The teaching of radiology is mostly opportunistic and traditional which includes film sessions, journal clubs, lectures and research hour. Teaching of skills is a neglected area resulting in lack of confidence in the performance of procedures.

The benefits of e-learning are underutilized, although infrastructure in the form of computers and internet facility is available at most places. Reflective practice is another deficient area for faculty and residents. Mentoring is often non-existent for residents although many medical colleges have a mentoring program for students. There is little usage of standardized patients although applicable for teaching communication skills, ethics and counselling to the residents. The shortage of trained faculty results in non-supervision of residents in some procedures which results in a high complication rate. Small group teaching is not practiced and large groups result in loss of interaction. Feedback to the residents on performance is inadequate, sometimes due to a lack of time or understanding by the faculty.

**Background:** The recent advancements in digital imaging technology research on computer assisted instruction tools started in 1970. Radiology resident learning is shifting from traditional textbooks and journals to Internet and short case review books. The initial computer-assisted instruction in radiology was focused mainly on describing a new learning program or tool related to improvements in computer technology. A meta-analysis of research conducted by the U.S. Department of Education found that higher education students in online learning generally performed better than those in face-to-face courses. A major argument for e-learning is that it enables learners to develop essential skills for knowledge-based workers by embedding the use of information and communication technologies within the curriculum. Computer based teaching with case studies improves students' problem-solving ability in radiology.

Outcome-based learning has been adopted by the UK's Postgraduate Medical Training and Education Board (PMETB), necessitating revision to the structure of postgraduate training and assessment. Curricula and assessment methods need to be reshaped by Royal Colleges to meet these reforms. There is a problem of inadequate training and insufficient experience of skills. It has been found that 200 or fewer cases during the training period are not sufficient for the physicians to gain an acceptable level of competence in sonography. The residents mention inadequate training and undersupervision of procedures resulting in poor skills.

Learning outcomes should emphasize the knowledge, skills, attitudes and behaviors expected of those in training. Assessments need to be aligned with curriculum and must be fair, reliable and valid.

The mental activities involved in learning can be divided into four categories: (a) social interaction, (b) processing verbal and other symbolic information, (c) direct experience, and (d) reflection. Learning in real life usually combines activities from different categories and is always interwoven with the sociomaterial world. In contrast, traditional school learning tends to focus mainly on one type of activity, processing symbolic information.

Radiological Society of North America (RSNA) in 2005 convened 55 individuals, representing 15 organizations and some residents to discuss modern adult educational methodologies and to identify the implications for radiologic education and how radiologists learn. The recommendations were as follows:

1. Enhanced usage of web-based educational materials.
2. Development of resources to; (a) improve radiologic education by incorporating training to be a good educator, (b) training medical education researchers, (c) training residents in research and leadership, and (d) development of a curriculum for professionalism.
3. Applications of medical simulation to residency training.
4. Training radiologists for practice-based continuous quality improvement.
5. Exploration of communities of learners by testing models for creating virtual networks of radiologists with similar practices, interests, and learning needs and sharing of resources.

**Plan for improvement:** Radiology is extremely adaptive to change conventional teaching methods to computer-based instruction. An integration of computers with small and large group instruction allows optimal use of faculty is in conformity with andragogy theories and well

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accepted by students.\textsuperscript{15} Web-based learning is widely available, economical and accessible at all times and frequently updated. Effective evaluation of web-based material is required to maximize the benefit to the user: A method of evaluating radiological educational websites has been described.\textsuperscript{16} The evidence from the current literature in support of e-learning is overwhelming as mentioned above. The computer rooms in Radiology Department can be used for e-learning and CDs, DVDs with educational content can be provided. Internet facility is available and needs to be utilized in an appropriate manner.

The development of skills could benefit from Direct Observation of Procedural Skills (DOPS). Continual assessment, both formative and summative is the objective of ensuring clinical competence. DOPS is one such procedure that can have a role in formative assessment of Radiology Residents. It can be used to evaluate residents’ performance, provide feedback and identify areas for improvement.\textsuperscript{17}

Simulation can be used to train residents remotely from patients, in complete safety, reducing the risks of complications and represents successful adoption into the interventional radiology curriculum.\textsuperscript{18} Standardized patients can be used to teach communication skills, ethics and counselling to the residents.

A curriculum is an urgent requirement which should provide clear objectives for resident training. Teamwork at level of faculty and residents is conducive to learning. The residents can study topics of interest more deeply and develop expertise in certain areas. The tasks undertaken by residents should be challenging to arouse interest and concentration.

Faculty should be developed for mentoring and trained for being well versed in the latest concepts of teaching and learning. In comparison with one-day workshops continuing sustained programs, in which faculty has an opportunity to revisit teaching on multiple occasions, work most effectively.\textsuperscript{19} Mentoring is an important activity and faculty needs to act as mentors for the residents. The faculty development is also important as they are role models for the residents. Ethics is another area where the residents are influenced by observing the faculty. Formal teaching of ethics is necessary but residents learn a lot from faculty during daily routine work. A dedicated workshop for teaching ethics is essential and residents are to be encouraged to participate in conferences on ethics.

