiences beyond the traditional academic half-day format.

3.4.1 CanMEDS Academic Half-Day Presentations

The critical step for either approach is CanMEDS topic selection. There are a number of topics relevant to the six CanMEDS Roles of Communicator, Collaborator, Manager, Health Advocate, Scholar, and Professional that can be adapted to the everyday experience of the radiology resident and practicing radiologist (Table 3.2). After gaining

Table 3.2 CanMEDS topic ideas for half-day

CanMEDS roles	Topics ideas
Communicator	Informed consent and mental capacity issues
	Effective oral and written communication
	The radiology report
	Breaking bad news
	Public and Media communication skills
Collaborator	Conflict resolution:
	Resident to resident/faculty/technologists and support staff
	Resident to referring services
	Building and participating in interdisciplinary teams
	Effective team functioning and team dynamics
Manager	Work/life balance and stress management
	Technology and electronic resource utilization
	Healthcare economics and cost of radiologic healthcare delivery
	Business and practice management issues
	Career planning – fellowship choices; academic vs. nonacademic practice
	Job searching
	Contracts, marketing, and negotiations
	Building your Radiology CV
	Accounting: business and personal
Health Advocate	Radiation safety
	Workplace safety issues
	Screening programs
	Patient education
	Infection control education and practices
Scholar	Research and publication ethics
	Critical inquiry and critical appraisal
	Teaching skills – methodology and effective techniques
	How to assess and give constructive feedback
	Effective personal learning strategies and goal setting
Professional	Morality and professional codes of conduct
	Professional misconduct and disruptive physician behaviors
	Disclosure of error, or adverse events/misdiagnosis
	Medical legal issues
	The physician apology
	Patient confidentiality
	Bioethical principles
	Medical legal issues

familiarity with the CanMEDS Roles, the next step is collection of relevant CanMEDS content or topic ideas. Collect and write your ideas down. Share ideas with other programs in your specialty, as well as those outside of your specialty. Pay attention to local hospital bulletins, postgraduate education office activities, and local health organizations. Often there is a local expert who can contribute to your educational program. There are a variety of different sources of potential seminars or workshops. Identify and collect relevant articles from radiology and nonradiology journal publications, professional association journals, newspapers, provincial college publications, and malpractice association bulletins to quickly accumulate a wealth of potential topics for consideration. A list of resources relevant to CanMEDS topics is provided at the end of this chapter. Although by no means comprehensive, it provides an example of the types of articles and publications that lend themselves to developing a CanMEDS curriculum topic.

3.4.2 Idea 1: Small-Group Presentation of CanMEDS Topics: Format and Description

The small-group exercise format involves the development of a specific CanMEDS topic relevant to radiology, with defined learning objectives. With this approach, small-group tasks are assigned to the residents in order to present to their peers content relevant to the CanMEDS topics addressed in the group task. This may involve exploring some developed clinical scenarios or presenting material specific to their assigned questions or research issues. The key to this approach is active resident involvement in order to engage them in the topic and invite discussion amongst their resident colleagues. With minimal effort, a number of different topics can be developed, with potential for repeat utilization in the program curriculum, on a rotating basis. When well-designed, the small-group presentation format takes only 1 h for residents to present at half-day. With resident input and creative presentation, this specialty-specific CanMEDS content has impact.

Steps for small-group presentation:

1. Select a topic relevant to the CanMEDS Role you wish to cover in your half-day. Some topic ideas are listed in Table 3.2. Often the selected topic will address more than one CanMEDS Role.
2. Perform a brief review of the literature and/or review the file of relevant articles you have collected (also see resource list at the end of this chapter). Identify some key relevant resources or articles for distribution ahead of time.
3. Write a brief introductory paragraph to introduce the topic; and describe its importance for radiology. This will assist in developing the objectives for step 4.
4. Develop some CanMEDS learning objectives for the session, based on your selected topic.
5. Put together some case-based scenarios, or specific group tasks/questions you wish the groups to research and present.

6. Pre-circulate the following items 1–2 weeks before the scheduled half-day:
   – Session description, including background and learning objectives
   – Group assignments (split in to two or three, depending on your program size and breadth of topic)
   – Key references/articles – these can be electronically distributed in PDF format.
7. Each group must present the information to their peer resident group, inviting active discussion. The groups are directed to put together a short presentation (e.g., 15 min), facilitating discussion around their assigned group task or questions.
8. Evaluate the resident presentations.
9. File the session along with the relevant resources for future reference. You can ask the group to submit their presentations or any material they developed for documentation and future reference.

With three small-group assignments of 15 min duration, the entire session and topic can be covered in 1 h, including time for discussion. With this format, half-day afternoons can include distributed non-Medical-Expert Role topics throughout the academic year, along with the essential Medical Expert educational curriculum.

3.4.3 Examples: Sample Small-Group Sessions

Sample sessions provided in this chapter are outlined in Table 3.3:

3.4.3.1 Example 1

RADIOLOGY CanMEDS TOPICS
TOPIC: The Radiology Report
CanMEDS Role: Communicator

Table 3.3 Sample small group sessions for CanMEDS Role education

Title	CanMEDS Role
The radiology report	Communicator
Conflict resolution and team skills	Collaborator
Physician well-being and work/life balance	Manager, professional
Population screening	Health advocate
Guidelines and tips for teaching and presenting with powerpoint	Scholar
The resident as a professional, role model, and effective communicator	Professional and communicator

Background

The radiology report is the mainstay of communication between radiologists and clinicians. As diagnostic imaging departments operate in a digital environment, the face-to-face interaction between imagers and clinicians, even in the hospital setting, has been significantly reduced. In community settings, the referring physician and imaging specialist rarely communicate directly. The radiology report is the key information piece connecting these two medical parties.

Learning objectives

1. To review the essential components of a "good" radiology report
2. To discuss some strategies for enhancing the communication of important findings in your radiology report
3. To review some different styles of reporting

Please split yourselves into three small groups, in order to address the following topics and questions. Your group should be prepared to present a 10–15 min presentation on your assigned topic.

Group 1: What makes a good report?

- Report format: what are the general attributes of a "good" report?
- Create a sample standard template with headings and recommendations for structuring reports
- What are clinicians looking for in a radiology report?
- Choice of language: What terms should be avoided? Provide some examples. Why should these be avoided?

Group 2: Learning to report

- What are some strategies for learning to report?
- What are some suggestions for enhancing/improving your current reporting style?
- Create a "Do's and Don'ts" list for reporting that would be useful for residents – both beginners and those more experienced at dictating.

Group 3: Horizons in reporting

- Outline the advantages and disadvantages of reporting in a digital environment, with computer-based technologies.
- What is structured reporting? How does this differ from free-form reporting? Provide an example, contrasting the two forms of reporting style for a case.
- What are the advantages and disadvantages of these two different forms of reporting?
- Outline some preventative strategies for avoiding destructive conflicts
- Under what settings or types of exams might structured reporting be most useful?
- What are some "new horizons" in radiology reporting?

3.4.3.2 Example 2

RADIOLOGY CanMEDS TOPICS
TOPIC: Conflict Resolution and Team Skills
CanMEDS Roles: Collaborator, Communicator, Professional

Background

"Conflict is ubiquitous in medicine." Although it is an inevitable part of our medical experience, it is important to recognize sources of conflict and effective means for dealing with it. In radiology, the trainee and faculty are in constant interaction with other clinical services, allied health team members, support staff, patients, and family members. Daily situations arise where conflict may negatively influence outcomes. The purpose of this session is to identify some precipitating factors and introduce some strategies for improving and avoiding these situations.

Literature and research indicate that team building increases efficiency and productivity. It is important to recognize the factors which comprise a healthy and effective team.

Learning objectives

1. To develop an understanding of the complexity of conflict
2. To identify situations and personal interactions in the radiology environment which lead to conflict
3. To recognize and discuss some important steps in achieving successful conflict resolution
4. To understand the essential qualities of effective/successful teams

Please split yourselves into three small groups, in order to address the following topics and questions. Your group should be prepared to present a 10–15 min presentation on your assigned topic.

Group 1: Conflict definition and sources

- What is conflict?
- What are common causes, forms, and sources of conflict?
- Why do conflict or team difficulties arise? Provide some examples/illustrations

Group 2: Conflict resolution – styles and suggested strategies

- What are the five different styles of conflict resolution?
- Highlight the key/important steps in achieving successful conflict resolution
- Describe some conflicts that may be encountered in radiology-specific settings, for instance:
  - Ethical
  - Patient/family

  - Peer
  - Supervisor/faculty
  - Other health team member or physician

- Outline some strategies for conflict resolution in your selected scenarios

Group 3: Team building and strategies for dealing with team challenges

- What are the essential qualities of a successful team? Define/describe these behaviors or qualities.
- Outline some preventative strategies for avoiding destructive conflicts in teams, as well as some strategies for dealing with challenging team issues.
- How can these strategies be developed or enhanced for building and maintaining: a successful radiology resident group; a successful radiology department?

3.4.3.3 Example 3

RADIOLOGY CanMEDS TOPICS
TOPIC: Physician Well-Being
CanMEDS Roles: Manager, Professional

Background

The practice of medicine is a lifelong challenge. It takes hard work and dedication to enter and excel at medical school; however, the challenges do not stop there, as the demands of residency and medical career beyond can be intense. There is a need to effectively nurture and develop a successful medical career, establish and maintain ties with friends and family members, as well as develop interests outside of medicine. Balancing the work–life challenge can be difficult. Stress and workload can affect performance both at work, as well as in your personal life. Physicians must pay attention to stress management, preventative health and self-care strategies.

Learning Objectives

1. To identify potential stressors which challenge residents in the workplace and in life outside of work
2. To discuss some practical strategies for stress-management, personal scheduling and studying in residency, and improved personal health/well-being
3. To identify important warning signs of stress in yourself and others
4. To identify available resources for assistance with stress and work-related issues

Please split yourselves into three small groups, in order to address the following topics and questions. Your group should be prepared to present a 10–15 min presentation on your assigned topic.

Group 1: Identifying stresses

- Outline potential stressors that face:
- All residents
- The radiology resident
- The practicing radiologist
- What specialty-specific factors challenge physicians as apposed to other professionals? What are common causes of physician "burnout"?
- Discuss the challenge of "perfectionism"

Group 2: Physician stress and basic self-care

- Discuss some important "back to basics" strategies for improving or maintaining good health, self-care, and work/life balance during residency
- What are some strategies for organizing work responsibilities and study time to facilitate effectiveness at work and wellness in personal life?
- What makes a physician resilient?
- What are some personal practices that can enhance resilience and assist with stress?

Group 3: Advanced strategies for coping

- Identify important "warning" signs for dangerous or self-destructive behaviors in yourself and others
- What steps should you take when you recognize overwhelming stress in yourself or others?
- What can organizations or residency programs do to promote resident well-being?
- What are the local resources or contact people at your University or program who can assist with stress management and important work/life issues?

3.4.3.4
Example 4

RADIOLOGY CanMEDS TOPICS
TOPIC: Population Screening
CanMEDS Roles: Health Advocate

Background

Screening has become a health issue intimate with diagnostic imaging, as new technologies have facilitated more elegant imaging of the body. When screening is discussed, it generally refers to an individual test, for instance mammography with breast screening programs. The screening process itself, however, involves many steps, including identification of the population at risk, to the diagnosis of the disease or its precursors in certain individuals, to the treatment of those individuals.

Screening programs can be controversial – the decision to introduce screening involves review of the test effectiveness, as well as careful consideration of cost. Solving problems that arise from screening test findings can be much more difficult. The “incidental finding” is an example of this. The overall benefit to the individual and community at large should be proven, before wide-scale support is merited. There are emerging trends in screening for disease, including the practice of whole-body CT screening. As radiologists, we should be aware of the critical steps required to evaluate a screening test and screening program, as there are important scientific, ethical, and economical considerations.

Learning Objectives

1. To become familiar with the principles involved in the evaluation of a program for screening of disease
2. Identify the important factors that determine the effectiveness of a screening program
3. To increase awareness of the harms vs. benefits of screening practice
4. To discuss emerging trends in self-referral and imaging for early disease detection

Please split yourselves into three small groups, in order to address the following topics and questions. Your group should be prepared to present a 10–15 min presentation on your assigned topic.

Group 1: The Basics – Important principles in screening

- Define screening
- What are the classic criteria required for screening?
- What are the descriptors of an ideal screening test?
- Define “lead time bias” and “length time bias”
- Discuss and provide some specific clinical examples that illustrate these concepts
- How is screening effectiveness determined?

Group 2: Harm vs. Good

- Discuss issues of “harm” vs. “good” in screening and provide some specific examples in radiology
- Discuss the issues related to false positive and false negative results in screening, along with their potential impact. Illustrate these with some examples
- Discuss the potential harm of over-diagnosis and psychological implications for patients

Group 3: Beyond screening – controversies in self-referral and whole-body CT

- What are the controversies around whole-body screening (WBS)?
- Discuss the apposing arguments for this practice.
- What are the potential medical, ethical and medico-legal implications?
- Is WBS truly screening? Why or why not?

3.4.3.5 Example 5

RADIOLOGY CanMEDS TOPICS
TOPIC: Guidelines and Tips for Teaching and Presenting with PowerPoint
Techniques and Strategies for Enhancing and Improving your Teaching Effectiveness and Oral Presentations
CanMEDS Role: Scholar

Background

The presentation of information and scientific material at meetings and conferences is an important method for conveying information and new ideas to colleagues and learners. Effective presentations are also important when teaching medical students, peers and other health team members. At meetings, conferences, and rounds, there are certain presentations and lecturers who stand out against those that are less effective. Have you ever considered why this is?

It is important to recognize that PowerPoint (Microsoft, Redmond, WA, USA) is only a tool – it is not a teaching method. While widely utilized, it is not always the most effective means of teaching or communicating, particularly if not used with care or forethought. For radiology, PowerPoint is a very functional means for conveying information, particularly, given the digital nature of imaging. The radiology resident as a teacher or presenter at a scientific meeting must learn to use this tool appropriately, in order to convey their message and impart information effectively. The key features of any successful presentation are the teaching skills: choice of content, organization, visual enhancement, and oral presentation skills and delivery. We need to consider what we are teaching and how we are teaching it, in order to best utilize and take advantage of the tool of PowerPoint.

Learning Objectives

1. To review important principles for presentation structure, content, and organization
2. To learn skills for enhancing PowerPoint presentation of images and text, in order to increase effectiveness of presentations
3. To review strategies for enhancing delivery of your oral scientific presentations and didactic teaching

Please split yourselves into three small groups, in order to address the following topics and questions. Your group should be prepared to present a 10–15 min presentation on your assigned topic.

Group 1: Practical aspects

Review and describe the important principles for slide preparation. Your group focus is the overall scheme and format selection for presentations.

- Background selection – color/design: what should you choose and why?
- Font selection
- Guidelines for color use on text and imaging slides
- Content per slide – bullets vs. sentences?
- How can you optimize pointers for the audience?
- Should blanks or fillers be used? Why?

Provide slide examples that highlight the above important principles, illustrating the above tips with a poor slide format, followed by optimized content, color, and outline.

Group 2: Images and animation

Radiology images are key components of teaching with educational radiology material. Please discuss the following:

- How to select an optimal image
- How to decide how many images to use
- Should you use the whole image, or only part? Why?
- Outline the advantages and disadvantages of using animation
- How can animation be used effectively – is there any role for it?

Provide slide examples that highlight the above information, illustrating important tips for image enhancement. Also demonstrate ineffective and effective use of animation.

Group 3: The Anatomy of a good talk

Designing your talk to meet the needs of your target audience is important. Additionally, you must structure your talk effectively, in order to cover the content and message you wish to deliver. Lastly, the presentation is only as good as the presenter!

- What are important features to consider when assessing your target audience?
- What advice do you offer for outline and structure of an effective talk?
- What are some tips and rules for giving a good presentation?
- How can you keep your audience engaged?
- How do you advise preparing or dealing with questions?
- How can you improve your teaching and oral presentation skills?

3.4.3.6
Example 6

RADIOLOGY CanMEDS TOPICS
TOPIC: The Resident as a Professional, a Role Model, and an Effective Communicator
CanMEDS Roles: Professional, Communicator

Background

As radiologists and residents in training, we need to strive to excel beyond our role as image interpreters. It is critical that we learn how to interact effectively with patients, colleagues, and other staff members. Professionalism and good communication skills are interlinked key behaviors.

Residents are exposed to role models (good and bad) throughout their training. It is important to recognize that residents themselves are role models for peers, junior residents, and medical students and can therefore have significant impact on learners who are exposed to their behaviors.

Learning Objectives

1. To explore professionalism and the behaviors and attitudes that define it
2. To review some techniques for enhancing communication and professionalism
3. To develop an understanding of the importance of the resident as a role model for junior learners

Please split yourselves into three small groups, in order to address the following topics and questions. Your group should be prepared to present a 10–15 min presentation on your assigned topic.

Group 1: The resident as a professional

- What are some definitions of professionalism?
- Outline and describe some example behaviors or attitudes which characterize professionalism.
- What are some of the environmental factors which may contribute to unprofessional behavior in physicians?
- Outline and describe a few different scenarios where you have observed unprofessional behavior (action, communication, attire, attitude, etc). For these same scenarios, offer a different outcome for the interaction and scenario which demonstrates enhanced professional behavior.

Group 2: The resident as a role model

- What types of behaviors define a role model?
- What is the function of a good role model?
- How might a resident or junior staff radiologist enhance positive role modeling in their program or workplace?
- Describe two different scenarios where you have observed excellent role modeling by a senior resident. Highlight what specific professional behavior or communication skills made this encounter memorable.
- Describe two examples of poor role modeling and how this might have been more effective.

Group 3: The resident as an effective communicator

- Describe some factors that link effective communication with professionalism.
- Outline some effective traits of good communicators.
- Provide some “tips” for effective communication skills in patient interactions.
- Describe two different scenarios where you have observed communication skills with patients: one effective; one ineffective. For the ineffective encounter, explore some different techniques or methods whereby this encounter would have had a more positive outcome.
- Describe two different scenarios where you have observed communication skills between radiologists and other staff members: one effective; one ineffective. For the ineffective encounter, explore some different techniques or methods whereby this encounter would have had a more positive outcome.

3.4.4 Idea 2: CanMEDS Retreat Day: Format and Description

The Retreat Day format, groups a number of similar CanMEDS topics into a more concentrated design. This approach requires investigation of local, provincial, or national experts who may be able to present CanMEDS relevant content to your resident group. Once a CanMEDS theme for a retreat is selected, preferred topics for presentation are formulated, along with educational goals for the half- or whole-day format. Review of the CanMEDS themes outlined in Table 3.2 can assist with designing your retreat days. If local experts are utilized, costs can be contained.

For developing a retreat format for presentation of CanMEDS topics, here are the steps:

1. Identify the CanMEDS roles you wish to address in your retreat. Often more than one role can be covered in complimentary presentations.
2. Strike a small planning committee. It is useful to have resident participation in brainstorming for topic development. This also engages the residents in the process as they assist in developing the format and content for the retreat and can survey their resident peers for items of interest.
3. Develop a list of ideas based on step 2.
4. With faculty input, identify speakers or resources in your community and beyond. Helpful sites or sources of information include internal departmental and hospital/university resources, your Postgraduate Medical Education office, community practices, resident alumni, provincial and national radiology organizations, the Royal College, malpractice organizations, your local licensing authority, and private industry.
5. Contact the speakers with topic ideas. Potential speakers can often assist in further developing objectives and content for presentation based on their experience and expertise.
6. Ask your speakers to prepare material that encourages active participation of the resident group through discussion or workshop/brainstorming format.
7. Select a date and venue. This can be hosted either internally, at your hospital or university site, or if funds permit an off-site venue. If it can be facilitated, an off-site

event is an opportunity for a "meet and mingle" social gathering which can add to your resident morale and collegiality, as well giving a positive "spin" to the CanMEDS retreat day.

8. Evaluate your session, providing feedback to your speakers and training committee.

3.4.5 Sample Retreats

3.4.5.1 Example 1

RADIOLOGY CanMEDS RETREAT
TOPIC: Career Counseling and the Business of Radiology
CanMEDS Roles: Manager and Professional

Learning Objectives

1. To educate residents about the important aspects of Medical Practice
2. To educate residents regarding important aspects of transition to practice and the different types of business practice options
3. To learn about different types of radiology career opportunities (community vs. academic)
4. To learn the "next steps" toward making an informed decision regarding appropriate career choices

Workshop Outline

- Welcome and Introduction
- Introduction to Radiology Practice
- Business Practices
- "Other things to consider"
- "If I only knew then what I know today"
- "Where do I go from here?"
- Wrap up

Workshop Content

Welcome and Introduction

Assign a moderator for the entire retreat day. Ideally this should be a practicing radiologist interested in the transition to practice and career management. The moderator's role is to welcome the participants, provide an overview of the day's content and facilitate discussions following each speaker.

Introduction to Radiology Practice

In this introductory section, the selected speaker outlines the "current state of affairs." This person can be a representative from your provincial or national radiological association. Content included in this presentation should address current manpower issues and subspecialty areas of need, in order to provide guidance for fellowship selection and workplace choices. It is helpful to present statistics regarding the working profile of radiologists in your region, (gender, part-time vs. full-time, academic vs. community settings) in order to educate residents on the current regional workforce of radiologists. The role of the provincial association can also be discussed, educating residents on the role of professional organizations and what they offer residents, future graduates, and practicing radiologists.

Business Practices

A chartered accountant is a suitable speaker for this session. Important information to share includes a description of different types of practices and partnership arrangements, personal tax and income implications, as well as personal incorporation and investment advice.

"Other things to consider"

The ideal speaker for this session is a practicing radiologist with a business interest. Potential topics for presentation include ethical billing practices, practical tips for entering into practice, licensing issues, and job searching techniques. This physician can also discuss regulatory bodies and responsibilities to the profession, including commitment to professional standards.

"If I only knew then what I know today"

This session contrasts two different work settings, with suggestions and advice relevant to their work environment: one a community radiologist; one an academic radiologist. Each can share with the resident group their decision-making process for selecting their career path, including the past and present pros and cons. Additional useful material includes "a day in the life" of a community-based vs. academic-based practitioner.

"Where to I go from here?"

At this point, the moderator summarizes much of the information presented during the day, highlighting the transition to practice experience and important "take home" points.

Wrap up

The Program Director and/or committee organizers thank the invited presenters and remind the resident group regarding the important CanMEDS Roles addressed during the retreat day. The specific roles are highlighted, along with their relevance to the participants' current position as resident trainees and future practice as radiologists.

3.4.5.2 Example 2

RADIOLOGY CanMEDS RETREAT
TOPIC: Communication and Conflict Resolution in Radiology
CanMEDS Roles: Collaborator, Communicator, Professional

Learning Objectives

1. To educate residents about the importance of effective communication and collaboration and how this ultimately impacts on patient care
2. To understand the medico-legal implications of effective communication
3. To learn strategies for effective conflict resolution
4. To reinforce how communication and conflict resolution are a key component of the CanMEDS competencies
5. To provide residents with strategies for effectively working on teams

Workshop Outline

- Welcome and Introduction
- Communication – “It’s all about the patient”
- Communication and Delegation Issues from the Medico-legal Perspective
- Strategies for Conflict Resolution
- Where do I go from here? Implications for mobilizing conflict resolution strategies during residency training.
- Wrap up

Workshop Content

Welcome and Introduction

A moderator is selected for the entire retreat day. This person should be familiar with CanMEDS and have an interest in the Communicator and Collaborator Roles. The moderator welcomes the participants, and provides an overview of the day’s content. During the day, the moderator also facilitates discussions, highlighting the importance the physician CanMEDS competencies play in the topics discussed.

Communication – “It’s all about the patient”

This introductory session is ideally a physician who functions in a key-facilitator capacity in the hospital. An example might include a patient safety officer, staff person from risk management or medical affairs. The emphasis of this presentation is on the importance of strong communication skills and their impact on patient care. Information presented might include case scenarios or discussion of situations where problems commonly arise, including sources of conflict, diagnostic errors, and common patterns of physician miscommunication.

Communication and Delegation Issues from the Medico-legal Perspective

A representative from the national malpractice association (Canadian Medical Protective Association) is invited to present information to the resident group, discussing the importance of effective and appropriate communication skills in practice. This should include discussion of both written and verbal communication skills, and the implications for both when there is communication breakdown.

Strategies for Conflict Resolution

The invited speaker for this session is a professional mediator or expert in conflict management, with a specific interest in the healthcare environment. This session will likely represent the largest time designation for the retreat, focusing on the definitions of conflict and conflict resolution theory. Scenarios are presented with small-group breakout sessions, followed by discussion. The session can also include an open forum during which residents are able to freely discuss instances where they have encountered conflict in the workplace and through group discussion, formulate ideas and strategies for resolving these types of issues. Residents are encouraged to implement these strategies in their future encounters.

3.5 Wrap Up: Where Do I Go from Here? Implications for Mobilizing Conflict Resolution Strategies During Residency Training

The moderator summarizes the content from the day, emphasizing the roles of Communicator and Collaborator as key physician competencies for conflict recognition, management, intervention, and prevention. By reviewing topics from Table 3.2, ideas for future workshops can be grouped into a half- or whole-day format, in order to present material targeted to specific CanMEDS Roles.

3.6 Summary

For both the small-group format and retreat-day approaches, it is important to compile and collect the session outlines and resource material and content, in order to document and store your CanMEDS curriculum items. In this way, communication of your program content to accrediting bodies or your university is facilitated (for example, program binder). For the small-group session format, include the session handout and resources. For the retreat format, include all the contact information and credentials of your presenters. Include a sample of your evaluation form.

While the examples provided offer one example from each of the non-Medical-Expert competencies, topics highlighted in Table 3.2 offer a variety of additional potential ideas

Table 3.4 CanMEDS Roles beyond the radiology half-day

CanMEDS Roles	
Communicator	Patient/radiologist interactions: e.g., during procedures, ultrasound scanning
	Communicating imaging results directly to patients
	Obtaining informed consent
	Formulating written radiology reports and consultations
Collaborator	Participating in multidisciplinary activities: e.g., ICU case review, Rad/path rounds, multidisciplinary rounds
	On-call team experiences
	Dealing with any conflict arising between coworkers
Manager	Prioritizing/triaging referrals and protocoling requisitions
	Time management on rotations and work assignments
	Roles as senior resident, Chief Resident, committee memberships
	Effective utilization of technology: PACS, computer software, on-line resources
Health advocate	Consideration of risk/benefit ratio of radiologic tests
	Radiation safety principles and choice of best test
	Participation in screening programs (e.g., breast screening)
	Patient education
	Infection control education and practices
Scholar	Journal Clubs
	Participation in research projects and scholarly work
	Critical appraisal of the literature
	Teaching medical students, co-residents, technologists, patients
	Developing an effective personal education plan
Professional	Recognizing and maintaining patient confidentiality
	Punctuality, work ethic, professional appearance, and communication
	Awareness of own limitations
	Self-assessment and incorporating feedback

for other sessions. For retreat days, ideas can evolve and be grouped together for presentation. Often there can be shared resource people from other university postgraduate programs. A collaborative approach with others from within or outside of your program can further assist in developing these group sessions. The retreat format can also include some of the small group format content.

3.7 Taking CanMEDS Beyond the Academic Half-Day

Although the main focus of this chapter is the incorporation of CanMEDS topics into the half-day format, there are opportunities to highlight and educate residents and trainees regarding these roles during daily activities. In addition, program correspondence and documentation should always explicitly identify these roles, in order to reinforce their application to everyday work. Examples of these activities beyond half-day are highlighted in Table 3.4.

3.8 Take Home Message

The most important first step in developing and implementing a CanMEDS curriculum in your academic half-days is becoming familiar with the CanMEDS competencies and what they mean for radiology. Once aware of the roles, the next step is to identify topics of interest and areas of need in your program curriculum. Following this, consider your local resources in order to best decide how to tackle and present the topic, either in the small-group or retreat format outlined. Both approaches are feasible and can be complementary.

3.9 Final Tips

- Make the content interesting and relevant to their everyday practice as residents and future role as radiologists
- Provide content that is radiology-specific
- Keep an ongoing file of relevant CanMEDS content: articles, topics, ideas
- Document and file: keep a binder or file of the CanMEDS topics you have presented, along with a master list outlining each session you have developed and the specific CanMEDS Role or Roles it addresses
- Explicitly label the CanMEDS content: identify this on the session handout, objectives, correspondence, evaluations, and any relevant additional documentation
- Highlight specific CanMEDS learning objectives for each session
- Color code your half-day or educational curriculum outline to highlight the CanMEDS Roles – if more than one addressed in a seminar or exercise, label as both
- Inform your training program committee: discuss and include upcoming CanMEDS items on your agenda, program website, and newsletters

Residency educational curriculum must address physician competencies by extending beyond the context of traditional medical knowledge acquisition, with the overall goal of quality patient care. While the examples provided are not intended to be fully comprehensive, we have provided a guide for development of further ideas and radiology program content.

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Amis ES, Butler PF, Applegate KE, Birbaum SB, Brateman SB, Hevezi JM, Mettler FA, Morin RL, Pentecost MJ, Smith GG, Strauss KJ, Zeman RK (2007) American college of radiology white paper on radiation dose in medicine. J Am Coll Radiol 4(5):272–284
Cascade PN (2004) Unnecessary imaging and radiation risk. J Am Coll Radiol 1(10):709–711
Cascade PN, Webster EW, Kazerooni EA (1998) Ineffective use of radiology: the hidden cost. AJR Am J Roentgenol 170:561–564
Dunnick NR, Applegate KE, Areson RL (2005) The inappropriate use of imaging studies: a report of the 2004 intersociety conference. J Am Coll Radiol 2:401–406
Malone JF (2008) New ethical issues for radiation protection in diagnostic radiology. Radiat Prot Dosimetry 129(1–3):6–12
Swensen SJ, Johnson CD (2005) Radiologic quality and safety: mapping value into radiology. J Am Coll Radiol 2:992–1000

Scholar

Resident Teaching and Effective Presentations

Collins J (2006) Keys to educator effectiveness in radiology. Acad Radiol 13:641–643
Collins J (2004) Education techniques for lifelong learning. Making a powerpoint presentation. Radiographics 24:1177–1183
Collins J (2001) Education techniques for lifelong learning. Giving a powerpoint presentation: the art of communicating effectively. Radiographics 24:1177–1183
Daffner RH (2003) On improvement of scientific presentations: using powerpoint. AJR Am J Roentgenol 181:47–49
Daffner RH (2000) On improvement of scientific presentations. AJR Am J Roentgenol 174: 1229–1231
Logan PM (2001) Preparing and presenting a scientific paper. Can Assoc Radiol J 52(6):361–365
Logan PM (2004) Preparing an educational exhibit. J Am Coll Radiol 55:82–86
Murray M (2008) Radiologists as teachers: the value of engaging in conversation. Clin Radiol 63(2):207–209

Roberts CC, Chew FS (2003) Teaching radiology residents, and radiology residents as teachers. Acad Radiol 10(Suppl 1):S97–S101

Shinn LJ (2001) Strategies for effective presentations. J Radiol Nurs 2316–2318

Shepherd M (2006) How to give an effective presentation using powerpoint. Eur Diab Nurs 3(3): 154–158

Williamson KB, Kang YP, Steele JL, Gunderman RB (2002) The art of asking: teaching through questioning. Acad Radiol 9(12):1419–1422

Professional
Professionalism and Role Models

Borgstede JP (2005) Professionalism. J Am Coll Radiol 2:873–874

Donnelly LF, Strife JL (2006) Establishing a program to promote professionalism and effective communication in radiology. Radiology 238:773–779

Duff P (2002) Professionalism in medicine: an A-Z primer. Obstet Gynecol 99:1127–1128

Duff P (2004) Teaching and assessing professionalism in medicine. Obstet Gynecol 104: 1362–1366

Francis IS (2008) Finding and maintaining professionalism in radiology. Clin Radiol 63:15–17

Gunderman RB (2001) Patient communication: what to teach radiology residents. Am J Roentgenol 177:41–43

Gunderman RB (2002) Role models in the education of radiologists. Am J Roentgenol 179: 327–329

Lee AG, Beaver HA, Boldt HC, Olson R, Oetting TA, Abramoff M, Carter K (2007) Teaching and assessing professionalism in opthalmology residency training programs. Surv Opthalmol 52: 300–314

Wood J, Collins J, Burnside ES, Albanese MA, Propeck PA, Kelcz F, Spilde JM, Schmaltz LM (2004) Patient, faculty, and self-assessment of radiology resident performance: a 360-degree method of measuring professionalism and interpersonal/communication skills. Acad Radiol 11:931–939

Patient Confidentiality

Bovi A (2003) Council on ethical and judicial affairs of the American Medical Association. Ethical guidelines for use of electronic mail between patients and physicians. Am J Bioeth 3:W-IF2

Dodek DY, Dodek A (1997) From Hippocrates to facsimile: protecting patient confidentiality is more difficult and more important than ever before. Can Med Assoc J 156:847–852

Heilman RS (1994) Patient confidentiality: radiologists can do better. Radiographics 14:254

Stanberry B (2006) Legal and ethical aspects of telemedicine. J Telemed Telecare 12:166–175

Sharfstein D, Cupta A (1995) Confidentiality of radiologic images. Radiology 195:873

Ubel PA, Zell MM, Miller DJ, Fischer GS, Peters-Stefani D, Arnold RM (1995) Elevator talk: observational study of inappropriate comments in a public space. Am J Med 99:190–194

Building a Teaching Module in Clinical Inquiry for Radiology Residents[1]

4

Stephen James Karlik

4.1 Overview

Critical appraisal is the process of systematically examining scientific research to assess its validity, the quality of the results, and its relevance to our practice. We live within an era of information overload, and it is imperative to separate the essential from the nonessential in a systematic, responsible, scientific, and time-conservative manner. The best available radiological evidence must be identified when even the best research may have flaws. We need to be able to judge whether conclusions are supported by results that have been obtained and analyzed in a nonbiased manner. This chapter will provide an overview of critical inquiry as applied to scientific investigation: teaching objectives for critical inquiry; examples of available resources; and examples of ways in which specific critical inquiry topics might be addressed.

Critical inquiry is the term used to describe a process for the systematic evaluation of a program, process, or, as in this chapter, published scientific information in the radiological field. Critical inquiry is an open cycle of questioning based on empirical data (Rossman and Rallis 2000) and is a combination of deliberation and action (Garrison et al. 2000). In generic terms, the cycle begins by establishing the criteria for the judgment of the validity of an idea, concept, or scientific finding. Next, the data is examined and evaluated for its ability to support the concepts under investigation and assigned a value and interpretation to the analysis. Based on these steps, changes to practice are initiated and the evaluation process begins again. When applied to scientific investigation, this cycle of thought has been called the "loop of science" (Karlik 2001) where a research question is formulated, the study designed, data collected and interpreted, and the results incorporated into practice.

This process of critical inquiry, in the general sense, is associated with a series of steps triggered by an initiating event (in our case, a radiological article or question). The exact

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form this takes is both context- and domain-specific (Garrison et al. 2000). Hence, the rules we learn to evaluate a radiological article will not be the same as the criteria we employ to judge the effectiveness of a new piece of government legislation. However, the former are closely related to the rules for the evaluation of information from other scientific disciplines (Staunton 2007). In radiology, critical inquiry is based on rigorous criteria and not subjective interpretation. In fact, learning established criteria for scientific inquiry releases one from domination by experts, distortions from viewpoint, and misunderstandings from lack of knowledge (Kim 1999). Therefore, it is important to teach radiology residents clear, discipline-specific criteria that can be uniformly applied.

An "objective assessment" of the information involves determination of methodological and radiological soundness. Evidence-based radiology (EBR) consists of seeking the solution to a radiological problem by (1) defining a question, (2) analyzing the available evidence, and (3) acting on that evidence. The pivotal second step in successful EBR depends on the ability to apply the tenets of critical appraisal. Thus, critical appraisal is the essential component of EBR used to make sense of research practices and outcomes in order to tie it to radiology practice. *Radiology* has recently published a series of articles summarizing the steps in evidence-based medicine as applied to our discipline (Maher et al. 2007; Malone and Staunton 2007; Medina and Blakmore 2007; Staunton 2007; van Beek and Malone 2007).

How do we address the goal of teaching the skills of critical inquiry to radiology residents? Our program contains three components which address these topics. Firstly, each July and August in their training, the residents receive 83-h didactic sessions on the basic fundamentals of critical inquiry, the composition of which is discussed below. Secondly, all residents annually present a recent and relevant research paper at Journal Club. This provides a specific opportunity to analyze and present new data which is beyond current textbook information. Thirdly, each resident performs one research project under the supervision of a Radiologist or Imaging Scientist. Analyzing the literature with respect to an individual project topic reinforces the skills learned in the lecture and presented at journal club.

4.1.1 Evaluating a Diagnostic Test

There are three basic sections to the evaluation of a journal article: Are the numbers in the study valid? What are the results? How large is the effect? And are the results sufficiently generalizable to my practice? Excellent guidance for the evaluation of a paper which uses or describes a diagnostic test can be found in Jaeschke et al. (1994a, b) and Greenhalgh (1997). Assessment techniques have been summarized for testing the validity and strength of publications in the radiological literature (Dodd et al. 2004). Also, Medina (1999) has written a condensed version of the basics as applied to neuroradiology.

To start, as with any diagnostic test, analysis of the efficacy of the imaging technique or procedure starts with a determination of the strength of the imaging test performed. This is accomplished by the construction of a conventional 2 × 2 table and the calculation of true positive, true negative, false positive, and false negative fractions. From these, the test properties can be calculated yielding the sensitivity and specificity (with 95% confidence intervals). Subsequent calculations would also yield other parameters including positive and negative predictive values, and positive and negative likelihood ratios. Also essential is an evaluation of whether the data described and analyzed are useful in your practice. This assessment must consider not only the patient population, but also the applicability of the test to the equipment you use, the analysis software, and the image displays used.

4.1.2 Radiology-Specific Questions

Although papers which contain radiologic data bear many features in common with papers describing other diagnostic tests, there are definitely discipline-specific aspects to be considered. In order to test validity, it is common to evaluate questions of reference standard, blinding, the spectrum of patients, and whether the outcome of the test influenced the use of the reference standard. In radiology, we use a wide variety of techniques from plain films to elaborate programmable cross-sectional CT and MRI techniques. We also need to ask whether the paper describes the imaging technique in sufficient detail to be replicated on the equipment you use. To reiterate, in order to evaluate a paper on a diagnostic test, we must determine the quality of the results by identifying test sensitivity and specificity, likelihood ratios, and predictive values. However, we do not routinely evaluate whether the imaging test and gold standard (possibly another imaging procedure) had been performed to the same high standard. Radiological research is plagued by the moving target of technological development. It seems that the medical-imaging equipment manufacturers have new upgrades every year. Even dramatic new techniques to enhance our discipline appear frequently, such as multidetector CT, 3D ultrasound, or 3 T MRI. It is very difficult to keep the level of science up to the level of innovation, particularly as it takes a long time from the generation of an idea and the acquisition of data to the appearance of the publication.

There are additional radiology-specific questions which should be addressed in the analysis of diagnostic radiology research studies. Some examples are: If an X-ray-based technique has been employed, have the authors used the lowest dose? Has the radiation dose been tailored to the patient for the lowest possible dose consistent with a diagnostic scan? Did all reviewers of the films use the same workstations or display equipment? What was the experience of those readers?

4.1.3 Hierarchy of Research

Radiology studies are known for being identified with the lowest levels in the hierarchy of scientific evidence. The Oxford Center for Evidence-based Medicine describes the levels of evidence for diagnosis (Dodd et al. 2004). Structured reviews, upon which the highest two levels of evidence are based, are profoundly deficient in the radiological literature. A good example of this class of publication is a meta-analysis of the diagnosis of malignant solitary pulmonary nodules (Cronin et al. 2008) with a review in Steinberg (2008). Didactic guidelines for conducting systematic reviews of diagnostic studies have been suggested (Deville et al.

2002). For diagnostic tests, cohort studies can be Level 1 or 2 only if being a validating study (Ib) or with good reference standards (2b). A quick perusal of *Radiology* or *American Journal of Roentgenology* reveals many studies at inferior Levels 3 through 5 which describe nonconsecutive studies, inconsistent applied reference standards (Level 3b) case control studies (Level 4), or expert opinion or bench studies (Level 5). The randomized controlled trial is exceeding rare in the radiology literature and a multisite randomized controlled trial is even scarcer.

4.2 Barriers to Evidence-Based Radiology and Critical Inquiry

There are four principle issues which arise when we try to enhance the critical inquiry abilities of our residents (and staff). From the beginning, there is a general lack of specific critical inquiry experience and training in the radiology discipline and therefore we are starting from scratch. The effort needed to perform critical inquiry can be viewed as wasting time used better elsewhere. There is lack of sufficiently robust research data in many areas. Finally, there may be lack of confidence in Evidence-Based Radiology procedures by faculty and mentors.

Residents are in the transition zone of learning their chosen discipline. The apprentice gains knowledge from mentorship of teaching radiologists with daily clinical material and at rounds, with teaching files showing images of common and rarer findings, and textbooks of modality-specific findings and anomalies (see Chap. 2 – Curriculum Matters! Designing curriculum for resident rotations). It does not seem that expert opinion (authority) fits into the EBR paradigm. One needs time for access to the relevant literature for critical inquiry to work. Time is also needed to systematically evaluate the evidence. In residency, as in practice, there are many demands on time which can easily be rated as more important than EBR. However, radiologists who understand the properties of diagnostic tests and can employ quantitative approaches to evaluating those tests should be able to make better diagnoses. Unfortunately, we can provide no evidence that teaching and adopting EBR methods make a better radiologist.

At least the teaching of critical appraisal portion can prepare the resident for continuing personal development (Smith et al. 2006). Those who can evaluate the future literature more effectively and distinguish strong from weak evidence will be well-prepared to accept or reject new advances as promulgated by researchers or instrument manufacturers. It is unfortunate that residents are not evaluated on their ability to perform critical appraisal, either in training or at the Royal College exam.

4.3 Defining the Critical Inquiry Agenda and Resources

In order to achieve even modest capabilities in critical inquiry, there are many topics which need to be addressed in the residency training program. A firm grounding in statistics as applied to radiology is a fundamental requirement. To that end, two principal journals in the field have hosted a series of papers addressing the core capabilities for statistical analysis. Table 4.1 lists the articles which appeared in the *American Journal of Roentgenology* in the "Fundamentals of Clinical Research for Radiologists" series. Table 4.2 lists the articles which have contributed to the *Radiology* "Statistical Concepts" series. These two series contain highly focused and authoritative description of a variety of topics which need to be taught to residents during the training program. Although there is considerable overlap, the contributors have complimentary ideas and it is worth using ideas from all available resources for lesson planning.

The modules from these series can be divided into three levels. Basic modules include an introduction to radiology research, the research framework, developing a research protocol, population selection, data collection, and statistical planning. Intermediate modules contain information on screening, presenting data, probability and sampling, observational studies, and outcome analysis. The advanced modules include means and medians, agreement, correlation, regression, receiver operating characteristic (ROC) curves, survival analysis, and

Table 4.1 Fundamentals of clinical research for radiologists (*American Journal of Roentgenology*)

Beam CA (2002) Statistically engineering the study for success. AJR 179:47–52
Beam CA, Blackmore CC, Karlik S, Reinhold C (2001) Introduction to the series. AJR 176:323–325
Blackmore CC (2001) The challenge of clinical radiology research. AJR 176:327–331
Blackmore CC, Cummings P (2004) Observational studies in radiology. AJR 183:1203–1208
Crewson PE (2005) Reader agreement studies. AJR 184:1391–1397
Crewson PE, Applegate KE (2001) Data collection in radiology research. AJR 177:755–761
Herman CR, Gill HK, Eng J, Fajardo LL (2002) Screening for preclinical disease: Test and disease characteristics. AJR 179:825–831
Hollingworth W (2005) Radiology cost and outcomes studies: Standard practice and emerging methods. AJR 185:833–839
Jarvik JG (2001) The research framework. AJR 176:873–878
Joseph L, Reinhold C (2003) Introduction to probability theory and sampling distributions. AJR 80:917–923
Joseph L, Reinhold C (2005) Statistical inference for continuous variables. AJR 184: 1047–1056
Joseph L, Reinhold C (2005) Statistical inference for proportions. AJR 184:1057–1064
Karlik SJ (2001) How to develop and critique a research protocol. AJR 176:1375–1380
Karlik SJ (2003) Exploring and summarizing radiologic data. AJR 180:47–54
Karlik SJ (2003) Visualizing radiologic data. AJR 180:607–619
Kazerooni EA (2001) Population and sample. AJR 177:993–999
Obuchowski NA (2004) How many observers are needed in clinical studies of medical imaging? AJR 182:867–869
Obuchowski NA (2005) ROC analysis. AJR 184:364–372
Obuchowski NA (2005) Multivariate statistical methods. AJR 185:299–309
Plevritis SK (2005) Decision analysis and simulation modeling for evaluating diagnostic tests on the basis of patient outcomes. AJR 185:581–590
Stolberg HO, Norman G, Trop I (2004) Randomized controlled trials. AJR 183:1539–1544
Stolberg HO, Norman G, Trop I (2005) Survival analysis. AJR 185:19–22
Weinstein S, Obuchowski NA, Lieber ML (2005) Clinical evaluation of diagnostic tests. AJR 184:14–19

Table 4.2 Statistical concepts series (*Radiology*)

Applegate KE, Crewson PE (2002) An introduction to biostatistics. Radiology 225:318–322
Applegate KE, Tello R, Ying J (2003) Hypothesis testing III: counts and medians. Radiology 228:603–608
Eng J (2003) Sample size estimation: How many individuals should be studied? Radiology 227:309–313
Eng J (2004) Sample size estimation: A glimpse beyond simple formulas. Radiology 230:606–612
Gareen IF, Gatsonis C (2003) Primer on multiple regression models for diagnostic imaging research. Radiology 229:305–310
Halpern EF, Gazelle GS (2003) Probability in radiology. Radiology 226:12–15
Kundel HL, Polansky M (2003) Measurement of observer agreement. Radiology 228:303–308
Langlotz CP (2003) Fundamental measures of diagnostic examination performance: usefulness for clinical decision making and research. Radiology 228:3–9
Medina LS, Zurakowski D (2003) Measurement variability and confidence intervals in medicine: why should radiologists care? Radiology 226:297–301
Obuchowski NA (2003) Receiver operating characteristic curves and their use in radiology. Radiology 229:3–8
Obuchowski NA (2003) Special topics III: bias. Radiology 229:617–621
Proto AV (2002) Radiology 2002 – statistical concepts series. Radiology 225:317
Sistrom CL, Garvan CW (2004) Proportions, odds, and risk. Radiology 230:12–19
Sonnad SS (2002) Describing data: Statistical and graphical methods. Radiology 225:622
Sunshine JH, Applegate KE (2004) Technology assessment for radiologists. Radiology 230:309–314
Tello R, Crewson PE (2003) Hypothesis testing II: Means. Radiology 227:1–4
Zou KH, Tuncali K, Silverman SG (2003) Correlation and simple linear regression. Radiology 227:617–622
Zou KH, Fielding JR, Silverman SG, Tempany CM (2003) Hypothesis testing I: Proportions. Radiology 226:609–613

clinical trials. The journal references cited in Tables 4.1 and 4.2 address statistic and experimental design issues in general and those peculiar to radiological research.

