WEB-BASED IMAGES FOR EFFECTIVE CLASSROOM LEARNING AND TEACHING OF MEDICAL PHYSICS

Perry Sprawls
Emory University, Atlanta and Sprawls Educational Foundation, www.sprawls.org

Abstract— **The internet and World Wide Web (the web) is an extensive source of images and related visuals that can be used by medical physics educators to enhance and add value to their classroom and conference presentations and discussions. This is a result of the connectivity between local classrooms and the many creators and providers of visual resources from anywhere in the world. A major value is when materials, including images, are posted on the web they are indexed by subject and can be searched for to find visuals relating to all medical physics topics. In addition to searching the complete web by specific subject or topic there are collections or teaching files provided by medical institutions and organizations that provide a comprehensive overview or "table of contents" is helpful. The technical capability of the web is providing opportunities for major enhancements to medical physics classroom education. This includes the opportunity for medical physicists to share their creations of images and visuals with other physicists anywhere in the world in the spirit of *collaborative teaching*.**

Keywords— **Images, Visuals, Clinical, Concepts, Teaching**

I. INTRODUCTION, OVERVIEW, AND OBJECTIVES

The internet and world-wide-web (WWW) is making major contributions to medical physics education with a variety of methods and applications. Online modules, textbooks, and other study materials provide learners/students with opportunities to study and learn wherever they are located and not gathered in group activities; physical classes and conferences. While this provides many learning activities throughout the world there remains great value in classes and conferences with *medical physicists* actively leading the learning process and interacting with the learners. Both the learning and teaching that occurs in those activities can be made much more *effective* with images and visuals that "provide windows" through which the physical universe related to medical physics can be observed. This enhances the ability of the medical physics educator to guide the learning process using their knowledge and experience. A major value is learning through *visual observation* contributes to the development of sensory conceptual knowledge structures that are required for applying medical physics to many clinical activities; by both physicists and physicians. The internet/www is now an extensive and valuable source of images and visuals that can be used to enhance classroom and conference teaching and learning activities. After reviewing the concepts and factors related to effective learning and teaching and how both are enhanced with images then the web as a major resource will be described. This will include the scope of image content, searching and downloading, legal and academic ethical issues, class and conference room applications, and opportunities for medical physicists to contribute to enriched medical physics education around the world. An overview is provided in Fig.1.

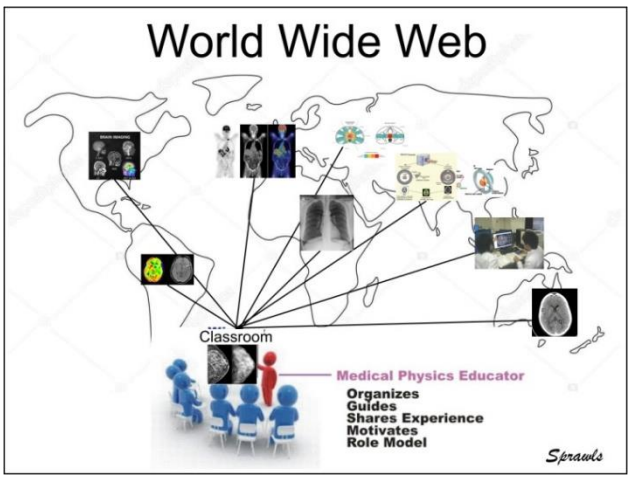

Fig..1. The World Wide Web as a valuable resource for effective learning and teaching of medical physics.

Web-based images are especially important for classes in Low and Middle Income Countries by providing low-cost access to the collective medical physics educational resources from around the world..

