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Learning Objectives in Radiology Education:

Why You Need Them and How to Write Them

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Learning objectives are a critical step in the creation and implementation of a radiology curriculum. Their use is mandated by the Liaison Committee on Medical Education, the Accreditation Council on Graduate Medical Education, and the Accreditation Council on Continuing Medical Education, but more importantly they can have a significant beneficial impact on quality of radiology education programs. Learning objectives guide student learning, help clarify our teaching goals, and simplify learner testing and evaluation. This article will review the components of a proper learning objective and provide a simple, straightforward approach to writing them effectively.

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A learning objective is a statement that describes in specific terms what knowledge, skills, or attitudes learners should be able to demonstrate following instruction. They aren't simply a "table of contents" style list of topics that will be addressed or a list of teaching goals for a session or course. Rather, a learning objective should outline what students will be able to do that they couldn't do before the teaching exercise. Fundamentally, learning objectives should target the essential take home points of a course.

The creation of learning objectives is often an undervalued step in medical curriculum planning, in part because as teachers we are often accustomed to focusing on our goals. Although it is useful to communicate what we as educators want to accomplish, in the form of a list of topics to be covered or "goals" for a session, this is not a substitute for learning objectives. Fundamentally, a learning objective is written with the intent of learning rather than teaching as the goal. Learning objectives communicate what the learner should be able to do as a result of the teaching session or curriculum. In other words, they are outcomes-based and learner-centered.

Learning objectives have been used in different areas of education for many years, more so after being popularized by Robert Mager in his text *Preparing Instructional Objectives* in 1962 (1). However, their integration into medical education, at least at a postgraduate level, is more recent, coinciding to a degree with the Accreditation Council on Graduate Medical Education (ACGME) guidelines for competency-based education (2). Among academic radiologists and undoubtedly physician educators in many fields, confusion still exists as to the correct use and utility of learning objectives. This article will review the components of a proper learning objective and provide a simple, straightforward approach to writing them effectively.

ADMINISTRATIVE OVERSIGHT: THE REQUIREMENTS

Whether pertaining to undergraduate medical curricula, radiology residency programs, or continuing medical education activities, learning objectives are now a required component in medical curricular planning.

Undergraduate Medical Education

The Liaison Committee on Medical Education (LCME) has been the accrediting authority for US medical schools since 1942 (3) and now has multiple requirements for the use of learning objectives in the undergraduate medical realm. Specifically, an educational program requirement (ED-1) states: "The faculty of an institution that offers a medical education program must define the objectives of its program. The objectives must serve as guides for establishing curriculum content and provide the basis for evaluating the effectiveness of the program" (3).

Graduate Medical Education

Similarly, progress in each of the six ACGME competency domains (patient care, medical knowledge, practice-based learning and improvement, interpersonal and communication skills, professionalism, and systems-based practice) is ideally demonstrated through accomplishment of defined "objectives." The ACGME requires radiology residency programs to

annually distribute written "competency-based goals and objectives for each assignment at each educational level" (4).

Continuing Medical Education

The Accreditation Council on Continuing Medical Education (ACCME) also requires "objectives" for each presentation "written to reflect… desired outcomes in competence, performance, or patient outcomes" (5).

The ACGME and ACCME do not use the actual term "learning objective," instead speaking in more general terms about "objectives." However, both sets of guidelines describe requirements for student-centered, outcomes-based objectives. Despite these multiple guidelines, learning objectives should not be viewed simply as an accreditation requirement.

THE UTILITY OF LEARNING OBJECTIVES

Learning objectives fundamentally allow communication with others about the content and intent of a teaching activity or curriculum. In addition to serving this purpose for curricular oversight agencies, as described previously, learning objectives also enable communication with faculty from other courses, programs, and institutions.