There may be some readers who feel that advanced statistics are inappropriate for the series of teaching residents. At a recent local journal club, the residents chose papers from the fall of 2008 for presentation that used a paired student t test, Cox proportional-hazards regression (Perea et al. 2008), two-tailed unequal variance t test (Leswick et al. 2008), chi-squared, Cohen kappa statistic (Moon et al. 2008), and Wilcoxon rank sum, McNemar test, and logistic regression (Atri et al. 2008). Clearly, current radiological literature contains very advanced statistical techniques. It is not possible to judge the veracity of a paper and perform a critical appraisal unless the analysis techniques employed are part of your experience.

These articles provide the necessary background for topics and ideas with examples drawn from radiological literature and practice to provide resources for statistical literacy (Applegate and Crewson 2004). At our University, we use the information to guide the structure and content of didactic lectures. An example of our strategy is described for the ROC curve in the following section. Another possible way to use the individual articles would be to assign one per resident, who prepares a dossier on the topic. This dossier

Table 4.3 How to read a paper (*British Medical Journal*)

Greenhalgh T (1997) How to read a paper: statistics for the non-statistician. I: Different types of data need different statistical tests. BMJ 315:364–366
Greenhalgh T (1997) How to read a paper: statistics for the non-statistician. II: "Significant" relations and their pitfalls. BMJ 315:422–425
Greenhalgh T (1997) How to read a paper: Getting your bearings (deciding what the paper is about) BMJ 315:243–246
Greenhalgh T (1997) How to read a paper: the medline database. BMJ 315:180–183
Greenhalgh T (1997) How to read a paper: Assessing the methodological quality of published papers. BMJ 315:305–308
Greenhalgh T (1997) How to read a paper: Papers that report drug trials. BMJ 315:480–483
Greenhalgh T (1997) How to read a paper: Papers that tell you what things cost (economic analyses) BMJ 315:596–599
Greenhalgh T (1997) How to read a paper: Papers that summarise other papers (systematic reviews and meta-analyses) BMJ 315:672–675
Greenhalgh T, Taylor R (1997) How to read a paper: Papers that go beyond numbers (qualitative research) BMJ 315:740–743

would include relevant primary papers which utilize the statistical technique (for example) and other textbook or on-line resources.

In addition to these two series in the radiologic literature are two published sets of valuable articles. The elements of the *British Medical Journal* series relevant to Radiology are listed in Table 4.3. These seminal papers, edited by Trisha Greenhalgh, provide a comprehensive definition for the critical appraisal. Additionally, the *Journal of the American Medical Association* published an excellent series of papers, called "The Users Guide to the Medical Literature" and papers on diagnosis (Jaeschke et al. 1994a, b) and how to use an overview (Oxman et al. 1994) are relevant to critical inquiry in radiology.

On-line sources are accumulating. There are many websites which can provide articles and content related to the critical inquiry effort (see Table 4.4). There are also several on-line tutorials available, for example, from the University of Massachusetts (http://library.umassmed.edu/EBM/tutorials/index.cfm), Boston University (http://medlib.bu.edu/tutorials/ebm/), and the University of North Carolina and Duke University (www.hsl.unc.edu/Services/Tutorials/EBM/welcome.html).

4.3.1 Teaching ROC: An Example of a Critical Inquiry Module

As there is insufficient space to depict an entire program, this section will describe the strategy to address one topic: ROC curves.

There are several components to teaching the ROC to the resident. Sensitivity and specificity are key concepts in building an ROC curve and these must be addressed at a prior time but reviewed to start the module. After all, an ROC curve is just a plot of sensitivity of test versus its false positive rate (FPR) for all possible cut points. There are many uses for ROC curves in radiology such as comparing the diagnostic performance of different modalities (Nihashi et al. 2007; de Bondt et al. 2007), displays (Wei et al. 2007), or

Table 4.4 Selected Internet resources

Evidence-based medicine
http://www.ebm.med.ualberta.ca/
http://www.medicine.ox.ac.uk/bandolier/
http://www.cebm.utoronto.ca/
http://www.evidence-based-medicine.co.uk/
http://www.cebm.net/index.aspx?o = 1157
http://www.poems.msu.edu/InfoMastery/
http://grunigen.lib.uci.edu/ebm-subject-guide.html
Analyzing a paper
http://www.bmj.com/cgi/content/full/315/7101/180
http://www.phru.nhs.uk/Pages/PHD/resources.html
http://www.shef.ac.uk/scharr/ir/units/critapp/
http://www.keele.ac.uk/depts/li/hl/pdfs/criticalnotes.pdf
http://www.sign.ac.uk/guidelines/fulltext/50/checklist4.html
http://www.mclibrary.duke.edu/subject/ebm?tab = appraising&extra = worksheets
Reviews
http://www.acpjc.org/
http://www.cochrane.org/reviews/
Users guides to the medical literature
http://www.cche.net/usersguides/main.asp
(All accessed December 1, 2008)

radiologists (Hock et al. 2008). ROC methodology includes all possible cut points for abnormal versus normality, can visualize the relationship of sensitivity to specificity, is unaffected by disease prevalence, and can be quantified, for example, by determining area under a portion of the curve (Jiang et al. 1996) to establish the strength of differences. ROC curves are often employed in journal articles today.

4.3.2 ROC Didactic Component

Two key references for the didactic portion of the module are the ROC journal articles from Obuchowski in the *American Journal of Roentgenology* and *Radiology* series (Tables 4.1 and 4.2). There are specific examples of different curves, their comparisons, and reference to mathematical methods. Remember that the accuracy, sensitivity, and specificity of a radiologist test are a synergy between the absolute technical ability of the imaging technique and the training, experience, and expertise of the radiologist making the interpretation.

4.3.3 Analysis of a Paper Which Uses ROC Methodology

The second component of the module on ROC curves is an exercise using a journal article on diagnosis and screening. The purpose of the exercise is to have the resident summarize and initially appraise a paper on the diagnosis of disease and actually perform and interpret calculations of sensitivity, specificity, likelihood ratios, multiple cutoffs, prior and posterior probability and odds, and importantly – construct an ROC curve.

However, the topic of the publication is not radiological, but from general medicine. The source of this data is unexpected: we use a journal article “Screening for Alcohol Abuse Using CAGE Scores and Likelihood Ratios” by Buchsbaum et al. (1991) (following the general outline of Dixon et al. 1997). This paper used the CAGE questionnaire for alcohol abuse in 821 patients attending a general medicine clinic from 1988 to 1990. The CAGE acronym identifies four questions: Have you ever felt you should *cut down* on your drinking? Have people *annoyed you* by criticizing your drinking? Have you ever felt bad or *guilty* about your drinking? Have you ever had a drink first thing in the morning to steady your nerves or get rid of a hangover (*eye opener*)? This paper addresses the concept that the number of positive answers are actually multiple cutoffs and consequently how understanding multiple cutoffs help us to better choose the best cutoff for screening using ROC and likelihood methodologies. The CAGE questionnaire showed a sensitivity of 80% and specificity of 86% for the detection of alcohol abuse at a cutoff of two affirmative answers (Ewing 1984).

One resident is selected in advance to summarize the paper; this 10 min synopsis would prepare the class for the topic and identify the key findings.

After this introduction, each resident is asked to perform the following analysis. To start the appraisal, the introduction to the paper is used to identify the medical issue, the patient at risk, the measurements being used, and the purpose of the CAGE score. The methods section is then used to identify the patient population used, the measurement devices, source of the “gold standard,” and to ask the residents to calculate posterior probability from posterior odds. The results are then analyzed to ascertain how many patients participated, to analyze the raw counts to see the proportion of men and women who reported any stage of alcohol abuse. Sensitivity and specificity of the number of positive answers recorded from the 821 patients is ascertained. The fraction of patients answering two or three questions positive is compared between alcoholic and nonalcoholic groups and their probabilities are calculated. The ratio of these represents the likelihood ratio for that score. Employing the sensitivities and specificities, the residents would draw the ensuing ROC curve. CAGE scores are then related to prior probabilities and posterior probabilities for alcohol abuse. The authors’ comments are then reviewed from the discussion. The residents are asked to evaluate the use of the multiple cutoff points and value of ROC, to identify the main conclusion of the paper, and whether it is supported by the data.

4.3.4 Performing an ROC Study: Diet from Regular Soda?

The third component of the ROC module is a “practical” in which we run an experiment to determine whether the residents can discern between diet and regular soda. Approximately two ounces of a variety of sodas are placed into identical plastic glasses in sufficient numbers for all attending residents to have a taste. The variety of available soft drinks is extensive and we easily can obtain twenty types, divided about equally between diet and regular.

Table 4.5 Sample scoring summary for soda tasting experiment with regular and diet sodas

		Regular	Diet	False positives	FPR	True positives	TPR
Score 1	Definitely regular	2	1	7/9	0.78	10/11	0.91
Score 2	Possibly regular	3	2	4/9	0.44	8/11	0.73
Score 3	Indeterminate	1	3	3/9	0.33	5/11	0.46
Score 4	Possibly diet	2	1	1/9	0.11	4/11	0.36
Score 5	Definitely diet	1	4				
Totals		9	11				

FPR false positive rate; *TPR* true positive rate. Cut points are chosen between *1* definitely regular and possibly regular; *2* between possibly regular and indeterminate; *3* between indeterminate and possibly diet and; *4* between possibly diet and definitely diet. For example, at the second cut, all definitely regular and possibly regular sodas are considered regular and the others are considered diet, which represents false-positives (4/9)

Although most are brown (cola or root beer) or clear (lemon-lime) there are obviously others, such as red, orange or green, which need a careful pairing between diet and regular. The samples are labeled 1 through 20 and the resident receives a scoring sheet where he/she is required to judge whether each sample is; (1) definitely regular, (2) possibly regular, (3) indeterminate, (4) probably diet, (5) definitely diet. Those familiar with radiological divisions of scoring for ROC analysis will be familiar with these five categories, but with diet and regular substituted for normal and abnormal. After the tasting is complete, the residents are given the "gold standard" identifying the drink type, which usually provides some surprises and a few laughs. With a few exceptions, the residents are poor at this discernment. Since the ROC curve has an area of 0.5 when random data is assessed, we start the analysis with a random filling in of the form to show that the ROC produces that type of curve. The residents are then charged with drawing their own ROC curves based on their choices. This is done by asking them to prepare a table where they identify how many diet and regular sodas they scored with each cutoff level as shown in Table 4.5. Regular is considered to be "normal" and diet soda as "abnormal" in the discrete five-point scale.

The next step is to calculate the false-positive and true-positive rates from the data shown in Table 4.5. Cut points are chosen between (1) definitely regular and possibly regular, (2) between possibly regular and indeterminate, (3) between indeterminate and possibly diet, and (4) between possibly diet and definitely diet. At the cut point between definitely regular (Score 1) and possibly regular (Score 2), definitely regular ($n = 2$) is considered "regular" while all others (Score 2–5, $n = 7$) are considered to be "diet" or false positive. Hence the number of false positives at this cutoff point is seven of nine actual "regular sodas," which yields a false-positive rate of 0.78. The table is then filled out for the other cut points. Remember that false positives identify abnormal (diet soda) when they are actually regular. Similarly, true positives are those which test as diet soda when they are, in fact, diet. Each cutoff point is evaluated for the number of true positives (diet) correctly identified and the true-positive rate is tabulated. Then the residents graph the false-positive rate (1-specificity) on the *x* axis against the true positive rate (TPR)

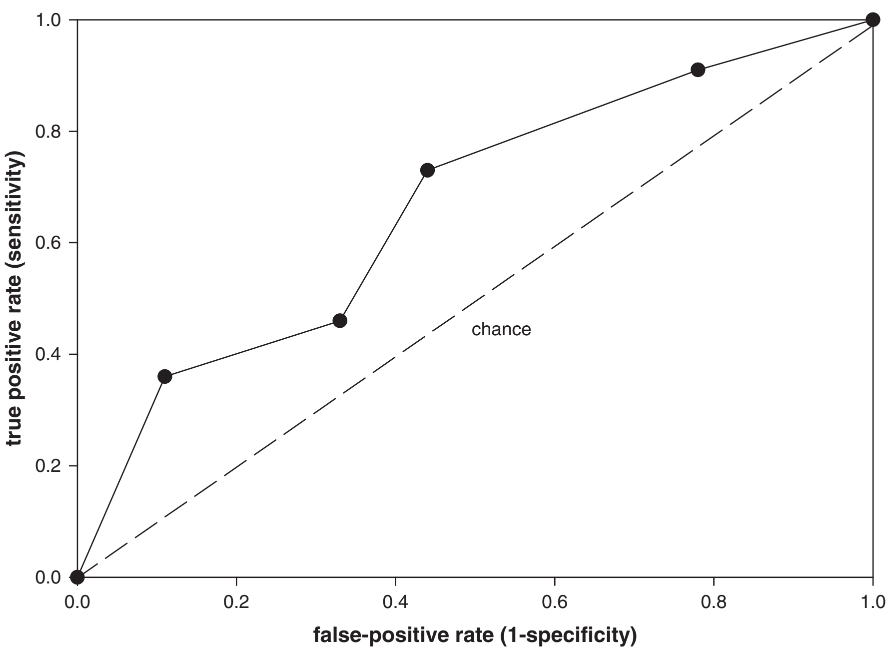

Fig. 4.1 Receiver operating characteristic (ROC) curve for regular from diet soda discrimination. Values of (0, 0) and (1, 1) were added to the false positive rate (FPR) and true positive rate (TPR) data shown in Table 5.4

(sensitivity) on the *y* axis to produce the ROC curve (Fig. 4.1). The discrimination for diet from regular is better than chance for this resident, but not very good either. The residents can compare the discrimination of their palates by determining the area under the curve (AUC) or the intercept of the ROC curve with a line at 90° to the chance line. The ROC curve shows the trade-off between sensitivity and specificity where any increase in sensitivity is accompanied by a decrease in specificity.

This completes the curriculum for the ROC curve using a didactic component, an interactive lesson with a specific journal article and then a "practical" application.

4.4 Conclusion

Critical inquiry is a fundamental skill which needs to be addressed in the training of radiology residents. It is fortunate that we have available expert assistance on-line and in print to help define the most important components with specific examples to assist in its teaching. It is left to the individual to customize their program and utilize these resources to the benefit of the residents' education and skills' development.

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The Medical Radiation Technologist: A Valuable Resource

5

Jamie Kueneman and Mark Hunter

5.1 Why this Topic?

In their introduction to this text, the editors identify that the ultimate goal of radiology and radiology education is to help patients. This comes as no surprise to educators in health disciplines as the most common answer to the question "Why did you want to be a physician, nurse, MRT, Paramedic?" is, "To help people." However, despite this almost universally expressed sentiment, health discipline education often does an inadequate job providing one of the key components required to deliver on this ultimate goal, that being the knowledge of, and developing respect for the competencies and capacities of health disciplines other than their own (Orchard et al. 2005). Failure to understand, and more importantly value the abilities of other health disciplines negatively impacts on interprofessional communication and, ultimately, has been identified as a contributing factor in many medical errors and negative patient outcomes (Miller 2003). As health professionals we all want to help the patients in our care, but too often our misperceptions regarding the scope of each others' practice coupled with communication strategies that are often ineffective, impairs our ability to deliver on that goal.

"Learning to work together" has been identified as interprofessional education and is not a new concept. However, while progress is being made to increase collaboration between the disciplines, (Carpenter and Dickinson 2008) surprisingly little has been done within our own house to educate, inform, and share information between the disciplines that work within radiology. This chapter is not intended to be a guide for interprofessional education, rather it is designed as a starting point, a place to find and clarify information regarding the scope of practice, expertise, education, responsibilities, and competencies of medical radiation technology. It is hoped that this work will lead to increased collaboration and perhaps even an interprofessional curriculum design that allows student radiologists

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and student medical radiation technologists (MRT) to interact and discover each others' gifts and talents as they learn how to help the patients they serve together. For ease of use and readability, we have designed this chapter as a series of questions and corresponding answers. The answers provided are primarily based on Canadian standards for medical radiation technology education and practice. Although the answers provided are primarily based on Canadian standards for medical radiation technology education and practice, similarities will exist with many other jurisdictions.

5.2 Who Are the People Behind the Aprons, "Shooting the Pictures"? (And What Do All of Those Letters Mean?)

In most jurisdictions the person "shooting the picture" is a member of a specialized, highly skilled profession known as medical radiation technology. The MRT utilizes knowledge developed from years of postsecondary education and clinical experience to administer radiation treatment, or to obtain images using ionizing radiation or electromagnetism.

In addition to obtaining images or delivering treatment utilizing these sources of energy, technologists are also utilized to acquire images employing high frequency sound waves (sonography). These technologists historically began their careers as MRTs and then pursued sonogaraphy as a postgraduate program. Today, it is becoming more common for students to enter sonography programs without having first completed an MRT program.

Given the unique aspects of diagnostic imaging and radiation treatment, MRTs typically specialize in one of the four disciplines of medical radiation technology: registered technologist, radiological technology (RTR), registered technologist, nuclear medicine (RTNM), registered technologist, magnetic resonance (RTMR) and registered radiation therapist (RRT). Each specialty of medical radiation technology has its own distinct educational process, and, as a result, it is not common for MRTs to practice in multiple disciplines.

5.2.1 Radiological (X-Ray) Technologists

X-Ray technologists use X-rays to produce diagnostic images or perform diagnostic procedures of body parts and systems. The profession of radiological technologist involves a broad variety of procedures and covers a number of specialties, including general radiography, mammography, angiography, interventional studies, fluoroscopic procedures, and computerized tomography (CT).

5.2.2 Nuclear Medicine Technologists

Nuclear medicine technologists administer radioactive substances called radionuclides or tracers, for diagnostic and treatment purposes. The nuclear medicine technologists can administer theses substance via numerous routes including injection, ingestion, or inhalation. Operating a gamma camera to detect the gamma rays emitted from the patient, the nuclear medicine technologists will then produce images which, depending upon the body system being assessed can indicate both structure and function. These images are then captured by the nuclear medicine technologists for review and interpretation by a physician.

5.2.3 Radiation Therapist

As an integral component of the radiation therapy team, radiation technologists participate in the development of treatment plans, perform treatment simulations, determine radiation doses, and administer the radiation treatment to a specific target area for the patient with cancer.

5.2.4 Magnetic Resonance Technologists

Magnetic resonance technologists operate complex equipment that produces magnetic fields along with radio-frequency pulses (electromagnetism) which are used to produce high-quality diagnostic images of the patient in a number of different body planes.

As well as generating images for review by physicians and radiologists or administering a treatment, the people "shooting the picture" are also responsible for ensuring the safety of the patients in their care during these procedures.

Given the radiology emphasis of this text, the remainder of the chapter will focus primarily on MRTs in the discipline of radiological technology.

5.3 What Education Is Required to Become a Medical Radiation Technologist?

The educational requirements for entry to practice programs vary depending on the discipline and the educational facility that offers the program. Graduates of community college programs may receive a diploma, an advanced diploma, or an applied degree upon program completion. University graduates are awarded an undergraduate degree. Regardless of the institution offering the program or the credential awarded, MRT graduates are required to achieve the same performance competencies.

MRT programs vary in length with most requiring between 24 and 32 months of intensive education and training. Depending upon the length and number of vacation periods, educational programs will typically range between 2 and 4 calendar years. Students develop their knowledge and capabilities in three distinct learning environments: traditional classroom, high-tech simulation areas, and, of course, clinical practice under the mentorship of practicing MRTs.

5.3.1 Radiological Technologists

Although regional variations exist, the profession-specific courses required in an MRT program include: anatomy and physiology, radiobiology, radiation protection, patient care, infection control, pathology, sectional and cross-sectional anatomy, radiation physics, professionalism, medical legal issues, and research methodologies.

Theoretical knowledge is used as an underpinning for simulation experience during which students develop their ability to correctly image body structures. Educational programs typically provide their students with significant amounts of "hands on" experience operating X-ray equipment to position and image simulated body components. These body components are actual skeletal structures imbedded in substances designed to simulate the density and shape of the soft tissue that would surround the skeletal structure. In addition to obtaining radiographic images students also learn the techniques required to capture and store images using both traditional film methods and digital technology.

Once students have demonstrated their ability to safely obtain a wide variety of quality images they then progress to the clinical environment where, under the supervision of practicing MRTs, they further enhance their ability to obtain radiographs on actual patients. Students will spend up to 1 year (approximately 2,000 h) in the clinical environment developing their capacity to function as an MRT.

5.4 How Does a Person Become Credentialed as a Medical Radiation Technologist?

Regardless of where an MRT student acquires the education for their specific discipline, or what credential they are awarded by the educational facility, graduates of each program typically must successfully pass a credentialing exam administered by an oversight body to be able to practice as an MRT. In Canada, the national certification exam is administered by the Canadian association of medical radiation technologists (CAMRT). To be eligible to sit the credentialing exam candidates must have graduated from a Canadian medical association (CMA) accredited education program. Information regarding the CMA accreditation process can be found at: http://www.cma.ca

5.5 Are Medical Radiation Technologists Regulated?

In most jurisdictions medical radiation technology is regulated by an oversite body. As is the case with other health disciplines, medical radiation technology has established standards of practice that MRTs are required to meet. The oversite body typically requires its members to practice ethically and to function within their defined scope of practice. In Canada, health care is a provincial responsibility, and, as a result, each province is responsible for creating regulatory mechanisms for the health care practitioners within its borders. Most health care disciplines (including MRT) in Ontario are self-regulating as established by the Regulated Health Professions Act (RHPA). The College of Medical Radiation Technologists of Ontario (CMRTO) is the regulatory body for MRTs practicing in the Province of Ontario.

With a primary function to protect the public, the CMRTO sets standards of practice for the profession, establishes entry to practice requirements and ensures the continued competence of its members. Additionally, the CMRTO is required to respond to complaints received from the public, other health care professionals or MRTs regarding the practice of a member. Complaints are investigated and disciplinary action taken according to established policy. Disciplinary actions can include:

- Revocation of the MRT's certificate of registration
- Unconditional suspension of the MRT's certificate of registration
- Conditions imposed on the MRT's certificate of registration
- Reprimand
- Require the MRT to pay a fine (College of Medical Radiation Technologists of Ontario 2009)

(Further information regarding the College of Medical Radiation Technologists of Ontario can be found at www.cmrto.org.) In areas that do not function within a self-regulation model, MRTs may be regulated directly by government or in some cases have their practice defined and monitored by the hospital or the radiologist that they work for. In the USA, eight states, Alabama, Alaska, Georgia, Idaho, Missouri, North Carolina, Oklahoma, and South Dakota do not have regulatory provisions for radiologic personnel (American Society of Radiologic Technologists 2006).

5.6 Are MRTs Required to Demonstrate Ongoing Competency?

As is the case with most health professions, MRTs are required to engage in continuing medical education (CME) to maintain competency. The College of Medical Radiation Technologists of Ontario (CMRTO) mandates that Ontario MRTs complete 25 h of CME annually and also stipulates that individual MRTs maintain a professional portfolio to document and validate ongoing educational activities.

Annually, MRTs are required to declare that they assess themselves as competent, have met their CME requirements, and do not have a criminal record. The regulatory body randomly audits a sampling of MRTs annually to assess compliance with the competency requirements.

5.7
Do MRTs Have Expanded Practice Roles?

The CAMRT defines advanced practice as *"a professional role that requires post degree/diploma educational preparation in combination with clinical skills acquisition to fulfill the requirements of the job. Elements of the role may be outside the established scope of the radiological technologist, nuclear medicine technologist, magnetic resonance imaging technologist or therapists practice and may overlap current areas of responsibility of another health care professional. These areas of responsibility may, or may not, include controlled acts or regulated tasks"* (Canadian Association of Medical Radiation Technologists 2005).

In some jurisdictions this allows the expertise of the MRT to be expanded to conduct components of radiology examinations that have been traditionally performed by radiologists. Having MRTs perform in what is known as an expanded or advanced practice roles allows the radiologist to then focus on more complex procedures and diagnostics (Parsons 2009). Skill sets that an expanded practice MRT could perform include independent performance of fluoroscopic procedures such as barium enemas, upper GI series, and modified barium swallows. These procedures typically require the MRT to provide an initial impression of the results of the investigation with reassessment and interpretation being conducted by a radiologist. In the USA, additional skill sets performed in advanced practice roles may also include selected vascular and nonvascular interventional procedures and selected peripheral venous diagnostic procedures (Parsons 2009).

Procedures that an Advanced Practice Radiation Therapist may perform include autonomous simulation and independent treatment of both new and follow-up patients in clinics. Advanced Practice Nuclear Medicine Technologists may independently perform PET/CT scans (Canadian Association of Medical Radiation Technologists 2005).

5.8
In What Ways Can a Medical Radiation Technologist Be Utilized as Resource?

The MRT is a valuable member of the health care team that can play an instrumental role in the treatment, well-being, education, and diagnosis of a patient on a day-to-day basis.

MRTs have the education and knowledge to understand the physics behind X-ray production along with the potential hazards and cumulative results that ionizing radiation can have not only to the patient but to other health care professionals involved in any imaging procedure. They can adjust the technical parameters of the equipment used to get the maximum benefit with the least amount of risk to the patient for any given procedure, and make adjustments as needed on a case-by-case basis.

When performing CT the technologist has the skills and knowledge and expertise to assist radiologists and residents to modify protocols for various scans which can lead to a reduction in patient dose. They build a rapport with the patient and can relay pertinent information to the radiologist which can lead to a modification of a procedure. Oftentimes this results in improved image attainment and facilitates diagnosis by the radiologist.

Although the MRT does not interpret the results of a diagnostic imaging procedure, through diagnostic interaction with the radiologist the MRT has the expertise to change the positioning of the patient or technical factors involved with creating the image to help enhance or improve an image if and when additional views, scans, or slices are needed.

When the radiologist is away from the department, the MRT can be resourceful in helping to assist emergency physicians and registered nurses with the ordering of diagnostic procedures by answering questions such as "which view would best demonstrate…?"

The MRT functions as an invaluable resource to protect the public and other health care professionals from radiation exposure by ensuring that adequate shielding is employed during all procedures. Additionally, MRTs serve as a source of information, educating patients and health care providers on the potential hazards of radiation exposure.

Once an imaging procedure is complete the MRT can give their impression of the images or identify any abnormalities they have noticed on the images. It is not uncommon for emergency physicians to ask MRTs to give a quick image consultation when the radiologist is not available in the department.

As a patient advocate the MRT is required to:

- Explain in detail all diagnostic and therapeutic procedures for the various procedures they perform
- Compile a thorough history of the patient which helps to aid in the diagnosis of the patient as well as establish any contraindications that the patient may have that would prevent them from having certain procedures completed
- Answer questions the patient may have with regards to the preparation for the procedure, about the procedure, and post care
- Assist to relieve any anxieties, the patient may have as a result of having a procedure completed
- Monitor the patient's vital signs and ensure they are well during a procedure
- Analyze creatine levels to ensure that any contrast to be administered will be delivered safely when assisting with specialized procedures
- Compile the necessary data required to complete any postprocessing that may facilitate ease of interpretation of CT, MRI, and digital radiography images for the radiologist

5.9 MRTs and Radiologists Have Been Working Together for Years, What Has Changed?

Expanding utilization of digital technology within the imaging disciplines has dramatically enhanced the ability to share high-quality images between colleagues and even between clinical sites. Ironically, however, the same technology that has facilitated this improved communication of data has resulted in less face-to-face interactions between the radiologist and the MRT and potentially further threatens interprofessional communication. Prior to the widespread use of digital technology, collaboration would occur either spontaneously or purposefully as a technologist would walk a film over to a radiologist or the radiologist would wait by the developer with the result often being an interaction and sharing of information as the image was interpreted jointly on a viewbox. With the ability to instantly transmit high-quality images with the push of the send button, these interactions which facilitated interprofessional communication and understanding have been significantly reduced.

5.10 A Case to Illustrate the Role of the MRT

A radiological technologist (X-ray technologist) was the lone MRT working in the Diagnostic Imaging Department on a Saturday morning in the pediatric area. A mother came in with her 3-year-old son for chest images.

The X-ray requisition ordered from a walk-in medical clinic earlier that morning indicated that the reason for the investigation was to rule out or confirm pneumonia. The mother chose to come to the hospital to have the images completed and then, as directed by the clinic, was intending to pick up a prescribed medication, go home to allow her son to rest, and follow up with the clinic on Monday with the results of the chest X-ray. A thorough history was taken from the mother of the child, and in doing so the technologist noticed that the child was short of breath and in a slight degree of distress.

PA and Lateral chest images were completed on the child. Viewing the images the technologist noted that the child's right lung was totally white and that there was an absence of any evidence of lung markings or lung tissue whatsoever. This caused the technologist to suspect that this child may have a lung tumor. Further questioning of the mother revealed that the child did not have any previous lung or chest problems and that the child had not had any prior chest images taken.

Utilizing their knowledge and experience, the MRT determined that this was far more serious than was indicated on initial assessment and that sending the child home to rest without further investigation was not an option. The MRT then placed a call to the on-duty emergency department physician, shared their interpretation of the images, and requested further assessment be done on this child.

After reviewing the chest images, the ER physician concurred with the MRT and consulted the radiology resident on call. A CT scan of the child's chest was promptly performed which confirmed that the child had a massive tumor on his right lung requiring immediate attention.

5.11 Some Concluding Thoughts

Our intent in writing this chapter was to enhance collaboration and understanding between medical radiation technologists and the radiologists that oversee their practice. Although time will be the yardstick required to determine if we have progressed toward this goal, discussions with MRT, radiologist, and radiology resident colleagues throughout the writing revealed refreshing support and encouragement for this work. However, these conversations also revealed that we must continually strive to avoid the trap of assuming that we know what we need to about the values, scope, and approach to care that the colleagues we work with everyday bring to clinical practice. Collaborating with radiology to prepare a similar style chapter for inclusion in MRT texts would help to avoid that trap.

The answers we provided to the questions posed were based primarily on the Canadian model of education and practice for medical radiation technology. Although the educational journey to prepare a MRT for clinical practice in other jurisdictions may not be identical to the Canadian model, similarities will exist. If you are at all unsure as to the standards of education and practice in your area we encourage you to pose the questions you have to the technologists you work with. We expect that they will be glad you asked.

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Scholarship as a Foundation for Health

6

Kathryn M. Hibbert, Teresa Van Deven, Rethy K. Chhem, and Kyra Harris

6.1 Introduction

The education of clinicians is based in both traditions and aspirations for collecting and applying knowledge in ways that are better than ever before. Gunderman has presented the idea (Gunderman 2006) that "the quality of medical education hinges on the quality of leadership in academic medical centers," with success dependent upon the ability to promote and encourage dialogue that inspires innovation and the consideration of an organization and its actions. Like many fields in the twenty-first century, advances and changes in imaging research, technology, and our ability to collaborate globally, have and continue to profoundly transform Radiology and Nuclear Medicine. Therefore, innovation in the education of tomorrow's experts in this department is both compelling and necessary.

Recognizing the symptoms of declining scholarly health among medical institutions worldwide, the Department of Medical Imaging (DMI) at the Schulich School of Medicine and Dentistry, the University of Western Ontario sought "professional help." In 2006, a Centre for Education was established to optimize the role and function of educational scholarship in the DMI through curriculum design and development, support for faculty in the "art of teaching" and the establishment of a program to foster scholarship in teaching. The ideas presented in our work draw upon a clinical metaphor, where the DMI is the "patient" and is given a professional examination. This case study documents the process undertaken by one physician-educationalist and two "Education Doctors" as they assessed the DMI's "clinical condition," arrived at a differential diagnosis, offered recommendations for "treatment" and explain their prognosis in this work.

The authors deliberately chose to use a metaphor to analyze and present findings that mirror an approach to image interpretation outlined by Dr. Fred Mettler Jr. in his 2005 text, *Essentials of Radiology* (Mettler 2005). Working within a radiological metaphor allows

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Case # 1139

PATIENT NAME: The Department of Diagnostic Radiology & Nuclear Medicine, Schulich School of Medicine & Dentistry, University of Western Ontario.

ADDRESS: London, ON, CANADA

CLINICAL HISTORY: The Patient presented with chronic longing for improvements to curriculum, an aching for faculty support, and a desire to improve the overall health and fitness of scholarship. The patient admits to a lack of attention, nurturing or exercise in this area. Symptoms and complaints have increased in intensity and do not appear to be responding to traditional treatments of this condition. As a result, patient was referred to specialists in Education for diagnosis and treatment.

Fig. 6.1 A radiological metaphor describing the UWO department of diagnostic radiology and nuclear medicine mirroring an approach to image interpretaion.

the authors to better understand the radiologist's world and respond in a language that may enable radiologists to better understand educational perspectives (see Fig. 6.1).

The first step in medical imaging is to examine the patient and determine the possible cause of his/her problem (Mettler 2005).

For background of the current study, the clinical conditions in this case required a full and complete history. Archived institutional records documenting previous exams, policies, guidelines, studies, and reports were gathered. Several interviews were conducted with those coming in contact with the "patient" (i.e., with students, residents, physicians, faculty administrators and staff at both the academic and the hospital sites). The preliminary assessment revealed concerns in several areas. A visual inspection showed a lack of clear objectives among the different members of the department. Problems with communication were evident, and included lack of meaningful feedback and protected time to work with others, and a desire for seamless compatibility for file sharing. On an emotional level, faculty appeared to have difficulty maintaining a work–life balance and coping with struggling students. Furthermore, the department has experienced an obsession with acquiring the latest imaging technology and expressed anxiety regarding the need to "lead" in Radiology teaching to be attractive enough to lure the "best and the brightest" to the field. Lastly, the department complained of weaknesses in its research and scholarship area but admitted to not exercising these skills.

A preliminary needs assessment had revealed significant "ailments" with respect to educational scholarship in the department. Despite cautions in the literature about allowing the development of a disconnect between medical education and health care (Whitecomb 2002), it appeared one may have already occurred. The dominant approach to practice appeared to be a technical, rational one as articulated by Barchi and Lowery: "No longer seen as the altruistic caregiver and creator of new medical knowledge, the academic physician all too frequently now appears as an employee of a monolithic, impersonal, financially driven enterprise" (Barchi and Lowery 2000), and thus overshadowing the motivation for devoting efforts to education. Hence the questions for this study arose: Within a specified institution, how is scholarship institutionalized in the department of radiology? What may be ailing medical education in this department, and how might it be treated?

6.2 Methods and Materials

Only after the patient is examined, can you decide which imaging study is the most appropriate (Mettler 2005).

To approach our research questions, we applied a mixed-method study, integrating both qualitative and quantitative approaches. Following approval from the appropriate institutional ethics committees, data was gathered from sources which included: *Official Texts* (specifically, institutional records, Royal College of Physicians and Surgeon's of Canada (RCPSC) Documents, CanMEDS documents); *Surveys*[1] (completed by undergraduate and postgraduate students, radiology faculty and administration); *Stories* of inspirational teachers and role models; *Observation and field notes* from meetings, rounds, educational series, conferences, and needs assessments.

For the quantitative analysis, we used descriptive statistics from the survey to provide demographic information, as well as to characterize baseline measurements that can be used for comparison in subsequent studies. The survey was made in electronic form, and was developed from the preliminary needs assessment and a review of the relevant literature. The aims of the survey were to gather insight into the experiences and opinions of the participants of the medical school community. Respondents, after self-identifying their role, were asked about their teaching, learning, and assessment experiences and about their own learning preferences. Furthermore, the survey asked about the extent to which their medical education was student-centered, how it could be improved, and whether their instructors had inspired a desire to work in radiology. They were also asked to rate the degree to which they felt prepared for subsequent training or professional practice. The survey utilized forced choice, ranking, multiple choice and provided space for additional comments.

After ethical approval was granted by the Research Ethics Board, the electronic survey was emailed to 566 individuals [from the university] in June of 2007. This included 30

[1] The survey is not included in this paper as a modified version is currently in use for a subsequent funded National study.

Table 6.1 Response to the electronic survey distributed to the DDRNM and medical undergraduate students at the University of Western Ontario

Status	Number receiving the survey	Number of respondents	Percentage of Respondents (%)
Department of diagnostic radiology & nuclear medicine (radiologists, residents, fellows)	30	27	90
Undergrad medical students at UWO	536	52	9

Nuclear Medicine Scientists, Radiologists, Residents, and Administrative leaders in the department, and 536 undergraduate medical students. No incentives were provided to participants. The response summary is recorded in Table 6.1. The contrast between the response rate from undergraduates and those directly involved with the DMI may reflect their interest and involvement in the medical imaging program and therefore have an influence on the outcome of the study. Given the exploratory nature of the survey, a chi-square analysis was conducted to provide insight into inter-group comparisons.

Qualitatively, a case study method was selected to allow an in-depth analysis of multiple sources. To first better understand the bounded system of the case (i.e., the present patterns in the DMI), data was collected from all participant groups over several months beginning in the spring of 2007. The use of narratives in this study was valuable, as positioning stories from practice next to survey data further informed the interpretation of the emerging departmental image. Narrative data included personal stories collected verbally or via email. In our review and analysis of the narratives, we were mindful of McKee's observation that "desire is the blood of a story.… The heart of a human being is revealed in the choices he or she makes under pressure" (McKee 2003). When reviewing our data, we considered the following questions: What do members of the department express as desires? What do they perceive to be preventing them from achieving these desires? How do they act to achieve these desires in spite of antagonistic forces?

6.3 Results

What should you expect from an imaging examination?… [I]mage interpretation will yield a differential diagnosis that must be placed in the context of the clinical findings (Mettler 2005).

The data from our observations and field notes strongly identified an expectation that students in medical school are independent learners – an attitude which influenced subsequent practices. Our discussions with faculty frequently revealed a common sentiment: *If students can learn the material on their own*, (and information required for the exams are included in notes posted online) *then teaching is not necessary* and indeed, qualitative evidence showed an overall lack of attention and support provided for curriculum development, teaching, assessment, and feedback. A review of the survey data for undergraduate

Undergraduate Preferred Modes of Learning		Undergraduate Top Three Experiences	
In-context (through examples, cases, hands on)	100%	Didactic Lecture	100%
Reading/reflecting	17.8%	Workshop/tutorial/small group lecture	90.4%
Practice/rehearsal	13.8%	Self Learning (electronic)	75%

Fig. 6.2 Learning preferences of UG medical students vs. learning experiences

students, (see Fig. 6.2) revealed the didactic lecture to be the teaching learning context most experienced by all students despite a preference for more individualized forms of learning. The dominance of the didactic lecture is often the result of attention to managerial, economic, and administrative concerns, rather than concern for pedagogy. In the typical didactic lecture, however, teaching is understood in traditional transmissional ways: the medical expert "has" the knowledge and must "give" it to the student. What gets ignored are skills and competencies that go beyond "medical expert" that are more difficult to develop through receptive learning approaches; skills and competencies at the heart of the respected CanMEDS Physician Competency Framework adopted in 1996 by the Royal College of Physicians and Surgeons of Canada. Further, the transitional demands on students as they move from undergraduate to radiology resident provide a salient example of the shift required from a predominant need for one set of skills (e.g., memorization, good study skills) to another set (e.g., communication, application, critical thinking). For example, we note in our data that for the undergraduate medical student, independent study is emphasized, leading to the development of one predominant set of skills focused around rote memorization for multiple choice exams. However, once students enter into residency, a new set of skills is required to present cases, generate a differential diagnosis, and work with referring physicians and occasionally patients. Problematically, undergraduate medical students often find themselves entering into residency having acquired the necessary knowledge but not the necessary skills to become good residents. We observed a second shift as residents moved into teaching positions and realized that they again required new skills, knowledge, and abilities.

The need for faculty support was well-articulated by the department. Responses on the survey indicated that 35% of residents felt insufficiently prepared to teach, while only 12% of radiology faculty acknowledged feeling insufficiently prepared. As we participated in the department however, we noted that "teaching" was understood solely in the formal sense, (i.e., lecturing in a traditional classroom setting), and was often assigned to the residents. Additionally, the curriculum in its current form does little to develop the significant component that teaching – understood broadly – will play in the life of a radiologist.

Two concerns that we heard frequently from both residents and faculty were the lack of protected time to devote to academic pursuits and a lack of confidence in their own knowledge and skills related to the required competencies. According to a recent profile, the typical Canadian radiologist works about 48 h per week (Beaudet and Baerlocher 2006), with direct teaching and education representing an insignificant portion of this workload. Examination of the current system showed that increasing the teaching load often "costs" radiologists in terms of clinical revenue, so, yielding an unattractive deficit. Time devoted to education usually generates no income, so it becomes important to recognize the nonfinancial dividends generated from the investment in educational initiatives to the overall "health" of the system. Systemically, current teaching efforts are conducted in fragmented snippets of stolen time by dedicated individuals with limited knowledge of curriculum design, teaching and learning theories or strategies.

A review of the curriculum and teaching schedule revealed an absence of a coordinated view of the curricular the "big picture" leading to unclear and scattered communication about its inherent parts. Many instructors receive teaching assignments with no information about where their teaching is positioned in relation to what students have already learned so far or will be learning. The singular or sporadic assignments leave little or no opportunity to develop any kind of teacher–student relationship – a theme that has been given importance in the narratives of some of the inspirational teachers. Complicating this, course and instructor feedback currently does little to provide meaningful information to inform changes in practice. Data regarding the radiologist's most frequent "teaching method" of choice (didactic lecture with PowerPoint) is illustrative of the lack of impact of the current feedback system. While this teaching method is efficient, portable, and reproducible, it was also ranked as the least pedagogically effective method by students. However, students made it clear that because they are assessed on the lecture material alone, they insist that the PowerPoint presentations be made available on-line after the class, and that faculty not stray from the topics in the presentation.

Our multiple data sources are better understood when situated contextually. Some stories from practice uncover unique insights which allowed us to compare and contrast themes across the data. Using the framework for analysis outlined previously in the methods section, three stories emerge that largely represent what we heard: Med Student Mary, Radiologist Rachel, and Administrative Leader Adam (see Figs. 6.3–6.5).

Viewing the image through the lens of the narratives illuminated a number of complex fractures between governing bodies and the institution, the institutions and the department, the department and the faculty and residents, and finally, between the "teachers" and the "learners." Below, we describe the fractures and the "natural positions" of the pieces that could promote healing.

One of the main fractures we found spurred from an apparent disconnect between the way that students say that they learn best, and what they actually experience. Our data revealed a discrepancy between the teaching preferences of students vs. instructors. When asked to rank their top five learning experiences, 50% of undergraduate students ranked workshops and small-group tutorials in the top two preferred learning experiences; 33% of residents ranked workshops and small-group tutorials first as well, followed by an equal number ranking clinical rotations second. Case-based presentations and on-call learning were ranked fifth in this response. In contrast, we see a shift to the didactic lecture being ranked first of the "preferred teaching methods" when we look at the instructor's responses. After arriving at these results we returned to the narrative data, to discover what the

"Med Student Mary"

Med Student Mary began her Undergraduate program in medical school fully expecting to meet caring teachers, only too happy to interact with their students outside of class and get to know them as 'real people'. She expected teachers who would not only uphold, but model high standards in the esteemed profession she had just decided to commit her life (and a substantial amount of her savings) to. Of course she understood that 'med school' would be a lot of work. She looked forward to it. The challenge of investigating and studying a large number of interesting cases appealed to her.

She was dismayed to learn that she would see most of her teachers for only a class or two per year, offering little opportunity for any type of bonding in either direction. Indeed, it appeared that instructors were, more often than not, completely unaware of the broader undergraduate curriculum in which the class they were teaching was situated, or knowledge of the core concepts which may or may not have already been taught. Increasingly Mary felt that along with a lack of structure, was a lack interest in their learning or any knowledge of teaching. The day she overheard one instructor gossiping about another, she began to have serious reservations about her career aspirations.

When she stopped to reflect upon her situation, she realized that as a group, she and her colleagues had been accustomed to working independently and studying hard in a somewhat competitive environment to gain entrance to medical school. She wondered how their 'student qualities' might have contributed to the learning environment that she was currently experiencing. On one hand, the exposure to various individual teachers offered the students opportunities to learn from specialists that represented the particular field that they were studying. However, students had demanded that all class notes be made available online. Instructors had complied, openly declaring that all exam questions would come only from material in the posted class notes. Is it any wonder that out of a class of 133 students, only 30 were in attendance?

Fig. 6.3 Workplace narrative of "Med Student Mary"

In addition, she observed that her instructors appeared to be chronically pressed for time, frequently apologizing for not knowing what the students had already learned. Some admitted that their clinical loads were so heavy that they had sufficient time to prepare the class as they would have liked to. Other instructors conveyed a clear message that the students were impositions on their time, and limited all interaction.

At first, Mary and her colleagues were furious and spent a great deal of time complaining about their plight. However, she had been in school long enough to recognize that while students are good at identifying problems, they are less likely to break the problem down and consider it critically. As she thought further, she wondered how the declining attendance might affect the instructor, especially one pressed for time. She began to wonder if the lack of 'protected time' the instructors frequently grumbled about, might even contribute to a resistance to developing relationships with the students. It may be a case of self-preservation: if instructors develop a relationship with students, their needs may be harder to ignore. She began to worry that to become a doctor would mean that she would need to forfeit outside interests and activities. She made a mental note to begin seeking role models who seemed to have managed that personal/professional balance.

Fig. 6.3 (continued)

"natural positions," might actually be. Further analysis across the data identified themes or conditions in which medical students suggested that they learn best: *Relevance* (i.e., problem-centered, learner-centered, and active; learners can understand how what they are learning applies directly to what they will be doing in practice); *Respect* (i.e., learning needs and preferences, opportunities for choice or self-direction, being part of a community, collaboration, valued structure); *Responsiveness* (i.e., consideration of where the learner is on his/her path, what is already known, what is needed to facilitate meaning making, and setting cooperative goals with timelines and then ensuring accountability for achieving those goals – relating both to the student and instructor).

