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Re-engineering the process of medical imaging physics and technology education and training

Perry Sprawls

Department of Radiology, Emory University School of Medicine, Atlanta, USA

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Abstract

The extensive availability of digital technology provides an opportunity for enhancing both the effectiveness and efficiency of virtually all functions in the process of medical imaging physics and technology education and training. This includes degree granting academic programs within institutions and a wide spectrum of continuing education lifelong learning activities.

Full achievement of the advantages of technology-enhanced education (e-learning, etc.) requires an analysis of specific educational activities with respect to desired outcomes and learning objectives. This is followed by the development of strategies and resources that are based on established educational principles.

The impact of contemporary technology comes from its ability to place learners into enriched learning environments.

The full advantage of a re-engineered and implemented educational process involves changing attitudes and functions of learning facilitators (teachers) and resource allocation and sharing both within and among institutions.

Keywords: e-Learning; Digital images; Effective learning; Efficient learning; Re-engineering

1. Introduction

The process of education has evolved over time in a continuing effort to meet the needs of society and individual goals with available resources. While traditional methods and practices of formal education, including lectures with writing boards, learner transcribed notes, and heavy reliance on printed materials are still effective for some disciplines, there are definite deficiencies when applied to the learning and teaching of science and technology, both on a local institutional and global basis. The deficiencies are both in *effectiveness* and *efficiency*.

1.1. Effectiveness of learning activities

Effectiveness determines the outcome of an educational activity as demonstrated by a learner's ability to perform specific tasks in pursuit of his profession or occupation.

1.2. Efficiency of learning activities

Efficiency determines the ability to achieve the desired outcomes with optimum use of available resources. Resources include the learner's time and finances, learning facilitator's time and effort, institutional facilities, infrastructure, staff, educational materials and media, both printed and digital, and hands-on learning environments including laboratories and clinical participation.

1.3. Re-engineering

Re-engineering is the systematic process of analysis, design, and implementation of an educational activity with optimized effectiveness and efficiency to produce specific outcomes. This is achieved with the appropriate use of state-of-the-art technology and the enhanced professional performance of learning facilitators.

The total educational process is analyzed to identify specific elements, functions, interactions, and desired outcomes. Underlying principles on which the re-engineered model is

E-mail address: sprawls@emory.edu.

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based include the educational classics of Robert Gagne's model of the levels and hierarchy of learning [1,2] and Edgar Dale's "cone of experience" addressing the compromise between the *effectiveness* and *efficiency* of learning activities [3].

2. Why re-engineer the education and training process?

Virtually all educational institutions, programs, and courses will benefit from some degree of re-engineering in preparation for current challenges and the future. This applies both to degree-oriented programs and continuing education lifelong learning opportunities.

The need to re-engineer the total process of educational activities for the physics and technology of medical imaging arises from a combination of ongoing developments and major evolutions occurring in the fields of both medical imaging and education. These include:

1. The growing utilization of both basic and advanced medical imaging methods around the world producing a need for many professionals (physicists, engineers, physicians, and technologists) educated in the science and technology of the imaging process and related activities.
2. The development and use of more scientifically sophisticated and technologically complex imaging methods and systems requiring knowledge by the users that is both more extensive and updated than in the past.
3. Traditional learning and teaching methods that do not meet these rapidly growing, and geographically dispersed, educational needs.
4. The availability of digital technology to enhance educational activities, especially applicable to the field of medical imaging.

3. The effectiveness of learning activities

The effectiveness of a specific learning activity (classroom discussion, laboratory experiment, individual study, etc.) to produce a desired outcome is determined not so much by the *quantity* but by the *quality* of the learning experience. Quality is a somewhat complex characteristic of a learning experience that includes the *richness* of the learning environment and the *organization* and *guidance* of the learning activities.

3.1. Levels of learning

The ability of learners to perform a specific task or function is strongly dependent on the level of learning they have achieved. The classic model of the hierarchy of learning developed by Robert Gagne is used as the basis for the illustration in Fig. 1.

The level of learning that is achieved is generally determined by the design and content of the learning activity and

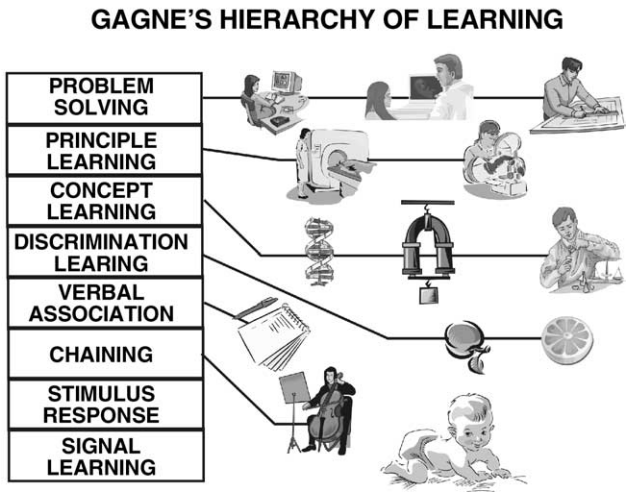

Fig. 1. The hierarchy of learning levels as formulated by Robert Gagne.

experience. While there is some need for the lower levels of learning, such as the memorization of names, facts, etc., most professional functions in the science and technology of medical imaging require knowledge at the higher levels such as rule learning and problem solving. Effective learning at these levels usually requires a well-developed knowledge at the conceptual level.

3.2. Learning objectives

A first step in designing, or re-designing, an educational activity is the establishment of the learning objectives that define the outcome of the experience. While the objectives are derived from an analysis of the functions or tasks to be performed by the learner in the professional practice, attention should be given to formulating the objectives to the appropriate level of learning.

A prevailing challenge in education is formulating objectives, providing educational experiences, and evaluating performance at the higher levels of learning. It is generally much easier to write objectives for, teach, and test the lower levels of learning.

Examples of learning objectives associated with the lower levels include:

- *Name* the two types of particles that make up a nucleus.
- *Write* the equation for Ohm's law.
- *Define* image contrast.

Examples of learning objectives associated with the higher levels of learning include:

- While using a light source and your hand to cast a shadow, *demonstrate* the principle of both geometric magnification and focal-spot blurring as in radiography.
- While looking at a radiograph, *illustrate* and *explain* the concept of contrast and how it affects the visibility of individual objects and anatomical structures.