More importantly, learning objectives can directly enhance the learning process for both students and teachers. Having a clear set of learning objectives can crystallize educators' teaching goals and ensure that the educational methods are aligned with the goals. For example, choosing the critical content to include in a teaching session is easier after having identified three essential skills or pieces of information we want the students to use. In this way, they can help teachers to select better material, which will be of greatest yield to the students. In addition, the appropriate format for an educational session can be dictated by learning objectives. For example, consider the following learning objective: "The student will be able to list a differential diagnosis for a focal lung opacity on a chest x-ray." This could be readily achieved in a lecture format. However, an objective that describes skills involved in actually reading a chest x-ray such as, "employ a systematic search pattern for interpreting chest x-rays," might be better achieved and practiced in an interactive small group format. In this way, the desired educational outcomes can directly guide the best teaching practices. Learning objectives can also help to focus a student's studying; ensuring that they concentrate on what is essential. Last, having a set of established objectives vastly simplifies assessment of learners and learning. If we have preidentified the most critical knowledge and skills, we have also preidentified what should be tested. In a well-designed curriculum, there should be cohesive interplay between these different components (6) (Fig 1).

THE COMPONENTS OF A PROPER LEARNING OBJECTIVE

A good learning objective should focus on critical information and should be written with the student's perspective in
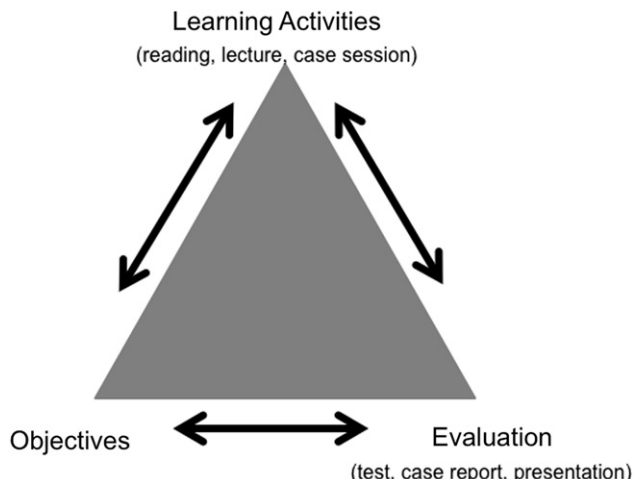

Figure 1. The relationship between learning objectives and other critical components of a radiology curriculum.

mind. Learning objectives should also be "active" and "outcome-focused," meaning they should clearly state what the learner will be able to do after the session. Moreover, these actions should be "discrete and measurable." In fact, both of these secondary criteria are screened by the LCME when they review learning objectives for a program (3). Unfortunately, most of these rules for writing objectives are not at all intuitive to put into practice. What exactly is meant for example by "discrete and measurable" or "active" and "outcome focused"? Fortunately, there is an easy resource for translating our goals for student learning into learning objectives that meet these criteria.

Bloom's taxonomy is a learning hierarchy, first described by Benjamin Bloom (7). It proposes that learning goals should vary in complexity according to the level of understanding and/or skill desired. In the hierarchy, learning begins with simple acquisition of knowledge and cumulatively builds toward a deep understanding and ability to critically evaluate material. In any curriculum, learning objectives will ideally represent several levels within this hierarchy (7) (Fig 2). Attention to this hierarchy can also serve as an important internal check, because one of the most common problems in radiology medical student education is failure to set curricular content at an appropriate level for the particular audience. If we fail at this step, will certainly fail in our teaching goals overall.

Bloom described three separate domains of learning: the cognitive, the affective, and the psychomotor domains. Skills in the cognitive domain include knowledge, understanding, and critical thinking on a given subject. The cognitive domain is by far the most frequently used in planning a radiology curriculum. Skills in the affective domain deal with emotions, empathy, and changes in attitude. Although less directly applicable to radiology learners, attitudinal change can be important in accomplishment of some of the ACGME core competencies, such as those in the realm of professionalism. Furthermore, the psychomotor domain, which pertains to learned procedural skills, has obvious application in any clinical field of medicine.
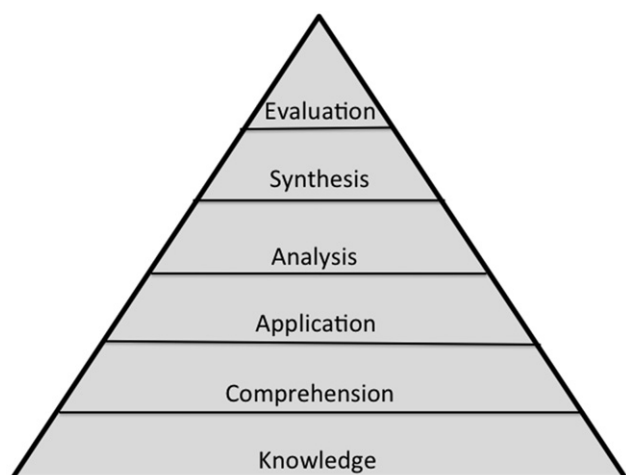
Figure 2. Bloom's triangle: cognitive levels in Bloom's taxonomy are ordered from the simplest (base of the triangle) to the most complex (apex of the triangle).