These conditions suggest that a shift is required from privileging considerations about "teaching" and "what is taught" to forwarding considerations about "learners" and "what is being learned." In our daily interactions with residents and faculty we also observed the ways in which the entire culture contributes powerfully to the learning environment. Undergraduate students, residents, and physicians all learn both positively and negatively

"Radiologist Rachel"

Radiologist Rachel smiles when she reminisces about her decision to become a radiologist. As a student, she knew early on that she had to pursue a specialty that engaged her intellectually. She had identified a number of areas that she was proficient in, but was really still seeking the inspiration that would help her make her decision when she attended a radiology lecture offered by a soft-spoken instructor. She marvelled at the way in which the instructor was able to explain the lesson in simple terms. He offered several examples, keeping in light and even injecting humour. His manner was warm and friendly and seemed to be in juxtaposition to the 'mind numbing' lectures it was sandwiched between that day. She chuckles as she recalls that her experience was not shared by everyone. Once the lights were dimmed and the lecture began, she recalls that half the class were already dozing and a few sneaked out the back to get a head start on their weekend plans.

She decided she had to know more, and took it upon herself to approach him. Her initiative paid off as he invited her to visit the department. That visit was the first of many, leading to a research project and a close relationship with an instructor who became a mentor and role model for Rachel. She recalled that the entire department contributed to her interest on a daily basis and nurtured her curiosity about the field.

When she became a radiologist herself, Rachel knew that she wanted to emulate her mentor and 'pay it forward' for the upcoming generation of radiologists. She considered the qualities that her mentor had demonstrated. He was certainly professional, knowledgeable, and approachable. She knew that he was well-liked and respected by his colleagues and adored by his patients. She closed her eyes, and pictured their interactions. Without fail, he was always smiling and despite a busy schedule, made you feel that he was happy to see you. He loved his job, took pride in his work, and it showed. It struck her that he had managed to find that all too elusive balance in life. He frequently talked about his children and was quite simply, a happy, well adjusted individual. *Yes,* she decided, *That is what I will commit to be for my students.*

Fig. 6.4 Workplace narrative of "Radiologist Rachel"

"Administrative Leader Adam"

Adam always knew that he wanted to become a family doctor and settle down in a small community. Recognizing that he would not have access to a radiologist in that setting 24/7, he sought an elective during his holidays, to better prepare himself for his practice. He was surprised to find that in that elective, the teaching was good, and the individuals he met were probably the most interesting and interested and well balanced individuals that I had seen in medicine. He found them to be well-balanced, interested in others, not just their craft, interested in patient as a whole. The ability to speak not only with patients but have a day to day interactions with a number of physicians from different specialties appealed to Adam. As he looks back on that experience, he remembers it fondly for his ability to savour the learning.

Over the years, Adam has witnessed a shift. He believes that radiologists need to not only have the intellectual skills, they need to also be psychologically and emotionally mature. Radiologist historically had better balanced lives, but imaging has become so busy it has become harder to maintain that balance. He considers too, that most of what he was trained to do is not what he is actually doing. He worries that the acquisition of knowledge and the ability to use that knowledge isn't an end in itself, it is part of the fun of learning but suffers under the pressure of a significant work load. He finds institutions to be reactive rather that proactive creating a tension between a rhetoric of support, and an infrastructure that works against it.

Adam knows that he has not resolved all of these pressures. He is frequently asked, "How do you get through the work load and be a source of inspiration for a student and have dinner with your own family?" and he acknowledges that currently, he has been missing dinner with his family. However, he has been working at building culture of support for those coming into the profession. For example, he assigns new colleagues to a good mentor, and expects residents to be learners and teachers. He understands that spending time enthusiastically with residents is beneficial for everyone: If we send the message 'we want to be with you' they will reciprocate. "It is better to mould someone early on that try to make a square hole from a round one when they are 50".

Fig. 6.5 Workplace narrative of "Administrative Leader Adam" from daily interactions with each other. As researchers have noted: “One of the most consequential and enduring aspects of learning to be a doctor is the formation of one’s professional identity – the development of a set of personal beliefs, values and role expectations that guide and inform virtually all subsequent behavior” (Suchman et al. 2004). Although this study focused closely on one department in one institution, it became clear that both the academic institution and the entire hospital environment need to be concerned with the level of professionalism, collegiality, and scholarship that is established. Our qualitative observations showed us that the current system is far from a culture of reciprocity. A culture of reciprocity recognizes that when we teach others well, we enhance our own understanding, confidence, and competence, and gain a degree of satisfaction by preparing a new generation of healthcare professionals better able to meet the challenges of the profession.

This approach to reading the DMI image offers an interpretation of one department viewed through an “educational lens.” In order to resist the urge to point out “abnormalities,” we must better understand what constitutes “normal” in this environment. For example, as we reviewed institutional records, we noted a significant discrepancy between identified institutional dollars committed to research vs. teaching. Indeed, attempts to learn about the specific allocation of resources to teaching proved challenging. Records and resources were plentiful in the area supporting research – in large part due to the required accounting for the significant allocation of funds. Relatively smaller amounts were dedicated to the scholarship of teaching, tracking, and collating the information proved piecemeal at best.

6.4 Discussion

A teaching hospital is a multidimensional institution, composed of people fulfilling diverse functions to achieve a range of outputs. Hafferty argues that in medicine, it is important to “create structures that allow individuals to reflect upon a larger structural picture of which they are a part” (Hafferty 1998). There is little point in considering “treatment options” if it is impossible for the “patient” to participate in them. In this paper, we apply a medical metaphor for diagnosing ailments in the approach to medical school education, and extend the metaphor to include the application of techniques, such as X-ray, Ultrasound, and CT imaging as a means to consider the larger picture as Hafferty suggests, but also to consider feedback and view the information in manageable slices/portions, which are used to formulate a targeted intervention.

6.5 Differential Diagnosis

An ultrasound examination uses high-frequency sound waves sent into the patient and supplies feedback on the patient’s internal structures from the echoes that travel back out to the observer. Using this model of the ultrasound to reflect upon our results demonstrated that there are indeed pathologies present in the department of radiology, and there is a genuine desire for treatment. The “sound waves” are created by us as educators practicing in the medical field. The echoes were seen in our daily interaction, and we have heard "shudders" of recognition that this ailment is an area that has been neglected for too long. When presenting differences in learning theories for example, we have repeatedly been told that there was no understanding of the vast implications of the uniformed instructional decisions that were being made. Furthermore, we hear a call for intervention to promote cultural changes and refocus teaching as a commitment to pedagogy. Although we have been met with some trepidation, there is a dawning recognition that teaching is a vital part of the future of the radiology department.

The use of X-ray imaging allows the viewer to visualize internal structures not visible to the naked eye. Using both qualitative and quantitative approaches in this study provided a contrast between knowledge claims grounded in the lives of the participants and those reflected in literature. Reviewing our rich data sources further illuminated important gaps and discrepancies. While analysis using the model of ultrasound confirmed the presence of pathology, analysis using the model of the X-ray imaging helped illuminate the underlying pathologies in the following areas.

6.5.1 Recognition

Our results showed that the most pervasive pathology within the department is that scholarship receives little recognition amidst complex and often competing agendas. Lack of academic recognition or reward, and lack of protected time and negative consequences (i.e., clinical deficits) for involvement in scholarship may also indicate that education is not seen as an equal contributor to the overall mission of the department. To properly train at a competitive level, education needs to be recognized as a vital, planned, and integral component of the radiology department – not "left to chance, aptitude or inclination" (Purcell and Lloyd-Jones 2003).

6.5.2 Curriculum

We observed that currently there is a great need for a coordinated, overarching curricular vision to be put in place. Without a well-developed curricular vision both learners and instructors are left with unclear expectations, objectives, or the ability to locate their learning or teaching in the "bigger picture." Also, without an explicit indication of what the learner is expected to know, do, and "be like" at the end of the course, the numerous skills and competencies that go beyond the "medical expert" that are necessary for the undergraduate student to become a successful resident are neglected.

6.5.3 Faculty Development

Pedagogically, we found pockets of innovative and successful teaching practices dependent largely upon the dedication of individuals. The creation of a Centre for Education has been a good first step toward enhancing the educational health for the department. However, there is currently a lack of faculty support and necessary venues for sustained faculty development and dialogue. This deficit may be effecting the noted disconnect between the way students say they learn best and what they actually experience. Further, a common lack of confidence felt by instructors regarding their knowledge and skills appears to be a main barrier to more formal understanding of pedagogy. Central to the need for better faculty development is the need to help instructors better understand the diverse needs of the learner and develop a repertoire of sound teaching approaches.

6.5.4 Role-Modeling and Mentorship

This study uncovered the need for a culture which promotes positive role-modeling and mentorship. Medical student "Mary" who was "dismayed to learn that she would see most of her teachers for only a class or two per year, offering little opportunity for any type of bonding in either direction." Radiologist "Rachel" knew that she wanted to emulate her mentor and "pay it forward" for the upcoming generation of radiologists, and Administrative Leader "Adam" found his teachers of radiology to be "the most interesting and interested and well balanced individuals" that he had seen in medicine. Mary laments the lack of bonding with her teachers and seeks a role model who has achieved personal and professional balance; Rachel talks about the importance of mentorship and how it influenced her career decision; Adam focuses on the importance of building a culture of support. Earlier, we noticed that perhaps given a lack of protected time to participate in such activities, some radiologists practiced a form of "self-preservation," actively avoiding getting to know their residents. This has lead to the cultivation of a culture far from the culture of support and reciprocity highlighted as desirable in the narratives.

6.6 Recommendation for Rx

A CT approach allows us to consider particular parts for targeted intervention, while retaining a visualization of the "whole." The CT "slices" we have chosen to focus on include both structural and cultural shifts in the following areas of possible treatment plans. Changing a culture begins by, first, changing expectations, communicating them clearly, and supporting the development of activities that meet those expectations. Using the CT approach, the following are generated and these are our recommendations for Rx:

6.6.1 Increasing Recognition and Rewards for Scholarship

It is integral to the health of the patient that scholarship becomes well-recognized within the department. One way to cultivate this change is through the implementation of programs aimed at faculty support and development. There is a need for sustained faculty development in ways that allow faculty to continually revisit, review, and reassess their own teaching. This approach will offer opportunities for scholarship of teaching and provide the opportunity to build a repertoire of teaching skills resulting in a more rigorous, pedagogically sound program. Participating in programs focused on the scholarship of teaching promises to influence the way faculty think and talk about teaching, and hopefully their approach to their role as teachers within the department. Formally recognizing and supporting effective teachers (both pedagogically and financially), would likely further educational innovation and help solidify the conception that scholarship in teaching is a valued component of academia.

Knowledge of medicine is a necessary but insufficient qualification for teaching radiology. Scholarship in academic medicine includes discovery of new knowledge and the integration, application, and teaching of said knowledge (Boyer 1990). To encourage faculty and residents to engage in scholarship, institutions must understand scholarship broadly (Boyer 1990), and ensure that participation in the scholarship of teaching is valued equally when making appointment and promotional decisions.

Further, the mission of the department must be better disseminated and scholarship should become an equally valued part of this mission. It could be strengthened by expecting all department members to participate in scholarly endeavors, and through opportunities for groups to collaboratively plan and participate in events tied to the academic mission. It must be seen as integral to the operation of an academic teaching hospital setting, and all members of the department must view themselves as contributors in some way to that goal.

6.6.2 Implementing Well-developed Curriculum

Given the adoption of the CanMEDS framework by the Royal College of Physicians and Surgeons of Canada, any curricular developments should integrate the CanMEDS competencies in their design. The curricular structures must then drive the organization of classes and their instructors, and expectations must be made available to both. Understanding where the “course” fits into the grand scheme of things reduces redundancies, overlap, and promotes a logical progression of learning.

6.6.3 Embracing Interdisciplinary Collaborations

The collaboration between the Faculty of Education and the Schulich School of Medicine & Dentistry allows us to create a community of scholars and develop insights through our shared understandings not visible through our own individual lenses. Situating ourselves in the medical world and inviting radiologists into our educational world have generated insights and deepened understandings for all participants.

6.6.4 Improving Communication

Clear communication of consistent expectations and resources available to support the achievement of objectives must be addressed. In imaging sciences, radiologists work with the "big picture" and yet the "big picture" in scholarship is obscured from their sight. It needs to be made visible so that they can provide appropriate responses. In addition, cultivating ongoing dialogue around issues of scholarship will encourage a shift from an esoteric understanding to a concrete understanding more likely to lead to productive change.

6.6.5 Generating a Culture of Role-Modelling and Mentorship

The qualitative results demonstrated that the professional culture encountered in the current structure of the radiology department contributes powerfully to the shape of the learning environment. Therefore, it is important to aim to develop a culture of reciprocity that fosters positive mentoring and role-modeling relationships. To do so, the department must recognize the destructive capacity of negative role modeling and work to address it. The next key step is to disrupt the factors which work against positive role modeling in the department (i.e., lack of protected time and clinical revenue deficits). To build a culture which supports scholarship, we need to expect participation in that culture by all members, and be willing to find creative ways to protect radiologists' time and income for academic pursuits. Making scholarship and research experience requirements when hiring residents or appointing new faculty will ensure those expectations are understood. Innovative ideas proposed by faculty members to further support this vision (e.g., mentorship program to introduce, train and advise residents' research and scholarship) should be supported in terms of protected time and protected income.

6.7 Prognosis

It has been said that "changing a curriculum is more difficult than moving a graveyard. Perhaps that is why there has been so little educational innovation by medical schools" (Swanson 1994). While we recognize the challenges that come with institutional change, we do not share such a fatalistic view when considering the potential of the department.

While treatment is necessary, the patient's future looks healthy. There are indications that the institution is already moving toward a more comprehensive understanding of what counts as scholarship. When a clear vision is articulated, and funds and rewards (both intrinsic and extrinsic) are allocated, change will occur. The department has already taken a big step toward a healthy future by acknowledging the issues and establishing the partnership with the Faculty of Education. One of the early lessons we learn as teachers is the importance of developing a scholarly community to nurture the intellect, engage in issues

Table 6.2 Assessing scholarship in a medical institution checklist, generated to help others interested in beginning this process at other institutions

Assessing scholarship in a medical institution	Yes	No
Is a broad understanding scholarship articulated as a priority in the academic mission and strategic plan of the institution?		
Are resources, recognition, and rewards committed to all forms of scholarship equitable? (e.g., celebrations and awards, resources, grants, funding, influence on promotion and tenure decisions)		
Does the structure and the culture of the institution regularly bring together leaders in all areas of scholarship to create and communicate a shared vision?		
Is a clear vision for scholarship articulated for students, residents, teaching faculty, and resident supervisors?		
Is the vision supported by appropriate structural and cultural supports such as:		
Overarching view of medical curriculum		
Coordination of specific curricular components within the whole		
Communication and access to the whole and its parts		
Resources required to meet objectives		
Support for the application and integration of knowledge		
Support for the pursuit of inquiry in all areas of scholarship		
Does the institution engage in regular "border crossing," bringing together scholars from "overlapping academic neighborhoods?"		
Does the institution facilitate the dissemination and translation of scholarship from inquiry to practice *and* from practice to inquiry?		
Examples of discovery		
Examples of integration		
Examples of application		
Examples from teaching		
Do members engage in the scholarly contributions of others? (reading the literature, presenting at the department level, conference, writing for publication)		
Does the institution have a process in place for critically assessing the current status of scholarship and a plan to improve the quality and the achievements in the future?		

around our practice, and critically reflect upon and assess what we do as an ongoing practice. As we worked through the process of "assessing" scholarship in our department, we generated a checklist to help others interested in beginning this process at other institutions (see Table 6.2). This checklist is not intended to be a definitive measure, but rather a series of questions to stimulate dialogue around the issues that may influence the way scholarship is enacted. This study highlighted a few of the broad "next steps" that need to be taken. We are currently assessing the scholarship of medical imaging departments across Canada to compare findings across institutions. Although we have just begun "border crossing," we expect to discover even more possibilities as we look toward a shared vision of educational scholarship in radiology as the practice of teaching is recognized for its ability to generate new knowledge. Improved health will be noted when student concerns are lessened and improved student learning is achieved with the ultimate goal translating into improved patient care.

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An Integrated Curriculum in Medical Imaging 7

Penelope Engel-Hills and Christine Winberg

7.1 Theory and Principle: Why an Integrated Curriculum in Medical Imaging

This chapter argues that a shift in educational practice is needed to adequately prepare practitioners for practice in medical imaging. Radiology is a rapidly changing, technology-driven field, requiring new forms of multidisciplinary practice. (Engel-Hills 2005) The content-based syllabus was effective as a guide for education programs that prepared novice practitioners to adapt their practice in a slowly changing environment. The challenge of professional education in this discipline today is to develop practitioners with entry-level competence for immediate practice and with the ability for continuous self-directed learning to deal with constant, rapid development. In the current environment, an integrated curriculum is an appropriate pedagogy to equip practitioners to enter this complex, changing workplace.

7.1.1 Definitions

The notion of an integrated curriculum is not a new idea. This form of teaching and learning has received much attention in educational settings at all levels. Lake's (Lake 2003) review article, although referring to the school curriculum from Kindergarten to grade 12, offers a useful overview of curricular integration. According to Lake (Lake 2003), there can be no single definition of an integrated curriculum, as one definition would not adequately describe the complex variations that are possible within the concept of integration. There are, therefore, many terms that relate to integration, including interdisciplinary, thematic, and synergistic teaching. Further, approaches such as community-based, problem-based, and guided discovery learning programs (Reser 2000) are also described as integrated. Thus, while these terms all describe different pedagogical approaches, they are all captured under the

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educational approach of "integrated," and are introduced as educational innovations with the goal of fostering student-centered, active learning. (Moust et al. 2004) Through a process of considering definitions of integrated curriculum, Lake (Lake 2003) suggests that this approach prepares the learner for life and for lifelong learning because it is how, in addition to what we learn, that will impact on us as lifelong learners (Haslett 2001). The integrated curriculum can therefore be considered as a broad description of curriculum design that includes problem-based learning (Haslett 2001; McLean 2004), project-based learning (Markham et al. 2003), thematically organized learning (Lipson et al. 1993), work-integrated learning (Adamson et al. 1997), and learning communities (Gabelnick et al. 1990).

The college of medicine at the University of Vermont (UVM College of Medicine 2003) identified three important integrations in the medical education curriculum. The first is the integration of basic and clinical sciences, with the focus on the integration of concepts. This integration does not mean that the clinician or basic scientist has to teach the other's concepts, but rather that the design of the learning experience encourages conceptual integration in order to achieve the curricular goal of educating doctors with the skills and motivation to continually access basic science knowledge. The second integration concerns interdisciplinary teaching, as opposed to traditional discipline-based teaching. The third integration requires collaboration among healthcare practitioners.

7.1.2 Knowledge in Professional and Academic Contexts

The theoretical framework for this chapter is built on related sets of concepts developed by Bernstein (1996, 1999, 2000) for understanding knowledge in professional and academic contexts. These concepts are explained, and the relationship between them is considered with reference to curriculum development in the field of medical imaging.

Bernstein (1996, 1999, 2000) distinguishes between academic and professional knowledge, which he describes as "vertical" and "horizontal" knowledge respectively. Vertical knowledge is associated with traditional academic disciplines; it is abstract and theoretical. In scientific disciplines, such as physics or anatomy, vertical knowledge is hierarchically organized and each knowledge structure is "coherent, explicit, and systematically principled" (Bernstein 1999). Horizontal knowledge, the knowledge that develops through practice, is typified as "everyday, context dependent, tacit, multi-layered, often contradictory across contexts but not within contexts" (Bernstein 1996).

Vertical, disciplinary, academic knowledge is the basic "reservoir" (Bernstein 1999) that radiologists-in-training draw on as they develop a range of professional "repertoires" (Bernstein 1996). Academic medical imaging knowledge is difficult to relate directly to radiology practice because it is based on hierarchical, decontextualized, abstract knowledge about imaging, and not on contextualized elements of practice. When vertical knowledge is drawn on in practice, it exhibits many of the characteristics of horizontality, that is, it becomes "situated" in particular contexts and tasks. Professional practitioners are also able to draw on a collective reservoir of established practical strategies, or they develop new segments of practice which could, in turn, become contributions to the collective reservoir (Bernstein 1996, 1999). Such "circulation" between the academic and practical domains extends the “reservoir” (the potential for practice of a particular community), and develops the “repertoires” of its individual members.

From the concepts developed thus far, we can construct a model of medical imaging knowledge as both vertical (in its academic form) and horizontal (in professional practice). All knowledge fields comprise elements of verticality and horizontality in different combinations. The interaction of both knowledge types will be necessary in designing a medical imaging curriculum that will both extend the disciplinary base of medical imaging and support its professional development.

Curricular arrangements are a function of the knowledge to be acquired; in professional programs there needs to be a coherent relationship between the knowledge to be acquired and its application. (Bernstein 1999) A metaphor that describes this concept is that of the “T-shaped” curriculum (European Science Foundation 2002) where the down-stroke represents a “reservoir” of disciplinary knowledge and the cross-stroke represents breadth and flexibility of competent professional “repertoires.” What is important is that knowledge within a program is “integrated at the level of meaning” (Bernstein 1999).

Theorizing academic and professional knowledge provides insights and understandings that can contribute to effective curriculum design and implementation in medical imaging. The interpretation of the key aspects of integration will differ, as will the specifics of the environment, hence there are many ways in which to achieve a T-shaped curriculum.

7.2 Practical Issues

An education program in the health sciences is best offered through the collaboration of higher education and healthcare institutions, with a conferred qualification that acknowledges the expertise and knowledge needed for practice and leads to a license to practice. Integrative scholarship applied to radiology encourages a comprehensive understanding of clinical and academic components and promotes interpretative thinking and learning for practice in a changing environment. Hence, it is suggested that an appropriate education program is designed through the identification of outcomes as a foundation for a well-planned and delivered integrated curriculum (Harden 2001) provided that the curriculum that is described in terms of “outcomes” includes knowledge-based outcomes and value-based outcomes as well as competencies. This is an effective means to establish a fully functional and integrated team that collaboratively achieves a quality service for the attending patients.

The integrated curriculum with the elements of: (1) a design that combines the learning areas through a thematic organizing principle; (2) a plan to demonstrate the relationship between concepts, principles, and topics; (3) a structured but flexible schedule; (4) the use of small-group learning activities; (5) the use of a wide range of information resources; and (6) an emphasis on assignments and integrated assessment (Lake 2003), is able to achieve the development of competence in complex forms of practice. The range of strategies for integration can be applied to the entire curriculum, a single aspect of study within a curriculum or any module or part and can be delivered to small and large student groups (DiPasquale et al. 2003; Bebb and Pittam 2004).

7.2.1 Planning an Integrated Curriculum

In the context of medical education, Harden (2000) describes 11 points of integration on a continuum between the extremes of subject-based teaching and a curriculum that transcends disciplines. Fogarty (1991) describes ten levels on a continuum of integration. These approaches are presented in Table 7.1. The general trend of the continuum is toward more integration, although as Reser (2000) points out, Harden's (2000) continuum may not be entirely hierarchical and integration can exist in all the levels. This would be true for the Fogarty (1991) continuum as well. These continuums are helpful in selecting an integrated curriculum suited to each unique context.

In planning for such an integrated curriculum the first step is for a joint team of educators and practitioners to identify the professional learning outcomes that must be achieved by those registered for the program (Harden 2000). The learning outcomes will focus on performance which can be described as doing with understanding, and will include actions, attitudes, and behaviors. The aim is professional competence and the outcomes must therefore be determined by those who know what the practitioner must be able to do. The outcomes are transparent and known to all involved including the student. There are no surprises in a fair system, and students can prepare themselves well for assessment tasks.

7.2.2 Implementing an Integrated Curriculum

To be successful in achieving the outcomes, the professionals in training will need to engage in learning activities that foster the integration of knowledge, understanding, skills, and clinical competence. The next step is therefore to design and plan a curriculum that prepares the novice professionals toward the achievement of the predetermined outcomes. An integrated curriculum has curriculum activities to enable learning of underpinning knowledge that is both foundational to future learning and core to the discipline. It also has workplace engagement that promotes the integration and transfer of cognitive knowledge, clinical competence, and generic skills (Engel-Hills 2005). Teaching learning and assessment activities must be selected to guide and support students to achieve the outcomes (Biggs 2002). The curriculum must be structured to present the learner with the opportunity to experience the real-world environment where they develop values, attitudes, and behaviors for practice as a member of an integrated healthcare team. The curriculum must further educate for a vision of development in order that practitioners entering the workplace optimally utilize the resources available and offer the best care to all patients. Alignment is essential in order that the curriculum activities and assessment methods build toward learning and involve "doing" so that students demonstrate achievement of the learning outcomes (Biggs 2002). Assessment is criterion-referenced with a focus on measurable outcomes that must be achieved.

Table 7.2 summarizes the characteristics of an integrated curriculum and provides motivation for the use of this curriculum design as appropriate for medical imaging programs.

Table 7.1 A comparative continuum for curriculum integration

11 Steps for integration Harden (2000)	Explanation	Ten views for integrating Fogarty (1991)
	Learners filter learning through the expert's lens, personal connections result in external networks of experts in related fields	Networked
	Disciplines are part of learner's lens of expertise and the learner becomes immersed in a personal learning experience	Immersed
Trans-disciplinary	The field of knowledge is the focus as the curriculum transcends disciplines and the disciplines are part of the real world experience	
Interdisciplinary	Themes as the focus with no reference to individual subjects or disciplines	Integrated
	A Metacurricular approach threads thinking, social and study skills as well as technology and multiple intelligences through the various disciplines	Threaded
Multidisciplinary	A theme is used to connect the concepts, topics, and ideas in each subject as the theme or problem is viewed through the lens of the subjects/disciplines	Webbed
Complementary	Theme-based integrated teaching sessions supported by subject-based teaching	
Correlation	Subject-based teaching with regular integrated teaching sessions	
Sharing	Joint planning and teaching to produce shared concepts, skills, and attitudes in two or more disciplines	Shared
Temporal coordination	Coordination of topics examined from different perspectives such that similar ideas are taught to coincide within the separate subjects	Sequenced
	Multiple skills; social, thinking and content-specific skill within each subject	Nested
Nesting	Content drawn from different subjects to enrich the teaching	
Harmonization	Consultative planning achieves connections between subjects that are separately taught	Connected
Awareness	Subject-based teaching and assessment but with communication between academics	
Isolation	Subject-based teaching and assessment	Fragmented

Table 7.2 Characteristics and rationale for an "integrated learning curriculum"

Characteristics	Rationale	References
Meta-learning	Learning how to learn, and thus becoming lifelong learners, is the only way in which students and practitioners will be able to adapt to rapidly changing technology	[29]; [30] (Hendry et al. 1999; Malhotra 1996)
Transparent learning objectives	These are minimum competencies for practice in medical imaging	[31] (Harris et al. 2005)
Thematically organized learning (content, scope, sequence)	The learning objectives are integrated into themes (e.g., "The Chest") which are meaningful for both academic study and clinical practice, and where the scope, level, and sequencing is appropriate to the level of the learner	[17]; [32]; [33] (Bebb & Pittam 2004; Graham & Wealthall 1999; Pirrie et al. 1999)
Knowledge generating	Practitioners as lifelong learners that can adapt to changing contexts and develop the profession will be an outcome of a knowledge-generating curriculum	[34] (Freeman et al. 2000)
Problem- and project-based learning	Beyond thematic integration, students who work on a real-world problem (e.g., preventing the spread of TB) develop not only skills, but "insights"	[35]; [36]; [37]; [38] (Rothenberg 2002; Everingham & Harris 2000; Stark 1998; Klein & Newell 1996)
Work-integrated learning	A variety of curricular practices, such as work-based projects, in-service training, and sandwich courses, facilitate the transition from academic classroom to professional working environment	[39]; [9] (Engel-Hills et al. 2005; Adamson et al. 1997)
Contextual learning	In order to build competent and caring professionals, there is need for contextually based learning, including learning in "high tech" environments and in community-based contexts, such as through service learning	[40]; [41]; [9] (Winberg 2006; Waghid 2002; Adamson et al. 1997)
Team learning	Group-based learning simulates real-world contexts in which there is inter- and intra-professional collaboration	[42]; [43];[44] (Wrightson & Cross 2004; Lavin et al. 2001; Bines 1992)
Sustainable assessment	Assessment practices should not only be aligned with integrated teaching and learning practices, but must support learning beyond the higher education setting	[45] (Boud & Solomon 2000)
Learning support information literacy language support infrastructural support administrative support flexible scheduling	Integrated curricula have many features of resource-based learning programs, thus students need to develop information literacy. In multilingual settings, support is needed for technical communication. Infrastructural and administrative support is needed for new practices, and teaching loads and learning timetables need revisiting	[46]; [47]; [25] (Winberg et al. 2005; Wyrley-Birch 2004; Schön 1983/1991)

7.3 Take Home Message

The traditional curriculum is not likely to prepare students adequately for the demands of the modern medical imaging environment. An integrated approach that encourages self-directed, deep learning (Klein 1997) and knowledge building, develops critical thinking (Perkins 1991), the ability to find information, creative problem-solving (Caine and Caine 1991), reflective practice (Schön 1983/1991, 1986), team work, and life-long learning (Payne and Nixon 2001) responds to the challenges of higher education for health science practitioners of today.

It is suggested that the key to effective learning toward competent practice is the inclusion of a participatory learning environment in a carefully planned integrated curriculum. It is the active engagement in learning activities that enables and encourages students to achieve the predetermined learning outcomes (Biggs 2002) identified to meet the needs of the environment and to respond to development and change. On a continuum of learner participation there should be few offerings where the learners are passively receiving information and many activities that are designed to promote active learning (Figs. 7.1 and 7.2).

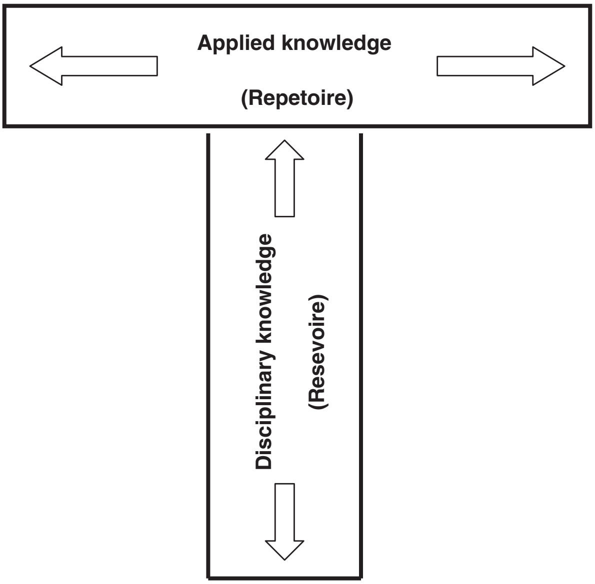

Fig. 7.1 Professional practice represented by the T-Shape (Adapted from Rip, 2004)

Fig. 7.2 Participatory learning increases in an integrated curriculum

In a well-designed integrated curriculum, cognitive knowledge is integrated with forms of practice, application, projects, and problem solving; this does not involve the loss of disciplinary knowledge, or the creation of an "empty curriculum" (Barnett and Coate 2005). An integrated curriculum that is built on an understanding of both disciplinary and professional knowledge can prepare students beyond the present context for the workplace of the future.

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Resident Case Review: Working Smarter to Optimize the Learning Experience

8

Andrew Leung

> Life is like a box of chocolates. You never know what you're going to get.
>
> Forrest Gump

8.1 Introduction

Case review is arguably the most important component of radiology resident learning. This process occupies the trainees for several hours each day. It requires independent scholarship and encourages interactive learning. This activity also establishes the foundation for future behavior in terms of both approaching a single case and managing a heavy workload.

Learning through the case review process is familiar to all radiologists and will be reminiscent of ward rounds to the clinician. During a typical neuroradiology rotation, a resident reviews 12–15 CT or MRI cases in the morning. They examine each case for pathology and identify normal anatomy along the way. The resident also learns to manage cases. They take calls from the clinical services, protocol requests, and troubleshoot for the technologists. Later in the morning, usually between 10 and 11 AM, the radiology consultant sits down with the resident and reviews the list of cases. The resident points out their findings and provides differential diagnoses. They question aspects of imaging. The consultant teaches around each case, discussing not only the anatomy and pathology but also the clinical presentation and management. This interactive exchange typically lasts an hour or two, after which time the resident dictates the cases. The teacher and student will reconvene in the afternoon for another session.

Resident learning at case review is subject to two major factors: the array of available cases and the quality of teaching interaction. The first issue is often under-appreciated if not

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unrecognized, while the latter is frequently assessed but can be difficult to improve. Day-to-day, the volume of cases in the unread list is unpredictable. The variety of cases in terms of type of study and pathology is even more erratic. The quality of interactions that occur during staff teaching can also be inconsistent, especially as workloadincreases. Residents themselves are highly variable in terms of productivity and diligence. Consequently, learning through the case review process is highly variable. However, it is too critical to the overall learning of the radiologist to be left to chance. This chapter will offer approaches to manage our version of Forrest Gump's "box of chocolates."

8.2 Case Review: Current Problems

Ideally, the Unread List contains an optimal volume and variety of cases, providing the educational experiences that would meet all levels of training. Uncommon types of examinations and rare diseases would be overrepresented. Staff teaching would be enthusiastic and thorough. Unfortunately, such a scenario is encountered on only a handful of days per month at best.

An irregular volume and variety of cases in the unread list hinders resident learning. If there are too few cases, the residents do not see enough variety. If there are too many cases, residents are forced to hurry through their work. Similarly, there needs to be an appropriate mix of study types. While reviewing 25 cases per day during a Neuroradiology rotation is commendable, the work is suboptimal if the mix consists of 23 CT heads and 2 CT lumbar spines but no temporal bone studies or CT angiograms of the circle of Willis.

The volume and variety of cases reviewed by a resident is a function of a level of training. Certainly, a first-year resident would not be expected to be able to read the same number of cases as a final-year resident. Expectations for what the residents should be able to know and do are outlined in the post graduate curriculum. Productivity should not depend on the ability or energy of the resident. Left to chance, certain types of cases may sometimes be avoided. At our institution, for example, spine imaging is universally disliked by our trainees!

There is even less predictability in the pathology encountered in the daily mix of cases. Even though we are partners with a busy and diverse department of clinical neurological sciences, residents can come to the end of a Neuroradiology rotation without having seen more than one or two cases of common diseases such as stroke, multiple sclerosis, and brain tumor. Their experience with uncommon disorders such as brain abscess, aneurysmal subarachnoid hemorrhage, and epilepsy is even more variable.

The development of stimulating and comprehensive lectures for residents and medical students takes time and effort. Finding meaningful cases and reviewing the literature is the first step. The second step is to consider how to thoughtfully develop a lesson that engages the residents in ways that optimize their learning. Because of the time commitment required to prepare quality presentations, they are highly variable and dependent upon the professional commitment of individual staff. As a result, resident learning at case review can resemble a game of chance. How might we address this in ways that result in improving the resident experience and ensuring that we are accountable to our curriculum objectives in a more systematic way?

8.3
Volume of Cases

A complex procedure can be made effortless with repetition. With this in mind, competency is more often being defined as the performance of a procedure a certain number of times. In many specialties, training guidelines now include well-defined minimums for specific patient care activities. Radiology residents must document interpretation of 240 mammograms (ACGME 2007c). At the end of a Neuroradiology Fellowship, the trainee should have performed 50 diagnostic cerebral angiograms (ACGME 2007b). During a family medicine residency, a minimum of 1,650 patient visits must be documented and the family medicine resident must as well be involved in 40 deliveries, of which 30 must be vaginal (ACGME 2007a). These numbers are often derived by "expert" consensus.

What then might realistic goals be to achieve competence in the interpretation of CT and MRI studies of the head and spine? The radiology resident case review experience can be quantified using the radiology information system, which is a digital archive of all radiology reports (Chew 1999). At our site, we have determined the average number of each type of study reviewed by our residents over the last 3 years. We stratified the data according to level of training (Fig. 8.1). As these residents have passed their board exams, employing the average volume as a guideline is a reasonable option, at least in terms of that immediate and tangible goal. A higher number, perhaps the 90 percentile, might be used as a benchmark to measure high productivity.

For the PGY-5 group, a different tactic is necessary. At this institution, the productivity of residents actually drops in their final year compared to their more junior colleagues. This phenomenon has been documented by other groups. One author felt this might be due to increased procedural responsibilities borne by final year residents (Knudtson and McGuire 2001). Our analysis is through accounts for angiographic procedures and spinal interventions as well as more complex CT and MRI cases. Most of our residents do not become involved with neuro-angiography and perform only a handful on lumbar punctures or facet injections. The complexity of cases is essentially the same for PGY-3–5. The graduating residents are using their time during the day to read around their cases more thoroughly and subsequently review a lower volume. They are also away from clinical duties frequently to receive mock oral examinations. While these are very effective styles of learning and exam preparation, concerns have been raised regarding the preparedness of new graduates for high-volume workloads encountered in all settings, especially the community (Knudtson and McGuire 2001). For these reasons, employing the past average for PGY-5 is inappropriate. The minimum should therefore equal or exceed the PGY-4 threshold.

As our overall volume of cases has increased steadily over the years, the residents are no longer able to read all the cases that come through the CT and MRI. This bounty of cases has had an unexpected consequence. Residents are now able to create their own

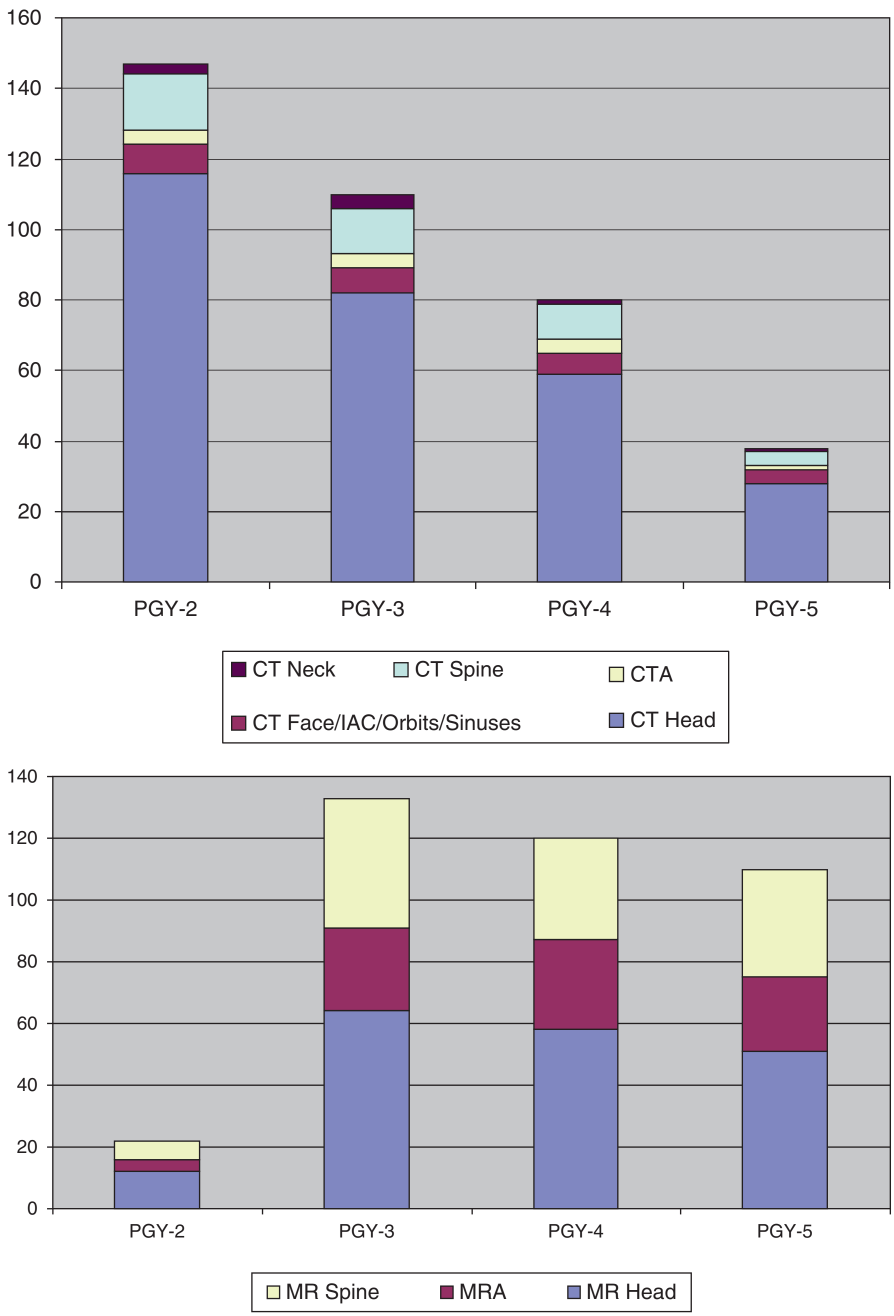

Fig. 8.1 (**a**) This graph demonstrates the average number of CT cases reviewed by residents during a 1-month rotation, stratified by level of training and study type. *PGY* postgraduate year; *CTA* computed tomographic angiography; *IAC* internal auditory canal. (**b**) This graph examines the average number of MRI cases reviewed by residents during a 1-month rotation, also stratified by level of training and study type. *MRA* magnetic resonance angiography

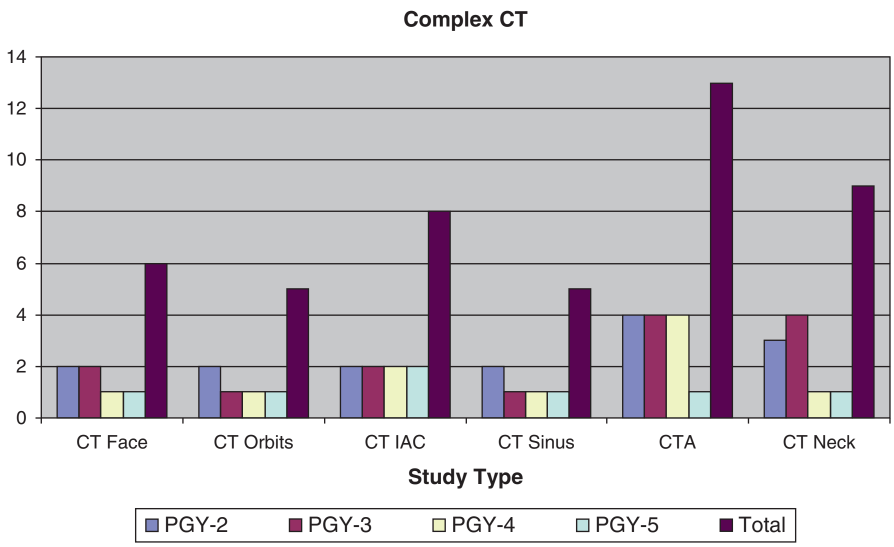

Fig. 8.2 This chart shows the average number of the more complex CT studies reviewed, sorted by level of training

workload, which leads some to select simpler exams. A close look at Fig. 8.2 discloses significant gaps in learning. The typical resident interprets eight CT exams of the temporal bone, five CT exams of the sinus, and five CT exams of the orbit over 4 years. This is insufficient to become adept in the detection and diagnosis of subtle abnormalities of the cochlea, osteo-meatal unit, and extra-ocular muscles. Having reviewed a total of 14 CT angiograms of the circle of Willis in the course of a residency is clearly inadequate. Compounding the problem, we have found that residents avoid these complex exams, if allowed, almost entirely. In PGY-2, only 2 of 17 residents over the past 6 years reviewed two or more of each types of exam. Even worse, only 1 of 23 PGY-5 residents reviewed two or more of each exam.

In retrospect, it appears somewhat naive to rely on residents to gather enough experience on their own accord with these less common exams. In response to these findings, we have established minimums of ten documented interpretations of each of these types of exams per rotation. Our residents now maintain a log of the cases they review, as shown in Appendix. The introduction of both clear goals and a process for monitoring their achievement of the criteria has been welcomed by our residents. Similarly, the Accreditation Council for Graduate Medical Education (ACGME) and Radiological Society of North America (RSNA) have created a web-based logs for US residents to record their cases (Larson 2007, ACGME 2008). Similar programs are available commercially from T-Res™ and E*Value™. These programs might be more flexible and comprehensive. Competency might then be based on a minimum number of cases read rather than just time spent in residency training (Chertoff 2008).

There is an obvious drawback to requiring residents to log all their work. For some rotations, this could become a considerable burden. Keeping track of 80–100 plain films each day would be onerous for both the residents and their staff. While some degree of oversight is necessary, the residents should not be buried in red tape and paperwork. It is probably reasonable therefore, to record the less common diagnostic cases and certainly feasible to log procedures. Alternatively, residents could document cases up to the minimum numbers required to demonstrate that they have satisfied the criteria. This may in fact serve to encourage them to seek out cases in those areas which they have not yet read sufficient cases to meet the requirements.

Using the radiology information system, an analysis of resident productivity can be performed quite effortlessly. A database which contains the types and numbers of cases dictated by a resident can be produced within minutes. An individual resident's productivity and workload can be assessed and compared with a local or national benchmark. Ideally, a program director or rotation co-coordinator would perform this analysis partway through the rotation to provide the trainee with interim feedback and ensure that appropriate goals and instructional "next steps" are set. Using the RIS is more accurate and more efficient than manual resident logs.

8.4 Variety of Pathologies

Of equal importance, residents must be exposed to enough pathology to hone their skill in detection of abnormalities, exercise their ability to describe findings, develop their capacity to formulate differential diagnoses, and learn how to manage complex and acute patients. However, the volume of pathology seen during a given day, week, or even month is unpredictable. At end-of-rotation interviews, residents have occasionally lamented the lack of exposure to relatively common diseases such as acute stroke, subarachnoid hemorrhage, and cauda equina as well as routine procedures such as fluoroscopic-guided lumbar punctures. Uncommon and rare diseases pose an even greater problem. Though by definition sporadic, these diseases are often of critical importance, and early detection and diagnosis can be essential.

As radiologists, our case mix generally depends on our referral sources. If we are to see the uncommon on a regular basis, we need local specialists who see patients with unusual problems. We are fortunate to have a regional epilepsy unit with ten beds. As a result we image a wide variety of epileptogenic foci. Likewise, we have a team of ENT (ear, nose, and throat) surgeons with an interest in the inner ear who provide us an enormous volume of temporal bone pathology. Unfortunately, we have only a single dedicated spine surgeon at our site. Our volume of uncommon spine cases is limited. Many programs suffer similar shortages in one or more areas.

Regardless of the cause, deficiency with a particular clinical scenario, disease, or type of study can be easily remedied. Unlike the clinical services, where actual patients are required for assessment, we can maintain a collection of interesting cases to supplement low volumes. If these studies are on PACS (picture archiving and communication system), the patient number can be provided to the resident, who can then examine the case and discuss the findings at case review in the same fashion as a fresh case. Teaching rounds are useful to address this issue with a larger number of residents.

A scarcity of procedures necessitates creative solutions. A facet or epidural injection offers a very similar experience in terms of patient positioning and needle placement as a lumbar puncture. A resident struggling with the Seldinger technique to gain access to the common femoral artery might spend time with the vascular interventional radiologist.