Reflection has been defined as “a generic term for those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to a new understanding and appreciation”.\textsuperscript{20} Reflection turns superficial learning into deep learning and log books with reflection transform into portfolios. The residents may be taught to develop capability for critical reflection as opposed to descriptive or dialogic reflection.\textsuperscript{21} Critical reflection takes account of the sociopolitical context in which events take place and decisions are made (roles, relationships, responsibilities, gender, ethnicity, etc.). Teaching reflective practice requires a workshop and provision of examples of reflection in the literature available. Maintaining a reflective journal is an extremely effective method to develop reflective Portfolio development with reflection as an integral part.

Feedback is important after formative assessments and should be built into the system to provide feedback during and at the end of rotation. Faculty needs to receive training for this activity and hopefully be able to provide an effective feedback to the residents.

Study guides are to be provided to the residents to provide additional cases and help in finding resources for learning. Peer assisted learning is to be encouraged with senior residents teaching the juniors. Radiographers teaching responsibility could be handed over to the senior residents.

The lectures can be improved according to Robert Gagne’s “Conditions of Learning”.\textsuperscript{22} They need to be interactive, stimulating and include assessment material such as images for interpretation and feedback on the interpretation may be provided during the session. Small group teaching based on the section of posting of the residents results in an individual attention.

**Implementation strategies:** Radiology educators should create awareness that excellent training and education for residents is in the best interests of the department and institution. Enhanced education can improve patient care outcomes and cut health care costs and complications. Professional arguments that teaching is a core activity and deserves to be done as best as possible must be understood by the faculty and administration. There is no point in undertaking a faculty development program if the institution lacks initiative and a commitment of time and money. Merely paying lip service to education can result in loss of motivation. The best time for implementation of the new strategies is at the start of the residency year. This requires a consultation with the residency director and coordinator and Chairman Radiology. The new strategies can be phased in after running a pilot and subsequent full implementation for all years of radiology residency.

Support from Dean, departmental chair and residency committee is vital for successful implementation of the new teaching methodologies. Barriers in implementation include faculty time as due to a rapid faculty turnover. There is a problem of availability of faculty to conduct training sessions and in curriculum development. The shortage of faculty can be compensated by development and training of all existing faculty members and recruitment of the graduating residents.
A lack of awareness of knowledge deficit, personal reluctance to change, ambivalence, and group mentality are significant barriers to positive educational change.23 The resources required include personnel and faculty. Faculty is required for facilitating training workshops and conducting discussions.

Table I summarizes the objectives, the current methods of teaching and learning as well as assessment. The proposed methods are mentioned with the expected outcomes and measurements of success.

**REFERENCES**


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<table>
<thead>
<tr>
<th>Objectives</th>
<th>Current methods of teaching and learning</th>
<th>Proposed methods</th>
<th>Outcomes expected</th>
<th>Measurement of success</th>
</tr>
</thead>
<tbody>
<tr>
<td>To use e-learning as a self-learning method and improve problem solving ability of the Radiology residents.</td>
<td>None</td>
<td>The computer room in the Radiology Department can be used for e-learning and CDs, DVDs with educational content can be provided. Internet facility is available.</td>
<td>Improvement in learning radiology and problem solving.</td>
<td>A comparison between residents introduced to e-learning and comparing with those not provided e-learning in initial stages. Pre and post-test of the residents.</td>
</tr>
<tr>
<td>To improve the procedural skills of the residents.</td>
<td>Opportunistic apprentice model</td>
<td>Use of Standardized patients. DOPS</td>
<td>Proficiency in performance of imaging guided procedures.</td>
<td>Comparison of complication rate prior and after applying new methods. Scores in DOPS.</td>
</tr>
<tr>
<td>Teaching communication skills, ethics and counseling to the residents.</td>
<td>None</td>
<td>Standardized patients. Ethics and communication skills Workshop.</td>
<td>Ethical practices and improvement in patient communication.</td>
<td>OSCE Patients’ complaints before and after new methods.</td>
</tr>
<tr>
<td>To develop mentoring for the residents.</td>
<td>None</td>
<td>Workshop for faculty.</td>
<td>Mentees professional development.</td>
<td>Enhanced performance by mentees in all activities after mentoring.</td>
</tr>
<tr>
<td>To develop a curriculum for the radiology residents.</td>
<td>Outdated</td>
<td>Team formation for development of outcome based curriculum.</td>
<td>Structure and organization in teaching and learning.</td>
<td>Measure whether the outcomes outlined by curriculum are achieved or not.</td>
</tr>
<tr>
<td>To help understand concepts and themes.</td>
<td>Traditional lectures</td>
<td>Improvement by interactive, stimulating and include assessment such as images for interpretation and feedback on the interpretation.</td>
<td>Improvement in routine work and better understanding of concepts.</td>
<td>Student achievement in tests and certificate exit exams.</td>
</tr>
<tr>
<td>To teach interpersonal communication skills and develop teamwork.</td>
<td>None</td>
<td>Small group teaching.</td>
<td>Deep understanding, self learning, problem solving and participation.</td>
<td>Improvement in presentation skills at various forums. Deep learning and better performance in procedural skills.</td>
</tr>
<tr>
<td>To develop study guides.</td>
<td>None</td>
<td>Team for developing study guides.</td>
<td>Provides additional cases and help in finding resources for learning.</td>
<td>Improvement in image interpretation in film sessions and routine daily work.</td>
</tr>
</tbody>
</table>