II. EFFECTIVE PHYSICS KNOWLEDGE AND LEARNING

Physics knowledge is a mental representation of the physical universe. It is composed of a complex network of elements including verbal/word descriptions, mathematical relationships, various sensory images, and concepts. Each has value with respect to performing specific activities in the practice of medical physics and applications of physics to clinical imaging and radiology. The process of developing effective knowledge structures for medical physics applications, especially for diagnostic radiologists, is described in previous publications (Ref. 1,2,3) A major factor is that many medical physics activities, often described as the higher-level mental

functions, including analysis, problem solving (non-mathematical), creativity, etc., require conceptual knowledge structures composed of images representing the physical universe. It is knowledge in the form of images that provides an effective connection to the physical objects, interactions, procedures, etc. within medical physics.

III. CLINICAL IMAGES AS PHYSICAL OBJECTS

Clinical images of the human body interior structures produced with the various imaging modalities; radiography, mammography, CT, MRI, etc. are *physical objects* with a combination of physical characteristics. Effective medical physics knowledge for many applications and functions for all radiology and medical imaging professionals; physicists, physicians, technologists, etc. requires *mental images* of *clinical images* along with knowledge of their physical characteristics.

Medical Physics Students and Trainees

Educational programs for medical physics students and trainees that incorporate many clinical images provide many values. Images are the physical objects they will be working with in many applications including quality assurance and the optimization of medical imaging procedures relating image quality to radiation dose. Including clinical images in the physics curriculum also enhances and supports learning of the other medical sciences–anatomy, physiology, and pathology–that is now recommended and required in many medical physics programs and for board certifications.

Radiologists and Radiology Residents

Physics is a required subject in radiology residency programs and for board certification. Providing effective physics learning activities for radiology residents is a continuing challenge for several reasons. A major goal is to provide physics instruction that is relevant to clinical imaging and of interest and motivating to the residents. That can be achieved through classes, conferences, and self-study activities that begin with and build a strong visual conceptual knowledge structure with images. Images are the interface between clinical medicine and physics. The visibility of the structure and conditions within the human body are determined by the *physical characteristics* of the images; including the physics of the imaging methods and the physical variables associated with the specific imaging procedure for each patient. Beginning a physics course with images as illustrated in Fig. 2 provides the foundation of a high-effective and valuable physics knowledge that will enhance the practice of diagnostic radiology. The emphasis on image based physics is consistent with trends in examinations for board certification.

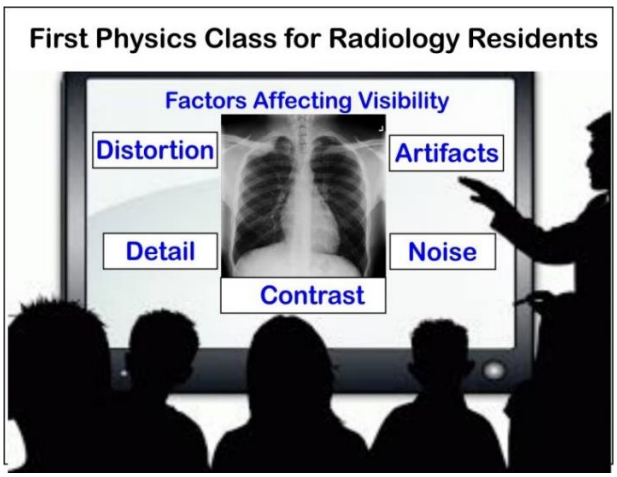

Fig. 2. Beginning a physics course and classes with images enhances interest and participation by residents. It establishes images as the physical object that is the foundation of clinical imaging.

Clinical radiology education is heavily based on "teaching files" of images collected within academic departments, by individual radiologists, and provided by several radiological organizations. It is the established method for teaching clinical radiology that can be extended to include the teaching of physics. Structuring physics education around clinical images helped establish physics as one of the valuable medical sciences in the minds of radiologists and radiology residents.

IV. IMAGES AND VISUALS TO DEVELOP CONCEPTUAL KNOWLEDGE

Developing effective knowledge of image characteristics, especially relating to visibility of clinical conditions, requires the use of images in the teaching and learning process. An example is the use of images to help learners develop the concept of quantum noise as illustrated in Fig.3.