8.5 Quality of Teaching

Just as in high school or medical school, the quality of teaching in residency is highly variable. We recognize this problem as program directors. We are dissatisfied with our current tools for assessing and evaluating instructors and programs and our colleagues are currently scrutinized by the residents with impersonal and often irrelevant web-based assessment tools. We award our excellent teachers and nudge those who need improvement. However, just as a systematic review and plan is required to improve resident learning, a similar review and plan is required to improve faculty development. Although classes, workshops, and mentors are offered to address this problem, time continues to present a challenge. Clear goals and expectations need to be established for instructors with multiple approaches to support individuals to improve their teaching practice.

Many of us approach case review in the same fashion as a jazz artist approaches music. Case review has a basic structure based around the studies in the Unread List, but otherwise our discussions with the residents are improvised. We differ extensively on our areas of interest and touch lightly upon those subjects outside our expertise. Occasionally we will bring in another soloist to confer over a particularly interesting or perplexing case. This approach is common, but too often leaves out key points and crucial information.

Comprehensive learning objectives provided to the resident at the start of the rotation would assist both the trainee and the consultant at case review, by offering a robust framework for discussion. Some sections in radiology, notably MSK and Cardiothoracic, have issued commendable curricula to define competency at each level of training (Flemming et al. 2007; Collins et al. 2005). After their first MSK rotation, residents must demonstrate "learning of pathophysiology and radiology of fracture healing and complication of healing such as delayed union, malunion, and nonunion." After their final chest rotation, the trainee must be able "to list and identify on a chest radiograph and chest CT four patterns (nodular, reticular, reticulonodular, and linear) of interstitial lung disease." Clearly, such a framework can provide a structure for our struggling jazz artists!

Objectives are not limited to knowledge. Outcomes-based education can improve skill acquisition. The chest curriculum requires that radiology residents "must be able to successfully perform thoracic biopsies and image-guided therapies (e.g., pleural drainage) with faculty supervision commensurate with experience and individual competence." I would argue that this objective as described is too vague. There are number of steps required to accomplish a successful biopsy and even more behind the scenes instruction to teach a resident to perform this procedure safely.

General surgery is developing their laparoscopic skills curriculum. They are examining all the factors involved, including goal-oriented training, sensitive and objective performance metrics, appropriate methods of instruction and feedback, an amount of overtraining, maintenance training, and a cognitive component (Stefanisis and Heniford 2009). When preparing curricula for technical skills, radiology can learn from the highly technical specialties.

8.6 Summary

To paraphrase the great muppeteer Jim Henson, I hope to leave my residency program a little bit better than when I got here. Examining case review seemed like a good place to start. It is certainly the most time-consuming component of radiology residents, and it may also be the most important.

Unfortunately, these encounters can be unpredictable, just like Forest Gump's box of chocolates. An enthusiastic consultant can create a stimulating session out of a long list of dull cases while a disinterested consultant will struggle to rouse any excitement even with great material. Some residents are keen and industrious while others are distracted or sluggish.

Fortunately, the solutions are straightforward. With PACS, we are not tied to "live" patients to deliver a radiology education. To make up for low volumes and lack of pathology, we can refer the residents to our interesting case folders. Competence can be linked to reviewing a minimum number of cases or performing a certain number of procedures. Web-based case logs for the residents to record their experiences are available through the ACGME and RSNA as well as commercially. A more cost-effective alternative to measure resident productivity is the Radiology Information System. By providing thorough and well-thought-out learning goals and objectives, we can give case review a solid educational framework.

However, old problems persist and new challenges arise. Motivating indifferent consultants will always be difficult. Determining minimum thresholds to define competence requires more study. Radiology is behind the more technical specialties in providing useful objectives for skills and procedures. While we are on our way, clearly there is much work still to be done.

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Appendix

This case log is used by the residents to monitor their experience during their Neuroradiology rotation. Our residents typically spend a week on CT, MRI, or angiography. There are specific goals for the different exam types depending on their assignment. While their productivity can be assessed using the Radiology Information System after the rotation, this method allows the resident to determine their needs during the rotation. If there have not been enough CT scans of the internal auditory canal (CT IAC), they can preferentially select those cases from the Unread List or approach the consultant for exams from the interesting cases file.

Weekly Log: Imaging

Date:__________________________

Resident:__________________________

Staff:__________________________

CT:

M	Tu	W	Th	F	Total	Guideline
						20/day

CT head			12/day
CT spine			5/day
CT angiogram (CT perfusion)			5/week (2/month)
CT sinus			8/month
CT IAC			8/month
CT neck			5/month
CT face/orbits			8/month

MRI:

M	Tu	W	Th	F	Total	Guideline
						15/day

MR head			10/day
MR spine			4/day
MR angiograms (MR perfusion)			5/week (1/month)
MR neck			4/month

Report Quality: ____

Weekly Log: Procedures Date:____________________

Resident:____________________ Staff:____________________

Angiography:

M	Tu	W	Th	F	Total

diagnostic cerebral		
aneurysm		
stroke		
spinal		
miscellaneous		

Spine:

M	Tu	W	Th	F	Total	Guideline
						10/month

lumbar puncture			4/month
facet injection			2/week
epidural injection			
vertebroplasty			
biopsy			

Technical Skill Assessment:____

____

Redesigning A National Training Program in Radiology: The Australian–New Zealand Experience

9

Shih-Chang Ming Wang, Joan Burns, Liane Walters, and John Slavotinek

9.1 Theory and Principles

9.1.1 Old Faithful

The national program for vocational specialist training in diagnostic radiology administered by The Royal Australian and New Zealand College of Radiologists (RANZCR) is highly regarded internationally, and has a long tradition of producing well-trained radiologists capable of a high level of general community practice, as well as equipping its graduates with the ability to become highly subspecialized and academic radiologists. Radiologists completing these programs have readily handled advanced subspecialty training fellowships in other countries, and several have gone on to highly successful international academic careers in Europe and North America.

This training program and its corresponding examinations once closely followed the pattern for the Fellowship of the Royal College of Radiologists of the United Kingdom, but have diverged significantly from that program, especially in the last 30 years. The RANZCR program is unusual, in that the same accreditation and examinations are used for candidates from three different countries: Australia, New Zealand, and most recently, from Singapore.

This chapter will focus on the specific steps taken to reform and modernize the training program for Radiodiagnosis in Australia and New Zealand. A new Radiodiagnosis curriculum has been in the planning and development stages for 5 years, and will be first implemented in January 2010.

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The current Radiodiagnosis training program is based on a few core elements:

1. *Apprenticeship-style training:* Trainees are mainly based at one center throughout most of their training, with loosely structured rotations between different areas and modalities of radiology practice over 5 years.
2. *"Seamless" Training:* There is no defined link between training progression and assessment at present, other than the requirement that the Part 1 examination be passed before the trainee can sit for the Part 2 exams. Training progress is evaluated by the supervisors of training by means of an annual report. There is also a logbook requirement.
3. *High-stakes summative national examinations:* These comprise a Part 1 exam taken in the first year assessing anatomy and applied imaging technology (AIT, *aka* applied medical physics), and a Part 2 exam for Radiodiagnosis and Pathology. This is pitched at a junior consultant level, and is taken in the fourth year of training. There is no final barrier assessment at the end of the training period. No research, publication, or thesis is currently mandated.
4. *Comprehensive government hospital training centers:* A relatively small number of such centers are fully accredited as the key anchor departments to deliver the full gamut of training experience. A few jurisdictions have developed training networks where a main "mothership" department manages trainee rotations between a range of smaller partially accredited training centers.

9.1.2 A Great Leap Forward

In 1998, the Australian Medical Council (AMC) undertook to review all specialist medical training programs in Australia in the light of increasing complaints that these programs were old-fashioned, not consistently supervised, did not have transparent curricula or assessment processes, did not follow modern pedagogical principles, and generally could be accused of having discriminatory criteria for trainee entry, progress evaluation, barrier assessment, and exit certification.

The RANZCR volunteered to be one of two medical colleges (the other being the Royal Australasian College of Surgeons) to undertake this as a pilot process. One of the recommendations from that process was to engage an educationalist to undertake a review of the College's examination processes. The main finding of this review (conducted in 2004) was that a more structured approach to the training program and assessment, including a formal curriculum containing required competencies and relevant documentation, needed to be developed, including the aims and purpose of training. Despite the fact that no corresponding push for change was coming from the New Zealand authorities, the joint nature of the training program and its examinations required that any changes be universal in design.

9.1.3 If It Isn't Broken…

Not surprisingly, there was some initial resistance to change. Familiar arguments about the robustness of the existing program and the high quality of its product were heard from some quarters. However, with considerable patience, the College Council, led by the President, and the Education Board, led by the former Chief Censor, gradually persuaded opinion leaders within the College and the wider radiology community of the need for change and the importance of a well-designed, properly implemented process. The general principle that a modern, appropriately devised curriculum should be designed and implemented was approved by the College Council in 2004 and the Curriculum Development Project commenced in 2005.

9.1.4 Change We Had to Have

In the course of many discussions, it became clear that all was not well in the Radiodiagnosis training program:

- Directors of radiology complained that their trainees were too exam-focused, paradoxically sometimes to the detriment of improving their radiodiagnostic expertise.
- Department directors also complained that the lack of regulation and explicit structure in the last year of training meant many trainees departed prematurely to seek subspecialty fellowships overseas, thus creating transient and unpredictable manpower shortages in their departments.
- Supervisors of training complained of difficulty in adequately evaluating trainees in larger centers or networks, where many trainees rotated between more than one site of training, and that no explicit parameters for identifying, managing, or terminating a poorly performing trainee were defined.
- Trainees, to varying degrees, complained of some lack of supervision, insufficient teaching, or both at some centers, particularly at smaller centers further from the major metropolitan teaching hospitals.
- Examiners complained that trainees appeared to be getting worse in their ability to interpret plain radiographs and barium studies, and were doubtful about their practical expertise in performing ultrasound examinations and interventions.
- Some trainees and disgruntled candidates, perhaps unsurprisingly, complained that some components of the final *viva voce* examinations were set at an unrealistically high standard.
- Examiners and candidates alike were increasingly aware that the format of the final *viva voce* examination no longer reflected the clinical practice environment that most trainees experience.
- Despite mandating high-stakes examinations in medical physics, classical and imaging anatomy, systems-based radiodiagnosis, and pathology, the College had little by way of specified syllabus or curriculum.
- Employers in private practice complained that trainees were not sufficiently prepared to function independently in private practice immediately after completing their training.
- Academic radiologists complained that the research and publication output of diagnostic radiologists in Australia and New Zealand was disproportionately low.
- Governments complained that radiologists as a group were unable to provide adequate imaging services for the relatively far-flung rural population, even in fairly large urban centers remote from the major cities.
- The educational basis of the training program and the examinations was opaque. Without an explicit curriculum, there was no basis on which to determine the appropriateness of the assessment. Following the review of the examinations, there were also some questions around the validity and reliability of the examinations.

Despite a long and proud tradition of producing high-quality diagnostic radiologists, it was clear that the RANZCR training program had to evolve into a more robust system. A key challenge was to manage this process without massive disruption to long-cherished elements and without disengagement of key stakeholders such as heads of department, examiners, trainees, and supervisors of training.

9.1.5
Starting with the End in Mind

The RANZCR radiodiagnosis training program has for decades functioned as a type of boutique cottage industry. Many of the processes are highly dependent on a small number of experienced staff, and few of the training and assessment processes are clearly and explicitly documented.

A modern curriculum and training program to replace this would have to follow certain key educational principles, namely:

- Explicit curriculum reflecting the goals and philosophy of the program
- Clearly defined syllabus and learning objectives
- Well-structured rotational training system
- Transparent, accountable, and appropriate assessment processes
- Broad and relevant assessment of all aspects of trainee competency

It became clear that such radical change could not occur in uniform rapid fashion across multiple training jurisdictions that had, over many years, each evolved local peculiarities based on distribution and mix of training centers, local training philosophy, and varying levels of case mix and supervision. A process of change management and progressive rolling implementation would be required to ensure a peaceful and smooth transition from the current program toward a new, more modern approach.

9.2
Practical Implementation

9.2.1
Curriculum Development

Once the initial decision was made to embark on the development of a modern radiology curriculum, several questions had to be answered. Firstly, what was the overall goal for the final product of this training program? Second, how comprehensive should such a curriculum be? Third, how would the new curriculum be implemented? And finally, how would the new curriculum alter the process of barrier assessment?

Answering these questions requires a detailed examination of what it means to be diagnostic radiologists, what skills are required of professional radiologists in specialist practice, a detailed plan for implementation, and the willingness to adopt new assessment methods in order to meet the vision of the new curriculum. In short, these could be phrased as follows:

1. "Who Are We?"
2. "What Should We Do?"
3. "How Should We Do It?"
4. "How and What Should We Measure?"

9.2.2 Who Are We?

Diagnostic radiologists in Australia and New Zealand overwhelmingly practice general radiology, though usually with specific subspecialty interests. Only a small number of radiologists are able to practice only one subspecialty in imaging; virtually all of these work in a small number of large academic or government teaching hospitals or highly specialized centers. More than half of all radiologists work in multimodality private practice or small hospital environments, where all forms of medical imaging may have to be provided by a small number (as few as one, and typically two) of radiologists. In addition, the realities of rural medical practice mean that the relatively small number of radiologists working in this environment must have good skills and knowledge in virtually all areas of medical imaging, from obstetric to geriatric. Clearly, while systems-based medical practice is increasingly the norm, and radiology practice in large metropolitan teaching hospitals tends to be relatively subspecialized, for the foreseeable future most of our radiologists must acquire a wide base of knowledge, expertise, and procedural skills.

This fact mitigates against designing a program that favors early subspecialization to the detriment of developing a broad radiological competence. It also mitigates against abbreviating the training program solely in the interests of faster throughput, as the scope of radiology knowledge and expertise has never been larger and continues to expand. Yet, any program for the twenty-first century must of necessity be able to prepare the future radiologist for an eventual career in subspecialist imaging practice, biomedical research, and multidisciplinary patient care.

9.2.3 What Should We Do?

After extensive discussion, and in line with AMC recommendations, the College decided to adopt the CanMEDS (Canadian Medical Education Directives for Specialists) framework, with the permission of the Royal College of Physicians and Surgeons of Canada, for defining the seven roles of the medical specialist as they pertain to radiodiagnosis (see Table 9.1).

The diagnostic radiology curriculum consists of seven roles which encompass the competencies of the specialty. These roles consist of the medical expert and six nonmedical-expert roles (Frank 2005). The RANZCR radiology training program has traditionally focused almost exclusively on the medical expert role. While this will remain dominant in

Table 9.1 CanMEDS roles as adapted to diagnostic radiology in the RANZCR context (Frank 2005; RCPSC 1996)

Skill set	Competency
Medical expert	Expert radiology knowledge
	Clinical decision-making skills
	Interventional expertise and judgement
Team work	Multidisciplinary care
Communication skills	Report writing expertise
	Presentation skills
	Patient communication and consent-taking
Patient support and advocacy	Appropriate use of medical imaging
	Radiation and electromagnetic safety
	Contrast agent safety
Professionalism	Ethical practice in radiology
	Patient confidentiality in imaging
Management and administrative skills	Rostering and rotation planning
	Space and resource planning
	Purchase of new equipment
Research and education	Continuing professional development
	Research skills and ethics
	Performing a literature search
	Appraisal of imaging literature
	Teaching and assessment of radiology
	Writing for publication and grant applications

the new curriculum, the adoption of this framework means that significant effort is required to ensure that appropriate training and expertise is obtained by all trainees for the remaining six roles. The specifics of each of the roles has been developed primarily by the Curriculum Advisory Committee.

9.2.3.1 Medical Expert Role

Within the medical expert role the following systems were identified for inclusion:

- Abdominal Imaging
- Chest Imaging
- Neuroimaging
- Head and Neck Imaging
- Musculoskeletal Imaging
- Pediatric Imaging
- Breast Imaging
- Obstetric and Gynecological Imaging
- Vascular Imaging and Intervention
- Patient Care and Safety

Table 9.2 Categories for learning objectives and topics

Category	Definition	Examples
1	"Must Know, Must Recognise"	Pneumothorax
	Extensive knowledge expected	How X-rays are generated
	Critical for patient care	Anatomy of the lungs
2	"Important to Know, Should Recognise"	Caroli's disease
	Good knowledge expected	Principle of k-space
3	Important for patient care	Anatomy of the mandible
	"Useful to Know, Good to Recognise"	Biliary adenoma
	Some facts known	Principle of MR spectroscopy
	Valuable in a minority of cases	Course of suprascapular nerve

Required skills and performance levels were developed for each body system. Conditions within each body system were divided into three categories ranging from common conditions to conditions that are rare but which should be known (see Table 9.2). An indicative list of normal variants was developed for each of the body systems. In addition, important conditions which may be life-threatening if undiagnosed over a period of 12 h were identified for development into a list of Key Conditions to guide early training.

9.2.3.2 Nonmedical-Expert Roles

Team Work

Radiologists establish and maintain cooperative relationships with patients, with radiology staff and with other clinicians to optimize patient care and to facilitate research and education.

Communication Skills

Radiologists recognize the importance of communication in best practice of medicine. They acknowledge the vital role of good communication skills in all of their extended roles.

Patient Support and Advocacy

As health advocates, radiologists responsibly use their expertise and influence to advance the health and well-being of individual patients, communities, and populations. Their knowledge of the risks and costs of imaging procedures, are balanced against the benefits to individual patients and the community. Advocacy may occur individually or as a group when influencing public health policy.

Professionalism

Radiologists aim to deliver the best possible quality of health care with integrity, honesty, and compassion. Radiologists exhibit high standards of personal and interpersonal behavior and they practice ethically with active concern for the patient, their profession, and society.

Management and Administrative Skills

Radiologists make decisions regarding effective utilization of finite healthcare resources in the context of individual patient care. They provide leadership in healthcare organizations and ensure effective work practices through adequate staffing and development of policies and procedures.

Research and Education

Radiologists recognize the importance of participating in and encouraging lifelong learning. They contribute to the appraisal, collection, dissemination, and understanding of health care knowledge. They assist and promote the education of clinical colleagues, other healthcare providers, students, patients, the community, and other bodies. Radiologists recognize the importance of research and actively participate in advancing the knowledge of their specialty.

9.2.4 How Should We Do It?

Traditionally the Educational mission of the College was delivered by a very “flat” structure, with the Education Board, convened by the Chief Censor and assisted by College staff, managing the entire process. However, the challenges of developing a comprehensive curriculum spanning an ever-widening range of issues meant, this structure had to be expanded significantly.

In order to develop the overall framework for the radiodiagnosis curriculum, a Curriculum Advisory Committee (CAC) was established to devise the specific training requirements and learning objectives for the entire program, and to advise the College’s Education Board. The bulk of this work entailed the development of a detailed medical imaging syllabus to incorporate all the key elements of radiodiagnostic domain knowledge.

9.2.4.1 Development of Syllabi and Learning Objectives

Members of the CAC developed and drafted topic lists and learning objectives for each of the major systems-based areas in diagnostic and interventional radiology. Furthermore, CAC members adopted a system to categorize the importance of any specific topic or learning objective into one of three categories based upon characteristics such as clinical importance, potential patient consequence, and frequency/rarity. During the subsequent consultation phase, examiners and subspecialists from major training centers and private practice were recruited to develop and refine these topic lists and learning objectives. They were also asked to advice regarding appropriate assignment of category.

The three categories are explained in Table 9.2.

At the time of writing, this approach, which is widely used in undergraduate medical student curricula, is virtually unique for a vocational radiodiagnosis training program. The importance of such categorization cannot be overstated, as it impacts upon all levels of training, learning, and assessment.

It is neither fair nor appropriate for high-stakes barrier examinations to demand the level of distinction defined above to be somehow inferred "by osmosis" in the course of routine training. It is appropriate that trainees be informed of the relative importance of specific areas of knowledge, and for the assessment process to be designed to reflect the relative importance of these categories of knowledge. The categorization of learning objectives greatly assists the trainee to prioritize his or her learning to ensure the knowledge objectives are met at the time of the final examinations.

While it is true that an expert in radiodiagnosis can be reasonably expected to know something about most aspects of medical imaging diagnosis, technology, and anatomy, it is equally true that some knowledge is more critical, and diagnostically more important, than others. Over the course of a radiologist's career, such distinctions become apparent with experience and practice. However, typically this requires many years to acquire in depth. In Malcolm Gladwell's recent book, "Outliers," this concept has been encapsulated in the "10,000 Hour Rule," which in essence states that true expertise in *any* domain requires approximately 10,000 h of application (Gladwell 2008).

For a radiologist, this equates to approximately 5 years of doing nothing but radiodiagnosis, 8 h a day, every working day. Conveniently, most radiodiagnosis training programs are 5 years in duration (as are most Australasian specialist training programs). However, the barrier examinations typically take place after 3 or 4 years of training. Furthermore, radiology trainees rarely do only radiodiagnosis. Considerable time is taken for managing patients, organizing workflow, discussing results and waiting between cases. For most radiologists, it takes around 10 years to personally experience this amount of pure radiodiagnostic application. Clearly, the assessment and learning of trainees cannot rely solely on the experiential process to ensure an adequate level of expertise in the allotted 5 years of training.

Although most effort was spent in development of the detailed syllabus for radiodiagnosis, it was clear that this approach should also be extended to include new syllabi for both Applied Imaging Technology (AIT, *aka* applied medical physics) and Anatomy. The latter processes were started after the radiodiagnosis syllabus was almost complete, and will be adopted for the development of a new syllabus in Pathology in the future.

9.2.4.2
Equity of Learning Materials

Traditionally, the training program has relied on specifying a range of textbooks for trainees to study from. In the past, it was possible for a trainee to read one major radiodiagnosis textbook and supplement his/her knowledge by dipping into large reference texts, reading review articles in peer-reviewed journals, and reading a few highly focused monographs. However, the scope of radiodiagnostic knowledge has exploded in the last two decades, along with the scope of imaging textbooks. It is no longer practical for any trainee to personally own an adequate number of texts to cover the range of knowledge required, and all but the largest training departments may fail to regularly update their libraries to reflect the rapidly expanding range of teaching material available.

Moreover, most such texts are focused on subspecialist knowledge, with highly detailed information that in general does not reflect the categorization of knowledge planned in this curriculum. The differing emphasis and inequity in learning resources available to different trainees in different centers has become a significant issue in a far-flung training program that spans from Singapore to Dunedin, but that only has about 300 trainees in total.

The Royal College of Radiologists (RCR) of the United Kingdom have, using government funding, developed a rich set of on-line radiodiagnosis training resources, known as the radiology – integrated training initiative (R-ITI), an award-winning, comprehensive series of some 750 e-learning sessions spanning 15 modules. This is the most comprehensive e-learning resource in vocational radiology training today, and is unlikely to be replicated by any other authority.

The system is universally accessible through the Internet, and tracks the progress of each individual trainee logged by the system; such progress can be checked by supervisors of training and directors of radiology departments. It includes integrated formative assessment, and is being regularly updated.

The RANZCR negotiated with the RCR to commence a trial of this system for its trainees in four centers across Australia and New Zealand in early 2009. If successful, further negotiations will be undertaken to determine if this system could be used by all RANZCR radiology trainees as a universally available learning resource in the future.

9.2.4.3
General vs. Systems-Based Training

There is significant philosophical tension in radiology training programs worldwide between the requirements for a broad range of imaging skills and knowledge, and increasingly sophisticated subspecialist radiology expertise that reflects the nature of modern clinical practice, especially in large tertiary-level subspecialized or comprehensive hospitals.

Because in the main the training of radiologists occurs primarily in such centers, and educational policy makers tend to work in centers of academic excellence, training and examination has tended to favor the acquisition of subspecialist knowledge and skills at a fairly early stage of training.

Some programs advocate the very early streaming of trainees into a single subspecialist area no later than after 3 years of training, and consider the product of their programs to be a subspecialist radiologist. At the other extreme, other programs (such as that provided by RANZCR) consider their product to be a very broadly skilled medical expert capable of becoming a subspecialist after a period of additional training and practice. The issue of whether or not the RANZCR should move toward a training program that allows true subspecialization was the subject of much discussion by Council and the Radiology Education Board.

A discussion paper was prepared that compared the training and practice environments in Europe, the United Kingdom, the United States, and Australia. The comparison found that for the most part, radiologists in Europe, the United Kingdom, Australia, and even the United States primarily practice as general radiologists with subspecialty interests, and outside of academic centers, exclusive practice in one subspecialty is not common.

In Australia and New Zealand, workforce surveys conducted in 2000, 2002, 2004, and 2006 indicated that our radiologists are largely generalists with a subspecialty interest with the subspecialization rate remaining at around 20%. The 2006 RANZCR workforce survey showed that 69% of respondents are in private practice as their primary work setting. This figure has remained consistent across all the workforce surveys conducted by RANZCR since 2000. In terms of training comparisons, most countries in Europe (including the United Kingdom) have a 3 + 2 year training structure or are moving toward this structure, with core diagnostic radiology learned in the first 3 years of training and special interest training in the last 2 years. However, the details of how these last 2 years of training are focused on subspecialty training vary greatly from one country (and even training center) to another.

The current Australian and New Zealand training program is 5 years in duration with core training provided in the first 4 years and the option for subspecialty training in the fifth and final year of training through appointment to an advanced training position. The United States training program is 4 years in duration and provides opportunities for subspecialty training after completion.

The CAC considered this discussion paper in October 2008. The paper was one of the sources of information used by the CAC to inform the development of the new Radiology Curriculum and Training Program Structure.

Eventually it was decided to adopt a 3 + 2 year structure, more in line with European and UK practice, but preserving the major barrier examination in the fourth or fifth year of training, with the progression of the trainee from "core" to "advanced" training occurring through an alternative assessment barrier, in the form of a portfolio assessment.

The new training program structure reflects the following principles regarding the balance between generalist and subspecialty training:

- The end product of the training program should be primarily a generalist radiologist, but the training program should provide the opportunity for *system-focused rotations* in the latter stages of training
- System-focused rotations should be differentiated from subspecialty rotations. These are proposed as defined training periods of at least 3 months, where a given trainee is ensured a minimum rostered time each week working closely with consultant radiologists who have claimed expertise in one subspecialty, even if that is based outside their main training center. This approach should ensure that most teaching hospital departments would be able to comply, and that senior trainees would still be available most of the time for general radiology rostering.

- A true subspecialist training program (e.g., training in one subspecialty only) is not feasible for most centers and trainees in the current Australian and New Zealand training environment; however, some system-focused rotations could be taken as full-time subspecialty training rotations if the centers are able to do this. For many trainees, this is already done for Pediatric Radiology, for example.

New Training Modules

In addition to developing a detailed list of learning objectives and associated categories, a number of additional training modules are planned in order to fulfill the requirements of training for the additional CanMEDS roles. These modules in general focus on nondomain expert knowledge. (Frank 2005; RCPSC 1996)

These are envisaged as short self-contained modules in addition to existing training materials and courses that are conducted for AIT, Anatomy, Pathology, and Radiodiagnosis. The proposed new modules are listed in Table 9.3.

9.2.4.4
How and What Should We Measure?

Training Progress and Practical Competencies

To date, the radiodiagnosis program has had a limited in-training assessment, essentially comprising an annual written assessment by the supervisor of training, and a procedural

Table 9.3 Additional training modules for the new curriculum

Module	When	Purpose
Key conditions	Year 1	Introduction to emergency radiological diagnosis Enable trainee to go on after-hours call before end of Year 1
Patient care and safety	Year 1	Radiation safety, especially fluoroscopy and CT Contrast agent safety and practice MR and ultrasound safety Taking consent for procedures
Evidence based radiology	Year 2	Evidence-based medicine and critical analysis of published literature
Audit skills	Year 2	Principles of conducting a clinical audit
Presentation skills	Year 3	Public speaking Preparing and presenting a conference paper
Ethics and research skills	Year 4	Research ethics processes and principles Research methodology
Management skills	Year 5	Financial planning Imaging resource planning and management Interaction with medical companies

logbook of directly performed vascular and interventional radiology cases, to be completed by the end of the training period. While the latter has distinct value in ensuring all trainees have a minimum hands-on experience in interventional procedures, the current written assessments are of doubtful value.

In a more holistic approach to training assessment, evaluation of progress and competence cannot and should not be dictated solely by relatively undefined high-stakes barrier examinations. While such examinations will remain important assessment instruments for knowledge-based medical expert evaluation, and provide examiners and trainees alike with a certain confidence in the level of knowledge achieved, it is clear that many skills and competencies cannot be easily assessed with such tools.

Most written and face-to-face examinations cannot and do not, for example, typically examine procedural skills, knowledge of patient safety procedures, or the ability to conduct research. Neither is it possible for such assessments to evaluate the ability of a trainee to interact effectively with other members of his or her department or hospital as part of the patient care cycle. The totality of training experience also cannot be encapsulated through traditional examinations.

Additional, very different tools are required for such evaluations. Such tools are eminently suited to assist supervisors of training and other members of the training department with in-training assessment of the progress and performance of any trainee.

A Training Program Assessment Committee (TPAC) was established to advise the College Education Board on adoption of the most appropriate means of evaluating training performance in a variety of settings and to implement agreed changes to current and future assessment processes. After evaluation of many different potential tools, new methods of in-training assessment were recommended for adoption. These are detailed in Table 9.4.

Table 9.4 Recommended in-training assessment tools for the new curriculum

Tool	Type	When	Evaluates
Directly observed procedures (DOPs)	Formative	Twice yearly	Ability to perform procedures
Individual patient examination (IPX)	Formative	Twice yearly	Ability to interpret and analyze an imaging examination
Director of training reports	Summative	Annual	Overall assessment of trainee competence and progress
Multisource feedback (MSF)	Summative	Annual	Ability to work in a team
Logbooks (US, VIR, gR)	Summative	Annual	Direct experience with specific skills
Project 1	Formative	Year 2/3	Ability to collate and present clinical imaging data
Project 2	Summative	Year 4/5	Ability to collate, analyze, and report biomedical imaging data
Portfolio	Summative	Year 3 Year 5	Totality of training experience

US ultrasound; *VIR* vascular and interventional radiology; *GR* number of general radiology studies interpreted

From Seamless to Stepwise

Apart from the high-stakes examinations, assessment within the current program can be kindly described as amorphous. The addition of several formative and summative progress assessments will allow trainees, training departments, and networks to better track trainee progress and performance and to identify trainees having difficulty at an earlier time than is currently the case. This will have the effect of "discretizing" assessment into 6-monthly or annual events that act as checkpoints to enable the trainee to progress to the next stage of training. The summative portfolio barriers would act to bookmark the end of key training periods and allow for a broad overview of the totality of a trainee's progress and development, suitable for external assessment and review.

The addition of these tools marks a fundamental shift in assessment philosophy in our program, essentially formalizing non-examination assessments of competence as potential barriers to progress. It is anticipated that this shift will eventually permit a de-emphasis on the current examinations, as well as enabling a more thorough and valid evaluation of overall competence and skills of trainees through the use of appropriate measures of competence and performance throughout training.

Examination Evolution

The old educational adage, "assessment drives learning" is highly relevant; to this can be added the adage, "curriculum drives assessment." By clearly specifying a comprehensive list of topics and learning objectives, and categorizing them by degree of importance, it is relatively straightforward to translate this into a blueprint for assessment. In the past, construction of the final barrier examinations could result in an inconsistent mix of questions by domain and a nonsystematic approach to question difficulty. Furthermore, examination candidates who repeatedly failed *viva voce* examinations were often at a loss to understand what level they should prepare and train for.

It is anticipated that applying these learning objectives and their categories to questions at the time of construction of examinations will allow for appropriate examination blueprints to be developed, both in terms of spread of domain knowledge assessment and by weighting of knowledge categories.

In future, the greater predictability afforded by this approach will enable trainees to focus more on critical and important knowledge, and will help to demystify the barrier examinations and make them less stressful. This in turn should enable trainees to spend more time acquiring practical skills and direct their attention to the additional learning modules and assessment tasks required by the new curriculum.

In addition, examiners conducting face-to-face *viva voce* examinations will have more guidance in the level of knowledge expected of trainees, and pass–fail determinations should become both more objective and more defensible over time.

Finally, the barrier portfolio assessment at the end of year 3 serves to reduce the current practice of trainees sitting for the Part 2 examination without adequate preparation, while the barrier portfolio assessment at the end of year 5 should eliminate the practice of trainees leaving for overseas advanced fellowships before completion of the training period.

9.2.4.5
A Training Blueprint

In order to visualize the overall training program including its assessment framework, a diagrammatic program structure encapsulating the major training and assessment elements was developed.

This new program structure was approved by the Education Board in late 2008, and the College Council in early 2009. This is seen in Fig. 9.1.

This map has already proven invaluable in presenting, explaining, and demystifying the new curriculum to all stakeholders. Radiologists are highly visual people, and find large amounts of textual explanation in unfamiliar educational terminology challenging. The diagram, while incorporating and clearly displaying many new educational elements, has had a comforting effect on most who have had it explained to them; so much so that one senior examiner and head of department has exclaimed that "this is what we are already doing!"

9.2.5
Planning the Delivery

A considerable amount of time and planning has gone into the development of a detailed curriculum incorporating (so far) three different syllabi, a range of new assessment

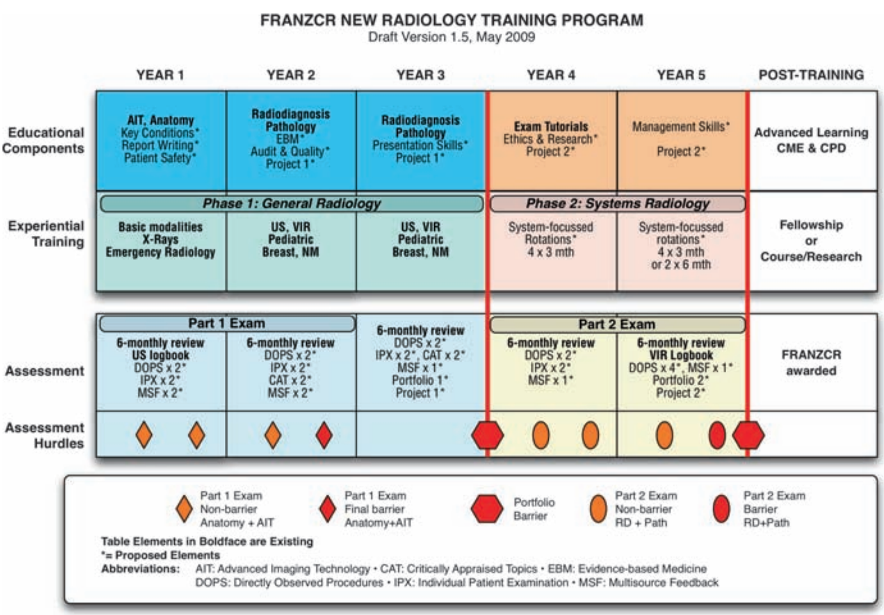

Fig. 9.1 Draft training program structure for the new RANZCR radiodiagnosis curriculum

methodologies, and several new training requirements and learning modules. A widely accepted program structure for the new program has been developed and publicized.

However, training does not occur in theory. The realities of training in widely differing medical practice environments remain a significant challenge to the delivery of this program over the coming decade.

9.2.6 Stakeholder Engagement

Since the commencement of the project to develop the Radiology Curriculum and the training program to deliver the curriculum the RANZCR has recognized the need to engage stakeholders throughout all stages of development and implementation. Key stakeholders in the development of the Radiology curriculum include directors of training (DOT), heads of department (HOD), trainees, consumers, examiners, branch education officers (BEO) and all radiology fellows.

The following strategies are being employed to engage stakeholders.

9.2.6.1 Director of Training Meetings

Director of Training Meetings are held at the Annual Scientific Meeting with updates provided on the progress of curriculum development. Workshops are also held during these meetings that cover skills development for DOT. In addition to the Director of Training Meeting held at the Annual Scientific Meetings a full day meeting for DOT will be held annually in September.

9.2.6.2 Examiner Briefings and Meetings

Examiners are briefed by the Chief Censor prior to the Part II examinations and at the Court of Examiners twice yearly. These sessions are used to provide an update regarding the format of the curriculum during its development. Invaluable feedback is being received from these senior College members who come from a wide range of training sites.

9.2.6.3 Radiology Curriculum Roadshows

A series of roadshows were planned for New Zealand and every state in Australia through 2009, to provide stakeholders with information on the development of the curriculum and plans for implementation of the curriculum. Wherever possible, separate sessions will be held for DOT, HOD and trainees.

Objectives for the DOT and HOD sessions were:

- Explain key concepts behind curriculum design and its role in assessment and training
- Discuss the drivers and rationale for the development of the new radiology curriculum
- Discuss the potential benefits of the new curriculum
- Discuss the roles and responsibilities of DOT, HOD and clinical supervisors in relation to radiology training and the impact of workforce shortages on fulfilling these roles
- Discuss the need for protected time for DOT's as a requirement for accreditation of training sites
- Review the proposed format and structure of the curriculum (content, phases and assessment tools)
- Discuss the proposed timeline for implementation of the new curriculum
- Acquire feedback from HODs and DOTs on potential challenges of implementing the Curriculum at training sites

The objectives for an accompanying trainee session were:

- Explain key concepts behind curriculum design and its role in assessment and training
- Discuss the drivers and rationale for the development of the new radiology curriculum
- Discuss the potential benefits of the radiology curriculum
- Review the format and structure of the radiology curriculum (content, phases, and assessment tools)
- Discuss the implications of the implementation of the radiology curriculum for current and future trainees
- Discuss any concerns trainees have in relation to accessing educational activities
- Discuss any concerns trainees have in relation to training

9.2.6.4 Engagement with Health Jurisdictions

As our training program is of necessity distributed in nature, it is crucial for there to be a clear understanding of the changes in philosophy and the impact that the new assessment and accreditation requirements will impose on existing training networks and centers.

It was recognized that the various health jurisdictions should be informed of the roll-out of the new curriculum and training program, and the potential impact this might have on workforce demands, in particular, the time and costs of providing improvements in education and training.

There were a number of strategies considered to address the issue of protected time for trainees and trainers, including the possibility of making protected time a requirement for accreditation of training sites. Clearly in stringent budgetary circumstances this is problematic, but adequate recognition of this important role of teaching institutions will be proactively pursued.

9.3 Take Home Messages

9.3.1 Change Is the Only Constant

A new curriculum is never "done." Since the educational landscape is ever-shifting, and the practice environment, new technologies, and the nature of medical practice are in a constant stage of flux, any new curriculum must be able to adapt to these changing circumstances. A process of regular review and renewal will be required, using a more proactive and structure process than has been the case in the past.

The radiology workforce shortage in Australia and New Zealand, which is worsening despite a steadily increasing number of trainees and is threatened by progressive retirement of the baby boomer generation of radiologists over the next decade, cannot be addressed directly by the development of a new curriculum. However, projections for increased population growth, and the increasing pervasiveness of medical imaging in the practice of clinical medicine, means that a significant increase in radiology workforce will be required over the coming decades. Since there is global shortage of radiologists, there is little alternative to greatly increasing the number of trainees, and by inference, the number of training sites where training is conducted.

This in turn requires that training networks become the norm for training rather than the exception, and the paradigm of single institution-dominated training will have to be adjusted. Already, the nature of medical reimbursement in Australia has led to a significant shift of imaging services from public to private centers, with many kinds of outpatient procedures no longer performed in large numbers in major teaching centers.

The explicit goals of the new curriculum to ensure training provides a broad and comprehensive exposure to all forms of radiology means trainees will inevitably have to obtain at least some of their training at sites that have not traditionally had significant numbers of trainees. These would include smaller general hospitals, rural training centers, and comprehensive private radiology practices.

The availability of the new curriculum and its much more explicit accompanying documentation will enable new centers to take on radiology trainees with greater confidence and potentially a greater level of assurance to trainees and examiners alike of a good quality learning experience. The ability to attract high-quality trainees will be a reflection of the perceived quality of the training experience offered by any particular training site or network.

9.3.2 A Single Step

The twentieth century has seen an extraordinary technological explosion in medical imaging that could not have been predicted at its beginning, when X-rays first swept the world of medicine. It is entirely possible that medical imaging at the end of the twenty-first century will be as unrecognizable to us today as modern imaging would be to Roentgen if he was still alive.

Training in medical imaging, therefore, must keep pace with the times, evolve with new technologies and practices, and adapt to ensure that new graduates in radiology are adequately equipped to compete and develop while maintaining their ever-increasing role at the center of clinical medicine investigation. This includes keeping pace with changes in educational best practice and innovations in teaching and learning.

The development of a curriculum for any vocational discipline in medicine is not to be undertaken lightly. It is a complex, major change process that takes time, great patience, extensive negotiation, recursive discussion, and continual analysis. And so it has proved for the development of this curriculum. Along the way, the process has allowed us to identify more clearly our training and assessment deficiencies and enabled us to articulate our vision for the discipline and its practitioners into the future, and to devise plans to address and improve problems in current training and assessment.

Furthermore, it has become clear that curricula are not an abstract exercise in theory. Curricular decisions have an impact on training delivery, will shape what trainees choose to learn and how they will be assessed, and have the power to act as highly influential instruments for change in education and clinical practice. In turn, these changes should lead to a profound shift over time in the type of professional radiologist that emerges from our program.

The process of development of a new curriculum has been a long and arduous one. Yet in a sense, we are at the beginning of a long journey. None of the new curriculum has been implemented at the time of writing. This represents the largest fundamental change in training and assessment philosophy in our College's history, and the first time that a global vision for educational policy has undertaken such an in-depth analysis, synthesis, and review involving such a broad cross section of stakeholders.

Instead of a process of natural evolution of training, which has marked most of the College's history in the twentieth century, this proactively planned, interactively designed, and progressively implemented program hopes to create a new type of radiology professional for the challenges of the twenty-first century, one who is flexible, broadly skilled, and knowledgeable, a self-directed learner capable of reflective analysis, with a high degree of personal and professional skills that will be required to cope with the unseen and unknowable challenges of the rest of his or her career.

We look forward to this new adventure in Radiology education.

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Training Musculoskeletal Ultrasound Specialists: European Education and Clinical Guidelines: Work in Progress

10

Andrea S. Klauser, Eugene McNally, and Rethy K. Chhem

10.1 Introduction

Musculoskeletal ultrasound (MSK US) comprises a wide range of different examinations increasingly performed by practitioners with different background (e.g., radiology, rheumatology, orthopedic surgery, physical medicine, sport medicine, pediatrics, internal medicine, general practitioners, anesthesiology, neurology). In most European countries, structured training programs are offered by Ultrasound Societies, Radiology Societies, Rheumatology Societies, Orthopedic Surgery Societies, fewer are given by Physical Medicine Society, Sport Medicine Society and there are even courses for medical and health professional students at the University. MSK US education courses and guidelines are still mainly based on National Ultrasound Societies, but efforts have been made to proceed toward a European concept. Several European societies are working on dedicated concepts: EULAR (European League Against Rheumatism) has elaborated a detailed education program for rheumatologists, ESSR (European Society of Musculoskeletal Radiology) offers standardized scanning protocols for different body regions and has started working on clinical indications for such protocols, and EFSUMB (European Federation of Societies for Ultrasound in Medicine and Biology) has proposed a curriculum for MSK US that sets standards for theoretical knowledge and practical skills. From the radiological point of view, The EFSUMB and ESSR concepts are of special interest and will therefore be discussed in more detail.

10.2 ESSR (European Society of Musculoskeletal Radiology)

The ESSR is dedicated to advancing knowledge of both the normal and abnormal musculoskeletal system by means of imaging that should enable both diagnosis and treatment.

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The ESSR provides a European forum for education and research of musculoskeletal radiology.

The ESSR is the primary organization in Europe that promotes the development, dissemination, and cost-effective implementation of state-of-the-art radiological concepts and tools in the musculoskeletal system. The ESSR aims to produce solutions to current and imminent issues by promoting and supporting research throughout Europe and to provide channels for continuous education. To achieve these two goals, the ESSR coordinates research activities, develops educational and multidisciplinary research activities, and encourages the presentation of the results of these endeavors at its annual meetings.

The subcommittee for ultrasound in musculoskeletal radiology was constituted in 2004 with the following aims: to promote ultrasound practice among musculoskeletal radiologists in Europe; to standardize MSK US scanning technique; to issue guidelines on clinical indications of MSK US ; to promote multicenter studies; and to support the ESSR in its coordination activities with different national and international societies of MSK US.

10.3 Work in Progress

10.3.1 Technical Guidelines

The ESSR is an educational, scientific society concerned with advancement of the art and science of musculoskeletal radiology. To promote this mission, the ESSR US group has issued technical standards for ultrasound examination of joints, including the shoulder, the elbow, the wrist, the hip, the knee, and the ankle with the aim of obtaining a global standard for MSK US training among European musculoskeletal radiologists (free access at http://www.essr.org/cms/website.php?id = /en/index/educational_material.htm). These guidelines have been obtained by consensus of a large number of experts throughout Europe and reflect what the ESSR considers essential scanning protocols for a complete high-quality ultrasound examination in each joint. Musculoskeletal radiologists who perform ultrasound are expected to follow these guidelines with the recognition that variations from them will be necessary in some cases, depending on patients' needs and available equipment. We believe these standards will improve education and practice among radiologists and appropriate use of ultrasound as a diagnostic modality of the musculoskeletal system. Such guidelines are not intended, however, to establish a legal standard of care.

10.3.2 Clinical Indications

The next goal of the US ESSR subcommittee is to issue ultrasound clinical guidelines in musculoskeletal radiology that would be representative of the viewpoint of the ESSR and, more generally speaking, of the whole community of musculoskeletal radiologists in Europe. To obtain educational standards and reference values, these guidelines will be prepared comparing the results of ultrasound and MR imaging based on a systematic literature review. Grading US as specified below will highlight best indications for MSK US in different pathologies:

0 = not indicated

1 = if other imaging not appropriate

2 = equivalent to other imaging modalities (other modalities might provide significant information)

3 = first choice level technique, other modalities rarely provide more information

The Oxford Centre for Evidence-based Medicine suggests levels of evidence (LOE) according to the study designs and critical appraisal of prevention, diagnosis, prognosis, therapy, and harm studies (http://www.cebm.net/index.aspx? o = 1025):

- Level A: Consistent Randomized Controlled Clinical Trial, cohort study, all or none, clinical decision rule validated in different populations
- Level B: Consistent Retrospective Cohort, Exploratory Cohort, Ecological Study, Outcomes Research, Case-control study; or extrapolations from level A studies
- Level C: Case-series study or extrapolations from level B studies
- Level D: Expert opinion without explicit critical appraisal, or based on physiology, bench research or first principles

In the absence or paucity of reliability and validity data, statements will be obtained by expert consensus.

