



Adult Learning Principles for Effective Teaching in Radiology Programmes: A Review of the Literature

Formation Médicale: Les Principes D'apprentissage De L'adulte Pour Un Enseignement Efficace En Radiologie : Une Revue De La Littérature

R. A. Arogundade

Abstract

BACKGROUND: Adult learning processes of acquisition of new knowledge, behaviours, skills, values or preferences generally occur as part of personal professional development. There is need for radiology residency trainers to understand the basic adult learning principles for effective teaching processes.

OBJECTIVE: To review the different adult learning styles, learning theories and educational practice as a guide for radiology residency trainers.

METHODS: Literature materials from journals, web articles and reputable textbooks in the last 20 years on adult learning principles in general and radiology in particular were reviewed.

RESULTS: Most medical educators, including radiologists, lack appropriate formal training background in educational practice. The adult residency trainee brings to the learning environment high quantity and quality of experiences and some amount of control. Connection of this rich adult experience base to the learning process requires facilitation and motivation by the radiology educator, who must be familiar with the use of appropriate learning theories and educational practices.

CONCLUSION: there is a general agreement about the content of good practice in adult education but a definite comprehensive list does not seem to exist in the literature. Nonetheless, understanding of the basic adult learning principles would aid the concept of guided training, where the adult residency trainee shoulders the bulk of the training responsibilities of acquisition of knowledge. *WAJM 2011; 30(1): 3–10.*

Keywords: Adult Learning Principles, Teaching, Radiology Residency, Review

RÉSUMÉ

CONTEXTE: Les processus d'apprentissage, des adultes, pour l'acquisition de nouvelles connaissances, de nouveaux comportements ; de nouvelles aptitudes, valeurs ou préférences font généralement partie du développement professionnel de tout individu. Il y a un réel besoin pour les encadreurs des résidents de radiologie à comprendre les principes de base de l'apprentissage des processus pour une formation efficace.

OBJECTIF : Revoir les différents modes d'apprentissage des adultes, les théories et pratiques de la formation comme un guide pour les formateurs des résidents en radiologie.

METHODES : Il a été effectué une revue de la littérature des 20 dernières années, à partir des journaux, articles des sites web et des livres de renommée portant sur les méthodes d'apprentissage des adultes en général et en radiologie plus particulièrement.

RESULTATS: La plupart des formateurs médicaux y compris les radiologues manquent d'expérience et d'entraînement dans la pratique de l'enseignement.

Le stagiaire en résidence de radiologie amène avec lui dans l'environnement de formation une grande expérience de qualité et une certaine maîtrise. L'intégration de cette riche expérience de base de l'adulte au processus d'apprentissage, nécessite des capacités de facilitation et de motivation imprimées par l'encadreur radiologue qui doit être familier des méthodes appropriées d'enseignement théorique ainsi que de ses applications pratiques.

CONCLUSION : Il y a un consensus général sur le contenu des bonnes pratiques éducationnelles pour l'adulte ; mais une liste exhaustive bien précise n'apparaît pas encore dans la littérature. Néanmoins, la compréhension parfaite des principes de base des méthodes d'apprentissage pour l'adulte aiderait au concept d'entraînements dirigés, là où les stagiaires résidents adultes endossent la plus grande part des responsabilités de formation pour l'acquisition des connaissances. *WAJM 2011; 30(1): 3–10.*

Mots-cles: Principes d'apprentissage pour adultes; enseignement; résidence en radiologie; Revue

INTRODUCTION

The process of learning is an inherent ability of man, which involves acquisition of new knowledge, behaviours, skills, values and preferences.¹ It may occur as part of education or personal development, such as in the attainment of consultant position, through a specialty-based postgraduate medical training.

Over the years, child and adult learning processes have been regarded as two completely separate outcomes of teaching, which have become opposite ends of a continuum, describing the extremes of interactions occurring between a teacher and students.^{2,3} What separates these two processes on the continuum is the quantity and quality of experiences the learners have when they enter the learning experience and the amount of control that the learners have over the learning process and environment.³ Malcolm Knowles, the recognized father of adult learning theory, identified andragogic or learner-centered model to describe the study of adult learning, while pedagogic or teacher-centered model is concerned with how a child learns.⁴ Compared to children and adolescents, adult learners have special needs and requirements that form the basic learning principles peculiar to that group. Understanding these principles of adult learning may assist teachers to become effective facilitators of learning.