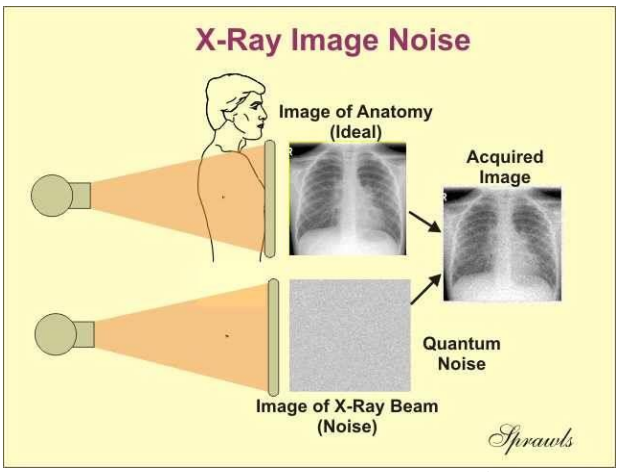

Fig.3. Quantum noise in a clinical image is an image of the x-ray beam (random distribution of photons) superimposed over the image of the human body.

In addition to *clinical images* of the human body which are the physical objects that are being studied, images and *visual representations* of the imaging process are essential to the development of physics knowledge that contributes to the understanding and effective application to imaging procedures. These are the visuals that provide "windows" that bring imaging procedures into the class and conference rooms where medical physics educators can use their knowledge and experience in guiding the learning process for radiology residents and others. An example of a visual for that purpose is shown in Fig. 4.

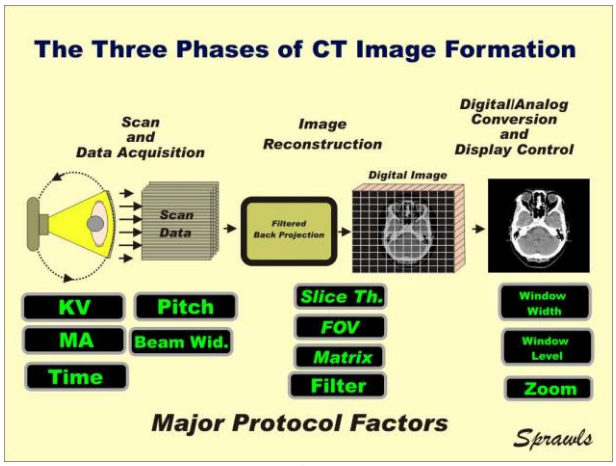

Fig. 4. A visual representation of the CT imaging process relating the protocol factors to the specific phases in the formation of images.

CT, as well as most modern imaging methods, are complex procedures with many variables and relationships. Physics knowledge that is of significant value to radiologists is the relationship of the image quality characteristics (contrast, detail, noise, etc.) to the complex set of protocol factors. This includes how each factor fits into the specific phases of the imaging process. This is used here to illustrate the characteristics of physics knowledge that ommiss high-quality clinical imaging activities for both physicists and radiologists. That is comprehensive sensory conceptual structures rather than memorized facts and symbolic representations which have other applications.

V. COLLABORATIVE MEDICAL PHYSICS EDUCATION AND TEACHING

The process of teaching medical physics is much more than standing before a class and lecturing and writing on a board. While this can convey some of the teacher's personal knowledge, especially facts and symbolic representations, to the learner that can be memorized it does not develop the highly-effective sensory conceptual knowledge that is required for applying medical physics in clinical activities.

A longstanding and continuing challenge is the availability of quality images and visuals that we, medical physics educators, can use to provide "windows" from the classroom to the physics of the medical procedures that are being learned.

It is beyond the capability; time, experience, and resources, of us as individual teachers to collect and develop all of the images and visuals that is needed in our classes. The solution is a "world-wide" collaborative effort in which many medical physicists are *developing* and *sharing* with others images and visuals that can be used in their class and conference presentations and discussions.

That is the concept of collaborative teaching.