Bloom's taxonomy has been modified to create various updated versions (8,9) with examples of "measurable action" words, such as "list," "describe," or "compare" that correspond to each level of learning in the hierarchy. An example of one such modified version is presented in Table 1 (10). This resource tremendously simplifies the process of writing a learning objective, because once an educator has decided what knowledge level is appropriate for a specific topic and group of learners, the creation of the objective is nearly automated by the language built in to the taxonomy.

WRITING LEARNING OBJECTIVES: A GUIDE

It is helpful to approach the process of writing a learning objective in a stepwise fashion. When designing objectives, an educator should consider the following.

Step 1. Decide what is critical for the students to take away from the session or course.

Step 2. Consider the depth of understanding (level of Bloom's hierarchy) that is appropriate for the audience level.

Step 3. Refer to Bloom's taxonomy to help guide the language of the learning objective by choosing a measurable action word from the appropriate level.

Step 4. Use the following formula to generate the learning objective: Who will be able to do how much (how well) of what by when (11).

In this formula, the "who" is the student or learner. The "to do" is the measurable action word selected from Bloom's taxonomy. "How much" or "how well" can be used in some cases to quantify the expected result or address the criteria for acceptable performance. The "what" is the relevant critical information or skill, and the "when" allows us to set an expectation as to when this objective is reasonably achiev-

able (by the end of the session? by the end of medical school?). Using this format it is easy to both generate proper learning objectives and recognize faulty ones.

Incorrect Learning Objective Format

- "This lecture will cover benign solitary liver masses and their appearance at computed tomography (CT)."

Written in this form, this is a teaching goal, not a learning objective. It explains a broad goal of the session, not a measurable outcome for the learner. A general rule of thumb is that any statement that addresses "coverage" of content is not a proper learning objective.

Correct Learning Objective Format

- "The participant will be able to identify cysts, hemangiomas, and focal nodular hyperplasia on CT after the lecture."

In this format, we identify who (the participant) will be able to do how much (identify) of what (cysts, hemangiomas, and focal nodular hyperplasia at CT) by when (after the lecture).

When generating a list of multiple learning objectives, the presented "ideal" format can become burdensome and redundant. In this instance, the description of the learner and the expectation of when the objective will be achieved can be included in a blanket statement at the beginning of the list (for example, By the end of the lecture, the student will be able to…).

The information that follows then includes only the do how much of what in the form of a measurable action word from Bloom's taxonomy and the critical information or skill to be accomplished.

A list of learning objectives in this shorthand format might look something like the following.

By the end of the lecture, the student will be able to:

1. List different types of pathologies that produce an "opacity" on chest x–ray.
2. Identify normal anatomic structures of the thorax on a chest x–ray.
3. Construct an appropriate imaging algorithm for work up of suspected pulmonary embolism.

In each objective listed here, the underlined word is the measurable action word taken from Bloom's taxonomy. Again, it is easy to see how an objective in this format fulfills the requirements discussed previously by accrediting bodies. They are student-centered objectives that describe what the student will be able to do after the teaching session. They use an action verb supplied by Bloom's taxonomy. Furthermore, these types of actions can be evaluated or measured to ensure that the student has indeed accomplished the objective. That is, in an examination or in an informal evaluation we can directly ask the student to demonstrate their ability to accomplish these actions.