Generally, most medical educators, including radiologists, lack appropriate formal training background in educational practice.^{3,4} The stimulus for teaching in such circumstances has largely evolved from watching other experienced educators in action. Adoption of this empirical approach to teaching may hinder progression of radiology education in tandem with the latest developments in educational practices.

Recently, in May and October 2009, the Faculties of Radiology of the National Postgraduate Medical College of Nigeria and the West African College of Surgeons, organised workshops aimed at equipping radiology residency trainers and examiners with examination-related and educational information. This review article represents a follow-up to these

workshops with the aim of reaching out to wider faculty members. Knowledge of the different adult learning styles contained herein would guide radiology educators to design characteristic adult training instructions.

This article reviews the science of adult learning and the basic principles, the major areas of research on adult learning, the learning theories and educational practice.

METHODOLOGY

This review study started off from the inspiration derived from two “Train-the-Trainers” workshops organised by the Faculties of Radiology of the West African College of Surgeons and the National Postgraduate Medical College of Nigeria in 2009. The workshop handouts and suggested references provided the foundation scientific resource materials for the study. Further literature materials on medical education and relevant behavioural science were obtained using Medline and Google search engines. Recognized web sites were accessed; the web addresses and dates of assessment being appropriately noted for referencing purposes. Reputable medical and radiology-related journals and textbooks on adult learning principles were also consulted through the internet. These covered principally publications within the last 20 years from 1990 to 2010, except in about four cases which fall within 1970 and 1987.

Information retrieved from the resource materials included the historical perspective of adult learning, definition of the learning process and the characteristics of the adult as a learner. Other details extracted for the purpose of this review exercise included the role of motivation in learning, the various existing learning theories, educational practice methods and the influence that learning theories may have on the concept of evidence-based radiology practice.

A quick internet search for scholarly articles using the expression “Adult learning principles 1990–2010” resulted in 1481 websites (<http://www.medline.com>), out of which the 30 articles referred to in this review were selected. Literature evidence showed that research on the

concepts of adult learning dated back to over a century and half, but Malcolm Knowles synthesized the available overwhelming number of concepts into an organised theory. There is general agreement about approaching adult teaching in a different way from that of a child, because the adult learns with different styles. This agreement is encapsulated in certain basic learning theories and principles in the discussion that follows.

Concept of Adult Educational Principles in History

In the domain of philosophy, a principle is considered the beginning of an action. The action of designing a course, a seminar or a workshop for the adult learner, for instance, helps to establish informed decisions of teaching and learning, which are referred to as educational principles.⁵ Such principles form the basis of setting the educational expectations, understanding of adult learning styles and possibility of solving problems through discussions.

Malcolm Knowles is considered the “father of adult learning”, although the topic has been traced to the discussions and researches of over a century earlier.⁶ In supporting his opposition to the view that adults are unable to learn, Knowles specifically stressed the rapidly accelerating pace of change in the society for which youth-acquired skills tend to become outmoded by new technologies.⁴ Knowles may not have invented most terms and concepts of adult learning principles; he was believed to have been the first to put them together into an organised theory.⁷ The premise of such theory in practical terms is the overriding priority of processes over contents when educating or training an adult.

Additional theories of adult learning have been developed since Knowles’ time to help improve understanding of how and why adults learn. The sheer number of these learning theories is overwhelming, but there is a great deal of agreement about what constitutes good practice in adult education as may be seen in the sections that follow, which have been developed by synthesizing information that appears in the consulted references in this review.

The Process of Learning

The most plausible of all the many definitions of learning is that given by Argyris,⁸ which states that “learning is not simply having a new insight or a new idea but a process occurring when we take effective action, when we detect and correct error”. The process of adult learning is thus aimed at changing the way he or she interprets and judges events, and ultimately the resultant response and reaction to daily life challenges. Linking learning to a change is, therefore, considered the key facet.

There are several steps in the learning process, some of which lead to change. The preferred place to start the learning process for appropriate change, according to Fosnot,⁹ is by taking a current action that directly involves the learner, who brings the required ownership and interest to engage in the process. But action by itself has been said not to imply learning because it is possible to develop skills and expertise through plain repetition and practice, leading to an implicit or tacit knowledge.^{10,11} This type of knowledge is the heart of many decisions based on “intuition”, when individuals learn without awareness and inability to explain or express in words. “Intuition” guides us in a direction that ends up being less successful because such knowledge cannot be controlled, shared or transferred to others. Conscious learning process represents the more beneficial knowledge with the attendant change.