4. MEDICAL IMAGE CONTENT OF THE WEB

The characteristic of the World Wide Web (www) that makes it a major educational resource is *connectivity*. It connects learners/students and educator/teachers with a constantly expanding universe of materials, especially digitized images and visuals that can be accessed and brought into the class and conference rooms to support learning activities. These are provided by many sources including educational institutions, scientific and medical organizations, publishers, the medical equipment and technology industry, and many individual medical physicists.. Most are available without cost but with some conditions as described later. When images are posted on the web they are soon detected by the so called "web crawlers" operated by the various search engines or services; Google is an example. Each image is indexed with specific terms relating to subject, category, source, etc. to the extent it can be determined. It is these terms associated with an image that make it possible to search and find images on specific topics.

VII. SEARCH BY SUBJECT ON THE WEB

Here we are using the search engine google image, https://images.google.com/ , for finding images and visuals on the web. This site provides a place for entering the subject or type of image to search for. Examples are provided below can be used to collect images for classroom presentations and discussions.

MRI Image Types

To find clinical images illustrating the different mri image types begin by entering "mri". A list of sub-topics will be displayed including "mri t1 vs t2".

Breast Compression in Mammography
Compression of the breast during mammography is an important topic for both medical physicists and radiologists. Excellent visuals can be found by entering "breast compression mammography".

Dose Reduction in Computed Tomography
various methods used for ct dose reduction can be discussed with visuals found by entering "computed tomography dose reduction".

Ultrasound Image Artifacts
A collection of clinical images displaying a wide range of artifacts can be found by searching on "ultrasound artifacts images".

These examples illustrate the types and range of clinical images and related visuals that are available from many sources that can be accessed by searching on the web. A major value is the ability to search on very specific topics as illustrated above.

VIII. LEGAL AND PROFESIONAL EDITHS ISSUES

While the majority of the images available on the web are free to use for educational purposes there are certain conditions and restrictions that must be considered.

Copyright Protection and Fair Use Copyrighting is a legal process, generally administered by federal governments, to provide creators, authors, and artists, with protection of their work from unauthorized use by others. The creators must apply for copyright protection and indicate on published work that it is copyrighted with words or the copyright symbol ©. A major purpose of copyright protection is to prevent others than the copyright holder from making copies, especially for commercial purposes or personal gain, without permission and authorization. For example it would generally not be legal to use someone's copyrighted image or visual without permission in publications, presentations, or multiple copies of educational materials.

Copyright law provides for the principle, commonly called "fair use" that the reproduction of copyright works for certain limited, educational purposes, does not constitute copyright infringement. Our interest here is specifically the use of images and visuals from the web in class and conference presentations and discussions. Generally the showing of a copyrighted visual in a classroom is not infringement. Individual clinical images as found on the web generally do not meet the requirements for copyright protection.

A general principle of the copyright process is to not interfere with or discourage the educational process and learning activities. As medical physics educators conducting classes and conferences we have the opportunity to enhance the activities with images and visuals downloaded from the web. It is also our individual responsibility to follow appropriate legal and professional guidelines and requirements. Most universities have staff, usually in the libraries that can provide information on copyright issues and especially the use of copyrighted materials for educational purposes.

Academic and Professional Ethics

In addition to the legal there are ethical issues that must be considered when using materials from the web. This applies specifically to visuals, illustrations, and diagrams that represent the creative work of individuals, fig. 3 is an example. Guidance is provided by the following quotation from the AAPM code of ethics.

Creative influence is the cornerstone of creativity and innovation. Without the appropriate citation or acknowledgment of the work of others, imitation of the work of others can result in plagiarism. All forms of plagiarism, including self-plagiarism, are dishonest and must be avoided.