TABLE 1. Bloom's Taxonomy of Educational Objectives

Competence	Skills Demonstrated	Question Cues	
Cognitive Domain			
Knowledge	Remembering of terminology, facts, and methods	Define Describe Identify Show Label	Examine Tabulate Name Write Quote
Comprehension	Understand the meaning of conceptual information; translate knowledge into new context; interpret facts; predict consequences	Summarize Describe Interpret Contrast Predict Associate	Distinguish Estimate Differentiate Discuss Extend
Application	Use previously learned information in novel situations; solve problems	Apply Demonstrate Calculate Complete	Solve Examine Modify Classify
Analysis	Understand the organizational structure of information; see patterns; organize parts	Analyze Separate Order Connect Arrange	Divide Compare Select Infer
Synthesis	Creative application of prior knowledge and skills to produce an original entity	Adapt Create Combine Integrate Modify	Generate Design Invent Compose Formulate
Evaluation	Judge relative value of information based on prior knowledge; make choices based on reasoned argument; recognize subjectivity	Compare and contrast Criticize Critique Defend Judge	
Affective Domain			
Attitudinal	Demonstrating or adopting attitude change	Consider Exemplify Modify Plan	Rank as important Realize Reflect Revise
Psychomotor Domain			
Performance or behavior	Skills associated with performing laboratory techniques, record-, physical examination, etc.	Calibrate Demonstrate Diagnose Diagram Listen/hear	Measure Operate Perform Record Write

Notably, the verbs included in Bloom's taxonomy (Table 1) all describe actions that can be rehearsed. A learner can practice making a list, identifying structures on a chest x-ray, or constructing an algorithm. Additionally, learners can self-assess to measure their own achievement of these tasks. Contrast these verbs with "bad" but commonly used action words such as learn, believe, appreciate, know, review, or understand. A learner cannot practice or demonstrate knowing or appreciating something. This type of action is not discrete and the outcome cannot be measured. Furthermore, these terms are vague and do not give the learner a clear idea of what is expected of them. These terms are not included in Bloom's taxonomy, and their use should be avoided.

Incorrect Learning Objective Format

- "The student will understand the role of radiology in the management of cancer patients following the session."

Although this seems to follow the correct format, there are still several problems with this learning objective. The word

TABLE 2. Learning Objectives Ranked to Levels of Bloom's Cognitive Domain

Bloom's Level	Competence	Example of Learning Objective
1	Knowledge	**Quote** risks associated with radiation exposure
2	Comprehension	**Discuss** the role of abdominal ultrasound in the assessment of an acute trauma patient
3	Application	**Apply** proper terminology when describing a fracture
4	Analysis	**Analyze** the bowel gas pattern on an abdominal plain film
5	Synthesis	**Compose** an appropriate imaging algorithm for a patient with shortness of breath
6	Evaluation	**Compare and contrast** the role of computed tomography versus magnetic resonance in the diagnosis of adrenal adenomas

TABLE 3. Benefits of Learning Objectives for Both Learners and Educators

Benefits of Learning Objectives

Allow communication with others about the content and intent of a teaching activity
Clarify and help direct teaching goals
Ensure that educational methods (eg, lecture, small group discussion) are properly aligned with the goals of the session
Help focus studying by ensuring that students concentrate on what is essential
Provide a check as to whether a curriculum teaches at multiple cognitive levels as outlined in Bloom's taxonomy
Simplify assessment: Assessment questions should match the content and Bloom's level of the relevant learning objectives
Give students a clear idea of what is expected of them
Give students a better platform to evaluate our performance as educators

"understand" is not included in Bloom's taxonomy because is too vague and not measurable, as discussed previously. Additionally, this objective is too broad and closer in scope to a teaching goal rather than an actual learning objective.

Correct Learning Objective Format

- "The student will be able to discuss current mammography screening recommendations by the end of the course."

In this objective, the action word (discuss) is measurable and can be assessed. Furthermore, the scope of the objective is more discrete. A student reading this learning objective would know exactly what was expected of them and how to focus their studies.