In contrast to intuitive or tacit knowledge, building a conscious learning is based on knowledge and ideas emerging only from a situation from which learners are able to extract meaningful and important experiences through the process of reflection. Principle of reflection on an action and the impact on learning has been researched by Ribeiro,¹² who concluded that the knowledge every adult learner brings into the learning process will be challenged when new experience shows that the knowledge is not applicable or cannot explain a result or event. The learner will have to reflect on the event, describe and explain it with personal frameworks for this challenge to be consciously perceived. The instructor,

acting as a learning facilitator, can invite the learner to talk about such event, focusing on observation, description of event in own words, and reflection on the thoughts of the event and the possible feelings the event may generate in him or her. The entire scenario describes a process that can increase in depth, going from mere cognition to metacognition; from being aware of what happened to developing awareness of how their frames, thinking patterns and assumptions, and values condition interpretation of what happened.¹²

The Adult as a Learner

Despite the plethora of journals, books, and research conferences devoted to adult learning across the world, we are far from a universal understanding of adult learning. Brookfield¹³ argues that any attempt to construct an exclusive theory of adult learning is a grave error, because he believes the variables of culture, ethnicity, and personality assume far greater significance over learning than does the variable of chronological age.

Nevertheless, understanding the best learning characteristics for adults is a critical requirement of an effective instructor. The field of adult learning was pioneered by Malcom Knowles, who identified at least four crucial assumptions about the characteristics of the adult learner.⁴ These include the assumptions of active and self-directed learning, experiential learning, relevancy of learning and goal-oriented learning. Indeed, several researchers have made important contributions to more than one of these areas. Taken together, these areas of research constitute an espoused theory of adult learning that inform how great many adult educators practice their craft.

Self-directed Learning

Adults are considered as autonomous and self-directed, but not all possess these attributes in equal measure. Self-directed learning focuses on the process by which adults take control of their own learning, which implies that maturity of adulthood overtakes the dependent personality of childhood.⁶ This provides opportunities

for the learner to identify problems, pose questions and explore solutions. Wilkerson *et al*⁶ stressed that teachers must be seen to act only as facilitators and guidance of the knowledge of the adult learner rather than dispensers of information.

There have been criticisms of this passive method of adult teaching and learning considered to be unproductive. Brookfield¹³ argues against the uncritical emphasis on self-directed learning as an adult characteristic. In his opinion, issues concerning the quality of such learning project were being ignored, since it empowers the adults to take control of their own learning, including learning goal setting, appropriate resources location, decision on which learning methods to use and evaluation of their progress. Another argument in the South African adult educational experience sees self-direction as firmly in the tradition of emancipatory adult education.¹⁴ Whichever argument is put forward, it is obvious that the “ultimate goal of education is for learners to learn well rather than the educators to teach well”⁴, which points to the concept of guided training for adult residency trainees, who must shoulder the bulk of the training responsibilities of acquisition of knowledge.

Experiential Learning

Another of the assumptions of adult education is the emphasis on experience as a defining feature of adult learning. Lindeman expressed adult education as “a continuing process of evaluating experiences” and that “experience is the adult learner’s living textbook”.¹⁴ Maturity culminates in accumulation of growing reservoir of life experiences that become an increasing resource for learning. Adult learners need to connect learning to this knowledge and experience base with facilitation of educators, who help to draw out these attributes relevant to the engaging instruction.²

Two discernible pitfalls have, however, been identified from the exclusive reliance on accumulated experience of the defining characteristic of adult learning. The first is that individual past experience is generally

culturally framed and shaped. Secondly, the quality or length of experience is not necessarily connected to its richness or intensity.¹³

Relevancy in Learning

Relevancy in learning is one of the major keys to learning for people of all ages. There is a growing opinion that new concepts should not win a place in the curriculum unless they are relevant and contribute to practice.² As a person matures, his readiness to learn becomes oriented increasingly to the developmental tasks of his social roles. This relevancy-oriented characteristic of the adult learner implies that learning must be applicable to the learner’s work or responsibilities to be of immediate value. In other words, the learning concepts must reflect familiar settings and interests of the learner.²