10.3.3 Annual ESSR Meeting: US Course

The annual meeting is the major European forum for sharing advances in musculoskeletal radiology, and offers excellence in education. The ESSR annual meeting focuses on a selected topic or region, therefore the theme of the US course is linked to it (ESSR 2007: shoulder, ESSR 2008: ligaments; ESSR 2009: hip). As different medical specialties might be interested in selected body regions only (e.g., hand surgery), specialized concepts/modules focusing on knowledge and skills specific to the anatomical region in question are required. Such a targeted module might be offered not only to radiologists but also for colleagues in other specializations, after they have completed a basic MSK US course.

Therefore, the annual ESSR meeting offers the radiological community a multimodality approach by offering an MSK US course on the first day and then the possibility to participate in the general congress meeting for the next 2 days on the same topic covering different imaging modalities.

An example from the ESSR US course program, according to the main theme of the 16th Annual Meeting of the ESSR 2009 “the Hip” is outlined below.

10.3.4 Module Systems

The Course consists of four modules:
Module 1: *Live demonstration of normal and US anatomy*
Module 2: *Hands-on sessions*
Module 3: *Case studies (advanced)*
Module 4: *Lectures on pathology (basic)*
Module 1: Live demonstration of normal and US anatomy

1. Two experts are involved simultaneously, with one speaker giving a theory lecture on ultrasound anatomy illustrated with a PowerPoint presentation, and the other pointing to images on the ultrasound monitor at the same time, visualized by simultaneous split screen presentation.
2. It is of importance to offer a simultaneous split-screen video projection, where, on the one side, the real time US image is shown, and on the other side, the transducer positioning on the volunteer. A sample schedule is in Table 10.1.

Module 2: Hands-on sessions (six experts)

Six sets of US equipment will be available in the room. The delegates are divided in $n = 12$ groups (A–I). Each group will have time to follow a half-hour session each on the upper and the lower extremity. The schedule is found in Table 10.2.

The anatomical structures to be examined in the hands-on sessions are found in the list of anatomical structures, which tutors and attendees will address to during the course, listed in Table 10.3.

Module 3: Case studies with video demonstrations (advanced)

Given concurrently with Module-2 by splitting the entire group into $n = 2$ subgroups (A–F and G–N). Each instructor will give the same presentation twice (see Table 10.4).

Module 4: Lectures on pathology (basic)

Table 10.1 Sample schedule for live demonstration of normal and US anatomy

15:00–15:30	Lateral & posterior hip anatomy
15:30–16:00	Anterior & medial hip anatomy

Table 10.2 Sample schedule for hands-on sessions

Time	US 1	US 2	US 3	US 4	US 5	US 6
	Anterior/ medial	Anterior/ medial	Anterior/ medial	Lateral/ posterior	Lateral/ posterior	Lateral/ posterior
16:00–16:30	A	B	C	D	E	F
16:30–17:00	D	E	F	A	B	C
17:00–17:30	G	H	I	L	M	N
17:30–18:00	L	M	N	G	H	I

Table 10.3 List of anatomical structures to be examined in hands-on sessions and which tutors and attendees will address during the course

Anterior hip	Lateral hip	Medial hip	Posterior hip
Anterior joint recess and anterior acetabular labrum	Gluteus medius and minimus muscles	Femoral nerve, femoral artery, femoral vein	Ischial tuberosity and origin of the hamstring tendons
Iliofemoral ligament	Greater trochanter and insertion of the gluteus medius and minimus tendons	Inguinal lymph nodes	Conjoined tendon of the long head of the biceps and the semitendinosus
ASIS and origin of the tensor fasciae latae and Sartorius	Trochanteric bursa *(landmarks)*	Pectineus muscle and Scarpa triangle	Semimembranosus tendon and myotendinous junction
AIIS and origin of the rectus femoris	Gluteus maximus	Adductor longus (tendon and proximal myotendinous junction)	Adductor magnus muscle
Proximal and central aponeurosis of the rectus femoris	Vastus lateralis, origin	Adductor brevis and adductor magnus muscles	Sciatic nerve
Iliopsoas muscle	Fascia lata	Gracilis (origin and muscle belly at the proximal thigh)	Sacroiliac joint: dorsal cleft
Pubic insertion of abdominal muscles			
Symphysis pubis			
Iliopsoas bursa *(landmarks)*			

Table 10.4 Sample schedule for case studies with video demonstrations

Groups G,H,I,L,M,N	
16:00–16:10	Case 1 Anterior/medial
16:10–16:20	Case 2 Anterior/medial
16:20–16:30	Case 3 Anterior/medial
16:30–16:40	Case 4 Lateral/posterior
16:40–16:50	Case 5 Lateral/posterior
16:50–17:00	Case 6 Lateral/posterior
Groups A,B,C,D,E,F	
17:00–17:10	Case 1 Anterior/medial
17:10–17:10	Case 2 Anterior/medial
17:00–17:10	Case 3 Anterior/medial
17:00–17:10	Case 4 Lateral/posterior
17:00–17:10	Case 5 Lateral/posterior
17:00–17:10	Case 6 Lateral/posterior

Table 10.5 Sample schedule for basic pathology lectures

18:00–18:20	Lateral/posterior pathology
18:20–18:40	Anterior/medial hip pathology

If the number of participants is limited to five delegates per US equipment, a total number of 60 course attendees can be trained with the program structured as outlined above. The case study module allows for dynamic demonstration of pathology, when no patients for the hands-on training are available to guarantee a thorough implementation of the multimodal program (see Table 10.5).

10.4 ESR (European Society of Radiology): Annual Meeting US Course

The ESR (European Society of Radiology) has had a long tradition of offering a basic US course combined with hands-on training sessions by European MSK US experts. In 2010 this tradition will be revitalized with the goal of offering annually basic MSK US course to the radiological community. Specialized knowledge can be further gathered in the annual ESSR course.

10.5 EFSUMB (European Federation of Societies for Ultrasound in Medicine and Biology)

This curriculum is intended for medical doctors who perform MSK US scans. It includes standards for theoretical knowledge and practical skills.

Training should be integrated in a 3-level system and modular, as some practitioners may need to be proficient in some specific areas of the musculoskeletal pathology they work with routinely (e.g., shoulder surgery, hand surgery, pediatrics, or rheumatic diseases). At least level 1 competence should be obtained by anyone performing routine unsupervised MSK US (EFSUMB Newsletter 2008).

Level 1

Level 1: Theoretical module

Attendance at a basic course of at least 3 days (18 h) including: Ultrasound physics and instrumentation, ultrasound techniques and administration

Normal musculoskeletal anatomy, normal MSK US findings, common pathological ultrasound findings in the musculoskeletal system

Level 1: Practical training

Level 1 competence requires:

To obtain level 1 competence status, it is recommended that the trainee should perform a minimum of 300 examinations under supervision within a year.

Examinations should encompass the full range of conditions listed in the competency assessment sheet – level 1.

A log book (or an illustrated log book) should be kept by the trainee, listing the number and type of examinations. Supervision of half of the 300 examinations can be achieved with approval of examinations in an illustrated logbook.

A level 2 or 3 practitioner should supervise the trainee. In certain circumstances ,it may be appropriate to delegate some of this supervision to an experienced level 1 practitioner with at least 2 years experience at that level.

During the course of training a competency assessment sheet should be completed and signed by the supervisor, as this will determine in which area(s) the trainee can practice independently.

To maintain level 1 status, the practitioner should perform at least 300 examinations each year.

Level 1: Competencies to be acquired

At the end of training the trainee should be able to:

Perform common MSK US examinations (shoulder, elbow, wrist/hand, hip, knee, ankle/foot, and common muscles) systematically, accurately, safely, and with proper report and documentation.

Differentiate normal and pathological findings.

Perform dynamic examinations.

Recognize when referral for a second opinion is indicated (e.g., any diagnostic doubt, soft tissue tumors).

Acquire knowledge about advantages, disadvantages and indications for alternative imaging modalities (e.g., MRI).

Diagnose common abnormal ultrasound findings in shoulder, elbow, wrist/hand, hip, knee, ankle/foot, and common muscles (e.g., effusion and synovitis, bursitis and cysts, tendon tears and tendinopathy, entesopathy, common muscle and bone pathology) (see competency assessment sheet – level 1).

Level 2

Level 2: Theoretical module

Attendance at one relevant advanced course at least or congress of at least 3 days (18 h).

Level 2: Practical training

Level 2 competences requires:

Achievement of level 1 competence

To conduct regular ultrasound clinics at level 1 and perform at least 500 examinations under supervision within a year

US examinations to be supervised by a level 3 practitioner or by a practitioner with level 2 competences and with at least 2 years of experience at that level

To be able to recognize and correctly diagnose almost all musculoskeletal pathological conditions (or all conditions within a specific area of a musculoskeletal pathology)

To maintain level 2 status, the practitioner should perform at least 500 examinations each year.

Level 2: Competencies to be acquired:

To accept and manage referrals from level 1 practitioners

To have knowledge of new ultrasound modalities

To teach ultrasound to trainees and to level 1 practitioners

To conduct some research in MSK US

To recognize and correctly diagnose almost all pathology in the shoulder, elbow, wrist/hand, hip, knee, ankle/foot, muscles, bones, and nerves (see competency assessment sheet – level 2).

To perform basic, noncomplex musculoskeletal US-guided interventions (e.g., aspirations, injections, drainages, biopsies)

Level 3

Level 3: Theoretical module

Attendance at two advanced relevant courses at least, or congresses with a total of at least 6 days during 2 calendar years.

Level 3: Practical training

Level 3 competences require the following:

In possession of level 2 competence

To conduct regular ultrasound clinics at level 2 for at least 2 years (at least 500 examinations per year)

To be occupied mainly with MSK US

To perform (or have knowledge about) specialized MSK US examinations

To perform advanced US-guided interventional procedures

Level 3: Competencies to be acquired

To accept and manage tertiary referrals from level 1 and 2 practitioners
To perform specialized MSK US
To perform all sorts of musculoskeletal US-guided interventions
To conduct substantial research in the field of MSK US
To teach MSK US to trainees and practitioners at all levels
To be aware of and to pursue developments in MSK US

Maintenance of skills

Having been assessed as competent to practice, for maintenance of practical skills and for keeping up with the newest developments, practitioners will have to pursue continuing medical education. Recommended numbers of examinations to be performed annually to maintain skills at each level are given in the text. Practitioners should:

Include MSK US in their ongoing continued medical education (CME) and continued professional development (CPD).

Audit their practice.

Participate in multidisciplinary meetings.

Keep up-to-date with relevant literature.

Minimum Training Recommendations for the Practice of MSK US in Europe summarized in following MSK US training competency assessment sheet (lit).

Core knowledge base – Level 1

- Physics and technology
- Practical instrumentation/Use of ultrasound controls
- Normal musculoskeletal anatomy
- US examination of normal joints and muscles

Competencies/skills to be acquired – Level 1

To be competent to perform/diagnose the following:

Shoulder

- Full-thickness rotator cuff tear
- Rotator cuff calcification (different types)
- Shoulder joint effusion and synovitis
- Biceps tendon (tendinopathy, luxation, rupture)
- Acromioclavicular joint pathology
- Hill-Sachs lesion
- (Rheumatoid erosions)

Elbow

- Lateral and medial epicondylitis
- Elbow joint effusion and synovitis
- (Rheumatoid erosions)

Wrist and hand

- Ganglion cysts
- Tenosynovitis
- Tendon rupture
- Joint effusion and synovitis
- (Rheumatoid erosions)

Common muscles

- Large muscle rupture, hematoma
- Abscess
- Myositis ossificans

Hip

- Hip joint effusion and synovitis
- Trochanteric bursitis
- (Rheumatoid erosions)

Knee

- Knee joint effusion and synovitis
- Baker's cyst (and rupture)
- Patellar ligament tendinopathy
- Quadriceps tendon rupture
- Identification of the menisci
- Large meniscus cyst
- Osgood-Schlatter
- Collateral ligament strain
- (Rheumatoid erosions)

Ankle and foot

- Joint effusion and synovitis
- Achilles tendinopathy and rupture
- Tenosynovitis

- Fasciitis plantaris
- (Rheumatoid erosions)

Other

- Identification of bone pathology
- Fluid at prosthesis/osteosynthesis
- Detection of foreign body

Competencies/Skills to be acquired – Level 2

To be competent to perform/diagnose the following:

Shoulder

- Partial-thickness rotator cuff tear
- Dynamic examination for impingement
- Ganglions
- Rotatorcuff interval pathology
- Frozen shoulder
- Nerve entrapment
- Identification of anterior and posterior glenoid labrum
- US-guided interventions

Elbow

- Biceps and triceps tendinopathy and rupture
- Nerve entrapment
- US-guided interventions

Wrist and hand

- Carpal tunnel syndrome
- Tendon adherences
- Ligament and pulley lesions
- Tumors other than ganglion
- US-guided interventions

Muscles

- Small muscle rupture
- Late complication of muscle rupture
- Identification of common muscle tumors

Hip

- Other bursitis than trochanteric
- Osteoarthritis
- Identification of anterior labrum
- Identification of iliopsoas tendon
- Snapping hip
- Inguinal hernia
- Groin pain
- Pathology of the infant hip
- US-guided interventions

Knee

- Meniscus tear
- Meniscus cyst
- Runner's knee
- Pathology of small tendons
- Osteoarthritis
- Cartilage lesion
- US-guided interventions

Ankle and foot

- Morton's neuroma
- Tarsal tunnel syndrome
- Ligament strain
- US-guided interventions

Other

- Withdrawal of foreign body
- Bone pathology (fracture, tumor)
- Doppler examination of tendons, joints, etc.
- Entesopathy
- Identification of common nerves
- US-guided interventions

The EFSUMB recommendations vary somewhat from those of national societies. However, a European consensus should be obtained in the near future.

10.6
EULAR (European League Against Rheumatism)

EULAR developed education guidelines for the conduct of EULAR MSK US courses because of a great interest in musculoskeletal US shown by rheumatologists across Europe (Wakefield et al. 2003; Backhaus et al. 2001). A three-level education model (basic, intermediate, and advanced) with timing and location related to the annual EULAR Congresses will be offered. The course duration will be 20 h. There will be a maximum of six participants per teacher and 50–60% of total time will be spent on practical sessions (Naredo et al. 2008).

Brown et al. (2005) advocated a comprehensive evidence-based, expert consensus-defined educational framework that provides a template for teaching and learning and standards for competency assessment. This should facilitate common principles of training in the rheumatological community, uniform professional practice, and a justifiable governance structure.

Although rheumatological MSK US is an expanding area, the published information on training is currently limited (Backhaus et al. 2001; Balint and Sturrock 2001; Filippucci et al. 2003; D'Agostino et al. 2004; Taggart et al. 2006).

10.7
Challenges in MSK US

Ultrasonography has been considered the most operator-dependent imaging technique. The paucity of studies on its validity, reliability, and sensitivity to change has largely contributed to this and has limited the development of multicenter and longitudinal ultrasonographic studies (Szkudlarek et al. 2003; Balint and Sturrock 2001).

The transition from novice ultrasonographer to competent and ultimately expert is a fundamental theme. Current training in MSK US reveals an absence of a unified educational structure throughout Europe, and often colleagues learn by ad hoc teaching or self-teaching programs (Filippucci et al. 2003), especially because practice and training recommendations dedicated to different specialties are missing. Nevertheless, US in general is well-anchored in radiological education.

Practical strategies that would contribute to improving education in MSK US are based on overcoming limiting situations.

There are a number of educational challenges that need to be addressed:

Evaluation of interobserver reliability between teachers of rheumatology courses showed moderate to good results, in sensitivities as well as in specificities compared to MRI, therefore consensus on standardization, scanning technique, and diagnostic criteria was advocated. The differences in scanning methods were also related to the dynamic examinations, needed for detection of subtle pathological findings. Therefore, training and standardization of musculoskeletal US are necessary to achieve higher interobserver reproducibility (Naredo et al. 2006; Scheel et al. 2005).

Model of training should include:

- Initial tutorial and practical demonstration
- Competency assessment regarding

Acquirement of standard reference MSUS images
Acquirement of reproducible measurement

- Examination by standardized protocols
- Focused examinations: Jamadar et al. (2008) showed that a focused examination of the distal extremities correlated with abnormalities in most cases. Therefore, addition of a focused examination to an examination by protocol further increases the identification of abnormalities.
- Training of US guided interventions

10.8 US-Guided Interventions

Although aspiration and injection of synovial joints and tendons is a procedure that is commonly performed by musculoskeletal clinicians or rheumatologists, the accuracy rate has been found to be surprisingly low even for superficial joints. Therefore, image guidance is more and more advocated, best performed under US guidance. The accuracy of MSUS-guided needle placement in both small and large joints is superior to needle placement using clinical examination alone for guidance (Raza et al. 2003; Balint et al. 2002). Even in joints more difficult to access as e.g., the sacroiliac joint, US guidance has shown to enable accurate needle placement; therefore, US guided interventions will be used more often in the future and also radiologists should be trained in that issue (Klauser et al. 2008).

Atchia et al. (2007) evaluated a modular, flexible training strategy to achieve competence in diagnostic and interventional MSK US in hip osteoarthritis. With a learner-centered curriculum, a self-directed learning strategy, and a minimum of direct supervision, a trainee achieved competence after scanning and injection of approximately ten hips.

MSK US guidance is a reasonable alternative to fluoroscopic guidance for instance, in hip aspiration and injection. Additional advantages of MSUS-guided hip injection are portability and lack of ionizing radiation, and easy measurement of the distance toward the target.

Quality of standard MSUS images of the hip

Atchia et al. demonstrated a successful protocol for training a novice in MSUS to become competent in first diagnosing hip effusion and/or synovitis followed by a MSUS-guided hip injection using a modular approach, with reliance on self-directed learning complemented with timely supervision from the expert. By using this approach, after ten consecutive MSUS-guided hip injections, the novice achieved a subsequent accuracy rate of 25/26 (96%) confirmed by radiographic localization of radiopaque contrast. They concluded that when close and continuous expert supervision may be difficult, this strategy could be applied in a stepwise fashion seeking to achieve overall competence.

Whether a modular approach or a structured practical experience and close interaction with, and supervision by, an experienced teacher as emphasized from Van Holsbeeck and Roemer to acquire a high level of competence in MSK US of all regions is more useful, will have to be further evaluated (van Holsbeeck 2004; Roemer et al. 2005).

10.9 Summary

US education courses and guidelines are mainly based on National Ultrasound Societies, and efforts are being made to develop programs based on a European concept.

Many medical specialties, as for example, radiology, rheumatology, orthopedic surgery, physical medicine, sport medicine, pediatrics, internal medicine, general practitioners, anesthesiology, and neurology are already performing MSK US and there are several others who are interested in acquiring the requisite skills to do so.

As different medical specialties might be interested only in specific body regions (e.g., hand surgery in hand sonography), specialized training focusing on their needs should be offered after completion of the basic course. Nevertheless, radiologists must have high levels of skills to carry out MSK US on all regions of the body.

There is wide variability in the personnel who mainly perform MSK US in different countries. It would be desirable to have a uniform comprehensive program in specialist education with a certificate awarded on completion of the requirements that would meet the eligibility conditions and expectations in different countries.

MSK US training is mainly based on courses, hands-on training, and training with experts. MSK US training can be intensified by additional training in other specialized Departments, thus expanding knowledge and skills.

Assessment of competency also varies in different countries. Requirements for competency can be based on course work that includes attending lectures, taking practical as well as theoretical examinations, by presenting a number of MSK US examinations and a certificate testifying the length of the training period. However, the time period (3–6 month) during which the training/examinations must be completed are yet to be finalized. Course duration of approximately 2 days can be suggested with a percentage of approximately 50% hands-on scanning spent on the course. Training levels might be split into basic and advanced or basic, intermediate, and advanced. In addition, modular courses in specific topics should be offered.

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Radiology Training in Thailand: Challenges and Innovations

11

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11.1 Introduction

The Radiological Society of Thailand (RST) was founded in 1962 and renamed, The Royal College of Radiologists of Thailand (RCRT) in 1995 under the patronage of His Majesty King Bhumibol (RCRT 2009). As we present an overview of our radiology department and outline some of the challenges and innovations from our experience, we keep in mind that in some cases, it is the very existence of challenges that motivates us to develop innovative solutions. Our challenges in Thailand include: a shortage of radiologists throughout the country and most specifically in nonmetropolitan areas; English proficiency concerns; and logistical issues pertaining to the fact that our residents are spread out both within and outside of the institution. In this chapter, we address these challenges and discuss the innovative responses that we have developed: policies to ensure radiologists remain in nonmetropolitan areas; an English language proficiency course; and the creation of an E-learning website.

11.2 Radiology Residency Training Programs: General Radiology

In Thailand, there are four radiology training programs: general radiology, diagnostic radiology, nuclear medicine, and radiation oncology (RCRT 2009; The Medical Council of Thailand 2009). General Radiology is a rather unique training program that involves all fields of Radiology. The resident will rotate into diagnostic radiology (24 months), nuclear medicine (6 months), and radiation oncology (6 months). Due to a serious shortage of nuclear medicine physicians and radiation oncologists in our country, particularly in the

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nonmetropolitan area, the primary aim of this training program is to train radiologists in a way that allows them to serve patients in all fields of radiology.

11.3 Lack of Radiologists

In 1967, there were only 93 radiologists in the country, and of those, 84 (90.3%) lived and worked in Bangkok. By 1993, the total number of radiologists in Thailand had increased to 446. By 2008, the population of Thailand had swelled to more than 66 million. Data obtained at the time indicate that 1,145 radiologists were registered in Thailand, of which 950 served in diagnostic radiology (Sitisara 2009). This resulted in a ratio of 14.4 radiologists per million people; the lowest among 27 countries surveyed across 4 continents (Nakajima et al. 2008; RANZCR 2004; Institute of Health Economics and Policy 2007; Beaudet and Baerlocher 2006; EAR 2004). For example, there were 36 radiologists per million people in Japan in 2006, 55 in Korea in 2003 (Nakajima et al. 2008), 64 in Australia in 2004 (RANZCR 2004), 95 and 60 in the United States and Canada in 2004, respectively (Institute of Health Economics and Policy 2007; Beaudet and Baerlocher 2006), and between 60 and 250 per million in European countries in 2004 (EAR 2004). The overall number of Thai radiologists is clearly insufficient. Compounding the lack of human resources is the steadily increasing demand for radiology procedures (Bhargavan 2008; Bhargavan et al. 2002).

The situation is critical, but it is even more critical in the nonmetropolitan areas. Because a substantial number of Thai radiologists prefer to live and work in Bangkok, the capital city, as well as in metropolitan areas, the ratio in the nonmetropolitan area is even lower. We needed to address this problem, so we instituted a program to ensure placement in the nonmetropolitan areas. The goverenment provided funds for those who intended to work in the nonmetropolitan areas after finishing radiology residency training. They were required to sign a contract upon entry into training. This scheme has worked well for those radiologists who go back to work in their hometowns; however, many of them do choose to return to the metropolitan areas after a few years.

11.4 Applications for Residency: Language Challenges

Radiology residency has become more popular over the years, and is one of the more competitive application processes among the specialties. The number of applicants has increased annually and there are currently more applicants available than positions. In Thailand, as in many countries, it is necessary to be certified as a medical doctor before being authorized to start radiology training. The entry into the training scheme is organized at an institutional level, and the institution forwards the names of selected applicants to the Medical Council, as it is this council which approves the subspecialty license.

In Thailand, the official language and mother tongue of the Thai people is Thai, as is the medium of instruction within the residency training program. This becomes problematic as virtually all textbooks and radiology reports are in English; a strong command of the English language (grammar, vocabulary, and comprehension) is therefore crucial. Incorrect syntax, spelling, and sentence construction errors are often found in radiology reports generated by our residents. We have recognized this as one of the significant challenges in our training.

Currently, in our institute, all applicants in all departments are required to pass an English examination as a prerequisite to applying. This score allows the committee to determine the applicant's language proficiency, and will ultimately play a factor in choosing the applicants in some departments. Recognizing the importance of a strong command of English, our department has instituted additional English tests. The applicants are required to:

- Write a short English essay introducing herself or himself, and bring it to the staff committee on the day of the English pretest
- Successfully complete the English pretest before entering the interview. This pretest focuses mainly on English grammar. The results of this pretest are considered before accepting an applicant into the program.

At this time, our institution has not put into place any procedures or guidelines if our applicants' English proficiency is not up to standard. We used to have, an English course for those in their second year of training. This course, conducted on-line and within a classroom setting, focused on developing the English language used in writing the reports and in writing a medical thesis. Students and their advisors met every 2 weeks in a classroom setting to review their homework. We acknowledge, however, that there were limitations to this course. Logistically, it was difficult for all residents to attend, as the class was held in the afternoon of the official workday and so there were times when not all could attend. We also, found that with the busy schedules, it was difficult for residents to find sufficient time to devote to their homework especially when they experienced difficulty with this second language. We recognize that English proficiency is a vital part of residency education and so we are now in the process of redesigning and reorganizing our English teaching program so that it can be effective and also work within the constraints of the program.

11.5 Length of Residency Training

For radiology training, there are two schemes available:

- A 3-year residency training program for any trainees who have completed 2 or 3 years of a clinical internship in the government-owned or private practice before entering the residency training. They would be trained for 3 years before they can apply for the Board examination.
- A 4-year residency training program for any trainees who do not undergo such clinical internship but enter the residency training program after medical graduation. Instead,

the trainees have to complete 1 year of a radiology internship in the department of radiology of the academic medical school owned by the government university. Such radiology internship is quite similar to that of a first-year residency. After that, they must enter a full training program in a radiology residency. Application for the Board examination is only eligible after having completed an overall 4-year training.

Nowadays, advances in technology have improved imaging equipment resulting in a marked expansion of the Radiology field (Bhargavan et al. 2002). The need to lengthen the training period has been raised (Dunnick et al. 2006). However, due to the shortage of radiologists in Thailand at this time, a 3-year residency training is still more appropriate.

11.6 Training Schemes

Our department has two magnetic resonance (MR) machines: one of which is 1.5-T MR scanner and another is a 3-T MR scanner. We have two multi-detector computed tomography (MDCT) scanners, i.e., 64- and 320-slice MDCT scanners. The former has been used for all routine services while the latter has been recently installed and primarily used for specialized cardiovascular imaging and neuroradiology so far. All MR and MDCT scanners provide 24-h services. We also have two angiographic units: one for neuro-angiography and another for body angiography and body intervention.

Training is based on rotations – beginning in the 2008 academic year, we have used both the organ-oriented rotation (chest, breast, cardiovascular, musculoskeletal, pediatric, abdomen), and modality-driven rotation (ultrasound, angiography, and intervention, CT, MR). The modality driven rotation will, however, be gradually deleted from the program. The duration of the organ-oriented rotation varies between 1 and 3 months, and may not be successive. For example, each resident will rotate into the musculoskeletal (MSK) unit for 3 months within 3 years of training. They have to take responsibility in all imaging modalities concerning MSK studies: plain radiography, ultrasound, CT scan and MR imaging. They have to attend, monitor and read all cases related to their rotation. One day before the CT or MR examination, the residents will bring the imaging requests to the responsible attending staff in each subspecialty in order to review previous studies of each case. Most of the time, we use the routine MDCT or MRI protocol but sometimes we need to tailor it for each particular case, depending on the patient's clinical context and what the clinician wants to know.

Routinely, the resident will check the adequacy of the images first and will subsequently notify the attending staff in a problem case via a phone call. The staff will review those images transferred through the picture-archiving and communication systems (PACS). Sometimes, the responsible staff will sit in front of the console to check the adequacy of the images and to offer further teaching (See Fig. 11.1). The case will be reviewed by the staff (if not taught on site) and read by the residents later in the day. Finally, every case must be thoroughly checked and countersigned by the attending staff.

In addition to the rotation, our department provides teaching hours in the morning and at noon time. The teaching scheme is divided into formal teaching by staff faculty in which the staff provide the teaching and residents present the assigned topics and the staff

Fig. 11.1 Group review for MR imaging in reading room. Picture-archiving and communication systems (PACS) connects all parts of the hospital

provides feedback. We also provide a teaching hour in the evenings about once a week – so in total, residents receive about 550 teaching hours per year.

The degree of the residents' supervision by attending staff gradually decreases with time. Residents perform and report procedures always under the supervision of a staff member. Our department approves the third-year (last-year) residents to report the plain radiograph and finalize it by themselves. Nyce et al. (2006) stated that the ultimate goal of Radiology is not to reveal findings; nor is it to recognize the findings that diagnostic images reveal. The ultimate goal of Radiology – and therefore of radiology education – is to help patients. Helping patients is our goal and we have designed our radiology educational program to meet this goal.

11.7 Additional Curriculum

At the time of residency training, the Radiology residents have to undergo other areas of study besides Radiology. These include:

- Radiobiology and Radiation Physics; which they have to study every Friday afternoon (about 2 h) for 8 months in the first year of training. This is the compulsory curriculum, like a prerequisite that they have to pass or they cannot apply for the Board examination. If they cannot pass in the first year, they can have a reexamination in the second year of training.

11.8 E-Learning for Postgraduate Education

We have created a website for all residents in our institute and have divided it according to each department. Because radiology residents have rotations in many buildings and in many sections including Nuclear Medicine, Radiotherapy, and Elective outside institute, we use this website for self-assessment and self-learning.

11.8.1 Self-Assessment Test

We post a “quiz” which includes questions created from the presented topics or previous teaching onto this website. Residents are required to answer each quiz within the assigned period of time. We have software that can alternate the choices so the residents cannot copy the answers from one another. We track how often each resident responds to this activity.

11.8.2 Self-Learning Materials

We cite the articles that the residents should read and post them under this heading. This provides a crucial reading guide for our trainees in terms of their own self-study.

11.9 Research

There is a requirement that all Radiology residents in all training programs have to complete one research project during their training. This is prerequisite for the Board examination, and has to be accomplished about 6 months ahead prior to finishing residency. We do not, however, require a full publication. In this scheme, our department has three staff members who are certified epidemiologists. They play an important role in guiding and supporting residents in their research projects. We also have a designated time for residents to present their work.

11.10 Final Examination

Final examinations to validate the training program are organized at a national level by The Royal College of Radiologists of Thailand (RCRT) in mid-June. The results are reported to the Medical Council of Thailand to approve and provide the subspecialty license. The examination is composed of the written and oral examinations. The written process may be writing, multiple-choice question (MCQ), or objective structured clinical examination (OSCE). The oral examination is film reading and interpretation, in which the resident has to interpret the plain radiograph, CT and MR images, and other image modalities related to the cases.

11.11 Subspecialties in Radiology

Subspecialties in Radiology are officially recognized in Thailand, and specific training programs are available for four subspecialties, namely, body imaging, body intervention, neuroradiology, and interventional neuroradiology. All programs have been conducted since 2004 (The medical council of Thailand, 2009). Subspecialty training starts after having completed the residency training program, either in Diagnostic Radiology or General Radiology. The entry into the training scheme is organized at the institutional level, and the institute will present the selected name list to the Medical Council and thereafter because the Medical Council will approve the subspecialty license. The applicants are interviewed by the committee of the institute. The criteria for selection are individualized for each institute, but are based mainly on the performance of the applicants during their residency training. Generally, the ones who choose a career path to serve with the government hospitals will have priority. This is one way to partially solve the government problem concerning the shortage of specialist in radiology in the nonmetropolitan area.

The academic year begins on the first of June and ends on the 31st of May of a 2-year cycle in each program. The trainees have to sign a contract of agreement according to the regulation of each training center. The trainees who cannot accomplish at least 75% of training period are not eligible to apply for the Board examination. The standard of the training center is regulated and has to be approved by the RCRT. It must have adequate equipment, qualified staff, a sufficient volume of patients or studies, and knowledge assimilation. The learning methodology consists of radiological practice under the supervision of the staff and the teaching includes conferences, lectures, tutorials, seminars, electronic materials, books, and journals.

All fellows are required to develop skills in research methodology and perform research under the appropriate guidance, similar to residency training. A completed research project is a compulsory part and is a prerequisite for Board examination. At least 1 month is provided to do this research. The assessment of fellows is multi-source feedback, daily practice group review, and conferences. Individual progress is evaluated annually by the staff faculty in the Radiology department. To maintain the standard of the training program, we have both the “internal audit” performed by other departments in our institute, and the “external audit” performed by the RCRT.

11.12 Closing Thoughts

As we revisit this historical overview of our residency training, we recognize the shifts and innovations that have helped shape our present program. The shortage of radiologists throughout the country and the pedagogical and logistics issues surrounding the English language proficiency course remain two of our challenges. By identifying the challenges, we aim to continue to strive toward solutions which will enhance our program and ultimately help us to provide better patient care throughout Thailand.

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Building Scientific Capacity in PET/CT for Global Health

12

Maurizio Dondi and Rethy K. Chhem

12.1 Introduction

The International Atomic Energy Agency (IAEA) is an international organization of the United Nations system. Initially founded as a nuclear watchdog in the aftermath of World War II, the Agency has widened its fields of interests to include several different programs on peaceful applications of nuclear techniques and among them, less widely known than others, the IAEA has a program on Human Health, which emerges from the Article II of the Statute: "The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world."

Positron emission tomography (PET) and computed tomography (CT) are two imaging technologies that have merged as a "hybrid" modality that provides both anatomical and functional data for the diagnostic of a wide range of pathologies, especially cancer.

12.2 The Challenge

Still the question remains: What has an intergovernmental organization like the IAEA to do with the delivery of advanced "high tech" medical imaging in countries where the huge investments needed to start a PET facility may appear far beyond their national health budget and may be low in priority, compared to other healthcare needs? In recent years, medical imaging has faced increasing costs, related to the introduction into clinical practice of new modalities (multiple slice CT scanners; MRI machines; as well as cyclotrons and PET). This resulted in medical practice also evolving towards more expensive techniques, in many cases challenging,

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but in most occasions unaffordable for developing countries. The Agency's role, in these cases, is that of advising the country to carefully plan according to its priorities and present available resources, but also keeping in mind that "planning for the future" is also a necessity. The IAEA recognizes the high cost of PET/CT when implemented in developing countries. In fact, the Agency only responds to member states' requests to assist them in conducting a feasibility study when there is a need. Otherwise, when a PET/CT is already in place, the IAEA would provide specialized programs to assist member states in building scientific and technological capacity in order to establish a sustainable development of this emerging diagnostic field.

The recognition of the power of PET has led to a booming interest in the utilization of PET/CT imaging in cancer management which has spread also to developing countries. To date, as many as 35 countries, almost a quarter of IAEA's member states, are already running a PET program or are very close to it. For instance, Latin America has more than 40 scanners, most of them installed in countries like Mexico, Brazil, and Argentina, and in Asia there are nearly a hundred, excluding Japan and South Korea. China and India have the biggest share, but also Viet Nam, Thailand, and Malaysia, to name a few others, have their PET programs. Almost all Eastern European countries already have at least one PET program running (Fig. 12.1).

These countries already have well-established healthcare systems and solid educational infrastructures. However, they may lack a critical mass of knowledge and expertise to plan, establish, and efficiently run a PET/CT program. The central issue is human resources capacity building and this is where the responsibility of the IAEA-Technical Cooperation Programme (TCP) and the Nuclear Medicine Section of the Human Health Division, come into the picture. Advice and expertise are provided in the preparation and planning phase as well as during the execution of the PET project. Actually, many of these countries have limited formal training programs in nuclear medicine of high academic standards. At best, qualifications are acquired by medical specialists from other clinical disciplines such as Oncology, Cardiology, or Radiology. In most situations, the acquisition of nuclear medicine qualifications was acquired through "on-the-job" training.

According to the Article II of the IAEA Statutes "the Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world" (IAEA 1989). It is delivered by the Division of Human Health, and its section of nuclear medicine and diagnostic imaging has the specific mission of fostering

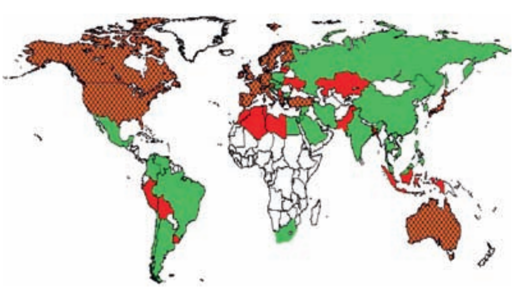

Fig. 12.1 World distribution of PET *green*: IAEA's member states where at least one PET program is already running *red*: IAEA's member states where PET programs are close to be implemented *brown*: Developed countries not included in IAEA projects

the application of nuclear medicine techniques in those diseases that may successfully be managed using radioisotopic applications. This mission is unique, as no other international organization, not even the WHO, has a similar role in promoting nuclear medicine in developing countries. In most cases, the Agency's role is to provide support for human resource capacity building. In some other cases, when less developed countries are involved, support is also given by acquiring appropriate equipment, such as SPECT cameras; dose calibrators; radiation monitors; equipment for stress testing, etc. and supporting their maintenance.

The long-term objective of the subprogram in nuclear medicine focuses on enhancing member states' capability to address health needs by the use of both imaging and therapeutic applications, as well as of molecular biology techniques, whenever they provide a cost reduction or are complementary to conventional techniques. This is done by planning and implementing relevant projects, developed to address local or regional health problems, and by technology transfer with emphasis on problem-solving capability (IAEA 2006).

12.3 The Educational Framework

The nuclear medicine program includes several types of activities such as Coordinated Research Projects (CRPs); curriculum and teaching materials design as well as educational/training activities through technical cooperation programs (IAEA 2006).

12.4 Coordinated Research Projects (CRPs)

CRPs are the translation of Article III of the IAEA statute which stipulates that the Agency should "encourage and assist research on, and development and practical application of, atomic energy for peaceful uses throughout the world…, foster the exchange of scientific and technical information on peaceful uses of atomic and encourage the exchange of training of scientists and experts in the field of peaceful uses of atomic energy" (IAEA 1989). Research efforts supported by the IAEA are normally carried out within the framework of CRPs. These are developed in relation to a well-defined research topic on which an appropriate number of institutions are invited to collaborate and represent an effective means of bringing together researchers in both developing and industrialized countries to solve a problem of common interest. Each CRP is essentially a network of 5–15 national research institutions which work within an operational framework for research with a similar and well-defined global or regional thematic or problem focus which is relevant to, or can be tackled through, nuclear technology. Often, those results quickly become of direct benefit to groups outside of the scientific community, for example to patients if the research is carried out in the human health program of the Agency. Coordinated research activities provide opportunities for scientists and institutions in member states to conduct applied research using nuclear knowledge to improve human health and nutrition. A few CRPs are offered to scientists from developing countries for a period of up to 5 years. They are conducted in collaboration with graduate program within local universities leading to a PhD degree.

12.4.1 An Example of a Doctoral CRP

"Doctoral CRP on Management of Liver Cancer Using Radionuclide Methods with Special Emphasis on Trans-Arterial Radioconjugate Therapy and Internal Dosimetry." Through this CRP, six students from developing countries (China, Mongolia, India, Singapore, and Vietnam) had the opportunity to work in sandwich programs with advanced institutions and have been able, in the end of the project, to submit and defend their theses before their universities. This was an open label, multicenter study to determine the utility of transarterial Re-188 conjugated lipiodol (radioconjugate) in the treatment of patients with inoperable hepatocellular carcinoma (HCC). Patients have been followed until progression of disease, death, or for at least 1 year after the courses of therapy. Parameters evaluated included response rate, as determined by contrast-enhanced CT; palliation of symptoms, improvement in quality of life (QOL), and overall survival at 1 year; and QOL parameters, including performance status (ECOG) and hepatic function (child's classification). The CRP started in the middle of the year 2000, as the first Doctoral CRP of IAEA combining Research and Development activity of the IAEA with the higher education programs of the participating universities in the member states. Besides developing a new cost-effective therapeutic radiopharmaceutical for treating HCC, and assessing its safety and efficacy; the second major objective of the CRP was to develop human resources in the field of radionuclide therapy through establishment of a link between the CRP activities of IAEA and the postgraduate medical education and training programs in the IAEA member states. The CRP has achieved most of its objectives, namely, development of Re-188 Lipiodol and standardization of the labeling procedure, development of Re-188 Lipiodol internal dosimetry protocol, evaluation of its safety for use on humans (Phase-1 study), evaluation of its efficacy in the treatment of HCC, and producing at least one PhD thesis per participating institute during the period of the CRP. Extreme cost-effectiveness, on-site availability and safety of the radiopharmaceutical make Re-188 Lipiodol therapy an attractive option for routine clinical use anywhere in the world.

12.5 Curriculum Design and Teaching Materials

Consultancies and technical meetings are organized to gather experts (5–20), to discuss themes that are relevant to the Agency's programmatic activities. These meetings lead to different outputs that include a large spectrum of publications (guidelines and teaching materials). The meetings are coordinated by a Project Officer, a staff of the Nuclear Medicine Section, whose duties are the identification of the topic(s), selection of the appropriate experts and consultants, and coordinating the meeting(s). Consultant meetings usually last for about 5 days. Themes and topics are selected according to the relevance and needs of developing countries.

12.6
Examples of Publications

12.6.1
Appropriate Use of FDG-PET for the Management of Cancer Patients in the Asia-Pacific Region. IAEA Recommendations

"Appropriate use of FDG-PET for the management of cancer patients in the Asia-Pacific region. IAEA recommendations" is one of those publications whose purpose is to develop a consensus statement based on evidence from existing systematic reviews, to make healthcare providers aware of the value of PET in the management of patients affected by cancer. This publication is the result of projects that the IAEA has initiated within the Asia/Pacific region, targeted at the technical aspects and quality assurance of PET scanning, and at identifying the indications for PET scanning most likely to provide the greatest benefit to both individual patients and to the health system. As an integral component of this program, the IAEA convened an expert consultant group to consider the available systematic reviews and to draft a list of indications for PET scanning. The expert consultant group was also requested to consider specific issues that may affect the utility of PET scanning in the Asia/Pacific region. The IAEA expert consultant group included four nuclear medicine physicians and one radiation oncologist. Consultants were chosen based on experience and leadership in the field of nuclear oncology, cancer management, and knowledge of needs in developing countries.

12.6.2
Quality Assurance for PET and PET/CT Systems

This publication provides guidelines for the implementation of quality assurance and control programs concerning the combined medical diagnostic modality of PET and CT technologies. These independent, but complementary, imaging techniques are of frequent and growing use within the fields of Diagnostic Imaging, Oncology, Cardiology, and Neurology, where they allow physicians to locate and diagnose malignant diseases accurately. Specific topics of discussion include frameworks for reference values, tolerances and action levels, minimal required configurations with corresponding performances characteristics, and the management of ancillary equipment.

12.7
Educational and Training Activities Through the Technical Cooperation Programme (TCP)

The TCP is delivered through National and Regional Projects and has three main aims: (a) building professional competences; (b) raising the level of managerial skills; (c) preparing future leaders in the field. The target groups include physicians, scientists, health administrators, and policy makers.

National projects are focused on national priorities or will address issues which are typical of a specific region. Typically, they are aimed at implementing new NM facilities or strengthening already existing practices in individual countries. Since sustainability remains one of the most relevant issues to be addressed for these projects to be successful in the long term, considerable attention is given to human resource capacity building through education and training activities. These projects have a strong managerial component and are run through the use of external experts who aid Agency's technical officer in running specific tasks. Professional skills and competences are raised by supporting fellowships of diverse duration (from a few weeks to 3–4 years) according to the needs and specific objectives of the particular country involved.

12.7.1 Example of TC National Project

Establishing a cyclotron facility and positron emission tomography centers in Thailand (IAEA 2008), which are aimed at establishing a cyclotron facility and related laboratories for the production of positron emitter radiopharmaceuticals in the National PET Centre at Chulabhorn Cancer Centre in Bangkok. These radiopharmaceuticals will also be distributed around several PET imaging centers in Bangkok. Advanced nuclear medicine instruments were installed, including PET/CT, cyclotrons, and radiopharmaceutical production facilities for PET tracers. Training was provided through 12 fellowships, a scientific visit, four expert missions, and two workshops. As a result of the project, medical diagnostics using nuclear medicine techniques to international standards are now available in Thailand.

12.7.1.1 The Impact

The project has greatly improved the national program for cancer treatment, facilitating access to improved health care and medical diagnostics using nuclear medicine techniques, as well as perfecting professional expertise in these fields. It has involved collaboration in research, education, and high-level technology with local institutes and abroad. This has resulted in good cooperation and the sharing of knowledge and experience among all nuclear medicine staff members in the country. The project also led to a regional meeting and a very successful international conference on cyclotrons and PET when nearly 400 delegates from 82 member states attended the IAEA's first *International Conference on Clinical PET (Positron Emission Tomography) and Molecular Nuclear Medicine* in Bangkok, Thailand, from 10–14 November 2007.

Regional projects have a much higher educational component. To this purpose, training courses are organized, including the preparation of syllabi, selection of lecturers and students, in addition to undertaking considerable active lecturing task. Regional Training Courses (RTCs) are typically held at regional level, and are financed through the relevant Regional TC project, designed to address a topic relevant to the MSs of that particular region, Latin America, Africa, Europe, or Asia. This mechanism has allowed a huge number of medical practitioners and/or scientists to get trained in all aspects of nuclear medicine, including PET/CT.

12.7.2
Examples of TC Regional Projects

12.7.2.1
Strengthening Clinical Applications of PET in 'Regional Cooperative Agreement for Asia' States

This project has the overall objective of improving cancer management through the effective and precise application of PET. Specific objectives are to enable RCA member states to understand the physiological and biochemical aspects of PET images for more effective image interpretation and diagnosis, and to understand the role of PET in decision-making for therapeutic strategies, especially in cancer patients; and also to provide nuclear physicians in RCA Member States with regionally harmonized training on the effective operation of PET–CT scanners, with guidance on harmonized QA/QC programmes. Expected outputs are the production of guidelines for optimum and efficient use of PET/PETCT scanners, strategies for safe operation and ideal throughput; guidelines for establishing PET facilities and brochures for clinicians and administrators; and enhancing the capability of applying the guidelines in clinical applications of PET and PETCT.

12.7.2.2
Distance-Assisted Training (DAT) for Nuclear Medicine Technologists

Distance-assisted training (DAT) for Nuclear Medicine technologists developed under the RCA (Regional Cooperative Agreement for Asia) umbrella. The DAT program was developed and managed under the auspices of the IAEA commencing in 1994 under RCA project RAS/6/022 and since 1999 under RAS/6/029. Initially developed to cover "conventional Nuclear Medicine applications" (Part 1), during 2008 the DAT training materials were extended to include SPECT/CT and PET/CT (Part 2) and prepared suitable for on-line delivery through a new website (DATOL – Distance-Assisted Training On-Line). The Research Institute for Asia and Pacific of the University of Sydney have supported the ongoing developments of DATOL and have made the commitment to provide continuing support to ensure quality management and best outcomes throughout DATOL delivery and evaluation. It was also suggested to transfer the Part 1 of the program to the on-line platform.