When using visuals that are the creative work of others that should be clearly indicated

4. . THE SPRAWLS ONLINE RESOURCES

The *Sprawls Resources* online at: http://www.sprawls.org/resources provides an extensive collection of images and visuals along with modules and textbooks that are being used by medical physics educators in many countries to enhance their teaching activities. The objective is to provide physics classrooms around the world with "windows" through which the medical imaging physics universe can be viewed and used by educators in the process of collaborative teaching.
Many of the visuals from within the *Resources* are organized in PowerPoint presentations and can be downloaded: http://www.sprawls.org/PhysicsWindows/ . This is to support the process of collaborative teaching as illustrated in Fig. 5.

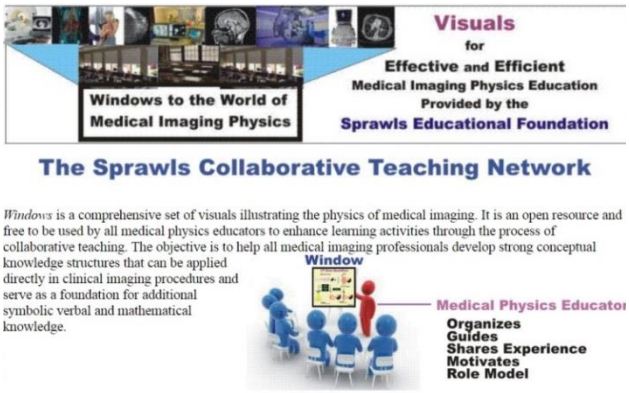

Fig. 5. Windows to the World of Medical Imaging Physics is a collection of images and visuals that can be used in class and conference presentations and discussions.

X. THE ENCYCLOPAEDIA OF MEDICAL PHYSICS

The online Encyclopaedia at http://www.emitel2.eu/ contains over 1500 images and diagrams that can be downloaded and used in classroom activities along with extensive text discussions.

4. OPPORTUNITIES FOR COLLABORATION AND CONTRIBUTIONS

Many medical physics educators have developed and collected images and visuals to use in their teaching. The educational value of these can be greatly enhanced by sharing with other educators throughout the world. This can range from a few very good visuals to complete class presentations. There are several methods that can be used to post images and visuals on the web.

Academic Institutions

The websites of academic institutions provide a special value for posting images and visuals for teaching. They are within a highly visible educational context that will be viewed by many and also on sites that are being searched by the web crawlers. Radiology Departments of many universities have developed and posted teaching files of clinical images. SUNY Upstate Medical University in Syracuse, NY provides an example of a teaching file devoted to medical imaging physics: www.upstate.edu/radiology/education/rsna/index.php

Medical Physics Organizations

Most medical physics organizations, from international to regional and national, have websites that have the technical capability to post images and visuals to support and enhance the teaching activities of medical physicists. This provides an opportunity for medical physics organizations to develop programs and procedures using their websites for sharing images and visuals to enhance classroom learning activates. In addition to promoting collaboration among members and more effective learning for students it provides international visibility for the educational materials posted by members.

MedPix® by The USA National Library of Medicine

MedPix® is a free open-access online database of medical images, teaching cases, and clinical topics, integrating images and textual metadata. Most of the content is clinical images and related data to be used by physicians, nurses, and other clinical professionals. There is a Physics category with limited content. It is available to medical physicists to upload images that can be used for teaching.

Login at: https://medpix.nlm.nih.gov/home

XII. SUMMARY AND CONCLUSIONS

Knowledge of medical physics that can be applied to optimize and improve clinical imaging procedures by both medical physicists and physicians requires a highly-developed conceptual mental structure consisting of images. This is developed by using images and visual representations of physics relationships in the teaching and learning activities conducted by medical physics educators. The connectivity provided by the internet and world wide web now gives educators access to an extensive collection of images and visuals that can be used to enhance their teaching activities. This recognizes the value of *collaborative teaching* in which both the creation and sharing of visuals and the class and conference presentations and discussions conducted by medical physicists for producing effective learning.

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Author: Perry Sprawls,. sprawls@emory.edu
Emory University and Sprawls Educational Foundation
www.sprawls.org