Goal-Oriented Learning

Adults are generally said to be goal-oriented to learning. This type of learning process involves time perspective changes of a matured person from one of postponed application of knowledge to immediacy of application. Accordingly, the orientation of the adult toward learning shifts from one of subject-centeredness to one of problem centeredness.⁶ In this circumstance, early classification of goals and course objectives is beneficial to the learning adult, who must appreciate an educational programme that is organised with clearly defined elements. Setting learning goals demonstrates an intention to achieve, which in turn activates the learner’s activities toward the goals, offering an opportunity to experience success. Educators must be skilled in assessing a learner’s readiness or progress toward goals because learners sometimes have unrealistic notions about the task to accomplish or possibly do not understand the depth of skill precision or depth of knowledge to master such skill.¹⁵

Motivation as Catalyst for the Adult Learner

Motivation, an important part of human psychology, concerns the process of activating, maintaining and directing

behaviour toward a particular goal. As a learning characteristic, motivation is not amenable to direct observation, but its presence can be inferred by the educator as a learner, works toward certain goals allowing predictions to be made about a learner’s behaviour towards learning.¹⁶

Learner motivation naturally has to do with the desire to participate in the learning process and concerns the goals that underlie involvement or otherwise in academic activities. Although, students may be equally motivated to enroll in radiology residency training programme, the sources of their motivation may differ. A resident doctor with poor basic and clinical medical background, whose attraction into radiology is purely due to computer technology, may get frustrated in the long term during training. On the other hand, adult learners who are motivated genuinely into learning by Abraham Maslow’s theory of self-actualization, which is the desire to develop one’s potentialities to the fullest and that of achievement motivation, which inspires the need to attain increasingly higher level of performance, are more likely to succeed.¹⁷

Motivation may be intrinsic or extrinsic. Intrinsically motivated learner

undertakes an activity either for its own sake, for the enjoyment it provides or the feeling of accomplishment it evokes, whereas an extrinsically motivated learner performs because of some factors external to the activity itself.¹⁷ A growing body of evidence suggests that when intrinsically motivated, a learner tends to employ strategies that demand more effort, enabling him/her to process information more deeply, particularly when confronted with complex intellectual tasks.^{17,18} In such circumstance, a learner uses more logical, information-gathering and decision-making strategies than does another who is extrinsically oriented.

It should be noted that an enormous gap exists between knowing that learning must be motivated and identifying the specific motivational components of any particular act of learning process. Educators must be familiar with motivational learning strategies that need to be planned to organise a continuous and interactive motivational dynamic for maximum effectiveness. The major factors and strategies of motivation at various stages of learning documented in the literature are shown in Table 1.¹⁸

It is evident from Table 1 that adult educators must recognize the importance

Table 1: Motivational Factors and Strategies in Learning¹⁸

Period of Learning	Motivational Factors	Motivational Strategies
Beginning of Learning Learner enters and starts learning	Attitudes – toward the environment, teacher, subject matter, and self Needs – basic within the learner at the time of learning	<ul style="list-style-type: none"> • Positive subject condition promotion • Negative learner attitude disabuse • Failure or fear factor removal • Learner esteem needs promotion
During Learning Learner involved in the body or main content of the learning process	Stimulation – processes affecting learner during the learning experience. Affect – emotional experience of the learner while learning.	<ul style="list-style-type: none"> • Learner reaction and involvement in problem solving and role playing • Organize content, themes and teaching procedures around learner concerns • Learner involvement and sharing through group co-operation goal.
End of Learning Learner completes the learning process.	Competence – a result of the learning behaviors. Reinforcement – value attached to the learning experience.	<ul style="list-style-type: none"> • Consistent feedback regarding mastery of learning. • Acknowledgement and affirmation of learners’ responsibility in completing the learning task.

of motivational factors of learning such as attitudes, needs, stimulation, affect, reinforcement, retention, transference and competence during the period of learning. It is to be noted that educators must set a friendly feeling or tone for the adult learning environment in order to show willingness to help the learning process. Williamson *et al*⁷ are of the opinion that mistakes provide some of the best learning opportunities as long as patients are protected. Learners should, therefore, not be reprimanded but encouraged to reflect on and learn from those mistakes.