12.8
Conclusion

This chapter reviewed the unique role of the IAEA in building capacity in nuclear medicine with a focus on PET imaging and PET/CT hybrid imaging. No other international organization has fulfilled such a tremendous contribution to the education and training of nuclear imaging or to contribute to the improvement of human health at a global scale.

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Building Capacity in Medical Physics for Radiological Imaging: Role of the International Atomic Energy Agency (IAEA)

13

Ahmed Megzifene, Donald McLean, and Rethy K. Chhem

13.1 What Is the Role of the Medical Physicist in Imaging?

The symbiotic relationship between physics and medicine has probably never been more evident, than in the development of radiological imaging for medical purposes. From the time of Röntgen, physicists have prepared the way through discovery and invention to be rewarded by the energetic uptake of an enthusiastic medical community. This rapidly established relationship allowed dissemination of the new medico-scientific technology, within months, to an eager world. Much slower however was the recognition that the indiscriminate use of radiation had unwanted harmful effects that were evident to both clinicians and patients, and experienced through personal suffering by both physicists and clinicians alike. The new discipline of dosimetry, or the measurement of radiation, arose out of this misfortune, and now is an essential element in the required knowledge needed for responsible radiation medicine. Of course, technology and medicine have continuously evolved over the last 100 years, with basic research from the imaging sciences, and the emergence of high-speed computers, allowing the primitive medical images produced by X-rays interacting with a fluorescent screen to make way for high-contrast sectional images from a computed tomography scanner, as but one example.

The role of the medical physicist in imaging can then be seen to contain a number of aspects.

1. *Contributing to basic research in dosimetry*
2. Contributing to basic research in image science
3. Education and training of medical physicists at tertiary institutions
4. Engaging in education at the clinical site for radiologists, radiology registrars, and radiographers and other clinical staff and trainee staff

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5. Clinical work in providing advice on equipment acquisition, optimization of clinical benefit and detriment and assurance of performance standards
6. Assessment of radiation dose levels for patients, occupational workers and members of the public
7. Engaging in clinical research, often with clinicians, on technical aspects of radiation medicine

The first two listed roles are most commonly undertaken in either university or private enterprise research laboratories and might not be expected to be a first priority in developing countries. The continuing emergence of software-based innovation, however, is less restrictive on the physical location of researchers when compared to past situations. The remaining role points, however, are increasingly important in developing countries, especially when the rapidly expanding "roll out" of many of these digital technology imaging modalities, for example, computed tomography, in these countries is consideredto have significant implications for the patient dose.

The roles of the medical physicist can then be classified into three basic areas namely, service, education and research. To build capacity in these areas certain educational tools are required.

13.2 What are the Educational Tools at the Disposal of the IAEA?

In the application of radiation to medicine in member states, the international atomic energy agency (IAEA) plays a dual role. The first is a proactive role where materials are prepared in the belief that they will be useful to the member states for the application of radiation medicine. In this case, the educational tools developed are usually either in the form of guidance material, or are activities to support the implantation of guidance material. Examples of such material or activities are given below:

1. Development of a guidance document, e.g. a standard, or quality assurance manual, etc.
2. Coordinated research projects (CRP) to test and adapt guidance material to conditions in the member states, and to otherwise transfer technology to the member states.
3. Development of education material such as curriculum, teaching texts or training packages.
4. Engagement in activities with professional organisation.

Secondly, the IAEA has a responsive role to play as far as the requests of member states for assistance in technical projects are concerned. Typically, technical cooperations (TCs) have three basic elements upon which a programme is developed. These are:

1. The placement of a professional from a member state in an institution of high standing in a field, through a fellowship, to allow a transfer of knowledge and skills.

2. The sending of an external expert to hold a training programme or assist the execution of a required technical task (such as the commissioning of medical equipment).
3. The acquisition of equipment for the member state in cooperation with that member state.

Of the three responsive tools, the most favoured are the tools of education, either by placing a professional externally for training or by bringing external experts to local training. However, these blocks can be used in many ways to build a large variety of responses to the particular needs of a member state.

13.3 Strategies for Building Medical Physicist Capacity in Imaging

Clearly, strategies for building capacity in medical physics will involve both proactive and responsive approaches; however, the needs of a member state need to be understood in order to determine the best strategies.

In an environment where professional medical physicists are few or even non-existent, advocacy for professional recognition is an important strategy. Without recognition of the need for medical physicists, it will be impossible to educate and train candidates for the profession to a suitable standard. Further, the retention of competent staff is also compromised without this vital step in capacity building. Once the need for medical physicists is recognised, it is necessary to strengthen or develop appropriate university faculty to deliver an academic education package. New graduates from such a programme will need clinical training, just as their medical colleagues, to make the transition from academic learning to professional responsibility. This requires a clinical training strategy. Another key element in capacity building is a response to the development of a regulatory structure, such as for radiation safety. Such a response can come in the form of guidance and standardization documents as well as occasional teaching workshops.

13.3.1 Advocacy for Professional Recognition

Advocacy for recognition of the role of medical physicist is as much about economic and societal factors as it is about education; however, without this recognition, the subsequently mentioned educational strategies are of little value. Sadly, the lack of effective advocacy is sometimes seen in some member states, where the country is a net exporter of medical physicists, while still suffering from a chronic shortage of those professionals within their own health systems. While this problem is not unique to medical physicists the profession does suffer from difficulties in job classification. After many years of non-inclusion the International Labor Organization[1] (ILO) in 2008 entered the medical physics profession with a classification under "astronomers and physicists". Advocacy by the IAEA with the

[1] The ILO maintains the international list of occupations known as the International Standard Classification of Occupations (ISCO).

support of the World Health Organisation (WHO) may assist to partially alleviate this problematic classification with the inclusion of a lead statement for this classification referring to some key elements of the clinical nature of the work of the medical physicist.

Another form of advocacy is through the proper use of regulatory standards for radiation safety such as the International Basic Safety Standard (BSS) (International Atomic Energy Agency 1996). These standards include an outline of international requirements for the work of medical physicist in dosimetry, calibration and quality assurance. Such standards ensure that those with proper qualifications administer the supervision of radiation matters at the clinical workplace, thus reinforcing and validating the internationally recognised educative processes. The main work of advocacy, however, is pursued in each national arena and here the IAEA can assist local professionals with advice and support including external experts for scientific events and individual consultations.

13.3.2 Strengthening the Standard of Academic Education

Given the support for professional advocacy, perhaps the most important educational strategy is the strengthening of the academic standard for medical physicists. This is currently agreed to be at the MSc level, thus carrying the problems of a low volume postgraduate programme. Such programmes however can be very attractive to a university physics department as the shortage of medical physicists ensures a continuing demand for the completing student. Challenges that need to be met by a national university undertaking medical physics education include:

1. The design of an effective curriculum.
2. The use of lecture staff with experience in the field.
3. Support in establishing a research culture that is relevant to the profession and of a standard that can attract national research funding and research students.
4. The provision of relevant scientific and clinical practical experience.

The IAEA has taken a proactive role with the provision of model curriculum and with the availability of high-quality resources such as study texts and electronic lecture material. This is certainly well-demonstrated in IAEA material for radiotherapy material (International Atomic Energy Agency 2005) which is currently being extended to cover medical physics for diagnostic radiology and nuclear medicine. Additionally, individual centres are assisted responsively by expert consultation.

The important question of lecturer experience and appropriate research culture ideally requires a cooperative agreement between academic and clinical institutions in much the same way as is required for a successful medical programme. Individual teaching staff members can also undergo fellowship training at a centre of expertise that might also act in a role of mentorship and become a peer institution to the developing university programme. Reactive IAEA projects can also assist in upgrading laboratory equipment to allow relevant practical experiences for the students.

The importance of strengthening doctoral programmes should not be forgotten in the desire to bring a clinical focus to academic teaching. Clearly, academic teaching and research is not sustainable without a new generation of medical physics academics with the required qualification standards. To facilitate the required research culture peer support, possibly involving formal memorandums of agreement, may allow the necessary external co-supervision of research students and research activities. The specific case of CRP involving doctrinal students is discussed further below.

13.3.3 Clinical Curriculum Design and Implementation

Just as it is established in medicine that university graduates need to complete a residency programme of clinical training before being accepted as fully qualified, it is becoming recognised that because of the increasing complexity of radiation medicine equipment, similar requirements need apply to medical physics. For the developing country this poses considerable challenges for curriculum design and its implementation. A successful clinical training programme needs to address the following issues:

1. Adoption of a flexible but structured programme of training to allow the registrar to integrate training and regular work experiences.
2. Use of a well-designed assessment programme to reward and lead the learner.
3. A clinical training site that can provide the necessary training experiences needed for completion of the training programme.
4. A clinical training site that has supervisors that are qualified and experienced in clinical practice.
5. A "critical mass" of residents to provide peer support.
6. An outcome award that gives the registrar a reward for the work involved in the training. This would usually be eligibility for a form of professional accreditation with socio-economic implications.
7. An organisational structure that can assure a standard of achievement and can solve any issues that arise during the delivery of the training programme.

A suitable programme model that has been developed by the IAEA for use in Asia has utilised a competency-based, modularised programme with centralised national coordination overseen by the national professional body. This programme has been successfully adopted in pilot sites in Asia for the discipline of radiotherapy (International Atomic Energy Agency 2009a). For the case of medical physicists in imaging, points 4 and 5 above pose an even greater challenge than in radiotherapy, and may require a greater reliance on external methods of supervision, mentoring and assessment.

13.3.4 Development of Standards of Practice

A significant work of the IAEA is the development of harmonised international standards of practice in radiation. In the field of radiation imaging dosimetry is an essential element

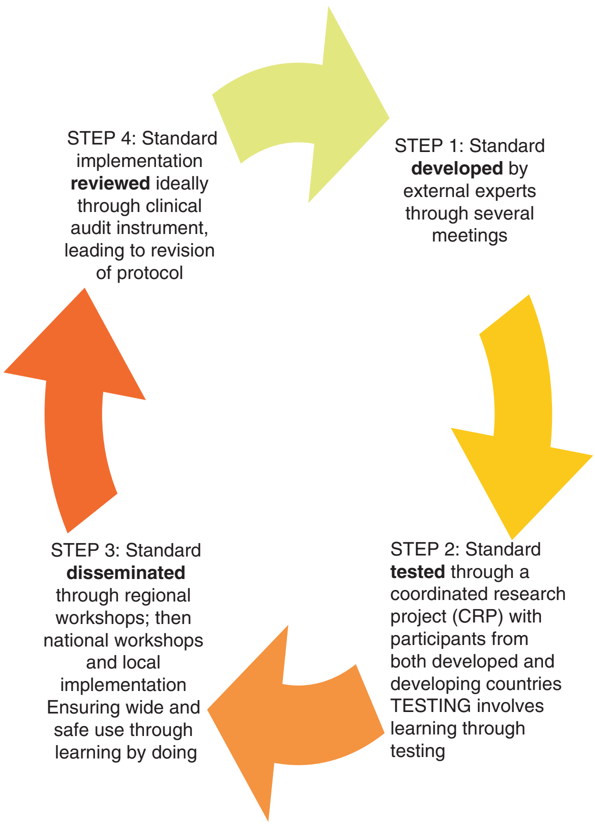

Fig. 13.1 Process for the development of an international dosimetry standard of practice

of work that benefits from international standardization (International Atomic Energy Agency 2007) as national recommendations may tend to be too specific. Countries with no national dosimetry protocols can be subject to confusion as different hospital physicists adopt varying protocols from other countries. The work of developing standards of practice includes four principle steps as described in Fig. 13.1.

Of particular note in this process is the role of the *coordinated research project (CRP)*. This process brings together contract-holder participants from developing member states of the IAEA and a smaller number of associates from developed states to engage in adaptive research that, in the case above, involves the testing and implementation of a standard of practice. Such activities are a valuable education strategy that involves the validation of the content of the standard of practice and its viability for implementation in various national environments. The CRP is also an example of project-based learning utilising the benefits of networking, knowledge transfer and skill development that takes place during the project amongst the participants. As mentioned in Sect. 13.3.2, a special case of a CRP can be used to facilitate the mentoring of PhD students by twinning a university in a developing member state with an established university in a developed member state. Under this process a viable external co-supervisor for the student is established and the progress of this arrangement is overseen by a formal review process.

The third step in Fig. 13.1 is discussed below as an example of continual professional development. The final stage to complete the learning cycle is the evaluation of implementation of the standard of practice. This is best done through a comprehensive audit process that considers all aspects of clinical workflow. In radiological imaging such a tool has been developed (International Atomic Energy Agency 2009b) which will add information during the review of a standard of practice before redrafting.

13.3.5 Continuing Professional Development

The training of medical physicists already employed in the workplace is an essential educational strategy for capacity building. One example of this is in the practical use of radiological dosimetry where workshops of typically 5 days duration are used to build knowledge and skills in dosimetry and to promote networking. These workshops aim to have a balance of didactic learning, reinforced with practical exercises in the clinical environment. In the case of the IAEA there is the capacity to hold regional events where two or more representatives from a country within a region[2] can attend, with the expectation that new knowledge and skills gained will be again shared in the country of origin of the participant. This is based on the "train the trainer principle". While such programmes might be challenging to run in a clinical environment, the outcome is usually rewarding as seen in recent results of participant evaluation of training courses taken one or 2 years after the completion of the course.

In order for a standard of practice to "take root" in a country, it is usually necessary that the professional returning from the regional workshop is in an environment that allows the new standards to be applied and adapted to the local environment. This will involve a certain degree of nurture and the ability of the professional to think analytically and to be able to eventually evaluate the implementation of any new programme. This is the keystone to the IAEA goal of local sustainability for all of their projects.

13.4 Conclusion

In an environment where the member states are from the extremes of development in radiation medicine, as well as from differing cultural settings, it is important that educational strategies incorporate diversity and are prepared to demonstrate the viability of educational strategies while allowing countries to adapt these strategies to their particular situations. The IAEA is in a unique position to provide both leadership and support through a variety of proactive and reactive activities available in its various programmes. When viewed as a whole, it is clear that no single strategy alone can achieve a significant building of capacity in medical physics for radiological imaging. Professional advocacy is hollow without a profession that is well-qualified,

[2]The IAEA Technical Cooperation Programme is divided in 4 regions, Africa, Asia, Europe and Latin America.

clinically trained and skilled in standards of practice. On the other hand, as had been previously pointed out, educational strategies will not be sustainable without professional recognition and the support that this gives through government and employer agencies.

To date perhaps the most compelling measureable results have come from continued professional development through regional and national training programmes. Evaluation has shown that essential professional standard of practice and other aspects of professional education simply are not available to participants from certain regions through any other method. Of equal interest is the anecdotal observation of the progress made in professional recognition in countries where academic strategies at universities have been undertaken with IAEA involvement. The results of such strategies are long term and difficult, if not impossible, to measure objectively; however, the progression from academic education to clinical curriculum implementation and professional recognition achieved by certain countries appears to be more than coincidental. It is also evident that in these cases, there has been much local work usually involving a champion in professional and educational endeavour. Perhaps one of the inspiring aspects of educational work in an international environment is the possibility of equipping energetic leaders in national settings with ideas and tools to be effective in building capacity in the application of radiation to medicine and particularly to medical physics in radiological imaging. The importance of educational principles in the work of capacity building has recently been well-appreciated within the human health division of the IAEA with a focus on staff development in Education.

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Challenges and Professional Developments for a New Chair/Chief

14

David A. Koff

14.1 Introduction

I will never forget this day, Thursday, March 29, 2007. On this day, I came to Hamilton to interview for the position of Chief Radiologist and Chair of the Department of Radiology at McMaster. Although I had managed a large private radiology practice in France and had practiced in an academic setting in Canada for 20 years, my experience with academic management was limited.

The weather was beautiful; an unusually mild day for the season, and the drive had been very pleasant from Toronto. The recruiter was waiting for me, and he took me to the large meeting room in the brand new building of the Faculty of Health Sciences. The glass-walled floating board-room was suspended above a large lobby with high trees and I recall noting the beautiful architecture. I felt that I was well prepared for the interview, and as the interview began, I found that I was not anxious because I never really imagined that I would ever have the job. My Leadership Mission Statement had been printed ahead of time and distributed to all the members of the selection committee. I had built my arguments on the basis of a review which had been performed 4 years earlier, in 2003, by two experienced active Canadian Chairs.

The review had emphasized the strength of the residency program, under the direction of the program director who, within 2 years, had successfully addressed many of the program difficulties identified in the previous review. The review had also identified a number of weaknesses in the other programs:

- Undergraduate program: the review identified that the weaknesses in this program was the fact that it was unstructured; subsequently, there was a low level of participation and involvement by faculty radiologists.

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- Fellowship: as each individual site recruited their fellows independently, there was no uniform coordination to meet the academic mission. To enhance the program, the review identified a need for a more cohesive organizational recruitment plan.
- Research: the review indicated that this area was particularly weak due to the decreasing amount of grant funding and the lack of protected time available for radiology staff to participate in research projects.

I had also looked at the teaching philosophy at McMaster and was aware of the Problem-Based Learning (PBL) method, which was one of the many accomplishments of McMaster.

14.2 Problem-Based Learning (PBL)

PBL is an educational construct that positions students as active solution-seekers to authentic, real-world problems that they can expect to encounter in their professional practice. It draws heavily on student-centered theories and social-constructivist pedagogies. In 1969, PBL was introduced into the clinical learning context for medical students at McMaster and soon adopted by many medical schools around the world.

The central idea of PBL is to expose the students early in the teaching process, to clinical settings and real-life patient cases; thus motivating learning as the students see the practical application of what they are learning. Although critics of PBL have railed against what they perceive to be a lack of traditional structure or depth of knowledge, the results obtained by medical students at McMaster meet or exceed those trained at medical schools not using PBL. McMaster students consistently obtain good results in the national licensing examination. This success has been linked to the use of the Personal Progress Index (PPI) which allows the students to gauge their progress in their knowledge base during the course of their studies.

Although the problem-based learning model has been successfully used in educational settings, including Harvard's Business School for many years, its adoption in medical education has been very slow. William Osler once said: "Education is a life-long process and we can only instill principles, put the student in the right path, give him methods, teach him how to study, and early to discern between essentials and nonessentials" (Bryan 1997). McMaster University has been a pioneer in implementing a system where students are active participants in the learning process. Therefore, a 3-year program was created, characterized by the absence of discipline-oriented subjects and replaced with an emphasis on problem-solving in clinical context. Although the program is shorter than the standard 4 years ascribed by most schools of medicine, McMaster students have much less vacation time than their colleagues.

The main features of the program were:

- The analysis of healthcare problems as the major way to acquire and apply knowledge
- The development of independent, lifelong learning skills by students
- The use of small tutorial groups, with five or six students and a faculty tutor in each group, as the central educational event

This last point has been the reason many institutions have not taken a PBL approach; it requires significant human resources as staff to devote their time to small group teaching rather than using the larger, traditional "lecture" contexts.

The program at McMaster went through a major revision in 1983 as new knowledge in human biology, health care, and determinants of health were included. The revisions did not require changing the organization of the medical foundations (MF) program, currently in Units (interdisciplinary blocks). Also, it retained its unique features: exposure of the students to clinical settings and patients from their first week in the program, lack of traditional examinations and assignment of grades at the end of each Unit, and involvement of students in the decision-making process of the program (selection of educational leaders, participation in various educational committees).

There are currently five MFs:

- MF 1: encompasses oxygen supply and exchange, which means addresses all problems arising from inspired air through to oxygen at the cellular level; the students learn about the respiratory, hematologic, and cardiovascular systems.
- MF 2: addresses aspects of homeostasis particularly that of energy balance, including issues related to the GI tract, endocrine system, and nutrition.
- MF 3: second part of homeostasis, including the balance of acid and base, blood pressure and renal function and then goes on to address reproduction and pregnancy and a number of issues in genetics related to reproduction
- MF 4: host defense, which includes immunology and infectious disease, and then moves on to look at neoplasia and the genetics of neoplasia
- MF 5: movement control and interacting and communicating, which includes the locomotor system, the nervous system, and behavior
- Aspects of human development will run through all of the five MFs.

A new curriculum has been added to the MD Program called Professional Competencies curriculum. Woven into the 3-year-program, it enables the student to pull together the complexities of clinical practice: ethics, communication skills, self-reflection, health systems, and interprofessional teamwork. The Professional Competencies program focuses on seven key domains:

- Effective communication
- Lifelong learning
- Moral reasoning and ethical judgment
- Population health
- Professionalism and role recognition
- Self-awareness and self-care
- Social and cultural dimensions of health

The Clerkship program aims at getting students to be self-sufficient in contemporary medicine. It consists of rotations in medicine, which includes geriatrics, surgery, family medicine, anesthesia, psychiatry, pediatrics, obstetrics and gynecology, and emergency medicine. There is also elective time, one half of which must be spent in clinical activity. Ultimately, the program is very successful in training the well-rounded doctors of tomorrow.

14.3 Back to the Interview….

In the end, the interview went well for me, and just 3 weeks later, I received a letter from the selection committee to let me know that I had been chosen for the position of Chair and Chief. I was thrilled to begin my work in this position but I was also very much aware of the challenges that lay ahead.

It was not a small change for me as the Diagnostic Imaging Department I had to take charge of as a Chair includes four hospitals:

- The Hamilton Health Sciences consists of three sites: McMaster University Medical Centre, Hamilton General, and the Henderson General;
- St. Joseph's Healthcare is the fourth site.

There are 59 radiology faculty members between all sites, five nuclear medicine clinical faculty, and nine basic scientists. Our cancer center, the Juravinski Cancer Centre, based at the Henderson General Hospital, is the second largest in Canada and fourth in North America. The Hamilton hospitals are a tertiary referral site for the central west region, providing specialized healthcare services to a catchment population of 2.2 million. The HHS is amongst Canada's largest teaching hospitals. Each hospital has specialty expertise: the Hamilton General Hospital (HGH) has the regional burn and trauma program, cardiac and vascular, as well as neuroscience programs. The trauma unit is the second busiest level 1 trauma center in the province. The McMaster University Medical Centre (MUMC) houses the Children's Hospital, including a large NICU, as well as the women's health program. There is a large volume of high-risk obstetrics. The Henderson Hospital besides its focus on oncology has also a large orthopedic program. The St. Joseph's Healthcare Hamilton (SJHH) has specialty services in kidney and urinary disease, head and neck surgery, as well as respiratory medicine and thoracic surgery. All sites have strong Internal Medicine and General Surgery programs and services. Combined, there are over 1,157 inpatient beds, as well as large, active outpatient programs.

In terms of imaging resources, we have five clinical MRIs distributed at all sites including a 3.0 T magnet at St. Joseph, as well as a 3.0 T research magnet also St. Joseph's. There are eight CT scanners, two at each site. A PET scan is available at St. Joseph's.

It was time to look at our issues and try to bring a new dynamics to our structure. So, I decided to review our different programs and use some simple business tools to try to improve. Often, breakdowns come from inaccurate perceptions or a lack of communication.

14.4 Undergraduate Program

Referring to what had been shared in the external review, 5 years ago, there was an indication that there was not sufficient support or resources and that there was a certain degree of tension between the responsibilities of teaching and the demands of the clinical services.

The University was frustrated that Diagnostic Imaging (with the exception of ultrasound anatomy) was not a major participant in teaching.

By the time I began my work, a number of issues had already been addressed and the situation was already better because the groups were now appropriately staffed, with a number of International Medical Graduates who had been happy to take over the tutoring. These graduates all went through 2 days of mandatory training, and, despite the fact that some of them, who at the beginning had only seen in tutoring a way to strengthen their academic dossier for promotion, enjoyed it so much that they asked to continue to teach in their MFs.

The undergraduate program was managed by our Departmental Education Coordinator (DEC), a Foreign Medical Graduate (FMG) who, although he had no clinical license to practice in Canada, and although not a professional educationalist, has been extremely dedicated and very successful with his ultrasound anatomy teaching program. He has just finished writing an ultrasound pocket book which has been very well received by our students and we are considering expanding his work to CT and MR.

Unfortunately, the educational coordinator found challenges in engaging the radiologists to commit actively to undergraduate teaching. We looked at the teaching resources in the MFs and revisited our rosters to make sure that we had the appropriate number of tutors, enrolling enough staff to relieve the pressure on our DEC. I also gave him my support, but more importantly, we looked at the points of failure and tried to correct them:

- **Stipends:** We made sure that the tutors (or their partnerships) would get the stipends they were entitled to. This was withheld for complex reasons, mainly linked to administrative changes in the payroll system, but in solving this issue, people felt that they were recognized.
- **Leadership:** We created a new dynamic in refreshing the leadership for the program: one of our staff radiologists has a strong interest in undergraduate teaching and has already been instrumental in developing the radiology curriculum for McMaster, based in part on the AMSER (Alliance of Medical School Educators in Radiology) curriculum. He has contributed to unify the elective program at the different sites. I have enrolled him as Undergraduate Program Director and support his initiatives to develop more radiology presence.
- **Goal:** The goal is to create solid Radiology Foundations (RFs) blended in the MFs. The Canadian Diagnostic Imaging Guidelines has been adapted in our curriculum, and we wish to make our curriculum available to all students in North America. This curriculum is based on core radiology topics and is divided in two parts:
  - D1 – Physics concepts important to clinicians, radiation safety, imaging in pregnancy, and adverse effects in medical imaging
  - D2 – Organ-based curriculum components include: Chest, Musculoskeletal, Neuroimaging, Pediatrics, Women's imaging including Breast, Body imaging including GI/GU, Nuclear Medicine, Emergency Radiology, and Interventional Radiology.
- **Formal lectures:** Three formal lectures, providing an overview of core radiology topics, have been presented and recorded. Our RF directors present lectures at the start of each MF.
- **Education material:** An ultrasound anatomy book has been developed, with plans to extension to CT and MR; also CORA (Centre of Radiological Anatomy), an educational

initiative co-created at St. Josephs which makes teaching modules available to tutors and students, and will soon be available at all campuses.

- In order to get enough exposure to imaging and understand how radiology is a dynamic interactive component of advanced patient care, we also want to improve our elective program where the 2 weeks rotations should be mandatory for all students, and not only for the students who want to enroll in a radiology program.
- **Challenges:** One of the challenges is to get protected time for our program director in a system where clinical duties are privileged over academic work. I have been working to change the culture of the groups and ask them to contribute to the academic program in giving time to the staff who volunteer to take education responsibilities. Acquiring secretarial support is also a challenge.

14.5 Postgraduate Program

The postgraduate program, is in good shape. In less than 2 years after assuming the role in 2001, the director has successfully addressed all difficulties identified in the program review. She has benefited from strong support, with her group agreeing to give her a full academic day a week to work on the program. She also has appropriate administrative support. A few points to note:

- Our Residency Program Director has demonstrated great leadership and has revitalized the residency program with her energy and hard work.
- Our residency program has been rated as one of the two best residency programs in Canada.
- We have successfully passed the Royal College evaluation with no weakness identified.

The residents receive training at our four sites, where they find different expertise. The teaching program consists of daily rounds at each hospital, weekly academic half-days including CanMEDS topics (Medical Expert, Communicator, Collaborator, Manager, Health Advocate, Scholar and Professional). We have a well-developed Visiting Professor Series shared with University of Toronto. Residents have a chance to participate in teaching with medical elective students and junior residents. The residents have also to complete a research project before the end of their fourth year which will be presented to the Annual Radiology Research Day and will hopefully lead to a publication.

The strengths of our program, key to our success, can be summarized as follows:

- Dedicated, supportive faculty, responsive to residency program needs
- Available, dedicated Program Director, with protected administrative time
- Chair and faculty support
- Cohesive, collaborative resident group
- Wealth of pathology and case material in Hamilton facilities
- Excellent teaching from faculty

- Mentorship Program
- Quality of evaluation methods, including 6-month reviews, Objective Structured Clinical Examination (OSCE), and Mock Oral feedback
- Program-Specific Evaluative Sciences/CanMEDS workshops and curriculum
- Adequate resources and support for program needs: Armed Forces Institute of Pathology (AFIP), resident conferences, educational stipends

14.6 Fellowship Program

The external review had identified a lack of organized recruitment process for a university-based fellowship program. I felt that it should be easy to build a strong fellowship program with the clinical material, teaching expertise, and research potential available across the department.

This was one of my first tasks, as I strongly believe that fellows bring significant value to a department as they can expose us to different cultures, experiences, and also contribute to teaching and research. They enhance the National and International reputation of our department as they may spread the word about their experience and will recommend a fellowship at our institution to their colleagues if they have been happy with their experience.

I found a nonexisting program with each side recruiting its own fellows for some sites,based more on filling staffing issues rather than real teaching experience. As the individual partnerships fund the fellows, they want added value in return for their money. I wanted to build a fellowship program similar to our MSK program. Within this program, there is communication between the different sites and a fellow rotating between different hospitals gets the best experience from each department.

I decided to create a Fellowship Program Director position for the city in the same way that we have a Residency Program Director. Our Fellowship Director's partners have agreed to assign the role a dedicated academic half-day to build a program. We have also secured the administrative support he required.

A long-standing issue to develop more fellowship positions was the concern that the fellows would take away work from the residents and that residents would not be able to access angio and interventional procedures. But the residents have expressed that they enjoy having fellows as they contribute to their education. We have also been working at solving access to workstations as we have been able to obtain an unlimited licensing scheme from our PACS vendor.

Over the last year, the program has moved from being exclusively hospital-based to a centrally administered organizational structure, through the office of the Department of Radiology at the University, allowing for standardization of the fellowship experience. The subspecialty structure of the department is increasingly reflected within the Fellowship Program, such that more fellowships are focusing on system-based education.

Research is now an integral component of the program. Protected research time (1 day a week) is available to all Radiology fellows, and fellows are strongly encouraged to present their research at scientific meetings. All fellows must submit at least one peer-reviewed paper on their research project in order to complete their requirements for the fellowship. Fellows are expected to present their projects at the annual McMaster Radiology Fellowship Research Day.

An expectation of the Fellowship Program is contribution to the Postgraduate education program. Fellows participate in teaching residents and give at least one set of rounds at their site every 2 weeks. The fellows are also expected to present at each of the City Wide Rounds which are focused on their subspecialty area. The fellows participate in the on-call schedule at the site where they are scheduled. The on-call commitment for fellows varies between different fellowships.

The program is administered by the Fellowship Program Director, who reports to the Chair of Radiology and the Assistant Dean of Postgraduate Medical Education. The Fellowship Program Director heads the Fellowship Program Committee, which consists of the citywide Fellowship Program Coordinators. There are 15 funded fellowship positions offered by four major hospital departments. All fellowships are at least 1 year in duration.

Interventional, MRI, and Musculoskeletal Imaging fellows rotate through more than one department; all others spend the duration of the fellowship at a single site. Cross-sectional imaging offers four positions at St. Joseph and two at McMaster; we have three positions in musculoskeletal Imaging shared between St. Joseph, Henderson, and MUMC; and we have one position for all other programs: breast at the Henderson, Oncology/Cross-sectional at the Henderson, MRI at the General and MUMC, Abdominal/Interventional at MUMC, Neuroradiology at the General and MUMC, and Vascular/Interventional at the General, MUMC and Henderson.

This distribution between the sites ensures that the fellows get the best experience from their fellowship. We are working toward establishing a standardized application and selection process. Our program has been ranked one of the best fellowships at the Faculty of Health Sciences.

14.7 Continuing Education

Continuing Education has not been included in the academic review, but a good program is a sign of vitality of a healthy department and fits with the life-long learning education concept of McMaster. When I took over, the major activity was the Visiting Professor Series shared with University of Toronto and which brought to Hamilton six times a year a reputed expert in a clinical field for three teaching sessions. A major progress in this digital age has been our capacity to record and webcast the lectures, allowing us to open this source of education to participants outside our campus., Videoconferencing has also given an opportunity to a remote audience to interact with the presenter.

My goal was to expand the continuing education activities, not only to create more opportunities for teaching but also to create more interaction between staff radiologists and fellows at the different institutions. One of our radiologists at MUMC took the challenge and we started to work on citywide rounds. We had identified the six areas of subspecialization:

- Body and Abdominal Imaging
- Chest and Cardiac
- Neuroradiology and Neurointerventional
- Vascular and Interventional Radiology
- Breast and Women's Imaging
- Pediatric Imaging

Nuclear Medicine was not included in this program.

We had decided that the rounds would be rotated between the four sites and that the moderator would be from the site where the rounds are held. Staff and fellows are invited to present interesting cases in less than 10 min, followed by interactive discussions. We started with a weekly round, but as people wanted to attend rounds even when not in their subspecialty, the frequency ended up being too high and we ended up decreasing to once a month. Food and CME credits are provided, which of course contributes to the success.

Another endeavor is the organization of major conferences. I had been successful with my Medical Imaging Informatics and Teleradiology conference over the last years, and of course my program followed me to Hamilton. But I wanted to create more activities to increase our visibility. The musculoskeletal radiologists had been successful with a MSK conference at St. Joseph's this year, and they will hopefully repeat it.

A conference is not a simple venture and requires a lot of time and dedication. You have to build a program with good speakers if you want to attract an audience which is solicited on many fronts. So, we are creating a new conference in Oncological Imaging which will certainly be successful. To expand our visibility, we plan to webcast our teaching activities as much as possible.

14.8 Research

The reviewers had noted the decline in the amount of grant funding over the past few years. When I began, there was almost no grant money for Radiology. The only funded researchers were in Nuclear Medicine. We were lagging close to the last position for the amount of money raised among all departments at McMaster Faculty of Health Sciences. The reviewers had identified the reasons for this situation as:

- Lack of research culture in Medical Imaging
- Shortage of staff radiologists
- Lack of strong fellowship program
- Lack of protected time for radiologists to participate in research projects

Like all Canadian academic centers, there is the usual tension between research and teaching activities on the one side, and work load due to clinical services on the other. The main challenge is to be able to strike a balance.

There are two major ways radiologists are involved in research:

- Research directed at furthering the state of the art of imaging, where radiologists may be principal investigators; this is unfortunately a rare occurrence as radiologists do not have the time or often the support to undertake this type of initiative on a large scale
- Research that employs imaging methods as tools to support biomedical research, often initiated by outside clinical investigators; this is the most common situation and radiologists are enrolled to facilitate access to imaging modalities and results

The major issue is therefore how to give radiologists the opportunity to access research without disrupting the clinical activities.

The first step was to give them internal support so a departmental research committee was put in place. The role of the committee is to encourage research activities by providing financial support. The funds are generated by donations and contributions from manufacturers and by revenue arising from the provision of services to external researchers and contract agencies. The role of the committee also includes monitoring the research project, determining the appropriate use of funds, and maintaining a research inventory. A number of internal projects are funded up to $10,000 and the results are presented at the Department Research Day and submitted for presentation at major conferences as well as for publication in radiology journals.

But to restore our academic credibility, we have to do more and start applying for major grants.

14.8.1 MIIRCAM

The Medical Imaging Informatics Research Centre at McMaster University (MIIRCAM) is the result of the efforts of the radiologists at Hamilton Health Sciences and researchers and scientists at McMaster University. It is a joint program between the Faculty of Health Sciences and the Faculty of Engineering; it has been funded by both faculties.

The mission of MIIRCAM is to foster research and education in Medical Imaging Informatics in order to improve outcomes for patients through improved workflow, optimized utilization of resources, reduced errors, and efficient communication of results.

The Centre gives an opportunity to representatives from different clinical and scientific disciplines to join forces and collaborate on innovative research projects which will all contribute to our stated mission. The radiologists will benefit from the computational and analytical skills from the scientists and engineers involved, who will also participate in writing grants and publications. In return, the scientists are getting guidance and validation from the radiologists, as well as access to clinical data.

The list of potential research topics is long and includes:

- Advanced image processing; image segmentation; image registration; image fusion
- Human–computer interface; visualization; workflow; image compression
- Quality assurance; quality control

- Data mining and neural networks; content-based image retrieval; evidence-based guidelines; cross-modality visualization of disease entities; report-driven image understanding
- Psychophysics and reading environment

I have recruited a general manager who organizes the activities of the Centre. A number of projects have already been initiated, among them image compression and radiation safety.

14.9 Evaluation

14.9.1 Annual Review and Monitoring Tools

Among other challenges was the necessity to keep track of the academic activity and research productivity of our faculties. I adopted a simple process to look at:

- Education activities (the type of teaching, number of hours and mainly the evaluation from the students, residents, and fellows)
- Research productivity (the number of publications, presentations, and research grants)

The adoption of a standardized university-wide CV system helps us to collect the data and make sure that the faculties maintain their up-to-date information.

An annual meeting face-to-face is a good way to address potential issues, including threat to tenures and promotion related to a lack of activity, and as a way to redirect staff on the right path. It is also a unique opportunity to gather feedback on my activities as a Chair and to understand issues that I may have overlooked. This is beneficial both ways, and the annual review, which had at first generated some anxiety among our staff, is now a welcome opportunity.

14.10 Conclusion

As the new Chief and Chair, my first priority has been to restore trust within the academic department by clarifying the academic mission and offering strong leadership and adequate support. By clarifying the academic mission, we have seen a paradigm shift toward active engagement of the radiologists in terms of their commitment to education from within the undergraduate program to the recruitment and participation in the fellowship program. In terms of the research, our internal strategy with MIIRCAM has been to foster not only research and education in Medical Imaging Informatics but also to develop and sustain collaborative and innovative research projects amongst radiologists, engineers, and scientists. Certainly challenges remain, but as we venture forth with clear goals, an understanding of our priorities in terms of our practice, education, and research, and a provision of adequate resources, it is my hope that we will continue to contribute to and further develop our stated academic mission.

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Fostering a Translational Research Attitude Among Residents in Radiology/Nuclear Medicine

15

Aaron Fenster and Rethy K. Chhem

15.1 Introduction

Research laboratories in Medical Imaging Departments have made great strides in integrating a research mission over the past decade, but efforts must continue in order to prepare residents for the increasingly complex world of transdisciplinary research. Typically, while residents receive excellent training in their specialty, few are exposed to research with transdisciplinary teams or mentored in the translational skills required to move their discoveries and innovations into the clinical or the private sector. As health care moves increasingly toward the use of multidisciplinary teams, it is important that researchers learn to independently bridge different disciplines in order to actively participate as leading members of these teams. In addition, residents who decide to focus on research must be taught the professional skills necessary to transition from successful trainees to junior researchers, assuming duties such as

- Recruiting and managing technicians and students
- Equipping a laboratory
- Writing grants
- Navigating institutional and governmental bureaucracy and politics
- Building industrial collaboration
- Dealing with issues of intellectual property
- Translating innovation into the private sector
- Disseminating and publishing research

Residents who successfully transition from practitioners to researchers, learning in the process how to translate their discoveries into clinical use or industry, are most likely to become successful academic leaders of their own transdisciplinary teams.

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15.2 Transdisciplinarity and Professional skills

Typically, Radiology and NM residents are trained with a specific focus on clinical skills, which they perpetuate when they subsequently become faculty members in academic Medical Imaging Departments. One of the difficulties with developing disciplinary expertise in such a focused manner is that it does not include opportunities to develop the basic knowledge of other disciplines in ways that allow the various disciplines to "speak one another's language". Some try to supplement their knowledge by attending seminars in other disciplines (e.g., medical biophysics, biomedical engineering, immunology), but often find that they lack the practical knowledge to understand the seminars. Each discipline brings a unique discipline-specific language, tools, and technologies which can make communication, understanding, and problem solving across disciplines difficult. By including a transdisciplinary research training approach in the educational framework of our future researchers, we have an opportunity to address these challenges.

15.2.1 From Trainee to Team Leader

Our trainees have expressed a desire for further support to scaffold their transition from residents to leaders of their own research teams. Currently, they participate in an apprenticeship-style model, working closely with a research mentor assigned to them for the duration of their training. The research topic, the methods modeled, or the leadership style of their mentor may or may not be appropriate to the residents' individual interests and developing expertise. In the latter case, a negative experience can discourage potential researchers from careers in academia, prevent or inhibit the establishment of research programs in the early stages of their first clinical/academic position, or diminish the opportunities to translate their discoveries into clinical use or the private sector. Clearly, introducing trainees to a range of professional skills and leadership approaches is necessary for their success as leaders in research.

15.3 Innovation and Flexibility

Innovative approaches to resident research training development are essential when the training is to supplement existing Radiology and Nuclear Medicine resident training programs so as not to overburden them and encroach on their clinical training time. Trainees need to learn the tools and terminology used in other disciplines; they need to be exposed to their approaches and thinking; and they need to be taught the professional and translation skills to be a leader in their field. Technology can offer some support with this; on-line or pod-cast courses, seminars and special workshops scheduled during lunchtime and the early evening hours allow

Table 15.1 Learning Outcomes

Platform 1	Ability to identify areas of research excellence at the university or hospital
	Ability to form a productive collaboration with a researcher from a different discipline
	Ability to structure an appropriate research project
	Ability to complete a project and present it at a local, national, or international conference
Platform 2	Understanding of the physical basis of medical imaging technology
	Understanding of the relationship between image quality and the physical basis of medical imaging technology
	Understanding of the ethical issues related to clinical studies and trials using human research subjects
	Ability to perform calculation to estimate sample size required to test hypotheses
	Sufficient understanding of biostatistics to allow discussions with biostatisticians
Platform 3	Awareness of the requirements and methods to set up a research laboratory
	Awareness of the methods required to plan and write a research grant
	Awareness of the requirements for project and budget management, documentation, and data storage
Platform 4	Awareness of the issues surrounding the protection of intellectual property, i.e., patents and copyright
	Awareness of the limitations of nondisclosure agreements
	Awareness of the costs involved in the patenting process

maximum time flexibility. Another approach is to integrate the fundamental components of each training program to create a comprehensive interdisciplinary experience. The hallmark of this approach would be founded on four *key training platforms* (Table 15.1).

15.4 Platform 1: Integrated Research Projects

Key to research training is the choice of an appropriate research project. The choice of topic can be developed in ways that provide the resident with an appropriate interdisciplinary experience. This can be accomplished by having trainees choose research topics cosupervised by two or more participating faculty members *from different disciplines* – one Radiologist or Nuclear Medicine physician and a second from a different discipline. Research training themes should be based on existing areas of research excellence with key mentorship and leadership involving both physicians and basic scientists. Some example themes are:

1. Vascular imaging, genetics, and genomics of vascular disease
2. Functional neuro-imaging and psychology
3. Breast imaging and image processing/modeling
4. Prostate biopsy and mechanical engineering
5. Image-guided interventions and robotics
6. MSK imaging and biomechanics

By establishing themes based on areas of excellence and availability of research mentors, residents can then identify projects that specifically intersect these themes. Based on our experience during the last 6 years of our research program in London, Ontario, Canada, we believe that this is the most successful route to enable a transdisciplinary research approach and "mindset" in trainees. Examples of successful partnered projects were:

- *3D ultrasound guided breast biopsy* involving a radiologist and medical physicist
- *A new device for Stereotactic breast biopsy* involving a radiologist and medical physicist

15.5 Platform 2: Transdisciplinary Learning

Resident clinical training programs can similarly be enhanced with a transdisciplinary training experience. One approach is to allow residents to participate in specialized courses that introduce trainees to topics and concepts from other fields. To ensure that these courses do not interfere with the residents' clinical training program, these courses should be made available on-line, allowing residents to access them when time is available and allowing referral to new concepts at later times when the new knowledge is needed to solve specific research problems.

15.5.1 On-Line Foundation Courses

As previously discussed, it is important for trainees to understand each other's "language" and research. This can be achieved through two foundation knowledge courses. These courses should be *on-line* to maximize flexibility and allow distance learners to participate.

The first course proposed is the *Fundamentals of Imaging Technology* and the second is a comprehensive course on *Research Ethics and Biostatistics*, including the process of obtaining ethics approval. This course should also include biostatistics and preclinical and clinical trial health research. Residents have indicated that a weekly seminar series or an intensive week-long workshop on these topics is useful by introducing them to key concepts; however, we must be aware that the knowledge is lost without use. Having access to the information on-line will allow rapid refreshing of key issues and access to the information when needed.

Since the knowledge that these courses would address is fundamental, it makes sense for the course content to be developed in partnership with Radiology and Nuclear Medicine Departments in other Universities and even in other countries. Imaging physicists in London, Ontario have already established two on-line fundamental courses which have been highly successful. In addition to the 88 Imaging students, 53 other students from the University of Western Ontario, plus graduate students from the Departments of Systems Design Engineering and Electrical and Computer Engineering at Waterloo and from the

Department of Radiology and Clinical Neurosciences at the University of Calgary, have taken the Research Ethics and Biostatistics course as part of their curriculum. In addition, we are now in discussions to share our on-line courses with two Universities in China (Shanghai Jiaotong University, and Huazhong University of Science and Technology) and University of Moratuwa in Sri Lanka.

15.5.2
Research Seminars

A bi-weekly or monthly lunchtime Seminar Series will be held for residents only. This series presents a broad overview of research in Radiology and Nuclear Medicine, at a foundation level, and introduces residents to researchers from other disciplines who have an interest in imaging. The exposure to multidisciplinary approaches to research helps residents choose a topic of interest to them.

15.5.3
Scientific Communications

It is important for residents to develop scientific communication skills during their training program. Some universities offer mandatory communication courses that graduate students are required to study. However, to maximize the residents' time, training focused on communication could be integrated into the bi-weekly research seminars. Using a metacognitive approach, students can be taught the components of effective communication, identify and discuss the examples in their small group seminars, and practice short presentations. The culmination of their learning would occur by having the residents present their research project at a 1-day departmental research retreat; a day in which residents, physicists, physicians, and keynote speaker(s) present important research findings.

In 2005, we launched a new annual research forum called “London Imaging Discovery”. Specific names of departments and research institutes that operate academically under the umbrella of the University of Western Ontario were not included in order to “level the playing field” and bring us together as a community of researchers. “London” captured the geographical entity; i.e., the city in which all of the research and educational institutions are located. “Imaging” captured the place we all intersected, and “Discovery” suggests that we all have something to learn by coming together around our research. On a philosophical dimension, “learning by discovery” is certainly the method of teaching/learning at the graduate and postgraduate levels. Finally the acronym “LID” held dual meaning for us; the first brings to mind the lifting of a lid to knowledge not yet known. The powerful metaphor is an invitation to the trainees to learn by discovery. The second meaning draws on the eyelid, whose role is to protect the eye and therefore the vision. For those of us who work in Medical Imaging, the eye and the ability to perceive is a fundamental part of our role; having a clear “vision” cannot be underestimated. Medical Imaging has been recognized as one of the ten flagship programs at the University of Western Ontario because of its leadership in advanced research in this promising field. A clear, articulated vision has allowed the Department of Medical Imaging to achieve tremendous success in recruiting and retaining the best and brightest researchers in the field.