RANKING OBJECTIVES IN BLOOM'S TAXONOMY

Any curriculum will ideally have a mixture of learning objectives that reflect different levels of cognitive thought as outlined by Bloom. The admixture probably will not (and should not) evenly represent the different levels within the taxonomy. Rather, depending on the type of activity, difficulty of the relevant material, and sophistication of the learners, the level of the associated learning objectives should be adjusted accordingly. For example, the learning objectives for lectures or sessions occurring in the first weeks of medical school curriculum are often predominantly knowledge level questions because any time new content is introduced, it generally brings with it the need to master new nomenclature and concepts before more involved learning can occur. By the end of med-

ical school, students are expected to be able to analyze, synthesize, and evaluate medical information in the appropriate context. This is important because we need to teach students to become skilled problem solvers and diagnosticians, not just to be able to regurgitate rehearsed information. Ensuring that we teach and test at higher cognitive levels will help to impart these critical skills. In fact, the American Board of Radiology's new core and certifying examinations have been designed with this premise in mind. These examinations will include numerous interactive question formats that can test at higher cognitive levels of Bloom's taxonomy compared to a traditional multiple-choice examination (12).

It is possible to quantify the levels represented by a set of objectives for a given session, which allows the cognitive demand of a course or curriculum to be tracked over time. Keep in mind that this is not always an exact science; even education experts will sometimes disagree as to whether a particular action word pertains to one Bloom's level or the next. Because of this, there is some minor variability within the tables available online and in use at academic institutions. Examples of learning objectives ranked to each level of Bloom's cognitive domain are listed in Table 2.

ACHIEVEMENT OF OBJECTIVES

In addition to their other benefits (summarized in Table 3), having learning objectives as a guide can make testing and assessment of learners much easier. They provide a clear roadmap of critical content and concepts to be evaluated. Moreover, congruency of content between the stated learning objectives and the eventual assessments will minimize student

frustration and ensure that the learning objectives will not be ignored in the future.

Examination or assessment questions should match not only the content of the relevant learning objectives, but the cognitive level specified by Bloom's taxonomy. Typically, the level of the examination question should not exceed the level of the associated learning objective. If the examination question is written at a higher level, then it is not possible for the student to have prepared based on the cognitive expectations specified by the learning objectives. For example, if an objective asks the student to be able to list three different imaging examinations that can diagnose pulmonary embolism (a knowledge-level question), then the test question should not ask them to compare the advantages and disadvantages of each (a much higher order analysis-level question). For this reason, it is wise to rank examination questions in Bloom's taxonomy in addition to the objectives themselves. This ranking procedure can be incorporated into examination blueprinting: a process of generating examinations by linking the subject matter delivered during instruction and the items appearing on the test to ensure effective testing of essential knowledge and skills (13). This process provides an important opportunity to ensure that test questions content links to a stated learning objective and that the Bloom's level of the question and objective are concordant.

Last, having learning objectives, and thus giving students a clear idea of what is expected of them, gives the learner a better platform to evaluate our performance as educators. If objectives are set out clearly, the student will hopefully feel accomplished when they are achieved and appreciate our role in directing and facilitating their learning. Having a complete feedback loop also allows comparison of our performance to educators at other institutions, further opening the door for improved analysis and review of our teaching.

SUMMARY

Learning objectives are a critical step in the creation and implementation of a radiology curriculum whether at a medical student, resident, or postgraduate level. Their use is mandated by the LCME, ACGME, and ACCME, but more importantly they can have a significant beneficial impact on quality of radiology education programs. Learning objectives guide student learning, help clarify our teaching goals, and simplify learner testing and evaluation. Furthermore, writing clear and effective learning objectives can be simplified using a straightforward stepwise approach.

Writing learning objectives, however, should not be a static process. It is important to continue to test them over time. This should ideally include input from faculty colleagues, feedback from students, an analysis of examination performance (which may highlight objectives that need clarification or improvement), and feedback regarding our performance as educators. The need for iterative improvement of objectives over time is underscored by their integral association to all facets of a well-designed radiology curriculum.

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