The learning environment must be free from anxiety and intimidation, which may lead to failure, fear or loss of self esteem. In the process of protecting his sense of self-worth in the face of such challenge, the adult learner may use strategies that are ultimately self-defeating, such as withholding effort, cheating and procrastination, all of which are indicators of frustration.¹⁸ The major and most important source of frustration in the adult learning environment is, however, due to conflict of motives when the individual is unable to choose between two or more goals which are equal in terms of their attractiveness. The attraction of most trainee residents for extra income, to satisfy needs, acquired by way of truancy on their training posts, may stand in the way of success at the Fellowship programme. Through the process of attribution retraining, which involves modeling and socialisation, the trainer may help the trainee to concentrate on the tasks in hand rather than becoming distracted.¹⁹

Adults have many responsibilities that may constitute barriers against participating in learning, which must be balanced against the demands of the learning process. Some of these barriers include lack of time, money, confidence or interest and problems with child care and transportation. The best way to motivate adult learners is simply to enhance their reasons for enrolling and decrease the barriers.¹⁸ Adult learners must be fully involved in all parts of the learning process, including problem solving, role playing, stimulation and group cooperation. Completion of the learning process must be able to add

competence, reinforcement and retention values to the learning experience, without underestimating provision of consistent feedback regarding mastery of learning. Reinforcement is a very necessary part of the teaching and learning processes, through which instructions encourage correct modes of behaviour and performance. Retention by the adult learner is directly affected by the amount of practice during the learning and by urging sustained practice to maintain the desired performance. Students want feedback about their performance to gauge progress concerning knowledge, competence and course expectations. One potential problem that should concern educators is the perception by some learners that they receive little or no feedback, that feedback is not given on time or that the feedback provides no advice on how they could improve their performance.²⁰ Residents can benefit from formal and informal feedbacks on a more frequent basis to help correct errors and reinforce good behaviours.¹⁸ The instructor, peers and even self can all provide important feedback. Self critical reflection is an important element of adult learning programmes in line with the suggestion that "people do not learn from experience, but rather they learn from reflecting on experience".³ The concept of mentoring is an equally important longitudinal method of monitoring student performance. The mentor consistently monitors and guides the overall performance of learning over a long period of time to determine where the student's strengths and weaknesses might lie.²⁰

Overall, the job of the educator terminates only when the learner has been appropriately assisted in the retention, understanding, interpretation, and application of the taught information through the process of transference, which underlies the ability of the learner to use acquired knowledge successfully in a new setting such as post-qualification radiological practice.¹⁸

Learning Theories and the Adult Learner

The study of how learning occurs is an integral part of neuropsychology, educational psychology and learning

theory. A learning theory is an attempt to describe how people learn in order to help us understand the inherently complex process of learning. According to Hill,²¹ learning theories are capable of providing us with vocabulary and a conceptual framework for interpreting the examples of learning that we observe as well as suggesting where to look for solutions to practical problems. Adult educators must understand the process of learning itself, which is at the foundation of the overwhelming number of the learning theories. There are four main categories or philosophical frameworks under which learning theories fall: behaviourism, cognitivism, constructivism and social learning theory.

The behaviourist theory of instruction is said to be traditionally associated with the 20th century educational theorist B. F. Skinner.²² Behaviourists regard knowledge from an external, objective point of view. Rather than being interested in the mind of the learner, they focus on observable behaviour and change in the learner's pattern of response over time as he or she encounters different stimuli.²² In the assessment of the behaviourist educator, learner response either falls into the "right" or "wrong" category. Correct response given by the learner is considered as evidence of teaching success for the educator, while incorrect answer implies that further instruction is necessary until the correct answer becomes the fixed pattern of the learner's response. In effect, the behaviourist focuses on the connections between stimuli and responses and on how educators can evoke different response patterns in the learner through variation of stimuli.

Cognitive theorists look beyond behaviour to explain brain-based learning. They are interested in what goes on in the mind of the learner, focusing on information patterns therein fitted together as ideas and concepts and on how those patterns enhance or detract from learner's abilities to use what he or she knows to solve problems.²² In effect, cognitive theorists are more interested in how the acquired knowledge transfers to new situations. A key concept in cognitive learning theory is that knowl-

edge is processed on multiple levels, corresponding to the Bloom's taxonomy.²³

Bloom identified six levels within the cognitive domain (Table 2), from the simple recall or recognition of facts, as the lowest level, through increasingly more complex and abstract mental levels, to the highest order which is classified as evaluation.²³ Generating an appropriate differential diagnoses for a lesion by using previously acquired knowledge is done at a higher level of processing than mere information memorization. Memorization or rote learning avoids understanding of the inner complexities and inferences of the material, while the learner attempts to recall exactly the way it was read or learned.²³ Thus, cognitive learning theory stresses the importance of information processing as the learner becomes an active thinker who connects new knowledge with prior experience.