15.6 Platform 3: Professional Skills

15.6.1 Bi-Weekly Professional Skills Seminar Series

The bi-weekly seminar series can serve additional purposes by including topics focused on developing the professional skills that residents have identified as desirable. The transition from being a trainee to becoming a researcher (even part-time researcher) is a tremendous leap and most new staff members are unprepared for the challenges of building a research team, recruiting, training, and managing their own students and technicians, all while building a research reputation. Ideally, a small committee would be formed comprised of at least one staff member and one resident representative to generate the seminar topics in response to resident needs. Some possible research topics include, how to:

- Recruit staff and students, including effective interviewing and evaluation techniques.
- Structure a lab and generate a positive lab atmosphere, and communicate expectations as a junior researcher to their students.
- Plan and write research grants.
- Build and maintain research collaborations and manage budgets.
- Set up effective project management methods for their research that result in proper documentation, data collection, and eventual publication.
- Communicate research findings at conferences, and to the general public via the media.
- Deal with group dynamics, including difficult issues such as substance abuse, sexual harassment, depression and suicide, and lab romances.

15.7 Platform 4: Translation of Knowledge

Translation of knowledge gained in the research laboratory into clinical use or to the private sector is an issue that most trainees will not have experience with. However, knowledge of intellectual property issues, industrial relations, and commercialization is necessary for researchers to protect themselves and their work as they translate their research for the private sector.

Typically, research finding are published or presented at conferences. However, ensuring that the knowledge gained in the laboratory is used widely requires additional steps. For example, the development of a new MR pulse sequence or a new device to improve a biopsy procedure can be tested in one's hospital, but to ensure that innovations are used beyond one's hospital, the technology must first be proven in a trial and then made available widely through the private sector. Methods to plan and execute clinical trials used to demonstrate the utility of new imaging discoveries are dealt with in the previous platforms; however, issues surrounding translation to the private sector are sufficiently complicated that special attention should be devoted to it. To do this, researchers and physicians need to learn about issues related to intellectual property protection and the patenting process. They need to understand when public disclosure prevents the issue of a patent and the difference between copyright and patent protection. In addition, they need to become familiar with nondisclosure agreements and their limitations.

Although the resident's time is limited, the best way to address these very important issues is through half-day workshops. These workshops can be developed in partnerships with the physics and engineering research communities. Although some staff members in the Department may have private sector translation experience, none are experts in this field. Experts in this field should be invited to lead these topics. In Ontario, for example, The Ontario Centre of Excellence Office of Commercialization offers 1-day workshops on intellectual property protection and the patenting process.

15.8 Conclusion

All of these approaches together serve to develop the transdisciplinary professional skills of the Medical Imaging researchers of tomorrow. They respond to the needs articulated by the residents who have experienced the challenges and opportunities afforded through multidisciplinary research teams. They position the graduates of our programs in ways that ensure the exposure, the language, and the basic fundamentals of related programs are in place, allowing them to continue to look to the future with a clear vision and an ability to lead, collaborate, communicate, and conduct research effectively.

Fostering Research in a Canadian Radiology Training Program: A Residency Research Director's Perspective

16

Matthias H. Schmidt

16.1 Introduction

Radiology residents are required to assimilate a large volume of information over the course of a few short years. In addition, they need to develop perceptive and analytical skills crucial to the practice of radiology. This leaves them little time for other pursuits. Why should residents undertake research projects in addition to their clinical training? The practical answer, compelling to all Canadian residents, is that the Royal College of Physicians and Surgeons of Canada expects them to demonstrate the ability to conduct a research project (RCPSC 2004). Therefore, as residency research director, my immediate objective is to ensure that residents meet this expectation. However, there is a more philosophical answer that I find even more compelling. The Royal College's expectation is rooted in a broader set of beliefs that specialists in radiology should understand the importance of basic and clinical research to their specialty, critically appraise sources of medical information, and contribute to the development of new knowledge (RCPSC 2004). While every medical specialty, benefits continuously and visibly from advances in biomedical science, the close relationship between clinical practice and basic science is perhaps most obvious in radiology. A single scientific discovery, Röntgen's discovery of X-rays, marks the birth of our specialty, and ongoing basic and applied research since that day have made the ever-increasing power and sophistication of medical imaging possible (Kevles 1997). Radiologists have the opportunity to contribute to these technological advances. Meanwhile, a paradigm shift from "eminence-based" to evidence-based practice has taken hold in medicine, and the implementation of evidence-based radiology represents the next major challenge for our specialty (Blackmore and Medina 2006). Given the increasing complexity and cost of health care, and the increasingly central role of medical imaging within health care, it is imperative that radiologists base their practices on sound scientific evidence, and that radiologists spearhead clinical trials aimed at evaluating the impact of medical imaging

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on health outcomes (Hillman 2004). My ultimate objective, therefore, is to help residents understand the nature of research and the interdependence of research and radiological practice. It is my hope that all graduates of our program will practice evidence-based radiology and that many will make their own contributions to the advancement of our specialty.

16.2 A Proficient Resident Research Project

What is a good resident research project? The Royal College is not prescriptive with respect to the amount of time that residents should devote to research, the appropriate level of involvement of residents, the type of project to be undertaken, or indeed what constitutes a satisfactory endpoint. This gives individual programs considerable latitude in terms of setting expectations for resident research. I think that a good research project is one that can be completed within the time frame of a residency and, at the same time, one that meets the educational needs of the resident and scholarly needs of the program. It is important to remember that residents come to the program from many different backgrounds, and that their careers will follow different trajectories. Some residents embarked on their medical careers after only a few years of undergraduate study, while others completed graduate degrees in the physical sciences or life sciences before or during their medical training. Some residents plan to work in the community. Others are bound for academic practices at university centers. Consequently, a good project for one resident may not be a good project for another.

Research opportunities abound in all subspecialties of radiology, and fields of inquiry range from basic science to bioethics, health economics, and medical education. More important than the specific topic, in my mind, is the opportunity to learn about the research process. Residents should learn to identify important questions and to formulate testable hypotheses. They should learn to review and appraise the existing literature on their chosen topics and to decide what important questions remain unanswered. They should learn to design a sound study that has a reasonable likelihood of yielding statistically significant results, and they should work through the process of applying for funding and research ethics approval. They should collect and analyze data and synthesize their findings into a set of well-supported conclusions. Finally, they should learn about the peer review process and how to "sell" their findings and conclusions to an audience or a publisher. All radiologists benefit from a basic understanding of this process, and future academic radiologists especially need to practice these vital skills. Therefore, I prefer to see most residents conducting self-contained projects from start to finish. This approach generally limits them to small-scale projects, but it maximizes their learning experience. Sometimes, however, residents with extensive prior research experience may benefit more by contributing to ongoing, larger studies. For example, a resident with a background in community health and a focused interest in epidemiology may want to gain experience in the analysis of longitudinal health outcomes studies. The best way to do this might be to become involved in a study that has been underway for some time and is led by an experienced epidemiologist. In such a case, the mentor can make a point of reviewing and discussing earlier phases of the project with the resident.

Just as there are many potential subject areas for research, there are also many methodological approaches. I think that some research methods are more appropriate for resident research than others, based on learning opportunities and the likelihood of generating useful data within a reasonable period of time. For example, surveys, chart reviews, and meta-analyses can be good learning opportunities and can generate data in a relatively predictable fashion. At worst, the labor involved in such projects may be underestimated, necessitating an adjustment in the scale of the project. Case reports and descriptive case series might appear to be good resident research projects at first glance, because of their highly predictable nature. However, case reports do not qualify as research per se. Even case series offer little opportunity to learn about the research process, and they rank low in the hierarchy of evidence-based medicine (Oxford Centre for Evidence-Based Medicine 2009). Thus, I encourage residents to pursue case reports and series in the context of their clinical learning, rather than their research training. Laboratory research and clinical trials, on the other hand, might seem like the best way to learn about the scientific method. However, it should be borne in mind that laboratory research can be compromised by technical difficulties, and that clinical trials can be compromised by the vagaries of subject recruitment and retention. I recall, for example, a resident whose research project hinged on the recruitment of a large number of children for abdominal ultrasound examinations in the emergency department. Unfortunately, she was only able to recruit a small handful of children, due to the unpredictable timing of their emergency visits. Worse, none of the children returned for the required follow-up ultrasound in 1 month's time.

When can a resident research project be considered completed? In our program, presentation of a project at the annual departmental research day is considered a satisfactory endpoint, and a written report is not required. I favor oral presentations over written reports for two reasons: (1) Oral presentations allow residents to hone their presentation skills before a friendly audience; and (2) oral presentations showcase the residents' work to the department, serving as stimulus and encouragement to other residents and reinforcing the value placed on research by the department to all members. I strongly encourage residents to present completed projects at larger conferences and to submit them for publication in the peer-reviewed literature. This kind of wider exposure is obviously advantageous to the residents' careers, and it is also good for the department. However, recognizing the inherent limitations of time and resources available for resident research, I consider it something to strive for, rather than an absolute requirement.

16.3 Ensuring the Success of Resident Research

16.3.1 Responsibilities of the Program

There are a number of ways to ensure that resident research is completed successfully. First, the department has to set the stage for success by creating a research-friendly environment, investing resources and putting people in place to support research. Our department is fortunate to have a source of funding that allows us to provide seed grants to residents and faculty for small projects on a biannual basis. Financial support is also available for residents to present their work at conferences. We have a full-time biostatistician who, among other things, reviews all resident research projects prior to their commencement in order to ensure that the proposed methods are statistically sound. These encounters also provide an opportunity to educate residents about general statistical concepts, using their projects as a starting point for broader discussion. I have seen projects radically redesigned at this stage, for example when it became clear that the number of subjects required to answer the research question greatly exceeded the number of subjects that could possibly be recruited at our institution. Finally, research rounds in our department provide residents with another opportunity to seek feedback for their early works-in-progress. Here, fellow residents and faculty can provide constructive criticism and propose solutions to methodological problems. This can sometimes open new doors for residents who find themselves at a methodological impasse.

The appointment of a dedicated resident research director is another way in which a department can foster research. This role is distinct from the program director, who is responsible for the overall administration of the residency program, and the departmental research director, who is responsible for the administration of the department's intramural, collaborative, and contract research. In this role, I can work with the program director to ensure that residents receive high-quality instruction in research methodology and critical appraisal. I can argue for adequate time and resources to be allocated to research in the program's curriculum. I can also work with the departmental research director to ensure that residents are given every opportunity to become involved in the department's research activities. Finally, I can help residents to make wise choices with respect to mentors and projects at the beginning, and I can work with residents to help them stay on track.

All too often, resident research is expected to happen spontaneously in an academic radiology department. When it does happen this way, it is the result of a fortuitous combination of a motivated resident, an interested faculty mentor, and a project waiting to be started. However, the potential is great for residents to drift for a long time without a mentor or a project. I try to facilitate a good match between resident and mentor early in each resident's career. For example, a resident with little research experience or direction needs a mentor who will provide close guidance and a small, well-defined project. On the other hand, a resident with extensive research experience and ideas of his or her own might instead thrive under a mentor who is much less directive, but can offer valuable experience or access to databases, research facilities, and scientific collaborators. Of course, I do not discourage residents who come to me with specific mentors in mind. These residents have usually thought about their research interests and made good matches on their own. Regardless of the type of mentor, highly directive or mostly hands-off, I favor potential mentors who have an obvious interest in research and in resident education and who have a track record of completing projects with residents successfully in the past.

The next important choice that needs to be made early is that of a specific research project. Mentors can sometimes offer a selection of potential projects, each with its own unique appeal, and also with its own set of potential pitfalls. Obviously, it is crucial to avoid any project with a high likelihood of failure. I therefore meet with residents and vet their projects before they commence in earnest. In so doing, I draw upon a large personal experience of projects that have failed for many different reasons. For example, exploratory projects that ask too many questions, or poorly thought-out projects characterized by vague hypotheses and unclear objectives, can easily leave residents mired in large collections of data that are difficult or impossible to analyze. Some projects may be simply too large in scope or require too much background preparation to be completed within the time frame of a residency program. Research in basic science laboratories may require large blocks of time or unpredictable bursts of activity separated by relatively quiescent periods. This kind of ill-defined time commitment may work for a graduate student, but does not fit easily into a resident's rotation schedule. Projects that form a small part of a larger study may depend upon the success of the other parts. If so, they can be held up by inactive collaborators or other misfortunes beyond the control of the resident or the mentor. Truly innovative projects, involving the development of a new imaging technique or a novel application of an existing technique, can also be quite risky. For example, I recall a resident who wanted to use magnetic resonance spectroscopy, a technique he knew from his neuroradiology rotation, to measure choline noninvasively in the amniotic fluid of pregnant women, in the hope of being able to assess fetal lung maturity without the need for amniocentesis. After much preparatory work, he had to abandon his project when our basic science collaborators pointed out numerous methodological difficulties that he and I had failed to anticipate. Even now, I would not want to discourage a resident outright from attempting an innovative and ambitious project, especially if the project was the resident's idea. However, I would insist on early involvement of collaborators with the appropriate expertise and on the formulation of a good backup plan.

16.3.2 Responsibilities of the Resident

Staying on track is a major issue for residents, given the many competing demands on their time and attention. An early start helps. I meet with residents in the first year of their postgraduate training and encourage them to begin thinking about their research projects. I ask them to identify a potential mentor and a research question they would like to pursue. From there, I find it helpful to develop a timeline for resident research progress. This timeline is laid out in the form of a table, which I periodically update and use to track resident progress (see Table 16.1). Projects are divided into the following phases: (1) identification of a mentor

Table 16.1 Timeline for resident research progress by postgraduate year

Postgraduate year	Research question; mentor	Protocol; ethics; funding	Data collection	Data analysis	Presentation
1	X				
2	X	X			
3	X	X	X		
4	X	X	X	X	
5	X	X	X	X	X

and a research question; (2) development of a research protocol, submission of the protocol for ethical review, and application for funding; (3) collection of data; (4) analysis of data; (5) synthesis of findings and preparation of a presentation. Each phase is expected to take one academic year, more or less. However, the timeline is understood to be fluid, and delays can occur at any point along the way. Regardless, I find that timely completion of projects is very likely if residents stay somewhat within the timeline during the early years of their program. On the other hand, if a resident falls noticeably behind, this signals the need for an intervention, such as an application to the program director for dedicated research time, simplification of the project or, as a last resort, a new project. The final phase of the project is intentionally light. Our departmental research day is held in the fall, and senior residents present their completed projects at this time. Thereafter, in my experience, concern about the fellowship examinations, held in the spring of the following calendar year, displaces research from the minds of all but the most research-oriented senior residents.

16.4 Conclusion

In closing, I would like to emphasize that the only *sine qua non* of research is that one really has to want to do it. Funding, infrastructure, and protected time are all very important contributors to success, but they cannot substitute for the most important element – enthusiasm for research. If a department wants resident research to succeed, it has to convey the message to residents that research is valued. I try to impart my own enthusiasm for research to the residents. By advocating for continued departmental support, helping residents to make wise choices at the beginning and helping them to stay on track throughout their projects, I hope to ensure that every project gives satisfaction and a sense of accomplishment to the resident who completes it. Furthermore, I hope to ensure that every project fulfills its larger educational objectives of helping the resident to understand the nature of research and the importance of research to our specialty.

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Resident Recruitment and Selection 17

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17.1 Introduction

The quality of the resident recruitment and selection process makes a big difference for any radiology department. Selection and recruitment are among the most important activities of any organization. Bring great people on board, and the organization will tend to thrive. Bring the wrong people on board, and delivering the organization's mission successively will becomedifficult. The outputs of any organization, including a radiology residency program, hinge powerfully on the inputs to the program, and human resources represent perhaps the single most important input decision. Careful selection of the best resident applicants will strengthen the whole program.

17.2 Role of Residents in the Radiology Department

The success of a radiology department is impacted by its residents in multiple ways; it connotes far more than merely the program's pass rate in the American Board of Radiology examinations or the quality of fellowship and job placements its graduates obtain. In addition, the residents play an important role in helping to shape a department's work ethic, camaraderie, and morale. In many programs, the residents function as the glue that helps hold the department together, by providing constant interface between different sections and geographic locations. Beyond any particular department, the future for the field of radiology itself is powerfully influenced by the success of residency programs in attracting and selecting top candidates.

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17.3
Issues Surrounding Resident Recruitment and Selection

Yet, the topic of resident recruitment and selection has received surprisingly little attention, and many programs take this endeavor largely for granted (Green et al. 2009). They suppose that the current process has been developed over a period of decades, varies relatively little from program to program, and probably needs no improvement. We contest this view. To do something well, it is important to understand what we are doing and why we are doing it. Many programs would benefit from understanding in more depth the rationale for their current practices. Sorting and selecting candidates is one important reason to conduct interviews, but not the only one (Gunderman 2008). For example, interviews can also help departments to promote themselves to candidates and enable some faculty members to participate more fully in the activities of the residency program.

17.4
The Phases of Resident Recruitment and Selection

To help program directors, program coordinators, faculty members, and residents better understand the recruitment and selection process, we offer the following discussion of "dos" and "don'ts," or at least practices that we believe can make the biggest positive and negative differences. We do not intend to suggest that there is a "one-size-fits-all" approach, or that these considerations apply equally across institutions. Many additional factors, such as institutional culture, interests of key contributors, and available resources all deserve more attention. However, reflecting on and discussing these generic factors can help every program better understand itself and achieve its objectives.

We have loosely organized these factors as phases in the resident recruitment and selection process. It is important to consider each of these phases. The process as a whole can be likened to a chain, and no chain can be stronger than its weakest link. Getting six of these activities right but failing miserably at one can be as damaging as getting none of them right. For example, a poor interview experience can totally undermine a terrific website, thus compromising recruiting. Conversely, a program can do a great job of interviewing candidates but a poor job of reviewing their dossiers, thereby highly ranking some less desirable candidates while overlooking a diamond in the rough (Slone 1991).

The first such phase concerns the public image of the residency program. Are we making good use of electronic resources, such as the AMA/FREIDA (American Medical Association/Fellowship and Residency Electronic Interactive Database Access System) listing, the webpage of the program, and any additional information that is sent to prospective applicants who express an interest (Longmaid 2003)? This means not only keeping these resources up to date, but ensuring that they address the questions likely to be foremost in the candidates' minds. One such question is what strengths of the program distinguish it from other programs, for instance the quality and quantity of educational experiences for residents, and on-call responsibilities and teaching opportunities (Pretorius and Hrung 2002).

When applicants make poorly informed or misinformed decisions about programs, this hurts both the applicants and the programs into which they match or fail to match due to this poor information. A large proportion of the selection that takes place during interview and ranking season occurs not on the program side, but on the candidate side, when applicants try to determine which programs offer the best fit for their distinctive interests. There may be a risk in providing too much information, but in general, the stronger and more attractive the program, the more detailed the information it can afford to make public. By contrast, programs that provide applicants with little or no detailed information may raise suspicions in the minds of prospective applicants.

When selecting applicants for interviews, a number of characteristics need to be taken into account. These include evidence of medical knowledge (for which grades and test scores often serve as proxies), communication skills (as evidenced in the personal statement), past performance in clinical settings (as assessed by letter writers), the overall consistency of the candidate's performance (does the dossier hang together?), and evidence of leadership and/or creativity (such as research and/or service responsibilities) (Boyse et al. 2002). In general, people who have experienced difficulties keeping up with medical school are likely to experience similar difficulties in residency.

Another aspect of the application process that deserves attention is the frequency and intensity of contact between candidates and the program director, coordinator, and other faculty members in the department. Candidates who stay in touch and ask more questions may have a deep interest in the program. However, someone who inundates the program with minutiae may be indicating a high level of insecurity or a tendency to focus on details at the expense of the big picture. A slow-turnaround time on either side, applicant or program, may indicate poor time-management skills, questionable organizational skills, or simply a lack of interest.

The issue of salesmanship during the interview is an important one. To what degree does the program present itself enticingly to the applicant, and to what degree do candidates make their own best case to departmental interviewers? A program that makes little effort to make the interview experience an informative and enjoyable one for candidates may be placing itself at a competitive disadvantage compared to programs that present themselves well. Balance is needed on both sides. In some interviews candidates may have little to say, so that interviewers feel as though they are pulling teeth to get candidates to talk. In other cases, candidates may be so loquacious that interviewers feel they cannot get a word in.

From the program's point of view, it is important to pay close attention to candidates' interpersonal skills and habits (Altmaier et al. 1987). Do they make and maintain appropriate eye contact? Do they embrace the opportunity to make a personal connection by shaking hands, and learning the name of the person they are speaking with? Do they talk too much about themselves and their accomplishments, so that they come off as braggarts? Do they speak not only with the faculty but with residents and other applicants in a collegial tone? Their conduct toward nonphysician personnel is especially revealing. Do they ignore them or treat them with disdain?

The issue of follow-up correspondence is important. Do applicants send thank you notes to those they interviewed with? Do such messages demonstrate a real match between the interests and abilities of the candidate and the program's strengths? A program can distinguish itself from its competition if faculty take the time to write to candidates they interviewed, indicating how happy they would be to see the candidate train at their institution. Likewise, notes or phone calls from current residents conveying some details of their satisfaction with their program can be very powerful tools of persuasion.

In fact, the residents can be one of the most potent recruiting forces at any program, and it is important to invite their participation in the recruitment and selection process (Pretorius and Hrung 2002). Applicants who leave an interview where they never had an opportunity to interact one-on-one or in a small-group setting with residents may wonder whether the program has something to hide. Such an interview experience gives the impression that the program is so insecure that it does not want candidates interacting with residents in an unsupervised setting, where they might say something honest and unflattering.

Another pitfall is the temptation to play favorites, as when faculty, residents, or program staff are obviously friendlier to some applicants than others during the interview day. Even the applicants who receive special treatment may be justifiably put off by this, fearing that the program is dominated by favoritism. Something similar happens when programs make unfair selection decisions, taking a less qualified candidate over more qualified ones. Badmouthing the competition by deliberately disparaging another program shows a lack of professional judgment, which will leave a bad impression, and make program representatives who engage in the practice appear mean-spirited and insecure. The same can be said for leaking confidential information, which suggests that people in the program cannot be trusted.

When the time comes to rank candidates, it is essential to have good records from each interview day, so that those who make the final decisions know the impressions of those who interviewed the candidates. As applicants are reviewed prior to final ranking by the program, it can be very helpful to make their photos available, thus facilitating recall. When residents have enjoyed sufficient contact with candidates to form an impression, it is important to also take their input into account. The final ranking decision is often the work of faculty members, who have a great interest in ensuring that the program attracts first-rate learners.

Failing to get to know applicants, demonstrated by not calling them by name or failing to show any familiarity with their educational background, will tend to be interpreted by candidates as another indication of a lack of interest. After their interview is over, it is entirely appropriate for program representatives to provide some feedback on their level of enthusiasm, while being careful not to undermine the integrity of the match process. When such feedback is not timely, applicants may conclude that the level of interest in them is low. A final and obvious pitfall is a poorly organized and/or executed educational program, which inevitably suggests to applicants that the program regards education as a low priority.

When it comes to submitting rank lists, programs need to be wary of overconfidence of matching at the top of their list, by submitting a rank list that is too short. To be sure, every program would like to fill its positions by submitting a list only twice as long as the number of positions it has available, but such an approach can result in disappointment, leaving programs that could easily fill all their positions embarrassed and scrambling to reach a full complement of incoming residents. As a general rule, programs should probably rank most or all of the candidates they interview, with the exception of the few who were definitely disqualified by their interviews.

17.5 Conclusion

If radiology departments do an effective job of recruiting and selecting residency candidates, they will reap important benefits that extend beyond each resident's tenure. These benefits include higher-quality residents that fit well into the department and help to raise both the quality of its work and its level of morale (Gunderman and Jackson 2003). The spill-over benefits of great residents include an enhanced ability to recruit top residency candidates in future years, as well as enhanced performance and work satisfaction among departmental faculty and staff. Participating in resident recruitment and selection offers each of us the opportunity to build a brighter future for our program, the field of radiology, and the people who practice it.

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Building Capacity Within a Residency Program

18

Justin Amann, Teresa Van Deven, Kathryn M. Hibbert, and Jackie Windsor

18.1 The Chief Resident Role

The chief resident plays a critical role in the educational, administrative, service, and research mission of the residency program. As the future leaders in academic medicine, we felt it was prudent to nurture the leadership skills and capacities of residents in ways that would serve and support the health of the program both during their time with us, but also as they move forward into their professional lives. A review of past practices had revealed weaknesses. For example, in the selection processes, there was a lack of clear role definitions, eligibility criteria, a transparent selection process, training or support for the role, or even clearly delineated responsibilities. Despite the ambiguity, past chief residents have all succeeded in their roles and have provided excellent role models for our newer chiefs; however, the training committee decided that this was an area that could be strengthened. A goal was established to conduct a needs assessment and then to research and document a plan to address the shortcomings.

Our research revealed that our lack of attention to this area was actually quite common; few programs had clear processes, criteria, or policies in place. There also appeared to be conflicts between the ways in which the chief resident's role was conceptualized, compared to how it was carried out in practice. For example, developing leadership skills, learning management expertise, and influencing curriculum have been identified as the most dynamic parts of the chief resident's role; however, the pressures of administrative and scheduling duties seem to limit the educational role that the chief resident plays in reality (Norris 1990). We sought to explore ways to bring the ideal, closer to the reality.

In order to present a draft description of the role, eligibility criteria, responsibilities, and rewards, we first conducted a needs assessment of the program. Residents had expressed concerns about what the role entailed, how the selection was conducted, and what the benefits of

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participating in the process were. We surveyed several other Canadian residency programs across Canada and we had discussions with current and past chief residents to gather information about their concerns, struggles, and successes within the role. We positioned what we learned next to research conducted across radiology programs in North America, as well as drawing on practices within family medicine and psychiatry. Based upon this information, we generated drafts that we could come together and discuss, eventually agreeing upon a final document outlining the criteria for eligibility, responsibilities, rewards, and selection process.

The purpose of generating the document was to make the role, the process. and the expectations, explicit. We also decided to align the document with the CanMEDS competencies.

Criteria for Eligibility:

1. Strong academic performance (Medical Expert, Scholar, Communicator)
   (a) Strong clinical competence
   (b) Rotation ITERS all passes (no fails or borderline passes)
   (c) Annual ACR? OSCE all at or above par
   (d) Proven research and teaching skills
2. Demonstrated leadership skills, a role model for junior residents (Collaborator, Communicator, Health Advocate, Manager, Professional)
3. Strong attendance at all academic functions (Medical Expert, Scholar)
   (a) Visiting Professor
   (b) Research Day (Annual London Imaging Discovery Conference)
4. Strong communication/collaborator skills (Communicator, Collaborator, Professional)
   (a) Highly regarded by radiologists and residents
   (b) Well-regarded by referring clinicians (ER, ICU, Surgery, Medicine, etc.).

Responsibilities:

1. Member of Residency Training Committee
   (a) Voices/represents residents' interests
   (b) Assists in all aspects of program renewal
   (c) Provides resident input into all new decisions and policy discussions
2. Call
   (a) Scheduling, including holiday breaks
   (b) Arranging emergency coverage as needed

Liaison between residents and RTC faculty
   (c) Mentor/advisory capacity to junior residents
   (d) Feedback to Program Director/RTC about resident issues

Selection Committee
   (e) One or more of the Chiefs may help review the applications and interview (CaRMS and other) candidates

Assist with call preparation for PGY2s
   (f) Buddy Call planning and implementation
   (g) Impromptu call prep sessions, Thursday academic afternoon

3. Visiting Professor
   (h) Hosting/driving
   (i) Ensuring technical success

Rewards

1. Stipend – funded by hospitals
2. Experience (organization and leadership skills, team building)
3. Opportunity to affect program direction and improve resident education

Selection Process

1. Any resident interested must first meet eligibility criteria. At the year-end interview, the Program Director will review each resident file and inform the resident if he/she is eligible.
2. Most years, there are three or more eligible senior residents (PGY4-5, typically reached after 6 months of PGY4). If there are three, they all become chief by acclamation. If there are more than three, the residents choose the three Chiefs by Election (secret ballot).
3. In years where there are fewer than three eligible senior residents, the unfilled spots can be filled by residents from PGY3–4 cohort; interested candidates who meet eligibility criteria are to be elected by the residents in secret ballot.

The date of the resident election of the Chief Resident can be chosen each year by the residents in communication with the Program Director. The residents must all be aware of their eligibility status prior to this date.

Documenting the criteria, expectations, and process, signals to the residents that their interaction with referring physicians is valued; that their attendance at academic half-days is not only important for their own learning but also communicates to their junior colleagues a model of what is acceptable and expected. Generating explicit criteria for the role and the process creates a positive standard for residents. Research has consistently shown that when we articulate standards of practice, professionals rise to the occasion.

The next step we aim to address is the process for assessing and evaluating the chief resident performance and developing ongoing support and training for those who assume the leadership responsibility. We have come together as a planning team consisting of the program director, members of the residency training committee, and chief residents, faculty from the centre for education in Medical Imaging to create formative and summative assessment and evaluation tools for the chief residents' performance. Workshops planned over the summer academic afternoons focus on four pedagogical areas: Curriculum, Assessment and Evaluation, the CanMEDS competencies, and Mentoring. Residents and Chief Residents are recognized as important and influential teachers of medical students. They serve as role models and are identified by medical students as influential in their choice of specialties – both positive and negative.

Renowned educational reformer John Dewey championed "learning by doing" a century ago. He claimed: "What nutrition and reproduction are to physiological life, education is to social life. This education consists primarily in transmission through communication. Communication is a process of sharing experience till it becomes a common possession" (Dewey 1997). Although residents are expected to teach and evaluate students, few have had any formal teaching education and most radiology training programs do not have access to curriculum and pedagogical support. Recognizing this, we have expanded the support offered to faculty by the Centre for Education to not only include, but actively target residents (and chief residents in particular).

18.2 Radiology Call Preparation

18.2.1 Introduction

Preparation for call is of paramount importance to new PGY2 residents. The residency program provides this preparation in a variety of methods. These include the following:

1. Formal didactic lecture series (separate from Thursday afternoon academic half-day)
2. Rotations tailored toward providing skills and training required for call
3. Formal "buddy call" system
4. Objectives and expectations (included in this document)
5. Rookie call practice sessions
6. A precall exam, which the resident must pass prior to taking call

These points will each be documented in more detail below.

18.2.2 Formal Didactic Lecture Series

Based on our assessment of the key areas necessary to prepare PGY2s for call, a formal didactic lecture series was designed to ensure preparation of the following topics:

A–W workstation	Chest emergency	Spine trauma
Vascular topics	Peds cases	Obstetrics US
Body trauma	Ultrasound	Bowel
Abdominal, nontrauma	Emergency neuroradiology	CT head
CT or MRI	Head and neck emergencies	Facial and temporal bone trauma.

This year, new coverage of subtle stroke and missed cases will be introduced to augment topics covered in previous years. In the future, other radiologists will be invited to participate.

18.2.3
Early PGY2 Rotations

Residents start taking call responsibilities after participating in clinical rotations for 5 months. The 5-month rotation is tailored to preparing residents with the necessary skills and training required for call. They include 2 months of neuro imaging and 3 months of CT and ultrasound with a focus on abdomen and chest.

18.2.4
Formal Buddy Call

The "Formal Buddy Call" system is a new system built on an informal process in place in previous years. "Buddy Call" will be considered a part of the clinical rotations for the first 5 months of PGY2. The Chief Residents devise a schedule in which each of the new PGY2s will take between 6 and 11 weekday evenings, a couple of weekend evenings, and weekend days, increasing in frequency leading up to call. The PGY2 residents gain exposure to call through teaming up with more senior residents the months leading up to taking call independently.

Participating in "buddy call" provides:

(a) Exposure to common clinical scenarios that require urgent imaging (Medical Expert)
(b) Opportunities to learn to triage based on urgency of the clinical scenario (Medical Expert, Manager)
(c) Opportunities to learn correct scan protocols based on the clinical scenario (Medical Expert)
(d) Practice in developing communication skills for handling calls, interacting with technologists, patients, and referring physician residents and staff (Communicator, Manager, Collaborator, Medical Expert, Professional)
(e) An understanding of patient safety issues including radiation safety, contraindications to examinations, and alternate methods of imaging where appropriate (Medical Expert, Health Advocate)
(f) Knowledge of site-specific logistical details required to arrange and complete diagnostic procedures, and communicate these results per protocol (e.g., Rad Reports website) (Manager, Communicator, Collaborator)

18.2.5
Core Knowledge

It is expected that the PGY2 resident learns an appropriate amount of radiologic core knowledge that he/she will be able to begin call after 5 months. Radiology staff "back-up" is always in place, and there is also a second call resident who can be consulted. Each specialty area within radiology has a core knowledge base which must be learned during this time (Medical Expert).

The following is a partial list of acute imaging clinical conditions about which the PGY2 resident should be knowledgeable. This is not an “all inclusive” list.

18.2.5.1
Neuroradiology: Brain

Intracranial hemorrhage	Locations	Intraparenchymal
		Intraventricular
		Subarachnoid
		Subdural
		Epidural
	Causes	Trauma
		Aneurysm rupture
		Tumor
		AVM (arteriovenous malformation)
		Hypertensive
		Venous sinus thrombosis
Stroke	Recognize acute and subacute cortical and white matter infarcts	MCA (middle cerebral artery), ACA (anterior cerebral artery), PCA (posterior cerebral artery), Vertebro-basilar territories
		Hyperdense artery sign
		Hemorrhagic transformation
		Watershed infarcts
	Understand the role of CT and MRI in the workup of stroke patients	
Masses	Recognize masses	Intra-axial vs. extra-axial
	Understand principles of mass effect, midline shift, and herniation	Subfalcine, transtentorial, uncal etc.
Infection	Understand role of imaging in encephalitis, suspected brain abscess, and immunocompromised patient	
Hydrocephalus	Recognize ventriculomegaly, taking into account patient age	Presence of shunt, comparison with previous
Skull fracture	Recognize fractures, distinguish from sutures	
CT angiogram	Role in work-up of bleed, tumor, AVM (arteriovenous malformation), etc.	Carotid/vertebrobasilar dissection/injury

18.2.5.2
Neuroradiology: Spine

Trauma	Learn CT protocol, image review techniques for C-, T-, and L-spine fractures
	Learn the common types of fractures, mechanisms, and associated injuries
	Learn the imaging and clinical clues that would lead one to suspect neurologic or mechanical instability
	MRI of cord injury
Cord compression	Disk disease
	Tumor
	Abscess
	Hemorrhage
	Other

18.2.5.3
Neuroradiology: Head and Neck

Abscess	Retropharyngeal
	Parotid
	Submandibular
	Sublingual
	Submental
	Cervical
Facial trauma	

18.2.5.4
Chest

Trauma	Aortic arch injury
	Pulmonary contusion-laceration
	Bony injury
Pulmonary embolus	
ICU/sick patients	Miscellaneous questions (e.g., line placement)
Other	Pleural effusion vs. empyema
	Mediastinitis
	Esophageal perforation?
Vascular	Dissection
	Graft leak

18.2.5.5 Vascular

Aorta	Traumatic aortic injury (TAI) Dissection Aneurysm rupture
Peripheral arteries	Aneurysms, pseudoaneurysms
Deep vein thrombosis	

18.2.5.6 Abdomen

Trauma	CT of solid organ injuries, bowel, mesentery, ureter, bladder, etc. Contrast-IV, oral, rectal, bladder Delayed phase imaging for urinary tract injury Active bleeding from various sites
Iatrogenic	Postoperative abscesses, fistulas, bowel perforations Post-colonoscopy Post-gynecologic surgery-high suspicion for urinary tract injury
Infection	Colitis-pseudomembranous, infectious, ischemic Diverticulitis
Fluid collections	Simple vs. complex Intraperitoneal vs. extraperitoneal Blood, pus, urine, bile…
Inflammation	Pancreatitis Appendicitis Diverticulitis Liver infection, abscess Cholecystitis, choledocolithiasis, cholangitis, biliary obstruction Crohn's, ulcerative colitis
Urinary tract	Stones Hydronephrosis Complications of UTI (e.g., abscess) Renal/bladder trauma Occasional tumor bleed
OB/gynecologic	Ultrasound is mainstay Ovarian torsion Ectopic pregnancy Ovarian masses (cysts, hemorrhagic cysts, dermoid, tumors) Tubo-ovarian abscess, hydrosalpinx First trimester pregnancy (bleeding, dating, viability, ectopic)

18.2.5.7
Pediatric

Trauma	Role of CT vs. ultrasound Radiation dose issues in CT Scan protocols, technique varies with weight
Specific conditions	GI – intussusception, appendicitis, Meckel's, abscess, malrotation, bowel obstruction, Hirschsprung's GU – hydronephrosis, hydroureter MSK – hip joint effusion (ultrasound) Neuro – bleeds, seizures, hydrocephalus, trauma Child abuse – specific injury patterns

18.2.5.8
MSK

Fractures	Pelvis, knee, ankle, shoulder, elbow
Osteomyelitis	

18.2.6
Rookie Call Practice Sessions

These are educational sessions in which a PGY2 resident is given some mock call scenarios, with a staff radiologist and a senior resident observing. The PGY2 resident will field requests, protocol exams, and interpret clinical cases in a practice setting, allowing that resident to self-assess his/her own performance, and receive feedback from the staff and co-resident. These sessions will occur monthly, allowing the resident to build confidence and reflect on past performance. All CanMEDS roles are incorporated in these sessions.

18.2.7
Precall Exam

The University of Western Ontario Radiology Training Program Director collaborates with the radiology programs at McMaster, Toronto, Calgary, Ottawa, McGill, and Memorial in developing a precall exam. It is in an OSCE format, with nine stations, each lasting approximately 15 min. It tests anatomic and clinical knowledge relevant to call cases. Each resident must pass this exam prior to taking first call duties. A wide range of medical expertise required to pass this exam dictates regular reading and studying (see "Goals and Objectives" section, above).

18.2.8 Summary

This structured curriculum for call preparation provides each PGY2 resident with the skills and knowledge to comfortably approach call duties in a confident manner. Each resident is encouraged to take advantage of all other learning opportunities as well.

Call preparation at UWO was already a "strength" of the program, but these changes have strengthened it even further. Our residents have felt confident in their ability to deal with the demands of call, but are aware that they will sometimes need to call staff for assistance nonetheless.

18.3 Resident Selection Strategies

Our residents are selected through two routes: CaRMS and Re-entry pool. However, regardless of the route of entry, we decided it was time to reevaluate the process by which residents are selected. Previously, selection was made based on undefined criteria.

During this reevaluation process, we researched various resources; while recognizing that no one "human resource" book would be a perfect fit for any organization, we found Davila and Kursmark's (2004) book, "*How to Choose the Right Person for the Right job Every Time"* to be an extremely useful resource. The underlying theme is that the selection criteria should reflect the skills and attributes actually required to do the job. We have often struggled with designing interview questions; Davila and Kursmark suggest that the interview questions should ask the candidate what they have actually done in real-life scenarios and not just what they would do in hypothetical situations.

For us, the first step began with defining what the characteristics are for a good radiology resident. We recognized that the traditional criteria of publications, research projects, and presentations at radiology conferences were not always a good fit nor an accurate predictor of aptitude for radiology training. The preselection committee (consisting of the Program Director, the two Site Directors, and three residents) settled on what we thought were the characteristics of an "ideal" radiology resident. These were:

1. Intelligence (academic excellence, ability to learn, open-mindedness)
2. Work ethic (proven performer, initiative)
3. Radiology interest, aptitude
4. Communication skills
5. Team player (interpersonal skills, insight, confidence, knowing own limits)
6. Outside interests, experiences

These characteristics implicitly incorporate the CanMEDS roles, but we wanted to include all the CanMEDS roles in our selection process explicitly. To complicate matters, the application material that the Selection Committee receives from the candidates is not in a format that directly fits with either our own selection criteria, or the CanMEDS roles. The application material includes:

1. Dean's letter (rarely useful)
2. Reference letters (three or more – useful if a strong reference from a radiologist or any other physician, e.g., medicine, surgery, ER, ICU, family medicine, pediatrics, etc.)
3. Personal letter
4. Transcripts (undergrad, which include marks; med school, usually PASS/FAIL and therefore of little help)
5. Awards/scholarships
6. Ability to learn
7. Research/publications
8. Posters/presentations
9. Teaching – websites/files
10. Electives – in London, elsewhere
11. Technology aptitude
12. Jobs history
13. Teamwork (sports, performing, committees)
14. Volunteering

Some of these are not directly included in the application material and have to be teased out. We developed a weighting system that scored the various inputs according to our predefined criteria, and explicitly recognized the CanMEDS roles that we wanted to incorporate. This is summarized in Table 18.1, our CaRMS Applicant Worksheet:

The candidates who scored the highest in this preselection stage were invited for an interview. The interview process has been modified from previous years. We have traditionally had each candidate go through three 30-min interviews, where each group of interviewers asked nonstandardized questions. We recognized that this nonstandardized process leads to an inherent lack of reproducibility and possibly strong biases.

To address this, we selected a range of interview questions for each of the selection criteria and CanMEDS competencies we were seeking in any candidate. Each candidate was asked exactly the same questions, and their answers were scored on Table 18.2, a standardized form.

Their scores were all tabulated. In the end, we had a partially quantitative assessment for each candidate. When it came time to rank the candidates, we allowed for group assessment for a candidate's "fit" within our program, but the actual ranking of candidates was remarkably easy and without conflict when we looked at our quantitative rankings. We feel that the preselection criteria and the standardized questions allowed us to choose candidates in a more well-thought-out manner than in the past.

Table 18.1 CaRMS applicant worksheet

CaRMS Applicant Worksheet 2009

Candidate's Name:________________________; Med School:___________________ Year of Graduation:________

________Reviewer's name:_________________________________

		Intelligence (academic excellence, knowledge sponge, open minded/agile)	Work Ethic ("Proven performer", Initiative)	Radiology (interest, aptitude)	Communic ation skills	Team Player (interpersonal skills, insight, confidence, knowing own limits	Other (outside interests, experiences)
Dean's letter (ME, Col, Com, HA, S)	/2						
Reference letter #1 (ME, Col, Com, M, Sc, Prof)	/7						
Reference letter #2 (ME, Col, Com, M, Sc, Prof)	/7						
Reference letter #3 (ME, Col, Com, M, Sc, Prof)	/7						
Personal Letter (Com, Col, S, Prof)	/3						
Marks, undergrad **(ME, S, Man)**	/6						
Marks, Med School **(ME, S, Man)**	/6						
Awards/Scholarships **(ME, Sc)**	/6						
Ability to Learn **(ME, Sc, Com)**	/3						
Research/Publications **(S, ME, Col, Com, M)**	/7						
Posters and Presentations **(S, ME, Col, Com, M)**	/4						
Teaching – websites/files **(Com, M)**	/3						
Reference letter #4 (ME, Col, Com, M, Sc, Prof)	/2						
Reference letter #5 (ME, Col, Com, M, Sc, Prof)	/2						
Electives in London #1 (ME, Com, Col, S, Prof, HA)	/5						
Electives in London #2 (ME, Com, Col, S, Prof, HA)	/5						
Technology aptitude (S, Com, Man, Prof)	/3						
Jobs History (Com, Col, Man, Prof)	/10						
Teamwork (eg., sports, performing, committees (Col, Com, Man, Prof)	/10						
Volunteering (Col, Com, Man, Prof)	/2						
TOTAL	**/100**						

Electives (Radiology):_____________ ________________________ ________________________
Other___________________ ________________________

Red Flags:____

Other Comments:

London possibility ? : 1 2 3 4 5

18.4 Differentiated Instruction

In the educational domain, it is well-accepted and understood that learners come with rich and varied backgrounds, experiences, and abilities – what Luis Moll has referred to as "funds" of knowledge (Gonzalez et al. 2005). In professional educational contexts, and in particular, the elite professions such as medicine, there seems to be an expectation that learners are a homogeneous group. Perhaps this is in part because they have all successfully demonstrated their abilities to "do school" well; they have achieved high levels of performance in test-taking abilities and clearly are able to study and recall information for the exams required at most of the undergraduate medical school programs.

Table 18.2 Standardized form for UWO Radiology resident interview

UWO Radiology Resident Job Competency Interview Chart

Candidate's Name ____________________ Interviewer ______________________

Competency Category	Competency Name	Top Performance Actions / Proficiency Required	Score (Circle) 1 2 3
SKILLS			
Medical Expert Technical Knowledge and Skills	General Medical Knowledge	- Marks top 50% in class - Strong Rotation Evaluations - Clinical Reasoning/Judgement	1 2 3
	Anatomy	- Top 25% in Class - Applies knowledge clinically	1 2 3
	2D / 3D Visual Perception	- Understands imaging anatomy - Perceives abnormalities - Integrates 2D to 3D	1 2 3
Behaviours (Performance Skills)	Communicator	- clear talk with medical teams - relaxed, clear with patients	1 2 3
	Collaborator	- with other professionals - with technologists / RNs	1 2 3
	Scholar	- seeks knowledge / research - independent learner	1 2 3
	Manager	- efficient use of time - understands resource limitations	1 2 3
	Health Advocate	- concerned re: patient safety	1 2 3
	Professional	- conveys integrity - maintains standards	1 2 3
MOTIVATIONS			
Job Fit	Team Player	- Thrives in team environment - Contributes to team learning - Shares the common workload	1 2 3
	Technology Avid	- email, internet savvy - learns new systems easily	1 2 3
	Adaptable	- to program changes / evolution - ability to multitask	1 2 3

Added Notes:

When graduates enter a residency program, the set of skills demanded of them changes, often quite dramatically. The ability to simply recall information independently is supplanted with a need to apply the information in a constantly changing context, often under pressure or time constraints, in a peer group on the "hot seat" (i.e., at rounds), and with a level of sophistication that demonstrates an ability to think critically and communicate effectively. The student population has become more diverse in terms of age, gender, culture, and language, and yet the pedagogical response has remained constant. A single set of expectations for everyone to proceed through the program in the same way, at the same pace, with the same level of support does not respect the differences in our learners, and does not acknowledge the need for differences in our curricular responses. Let us think about this in medical terms:

Two patients present to an oncologist and after X-ray are assumed to have lung cancer.

Patient one	A CT scan confirms that the patient has a non-small-cell lung carcinoma. The patient is a young, female nonsmoker. The carcinoma is localized and limited to one lung. CT demonstrates that the patient has sufficient respiratory reserve. Due to the fact that: the carcinoma has not yet metastasized, it is only present in one lung, the patient is young and otherwise healthy, and she has sufficient respiratory reserve, the oncologist chose to use surgical intervention and remove the affected region
Patient two	A CT scan confirms that the patient has a non-small-cell lung carcinoma. The patient is an elderly smoker who ignored his pulmonary symptoms, shrugging them off as normal signs of old age. By the time the cancer is discovered, the patient is in Stage 3 as the carcinoma has metastasized. The patient has experienced significant weight loss. Due to the fact that: the patient is elderly, in Stage 3, and has experienced significant weight loss, the oncologist chose to use chemotherapy followed by radiation (not to be administered concurrently)

As a medical professional, the oncologist ultimately strives to choose the right treatment for each patient in order to see them recover as fully as possible.