Constructivism views learning as a process in which the learner actively constructs or builds new ideas or concepts. Constructivist theory of learning is more interested in what happens between and among learners,

stressing that learning is a largely social process.²⁴ Learners and educators are viewed as negotiators of mutual understanding through practice in realistic situations rather than that of expert telling learners what they need to know. Understanding comes as a product of interaction and knowledge. Therefore, in contrast with the previous two theories, constructivism focuses on educator-learner and learner-learner interactions to determine how meaning evolves through negotiation.

The social learning theory, plays a critical role in training and development. The radiology educator, by becoming a role model for the resident trainee, can improve the latter's behaviour. In fact, trainees are more likely to imitate their superiors than their peers because of their status, experience and reward power. Secondly, modeling has a considerable role to play in implementing a self-managed approach through self-observation and self-monitoring.²⁴

Educational Practice and the Radiology Educator

Effective educational practices represent the totality of the trans-

formative processes needed to coherently and developmentally manage the learning environment. The aim is to help students acquire the knowledge and skills necessary to succeed in a demanding global environment. Education in radiology and other fields of professional learning consists of three transformative components, namely the curriculum, instruction and assessment, necessary to achieve engaged and active learning outcomes.⁷

The term curriculum is said to have been described by John Franklin Bobbitt as the entire scope of formative deed and experience occurring in and out of training.²⁵ It consists of what we intend our students to learn and has two components – formal and informal curricula. Intentionally directed learning experience occurring in training and consisting of written learning objectives, reading assignments, lectures, course syllabi, etc is termed the formal curriculum. This is the component of the curriculum commonly attended to by most educators.⁷ The informal curriculum represents all the lessons acquired outside the formal channels such as how to consult with referring physicians or how to cope with procedure errors. In more general terms, informal curriculum refers to the expectations and beliefs held by both the learner and the trainee about each other's roles, about what defines the field of radiology, about how instruction should occur and about what the learner will do after completing the course of instruction.⁷ It is an unofficial but important learning experience in any residency training programme that needs to be stressed by radiology educators. Instruction is one of the most frequently used terms in all of education and virtually means the same thing with teaching. Defined concisely, educational practice instruction is what the teacher actually does in presenting the lesson.⁷ Instruction is, thus, a special form of teacher-student communication that is dependent on feedback to be effective. It may take the form of lectures, assigned readings or computer-based instructions, which may be planned or unplanned. Planned instruction by an educator generally takes place at a particular setting and time on a scheduled topic.

Table 2: Levels of Cognitive Domain of Learning (Bloom's Taxonomy)²³

Cognitive Level	Competence	Typical Intellectual Activity Verb
Knowledge	Learner recalls or recognizes information previously presented.	List, recite, group, name, locate, copy, label, define.
Comprehension	Learner changes the form of the previously learned information by translating it into his own words.	Summarize, describe, interpret, contrast, predict, associate, distinguish, differentiate.
Application	Learner has done something with what he/she has learnt, i.e. uses the information in a new situation.	Compare, categorize, relate, classify, outline, summarize, select.
Analysis	Learner is able to break down an idea into its principal parts or shows similarities between things.	Examine, investigate, analyze, categorize, compare and contrast.
Synthesis	Learner uses old ideas to create new ones, generalizes from given facts, relates knowledge from several areas, predicts, draws conclusions.	Develop, construct, design, hypothesize, compose.
Evaluation	Learner forms a judgment based on facts, examples and specific criteria.	Assess, decide, rank, grade, test, measure, recommend, select, judge, discriminate.

On the other hand, instruction may be delivered spontaneously, for example, during film viewing session in an unplanned manner. This sort of “just-in-time” or “teachable moment” learning processes can prove very valuable as radiology educational technique.⁷ There is no shortage of information on what constitutes a particular effective instructional method. However, the professional knowledge base of the trainee at a point in time provides the prerequisite that defines appropriate method for a given instructional content for the learner at a defined level of development.⁷

Whether formal or informal, all planning of instruction should begin with an assessment of what the student knows relative to the intended learning objective, which must be clear, specific, and related to the appropriate subject matter content. Analysis of information from this pre-assessment describes the characteristics of the student relative to the objective and further provides a basis of action along the instructional pathway.⁷

The instructor must also understand the available adult learning styles. Research has shown that there are many different learning styles that the adult learner may prefer, based on the influences of personality, intelligence, education, experiences, culture, sensory and cognitive preferences.³ Minutella described three dominant types of ways, which are based on how the learner prefers to consume, process and apply the new information.²⁶ Most learners are strong in one area, but also use the others as secondary methods.

The first of the adult learning styles described by Minutella is the visual. The visual learner might draw diagrams, view video or use pictures to help better understanding of information. In the second style, the auditory learner tends to learn best through lectures and discussions. The third style is kinaesthetic, by which the learner might prefer learning through note-taking and hands-on approaches. Studies have revealed that over a period of three days, knowledge retention is about 90 percent when all three learning styles are incorporated into a learning protocol.³

The third component of educational practice is assessment or determination

of what the trainee has learned. It is a more comprehensive appraisal of programme of learning than evaluation process, which refers only to a single instance of judgment.²⁷ Assessment at the conclusion of a lesson is meant to generate information for both the teacher and the student. The assessment must be directly related to the lesson objective, to achieve the purpose for which it was developed.

Written assessments represent formal documentation of the learner’s record, including course grades, records of standardized test performance and narrative performance appraisals. Informal assessment is an equally important factor in learning, as it provides such appraisals as oral feedback to the learner, providing advice on how to improve performance.²⁰

Learning Theories and Evidence-Based Practice in Radiology

Although Williamson and his colleagues explained some of the basic concepts of learning theory in radiology education,⁷ it is Edwin *et al*²⁸ who offered practical advice on how to apply broad learning theories to the teaching of evidence-based medicine. Evidence-based medicine (EBM) evolved as a method of providing the skills needed to manage the potential information overload of modern medical schools, using optimal clinical decisions and quantitative expression rooted in epidemiology and statistics.²⁹

Of recent, several important international reports have demonstrated the worldwide movement toward incorporating evidence-based practice into radiology (EBR) education.³⁰ In such circumstance, trainee residents who choose an academic radiology career path would be better prepared to begin the activities of “creative science” envisioned in EBR. In contrast to the emphasis on disciplinary competence in most current radiology trainings, intelligent integration of EBR teaching in the early stage of acquisition of practice-based learning, system-based practice and case-based learning will assist in maintenance of the high quality standards historically required from radiologists in general in the environment of 21st century practice.³⁰

Drawing from the facts of the various established adult learning theories enumerated in the previous sections, which identify the adult as a self-directed, problem-solving and case-based learner, it would appear that the adult learner is an ideal student to develop the critical mind and scientific productivity inherent in evidence-based radiology education.

Conclusions

There is need for radiology educators to be familiar with the characteristics of adult learners, the learning theories and the principles of educational practice in order to acquire appropriate strategies necessary to provide effective residency training. The matured adult brings focus, experience, zeal and orientation to the training arena, requiring educator’s motivation to blossom. Current trend in radiology education and other training sectors has moved from a teacher-directed model to a more learner-centered model. Thus, there is less emphasis on what gets transmitted to the learners and more emphasis on what the learners actually acquire.

The use of overlapping behavioural, cognitive, and constructive learning theories has influence on training instruction, curriculum and assessment. Newer instructional direction now focuses on learner’s approach to complex problem-solving situations in a cooperative setting rather than component skills. The expected learning outcomes now constitute the driving stimulus of the training curriculum, while assessment places greater emphasis on the observed learner progress rather than learner’s absolute level of knowledge. Provision of prompt training feedback is important to encourage learners to reflect on progress and learn from possible mistakes.

Summary

In summary, a review of the various adult learning principles, learning theories and educational practices has been undertaken with the aim of providing an informed guidance to radiology residency trainers. This is based on literature evidence that most

medical educators, including radiologists, lack appropriate formal training background in adult educational practices.

The adult learner generally enlists in the learning process for the purpose of acquisition of new knowledge, skills and attitudes as part of personal professional development. There is general agreement in the literature that adult teaching must be approached in a different way from that of a child, because the adult learns with different styles, bringing high quantity and quality of experience into the learning environment. This approach has been pioneered by Malcom Knowles who synthesized the available overwhelming number of concepts into an organised theory.

The radiology educator must be familiar with the use of appropriate learning theories and educational practices as pre-requisite for guiding the adult residency trainee as facilitator and motivator.

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