To do this, the oncologist assesses the patients' individual cases	What type of lung cancer does the patient have? How much of the lung(s) is affected? Where has the cancer spread? How old is the patient and what was their general health like before the cancer? How has the patient's health been affected by the cancer?

The answers to these questions will determine which treatment option (from a series of possible approaches) will be the most affective for each patient. Therefore, it is entirely possible, as seen in our example, that two patients with non-small-cell lung carcinomas would be treated using different treatment approaches. If the oncologist chose to treat both patients using the same approach, without considering the patient's individual factors, which would affect the success of that treatment, we would probably consider the oncologist to be negligent. However, it is commonplace for educators to use the same teaching approaches for all students without considering which teaching strategy will have the highest success rate for each individual student.

18.4.1 Let Us Consider this Within the Context of the Residency Training Program

During rotation one day, three different residents are assigned to the radiologist on duty. The first resident, "Roxanne" has been previously identified as a highly gifted individual. She catches on and works at a very fast pace. During radiology education in undergrad medicine she mastered the radiology basics quite quickly and because she was so interested, decided to do research on her own, looking at case-based websites on the internet. She has very good background knowledge of basic radiology and is already very able to apply her understanding of pathology to imaging cases (HIGH READINESS).

The second resident, "Bill," also has a good handle on the basics as he majored in pathology and anatomy prior to med school which he completed overseas. He has no problems with his English, but it seems like sometimes "discipline-specific" words can be quite challenging for him. Bill is still working on mastering the skill of applying basic understandings of pathology to the images, but can usually handle the more basic cases quite competently. He often looks to the staff radiologist for help, when 50% of the time he does not really need to (MEDIUM READINESS).

The third resident, "Eloise," was always a successful student in undergrad as she has great memorization skills and has mastered the art of multiple choice exams. Now that Eloise is a resident, she has begun to struggle. It is not enough to just know the information, but now she has to take that information and apply it to images which all look completely different to her. She is overwhelmed about how to actually go about problem-solving cases. When asked to do a case presentation in rounds or work on a case in rotation half the time she does not even know where to start (LOW READINESS).

What would you do? Students with less readiness need help to understand where their knowledge, skills, or understanding may be lacking and more directed instruction, with more concrete steps and a concrete pace (Tomlinson 1999). For example, when the Radiologist running rotation for the day realizes that Eloise has less readiness he allows her to watch him for part of the day. By allowing Eloise to watch him, she is able to self-assess what it is that she does not understand. After helping Eloise to work through some cases out-loud, the Radiologist offers Eloise feedback as to what she needs to work on in order to increase her readiness. By working with her directly and walking her through the cases, the staff Radiologist is providing her instruction which meets her readiness.

18.4.2 Planning for Differentiated Instruction

The radiologists in our example have a clear idea of what is required to support the notion of differentiated instruction, but that is often not the case. Too frequently, "difference" is associated with "deficient" in some way, and the negative connotations can seriously limit the possibilities for effective practice. It is necessary then to build structures to help students and faculty identify the need, and initiate an appropriate response in the absence of a culture that is well-informed in the ways to differentiate instruction. A parallel process of support needs to be in place to educate faculty about the differences and shake the dominance of the "one size fits all approach."

As a Radiology Training Committee, we initiated a process whereby learner needs could be identified, either by the resident or the faculty, in order to trigger an assessment by the Centre for Education, that would lead to an educational plan targeted at addressing the specific needs identified.

Differentiated instruction process

Although there is a standard route in place for completing a residency program, there are times when circumstances or different needs compel a reconsideration of how a resident may participate in the program and demonstrate the requisite knowledge, skills, and attitudes. This document outlines a process for initiating a program of differentiated instruction.

1. *Initiation*: A request for differentiated instruction can be initiated through one of two ways (or both)
   (a) Referral: A physician serving in the role of the resident's supervisor may submit a referral to the Residency Training Program Director (see Appendix A)
   (b) Application: The resident may apply for a differentiated program (see Appendix B).
2. *Needs assessment*: Once a referral or request has been initiated, the Residency Training Program Director will consult with the Centre for Education to activate a "needs assessment." The needs assessment will include the gathering of both informal and formal assessment data to inform the generation of a Differentiated Education Plan (see Appendix C)
   (a) The *informal assessment* may include
      – Observation of resident during rounds, journal club, workday
      – Input from supervisors at previous and current rotations
      – Samples of resident research, teaching files, etc.
      – Interview with the resident
   (b) The *formal assessment* may include
      – Review of the resident's file from the Program Director's office, including all ITERs (In-Training Evaluation Reports), exam scores from annual ACR, OSCE and oral exams, and other documentation
      – Review of any ERB (Evaluation Review Board) documents (if applicable)
      – Review of the resident's CaRMS application
3. *Radiology training committee review:* Once a needs assessment is completed, the Centre for Education Faculty in collaboration with RTC Program Director and the Chair of Medical Imaging shall make a recommendation to either proceed to develop a Differentiated Education Plan, seek further information, or deny the request
4. *Differentiated education plan*: Based on the results of the committee review, Centre for Education faculty draft a differentiated education plan that is collaboratively developed with those responsible for implementing it. The plan will be monitored and revised as needed, and will be in place for a negotiated period of time

Appendix A: Department of Medical Imaging

Referral for Differentiated Instruction.

Date:		Training year:	
Name:			

1. Statement of The Problem
2. What are the resident's academic and clinical strengths?
3. What are the resident's academic and clinical weaknesses?
4. What interventions or strategies have been attempted already and with what result?

Referred by:	Role:
Approved for Needs Assessment:	Date:

Referee:

Resident:

Resident Training Director:

Appendix B: Department of Medical Imaging

Application for Differentiated Instruction.

Date:		Training Year:	
Name:			

1. Statement of The Problem
2. What are your academic and clinical strengths?
3. What are your academic and clinical weaknesses?
4. What interventions or strategies have you attempted already and with what result?

Approved for Needs Assessment:	Date:

Resident Applicant:

Resident Training Director:

Appendix C:

Differentiated Education Plan

Date:	Training Year:			
Name:				
Area of Program	Accommodation/Modification/ Alternative Program		Documentation of Progress	Date
	Expectations	Strategy		

18.5 Conclusion

Within our group, these were the issues that were identified as needing to be addressed in order to continue toward building capacity for our residency program. The Chief Resident plays a key role in the educational, administrative, service, and research mission of the residency program. While fully recognizing the excellent work of our past Chief Residents, we felt compelled to generate explicit guidelines in terms of the role, process of selection, and expectations for our future Chief Residents. The radiology call preparation is of paramount importance to new PGY2 residents. We recognized that in preparation for call, a variety of methods would be most useful: formal didactic lectures, formal buddy call system; rookie call practice, and a precall examination. As we worked through the process of designing this curriculum, we felt that providing residents with a structured curriculum would ensure that the residents would have the skills and knowledge to comfortably approach call duties in a confident manner. As we reviewed our resident selection process, we recognized that our previous selection process was based upon undefined criteria. After consulting human resource materials, we designed a set of interview questions, explicitly included the CanMEDS competencies into our questionnaire, and designed preselection criteria in order to allow us to choose candidates in a more well-thought-out manner. Our final area of focus this year has been on the issue of differentiated instruction. Residents are not a homogeneous group; the student population has become more diverse and yet there remains a single expectation for everyone to proceed through the program in the same way and at the same pace.

The Radiology Training Committee began to address the notion that often, "difference" is associated with "deficiency." We initiated a process whereby residents' needs could be identified so that an educational plan could be designed to address those specific needs in a way that both respects and supports differences in our learners.

These are the key issues we identified this year, and we will, as a group, venture forth with ways to continue to build capacity within our residency program.

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Philosophy in Radiology: The Ontological Challenge

19

Cesare Romagnoli, James A. Overton, and Rethy K. Chhem

19.1 Introduction

The seventeenth-century philosopher Gottfried Leibniz lived at the centre of Europe's great enlightenment. The fields of science, mathematics, medicine and philosophy were blossoming, and scientific societies were starting to publish their results to a growing international community of researchers. Even then Leibniz saw problems of confusion, miscommunication and inefficiency, and began dreaming of solutions. Today, we have powerful tools, beyond his imagination, but as fields like medicine have become increasingly globalized, we are faced with greater risks of ambiguity and miscommunication.

Leibniz is remembered by mathematicians for inventing the calculus independently of Newton, and by readers of Voltaire for his argument that *ours is the best of all possible worlds*. He is less well known as an inventor, but in fact applied his knowledge of the binary number system to the creation of crude mechanical calculators. Although he was limited by the technology of the time, Leibniz dreamed of a *calculus ratiocinator*, a machine for reasoning which could be used to solve all philosophical problems (Peckhaus 2004). The problems themselves would be posed and answered using a *characteristica universalis*, a universal formal language of concepts.

Leibniz' dream has never been realized, but fragments of it are familiar to us today. His *calculus ratiocinator* prefigures the Turing machine, which is the mathematical model upon which our vast infrastructure of information technologies is built. The twentieth century saw incredible advances in mathematical logic and in the understanding of formal and natural languages, which Leibniz envisioned with his embryonic thoughts about software.

The problems Leibniz sought to solve with these inventions were practical problems of organizing and communicating information. He was the curator for a library of more than 100,000 volumes and advocated the founding of scientific societies across Europe. Although

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Latin was still the universal language of learning, communication was slow and printing expensive. The nascent sciences were stymied by secrecy among researchers and difficulties defining and standardizing terminology.

Today, although we have tools at our disposal which Leibniz had only begun to dream of, we are faced with the same problems. How do we organize and communicate information effectively and unambiguously in a discipline like medical imaging, which is today at the linguistic nexus of all medical specialties? This ontological challenge must be fully integrated into the design of the radiology curriculum.

19.2 Universal Language

Leibniz' dream of a universal language in which all scientific, philosophical and mathematical concepts can be unambiguously expressed has been shown to be a mirage. Gödel's theorems may prove that it is impossible in principle, but the pragmatic difficulties alone are staggering. The failure of Leibniz' solution, however, does nothing to show that the problems he saw were not real and serious ones.

Medicine, like other fields, requires clear and precise communication. More than many other fields, the pace of communication is high and the stakes are life and death. Radiologists find themselves at the intersection of a multitude of different disciplines. Physicians of all sorts require medical images of their patients, which radiologists must capture and interpret before returning the results. Medical images are used to guide treatments and surgical interventions, and so the radiologist must communicate clearly with his colleagues to guide their work. The radiologist's position at the centre of a network of communication about diagnosis, prognosis and treatment makes him or her very sensitive to this topic.

Radiological training, practice, education and scholarship should reflect this need for clear and precise communication. Improved communication can serve to:

1. Avoid miscommunication
2. Facilitate exchange of information in research
3. Reveal the presence of bad habits, which can conceal miscommunication and misconception

19.2.1 Failures of Language

The following two simple examples demonstrate how communication can all too easily break down. The first is a case of a misnomer, and the second of a conceptual confusion. Osteoarthritis (OA) is an English term to describe the degenerative changes in joints. Unfortunately the suffix "itis" is widely used to indicate inflammation (such as "urethritis" or "pancreatitis"), which makes "osteoarthritis" a misnomer. Other languages use words with the suffix "ose" to indicate degenerative changes in joints, e.g. "osteoarthrose" in French or "artrosi" in Italian. However, the habit of using “osteoarthritis” is so strongly embedded in English clinical practice that it makes impossible any change despite the advice of experts in the field.

One might reply: “Yes, it is a misnomer. But as long as we understand each other, there is no problem.” The problem, of course, is not that there is a single misnomer. A single misnomer is just one exception to the general rule, and it is simple enough to remember a single exception. The problem comes when the misnomers multiply. Exceptions make teaching and learning more difficult. If we are trying to explain to a first year student the concept that “information” usually means excess fluid in the joint, while “degeneration” means lack of fluid in the joint, the misnomer “osteoarthritis” requires further explanation to clarify unnecessary confusion. Not only is it difficult for individuals to remember all the exceptions, but it is also difficult to write a computer programme which can account for all the exceptions. Simple rules with no exceptions are to be preferred.

Exceptions to the rule can be surprisingly complex. For instance, most exceptions are local, in the sense that they apply to a single hospital or community of physicians. In this way, they are like a local dialect. In order to communicate outside that circle, to the wider community, one must remember the *scope* of the exception, and which *ad hoc* solutions the different communities have settled on. As with natural language, local dialects are quickly dropped in favour of international vocabulary by professionals trying to communicate and collaborate.

As medicine becomes more global, these communication problems become more difficult. For instance, the European Union (EU) plans to implement electronic health records (EHRs) for its citizens by 2015 (Commission of the European Communities 2008). The EU includes 27 member states, with 500 million citizens, speaking 23 official languages. The problems of translating between these languages are daunting and cannot be avoided. But the difficulties of translating between the regional professional “dialects” of medicine can be reduced, and avoiding misnomers is one small positive step.

At other times there are problems of misconception. The progress of liver disease diagnosis and therapy has brought the need of a more detailed anatomic description of this organ, beyond the classical division of surface anatomy into right lobe and left lobe. This is called “segmentation.” “Couinaud” segmentation is a good example: it is reliable but a bit cumbersome to use. Couinaud segmentation describes eight segments defined by vessels and fissures inside the liver, numerated counter-clockwise.

A “simplified” version of segmentation describes medial and lateral segments either in the right or the left lobe. However, the medial/lateral dichotomy refers in anatomy to the distance from the midline of the body. The liver is not a midline organ, but a right-side organ. Thus we have the possibility of confusing statements such as: “a nodule in the medial segment of the left lobe is lateral to a nodule located in the lateral segment of the left lobe.”

19.2.2
Biomedical Ontologies

Although Leibniz’ dream of a single universal language is a false hope, progress can be made when the problem is more limited in scope. Biomedical ontologies are designed with precisely this goal in mind.

Historically, “ontology” is the science of being – the study of what is. Although it has an ancient pedigree in philosophy, the term has been adopted more recently by computer scientists and knowledge engineers. The first step in developing ontology is to select a *domain*. The domain often corresponds to an existing field or branch of science, so there are ontologies for anatomy, genetics, radiology, etc. The next step is to create a *lexicon* for that domain, which is a list of terms and definitions. In anatomy the terms include the various organs and tissues of the body, and in genetics the terms include genes, gene products, and cell processes.

A lexicon is an unstructured list, but it can be enriched by specifying *relations* between the terms. In anatomy the “part of” relation is key: the right lung is a part of the lower respiratory tract, which is part of the respiratory tract, which is part of the respiratory system, which is part of the human body. In other domains the “is a” relation may be more appropriate. Enriching the lexicon with this addition structure transforms it into a *taxonomy*. A taxonomy has a tree structure, starting at a general root, and branching into evermore specific terms.

An *ontology* is a taxonomy which has been enriched with more relations. Beyond the taxonomy’s “part of” or “is a” relations we can include adjacency, containment, location, participation, transformation and other relationships. The taxonomic tree is transformed into a network of related terms. Human beings can follow this network to learn more about terms and their relations, and computers can use the network to perform powerful search and analysis operations.

An ontology works best if it is limited to a particular domain. But if the ontology is created using best practices, such as those described by the Open Biomedical Ontologies Foundry (OBO), then it can be made to interoperate effectively with other ontologies.

The OBO library of ontologies includes a wide range of domains, but the various ontologies are designed not to overlap. Each is designed by a committee of experts in the relevant domain, and is strictly limited to that field of expertise. When terms from other domains are needed, it is possible to link the terms in one ontology to terms in other ontologies, creating a network of ontologies. So, while there is no single universal vocabulary for all domains, there are smaller vocabularies for each domain, and these smaller vocabularies are linked together in an extensible network. The creation of networks like this on such a large scale has only become possible with the arrival of the Internet.

Examples of the ontologies which are particularly relevant to radiologists include the FMA the DO and RadLex:

- The Foundational Model of Anatomy (UWSIG 2007) is one of the largest and most complete biomedical ontologies available. It contains over 75,000 anatomical terms, covering human anatomy down to the scale of cellular components. Examples include FMA: 9,600 “prostate,” and the terms for the parts of the prostate and its neighbouring organs.
- The Human Disease Ontology (Northwestern University Centre for Genetic Medicine 2008) parallels the structure of the FMA and describes diseases of various portion of the human anatomy. Terms include DOID:47 “prostate disease” and its children, including DOID:514 “prostatic neoplasms” and DOID:8634 “carcinoma in situ of prostate.”
- The Radiology Lexicon (RadLex) (RSNA 2007) is a controlled vocabulary developed by the Radiology Society of North America (RSNA). There are ongoing efforts to transform RadLex from a lexicon into an ontology (Rubin 2007), and to reduce its

duplication of other more comprehensive ontologies like the Foundational Model of Anatomy (Mejino et al. 2008).

The FMA is among the oldest biomedical ontologies at just 15 years. Most are much younger and less complete. We are still in the early stages of the development and deployment of biomedical ontologies. But the principles are sound and the benefits are clear. In the following sections we discuss how ontologies can help to improve both the practice of radiology reporting, as well as radiology education.

19.3 The Structure of the Report

As we have seen, an ontology is a network of terms from a domain. But a network of terms, no matter how rich, is just a vocabulary and not a *language*. Physicians and researchers communicate by talking with each other and by exchanging written documents. Having a network of ontologies to draw on is just one step towards better communication.

What is needed is to take a description of a medical problem and transform it through various steps into a solution. Leibniz' *calculus ratiocinator* was supposed to perform this task, and we do use computers for some steps in this process. But without stretching the analogy too far, we can think of a clinical report as a "machine" for transforming problems into solutions.

Most radiologists would agree about the basic structure of a good report:

1. Clinical information
2. Technique of examination
3. Description of findings
4. Interpretation of findings
5. Conclusion

At every step ontologies are useful for improving clarity and precision. But *different* ontologies will be useful at different steps, precisely because the report involves the progressive application of different modes of language with different goals.

During the seventies, the French neuroradiologist Auguste Wackenheim tried to understand the report by applying structuralist philosophy, much in fashion at the time (Wackenheim 1985). The key distinction he tried to make was between *sign* and *signified*. The sign is the mark or icon which appears to us, for example a region of brightness on an X-ray film.In itself, the sign does not mean anything. It is not until we attach a *significance* to the sign that it comes to have meaning. The bright region on the X-ray film could signify a tumour, which is not a mark or icon but a thing in the world.

Relationships between signs and their significations become so habitual that we often forget that there is a distinction to be drawn. We look at an X-ray film and we "see" the tumour. But this leap from mark to meaning can be too fast, and can lead to mistakes and miscommunication. The language of sign and signification emphasizes the often arbitrary character of the relationship. There is nothing intrinsic about the marks "Obama" on paper or a computer screen that make them refer to the man inaugurated as President of the United States of

America on January 20, 2009. That is solely a matter of history, context and convention. The relationship between a bright region on an X-ray film is not conventional in the same way, but it is still a complicated one, mediated by imaging protocols, elaborate apparatus and various laws of physics. There is plenty of room for broken links in this long chain, and yet the process is reliable enough that we move from sign to signification with hardly a thought.

Starting with the classical distinction between sign and signification, Wackenheim distinguishes the comment (sign) and the interpretation (signification). The comment is supposed to be completely free of interpretation. Ideally, we should be able be able to comment on the X-ray film without knowing anything at all about what the signs and the marks mean. He calls the comment the "invariable" part of the report and the interpretation the "variable" part of the report, because the second part can change with the addition of more (clinical, pathologic, historical,...) information.

Interpretation assigns meaning to the comment – it tells us what the marks on X-ray film are about. The interpretation can be

- normal (no disease),
- specific (the signs indicate a small range of possible diseases),
- a specific (the signs indicate a wide range of possible disorders,) or
- pathognomonic (the signs indicate a single disease).

And there are many interpretations that we can give, depending on our decision to be more general or more specific in what we say. Looking at a CT image displayed on a computer monitor, we may take a dark region in the image to be a sign signifying a:

1. Hypoedense lesion
2. Cystic lesion
3. Cystic tumour
4. Serous adenoma

These four descriptions are not equivalent. Each one says more than the one before – it commits us to more stringent conditions of truth. There are many possible causes of a hypodense lesion, but a cystic lesion is something more specific, and a cystic tumour is more specific still. If we operate and find a mucinous ademona then we were wrong to think it was a serous adenoma, but we were right to say that it was a cystic tumour. Saying "serous adenoma" commits us to more than saying "cystic tumour."

The philosopher Karl Popper discussed *falsifiability* as a criterion for demarcating between science and pseudo-science (Popper 1959). Astrology is not a science because horoscopes are impossible to falsify – the astrologer can always reinterpret the facts to fit the prediction in an *ad hoc* way. Astronomy is a science because it is possible for a hypothesis to be tested and found to be false. In other words, hypotheses in astronomy are falsifiable.

We can also think about degrees of falsifiability. Each of the descriptions above is more falsifiable than the previous description, because there are more possible circumstances which would show it to be a false description. We can also use the language of *information* – each of the four descriptions is more informative than the previous one, assuming it is true.

We can apply this approach to better understand the nature of a report. The first section with the clinical information is the necessary background information, which explains *why* the radiological procedure was performed, but says nothing about the details of the procedure or the results. The second section with the technique of examination explains *how* the procedure was performed, but not the results. The third and fourth sections describe *what* was found, but they do so in different ways. The third section describes the findings as signs – it *comments* on the results of the procedure. The fourth section draws conclusions by *interpreting* the signs and assigning them significance. Each section adds more information, in the sense that each section is more likely to be *wrong* (i.e. falsified) than the previous section, simply because it is saying more about the radiological procedure than the previous sections.

(Note that "more likely to be wrong" refers to being wrong *about the procedure*. Perhaps it is very likely that the clinical information contains some mistakes, but those mistakes will usually be irrelevant to the radiological procedure. An exception would be the case where a mistake in the clinical information leads to a very different interpretation.)

The distinction between sign and signification is an important one, but it should not be taken to be absolute. Many philosophers in the Circle of Vienna and the Logical Positivist movement held the view that there could be a language of pure observation, completely separated from any interpretation. Rudolf Carnap attempted in his 1928 *The Logical Structure of the World* to provide such a language, and failed (Carnap 2003). Later philosophers including Thomas Kuhn rejected this programme, and held instead that all observation is *theory-laden* (Kuhn 1962). While the Logical Positivists wanted to find a language stripped of interpretation in which scientists could make unbiased descriptions of their experiments and results, Kuhn replied that changes in theory mean that old observations must be completely reinterpreted in the light of the new theory. (Both extremes are problematic, and there are many more moderate views in contemporary philosophy of science.)

In a recent editorial in *Radiology*, Ferris M. Hall predicts that the radiology reports of the future will utilize "a more structured organization and standardised language" (Hall 2009). Ontologies are part of the solution here – they standardize language use, and the use of the right ontology for the right section of the report improves its structure. Proper use of ontologies will be a step towards each of Hall's objectives for the reports of the future, namely to "facilitate data mining, offer a more quantitative approach to quality control, be more uniform and user friendly for clinicians reading the reports, and, hopefully, reduce errors by interpreting radiologists" (Hall 2009).

In short, when writing reports radiologists should be aware of the degrees of interpretation they are giving to their observations. Different degrees of interpretation will require different terms and concepts. This requires, in turn, different ontologies. There are many deep and subtle issues here about the use of language, and these problems deserve attention in radiological training, practice, and scholarship. But there are simple steps which can significantly improve the quality and utility of radiology reports.

19.4 Applications to Education

While saying that reports are "machines" for translating problems into solutions is only an analogy, it is literally true that human beings transform problems into solutions. When faced with difficult problems, a great deal of domain-specific knowledge is required first to understand the problem, and then to find the solution. Radiologists are experts in the domain of radiology. But no one is born an expert.

The discussion so far may seem far removed from the questions of radiology education, but it is not. Communication is at the core of radiological practice, and also at the core of radiology education. The prerequisite for successful communication is sufficient understanding, but understanding can be perfect while communication remains opaque. Students of radiology need to learn how to practise radiology, which requires both understanding and communication. And teaching itself requires both excellent understanding and crystal clear communication.

There is an extensive literature in electronic learning on the application of ontologies. Ontologies are used to organize and search teaching materials, and to find and adapt lesson plans and learning designs (Knight et al. 2006). The RadLex ontology was originally designed as a lexicon for organizing teaching materials for radiology, and then extended to other purposes.

Ontologies have also been applied to on-line learning in fields like law (Breuker et al. 1999). Insofar as ontologies enhance the ability of computers to manipulate information within the domain, they also offer opportunities for improving computerized tutoring tools and on-line learning.

But our current interests in ontologies are more general than these applications. It is when ontologies become part of the shared language of medical discourse that they become truly effective in improving communication and understanding.

What does this mean in concrete terms? First of all, it does *not* mean that there should be a course in ontology added to the curriculum. Instead, ontological thinking should permeate the curriculum:

1. Course textbooks should introduce the relevant ontologies and use the terms from these ontologies consistently throughout.
2. Quizzes, tests and exams should use the standardized terminology of the relevant ontologies to ensure that students learn and apply the right words.
3. Problem-based and team-based learning projects should include assessments of student communication. Students will be more successful when their teams use standardized language, especially when their team includes students from other disciplines.
4. Each course should be *situated* with respect to the larger network of ontologies. Students should finish their courses knowing which part of the web of knowledge their learning encompasses and how this knowledge connects to their other courses, past and future. Ontologies make this task easier by making the connections more explicit, but only if instructors make the effort situate their courses in the wider context.
5. Departments should have a “language guru” – a person who has the most experience with ontologies, and who can help adjudicate difficulties. Different people could be the experts on different ontologies. And ideally these people will be in communication with the designers of the ontologies, to give them feedback in the fine tradition of open collaboration that most ontologies embody.

In sum, the process of education is about communicating an understanding of a domain of knowledge to students and helping them to learn. Ontologies are useful for improving both understanding and communication: first because they offer a structure into which knowledge can be integrated and second because they offer a standardized language for navigating through this structure.

Ultimately, student radiologists must become practising radiologists, faced with all the problems of communication discussed in the previous sections. They will have to learn to write and read reports with precise understanding. They will have to communicate clearly and concisely with their patients and their peers. Ontologies are a practical way to improve on both counts, and an education which is permeated with ontological thinking is the best way to create an expert radiologist who understands the value of precise understanding and communication.

19.5 Conclusion

Leibniz was at the beginning of modern science and medicine, but many of the problems he saw are still important today. Indeed, as medicine moves at an ever faster pace and becomes increasingly globalized, clear and precise communication only becomes more difficult and more important.

Biomedical ontologies offer one way to alleviate these problems, by defining controlled lexicons of terms and definitions, and by connecting them together in networks of relationships and larger networks of ontologies. Terms from ontologies should be used in medical reports. But in the different sections of reports, it is appropriate to use different ontologies because different degrees of interpretation are being given. Ontologies should also be used in medical education–not included as an afterthought, but when ontological thinking permeates the curriculum.

It may be objected that the solutions we propose are nothing new, that we are merely putting old wine in new barrels. To a certain extent this is true – we are only asking our readers to take a new perspective on long-standing problems of language and communication. We reply that the new barrels add a new flavour to the wine, focusing our attention of new things (Breuker et al. 1999).

But work on ontologies does more than this. Relatively simple changes like standardizing language use can lead to significant improvements. Recent successes in many fields of medicine show that care can be improved with the disciplined use of tools as modest as checklists. We should no longer doubt the concrete benefits which come from simple, partial solutions to difficult problems.

These deep and subtle problems of language use and communication also show us that there is a two-way street between radiological practice today and contemporary philosophy of science. In one direction, a better understanding of ontology and epistemology is likely to improve the reliability and effectiveness of radiological practice. In the other direction, the complexity of radiology brings with it many interesting examples for the epistemologist and philosopher of science.

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Practical Rules of Engagement: Responding to Learners Experiencing Difficulty

20

Salvatore M. Spadafora and John G. Fuller

20.1 In-Training Evaluation Guidelines

- All trainees must receive regular written in-training evaluations usually at the end of each rotation or educational block. When blocks and rotations are long in duration this should be at a minimum every 3 months. There should be an interim evaluation which occurs approximately midway. This is of vital importance as the appeals policy of most Universities will overturn a failure on process if no interim evaluation is provided to the trainee. A written documented interim evaluation identifying performance objectives that must be met by the end of the rotation or block is essential.
- Each evaluation should be discussed with the resident who will be given an opportunity to provide written comment on the evaluation. A copy of the evaluation should be given to the resident and kept in the resident's file. Again, a note of caution: failure to adhere to this may be the technicality that leads to a successful appeal.
- Trainees should sign the evaluation noting whether they are in agreement or not. Should the individual refuse to sign the evaluation, this should be noted in writing on the evaluation form with a copy given to the individual and the program director.
- Only completed evaluation forms or other documentation received by the program director and reviewed with the trainee in question should be used by the program committee and program director to evaluate performance and make recommendations. It is best to remember never to allow hearsay or other undocumented materials from entering into discussion or deliberations, including minutes of residency training committee meetings.
- In-training evaluations must be done in a timely fashion and should be reviewed with the resident. A copy should be given to the resident within 2 weeks of the end of the rotation (ideally).

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- Where appropriate, evaluation should be based on input from as many supervisors as is appropriate on each rotation. Where the trainee has had exposure to many clinical teachers, preceptors, and supervisors, the evaluation should not be based on the impressions of one single evaluator. Multiple methods of sampling should be used in the evaluation process. These include:
  - Observations of clinical activity
  - Formal examinations
  - Observations of performance and procedures
  - Other methods as appropriate
- The evaluation should provide feedback that is constructive commenting both on the trainees' strengths and weaknesses.

20.2 Appeal of a "Failure" of a Rotation

Once a failure has occurred and has been documented according to the guidelines above, the trainee will have the option of appeal. These policies and structures vary by institution and University. All programs are required to have a documented appeals policy by accreditation standards, and are required to ensure their trainees have this policy given to them at the beginning of training. It is also important to give the trainee the policy again at the time of the documented failure so they are aware of their options. You should document that this policy was made available to the learner in question, and that they are aware of their right to appeal the evaluation.

Appeals can be undertaken at three levels in most training programs. Locally, the resident may appeal to the individual program coordinator or supervisor of the rotation at the involved teaching site or committee structure in charge of residency training program (residency training committee – RTC). Usually, this local level of appeal can involve questions regarding the assessment of academic judgment or specific skills of the rotation or specialty. As well the aspects of training and evaluation that are not pertaining to medical expertise but to the domains of the CanMEDS Roles, and the ACGME Competencies can be addressed. The appeal at this level may involve the department or departmental chair, but it depends on the structure of the department. Whether the appeal is successful or denied, there should be documentation in a point-by-point manner for all levels involved locally (supervisor, RTC, or Departmental). The basis for support or denial of the appeal is essential. Local appeals that are not well-documented and result in denial generally should not proceed to the next level until such documentation is obtained.

This is essential as from this point forward the appeal mechanism is usually based on matters of process and fairness and not on the judgment of medical expertise. This may vary in some institutions; however, excellent documentation remains a sound practice.

Most institutions that provide residency training have a limitation placed on the time by which an official appeal must be filed. This time varies greatly, with as low as five business days, to as high as 6 weeks from the date that resident has known about the failure in writing. Although this has not been well-studied, a general observation is that the shorter the time to launch an appeal seems to lead to more appeals. Oftentimes, a longer duration of time allowed to launch the appeal leads to more learner reflection and understanding of the remediation process as a learning experience rather than a punitive process.

All appeals from this point on require a written statement from the resident outlining the rationale for the appeal along with the appropriate in-training evaluation. Other documentation from the individual and the department as requested should be submitted. Appeals at this level are usually to the office of the assistant dean or associate dean of postgraduate or graduate medical education. Although each institution varies, there is usually an appeal committee that exists in the school of medicine or institution sponsoring the residency training. From this point unsuccessful appeals go to the level of the dean of the faculty of school of medicine associated with the residency training and on to the overall University governing body (often Senate) of the sponsoring University. In some US programs this will vary, where programs are not sponsored by a University but by other structures such as a healthcare institution, system, or hospital. Accreditation standards in general, mandate that appeals mechanisms exist at all levels; however, few appeals go beyond the assistant or associate dean level.

20.3 No Appeal of Failure: The Way Forward

Once a failure has been recorded by a program with good documentation at mid-rotation and end of rotation, it is then reported to the office of education that oversees postgraduate or graduate medical education. In the case of Canadian programs, this is the office of postgraduate medical education which has an assistant or associate dean overseeing the operations of the office. Each institution has varying structures to deal with the failure and plan for remediation at this point. However, all schools tend to have some common themes that oversee the remediation or repeating of the rotation.

These common themes include:

- The rotation failed does not count toward credit in the training program enrolled in.
- The resident must undertake a remediation of the failed rotation in order to continue in the program. In some cases the resident continues to train in other rotations before undertaking the remediation of the failed rotation.
- The remediation process is often overseen by a dispassionate third-party committee structure that does not always include the assistant or associate dean.
- The remediation plan and process is well-documented in writing and includes sign-off from the program director, the body overseeing it, and the resident.

Our institution uses a third-party review board to oversee all failed rotations and manage all remediation plans and any probation periods. Locally, we refer to this committee as the evaluation review board (ERB). This third-party advisory board provides a mechanism to assure that residents with unsatisfactory evaluations, residents who require remediation or probation, and those who may be dismissed have an objective, unbiased process of adjudication which is standardized for all trainees in all programs at our institution. ERB has the mandate to review and approve all remediation, probation, and dismissal recommendations. The board reports directly to the associate dean, postgraduate education, and its meetings and recommendations are confidential. When the resident under consideration by the third-party advisory board is from the same division or program as a member (faculty and/or resident) of the board, that member will be excluded from all the deliberations and decisions involving that resident.

Many institutions use similar third-party oversight committees. In general, the membership of these should be broad-based and include representatives from all constituencies.

Locally our ERB consists of:

- Five faculty members appointed by the dean of postgraduate education, who are familiar with postgraduate medical education but are not program directors. In many instances these are retired program directors.
- One of the faculty members will be appointed Chair.
- Two resident representatives appointed by the local house-staff association.
- One resident representative appointed by the internationally sponsored residents at our institution
- The postgraduate administrative officer (ex-officio)
- The members should be from as many departments and programs as possible.

As outlined, an unsatisfactory evaluation or failure should be reported to the education office that oversees the residency. There is often a time line for this. In most but not all programs, this is required to be reported within 2 weeks of the notification of the resident in writing of the failure. Attention to process is important and avoids appeals that can be based on lack of compliance to local school policy. The resident's program must usually submit a written remediation educational plan for the resident to the PGE ERB within 1 month of the unsatisfactory evaluation. The remediation plan must be a customized formal program designed to assist the resident in correcting his or her specific deficiencies and should include appropriate clinical activities. A remediation must have a defined duration, generally from 1 to 6 months and reflect the duration of the rotation in which the failure or unsatisfactory performance occurred. The plan must clearly define the educational objectives and the means of evaluation of these objectives.

At our institution the ERB must approve all remediation educational plans before implementation. The ERB may mandate that a remediation plan be revised before it is implemented. Locally at the conclusion of the remediation, the evaluations and outcome must be reported to the resident and the ERB within 2 weeks and be approved by the ERB. Closing the loop is very important.

Generally, if the resident successfully passes the remediation, he or she then returns to the program as a resident in good standing. If the trainee is unsuccessful (i.e., fails) in the remediation, then a defined period of probation must follow.

20.4 Writing Remediation Plans

It is difficult to do well that which we do not do often, and remediation plans for unsatisfactory rotations definitely fall into this category. They can challenge even the most dedicated and experienced educators. We have found that a template works best in assisting program directors in completing this documentation that can assist all parties in remedying previously unsatisfactory rotations.

In general remediation plans should include:

- The duration of remediation that reflects the duration of the rotation failed
- A detailed summation of the residents' history in the program
- Specific rotation objectives not mastered, or below expectations
- Specific activities (both clinical and non clinical) to be completed to match the objectives not achieved
- A comprehensive approach to all domains (CanMEDS and ACGME Competencies) of training where performance was not up to expectations
- Detailed means of measuring the specific outcomes must be clearly stated and related to the specific objectives that were below expectations (constituting the failure) and be related to the rotation activities that comprise the remediation plan.

A sample template is attached in Fig. 20.1.

20.5 Probation

In the event of an unsuccessful remediation, the trainee will then be required to undergo a period of probation. A probation period is an educational program of defined length, generally 2–6 months, during which the resident is expected to correct identified weaknesses or deficiencies. All probations must have an educational plan. (The template above is useful in the development of this plan.) The residency program should submit a written educational plan for the probation period to the office that oversees resident education at their institution for approval.

The stakes are high, as probation is the step before dismissal of the resident. Documentation that is timely, clear, and detailed is essential. The plan should be submitted within 2 weeks of an unsuccessful remediation.

The probation plan must include the educational objectives, the means of evaluating those objectives, and the duration. These components are very similar to the remediation plan. Appropriate clinical experience should be identified in the probation plan. The outcome of an unsuccessful probation (dismissal from the program), as well as the expected plans upon return to the program if successful, must also be included. These two outcomes should be stated clearly to ensure that the learner understands the high-stakes nature of the probation. The learner will sign this plan and by doing so acknowledge that success will lead to continuation in the program and that failing to meet expectations will lead to dismissal. Dismissals are rare, but almost always involve some threat or form of legal action. Having your documentation complete and accurate will greatly assist you in justifying your course of action.

At the conclusion of the probationary period, the Dean's office or oversight committee must receive copies of the final evaluation and the recommendation of the program for approval.

Sample Remediation Plan Template
– developed by Dr. J. G. Fuller, MD, FRCPC (Fuller 2000)

Date: <Today’s Date>

FOR: < *Resident LAST NAME, First Name* >
< Training Program Name >
< Training Year >
< Dates of Failed Rotation>
< Proposed Start Date of Remediation *(pending the approval of the Committee)*>
< *Location of proposed Remediation Rotation* >

A. REQUEST OF RESIDENCY PROGRAM COMMITTEE TO Central oversight committee

- □ Remediation period of ______ months
- □ Probation period of ______ months
- □ OTHER:

B. BACKGROUND

1. Trainee Information & overall rationale

Dr. << First Name, Last Name>> is a currently a << Resident OR Fellow OR Other>> in the ?? year of the << Program>>.
The << Program>> is a << duration>> training program.

2. Training Profile

The overview of the training profile is outlined below:

- DATES (e.g. July 20??-June 20??)
  - << Year One >> OUTCOMES of training and evaluations
- DATES (e.g. July 20??-June 20??)
  - << Year Two >> OUTCOMES of training and evaluations
- DATES (e.g. July 20??-June 20?)
  - << Year Three >> OUTCOMES of training and evaluations

NOTES:

- *Append ITERS, FITER*
- *Other relevant evaluations, documents*

3. PGE:ERB Profile *(to be completed by PGE Office)*

Outline previous Committee actions for this trainee:

- □ Not Applicable
- □ Dr.<< >> was previously considered by the Committee
  - on XX with respect to << REQUEST>>.
  - on XX with respect to << REQUEST>>.
- □ On XX, the Committee decided
  - << OUTCOME>>.

Fig. 20.1 Sample remediation plan template

C. PLAN

4. Rationale

- *Identify the aspects of the Trainee's performance or behaviour that require remedial attention* (*i.e.* Provide a brief summary in narrative form that outlines the rationale for request.)

5. Purpose of Remediation/Probation Plan

- *Describe the proposed remedial education and the resources available to the Trainee;*
- *State the specific duration of Remedial Period;*
- *Define the expected outcomes of the Remedial Period and how they will be evaluated; and,*
- *State the consequences of a successful or unsuccessful outcome of the Remedial Period.*

Purpose of Plan

□ To provide a period of focused education to enable the resident to meet the *PROGRAM*>> Goals & Objectives for << *Residency Training Level* >>
□ To provide a period of focused education to << DETAILS>>
□ To undertake a focused assessment (e.g. learning disability, medical, psychiatric, communication skills, technical skills)
□ Other: << DETAILS>>

Specifically, the PLAN will focus on meeting the goals and objectives related to:

□ Medical Expert	□ Communicator
□ Collaborator	□ Advocate
□ Scholar	□ Manager
□ Professional	

(The above CanMeds Roles can be substituted with ACGME Competencies)

6. Details of Remediation Plan

CanMEDS ROLE	Goals & Objectives	Learning or Teaching Strategy	Evaluation of Achievement	Notes

<u>*NOTES:*</u>

- *Comment on who is the supervisor for the remediation plan*
- *Comment on who is/are the mentor(s) during the remediation period*
- *Other evaluation of remedial progress*

Fig. 20.1 (continued)

7. Outcome of Remediation

Upon successful completion of the remediation plan

- Dr. << >> would <<begin his residency training for PGY ***X***

OR

- Dr. << >> would have completed the PGY **X** residency training

OR

- Dr. << Other planned outcome>>

8. Development of the PLAN

- Comment on review of PLAN by the Residency Program Committee.
- Comment on review of PLAN by the Resident.
- Comment on Resident opportunity to meet about PLAN with Residency Program Committee.
- Comments on any extenuating circumstances the Committee/Associate Dean should be aware of.

9. Signatures

______________________________ ________________

Program Director Date

______________________________ ________________

Resident Date

Fig. 20.1 (continued)

The outcome of the probation should be communicated in writing to the resident and to all stakeholders usually within 1 week of the conclusion of the probationary period. Tension is usually high, so time lines are more important than ever. If the probation is unsuccessful, the resident will be dismissed from the program. If the probation is successful, then the resident will return to the program as a resident in good standing. The probation period will usually have to be made up and the resident's length of training extended accordingly.

20.6 Dismissal

Following an unsuccessful remediation and an unsuccessful probation, the program director may recommend dismissal and if approved by the Dean's office or an appointed oversight committee, the resident will be dismissed from the program.

20.7 Emergency Situations, Special Circumstances of Learners in Difficulty

Not all learners in difficulty are in academic difficulty. In cases of actual or suspected unprofessional conduct, negligence, criminal activity, or when patient care or safety is clearly jeopardized, a resident may be immediately suspended from clinical activity, with or without pay, at most institutions that are involved with training residents. In such emergency situations, the program director or delegate must usually notify the assistant or associate dean of postgraduate or graduate medical education and relevant hospital/clinic administrators in writing as soon as possible and generally within two working days of the incident. Immediate written notification has been expedited greatly with the advent of electronic communication. A meeting involving the relevant stakeholders (associate dean, program director, hospital/clinic chief or vice president, and other stakeholders where appropriate) should be held within 1 week to determine the appropriate plan and to communicate the plan to the resident in writing. The Postgraduate/Graduate Education Dean should notify the appropriate stakeholders, who may be asked to make an inquiry and recommendation to the dean of postgraduate/graduate education and the program. In most situations, other bodies (police, hospital committee, University committee structure, courts, etc.) may conduct the inquiry.

Most Provincial or State physician groups or associations have programs in place to deal with substance abuse, disruptive behavior, and other issues relating to professionalism breaches. These programs can be invaluable in assisting with assessment, management, and ongoing monitoring of learners who find themselves in difficulty. In Ontario, the physician health program of the Ontario medical association has such a program and works with postgraduate medical education offices in the six medical schools to assist learners in a variety of areas (Ontario Medical Association 1995). In Canada, a network of ten such physician health programs exists under the umbrella of the Canadian medical association (Canadian Medical Association 2001). The American counterpart is the federation of state physician health programs. A detailed listing of programs by state can be located on-line (American Medical Association 1990).

20.8 Summary

The majority of the learners in residency training programs meet expectations and fulfill the specific rotation objectives during rotations during training. The learner in difficulty challenges the clinical teachers, supervisors, and educators in a program to balance the individual learning needs of the trainee against the programs responsibility to maintain educational excellence. Passing learners that fail to meet expectations dilutes the accomplishments of successful learners and weakens the academic components of the residency and the department that hosts it. The need to document early and document often in a clear and factual manner is essential. Those in positions of administrative authority must educate themselves as to the local policies that govern failures and work with both trainees and the Dean's office to plan and execute an effective remediation plan. The best preparation for an appeal is attention to documentation and processes that are fair and transparent. These situations can be stressful for learners and those who supervise them. The process outlined and the contents of this chapter are intended first and foremost to help the learner and not a means to facilitate dismissal. Our role is to assist the learner in meeting educational goals wherever possible. However, where this is not possible, this process and documentation is prerequisite to dismissal of a resident from a training program.

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Epilogue

J. O' Sullivan

Where Do We Go from Here?

This volume delivers on its promise to offer a practical guide others can draw on when designing educational programs in radiology. From the development of learning objectives, to the design of curriculum and resources, through to the selection and retention of residents, the contributors bring fundamental theoretical and empirical principles in teaching and learning to life – in the service of radiology education. In doing so, they demonstrate the leadership and partnerships that foster a culture of reflection and research on teaching and learning and serve as wonderful examples for others to follow. I applaud them.

This book is about radiology teaching, but the issues addressed and the commitment to addressing them is important and timely in most areas of professional education. Many educators are faced with the questions tackled by these contributors. For example, how do we identify those candidates we want in our (teaching, nursing, occupational therapy) programs? What do we want our graduates to know and be able to do? How do we design programs that will enable students to develop those competencies? How do we know how effectively they are learning and how ready they are for independent practice?

There is relatively little research to guide us.

The professional education community needs to build a body of knowledge, a framework to guide program development and evaluation. Such a framework should be built on established theoretical and empirical principles that are foundational to teaching and learning across the professions. Importantly, that framework should incorporate and reflect findings and principles, not only across, but also between and within specific professions and teaching contexts. Building that framework is essential for advancing education in radiology and other professions. It is also essential for the continued development of theory and research about teaching and learning. Understanding how teaching and learning

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principles, often established in controlled experimental conditions, play out in real world contexts enriches and expands our body of knowledge. Through partnerships between researchers and practitioners from many disciplines, we will come to understand how variables such as the age, expertise, and expectations of the learner and the teacher, cultural and linguistic backgrounds, technology, and context (e.g., major teaching hospital or a nursing station in a remote community) interact to effect teaching and learning in the different professions. Findings from such research will in turn contribute to refinements in theory and to new directions in research.

The knowledge base in the respective professions is increasing rapidly as are the competencies expected of the next generation of professionals. It is our responsibility as academicians, practitioners, teachers, learners, and leaders to see that knowledge about how to teach is developed and applied in professional education at the same rate if not faster. There is much to be done and no time to be lost.

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