



Toward Teaching at Higher Levels of Cognition

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How should one measure the effectiveness of a collegiate academic program? What qualities should an effective program possess? Bloom, Madaus, and Hastings (1981) stated that "education is a process of change; students must be changed in some way through the instruction they receive." College academic programs seek to "change" students by developing and enhancing abilities required in a professional career. Such required abilities include: (1) the ability to communicate intelligently and effectively; (2) the ability to think and perform independently; (3) the ability to evaluate existing products and ideas and create new ones; and (4) the ability to transfer and apply curriculum based knowledge to career-based situations.

In an effort to help students develop the types of abilities that will be demanded in their careers, professors need to examine the purpose of their instruction and ask themselves the following questions:

1. To what extent is our system of educating students effective in providing them with not only information, but also experiences in using that information in situations similar to those they will encounter in their careers?
2. To what extent does instruction focus on **what** and **how much** information students learn compared to **how** it is actually being learned and how it will be used?
3. What opportunity is provided for students to think independently, to create new solutions to old problems, or foresee potential problems and seek solutions?

Professors share in the responsibility for student learning and need to take steps to ensure their adequate preparation for careers. If all students can do is repeat back to the professor information that has been given to them, then not much instruction of an enduring nature has taken place. Many students make the mistake of assuming they have "learned" adequately if the information seems to make sense as they read it in a textbook or hear it in a lecture. If experiences are not provided through coursework enabling students to use and internalize such information, they may be unaware of their abilities to do so until it is too late — when they are confronted with a career situation that requires such behavior (Bransford and Stein, 1984).

To gain a sense of the effectiveness of education in preparing students for career demands, it is necessary

to look at the specific types of positions being filled by new graduates of agricultural colleges. Are there certain requisite abilities common to most or all of these positions (e.g., critical thinking skills, decision making skills, creative thinking skills, etc.)? Once such abilities are identified, it is necessary to relate them to the classroom. Are class discussions, student assignments, and examinations promoting the development and enhancement of these abilities? If not, further study and action is needed.

Development of a system of classifying activities and behaviors in the classroom could simplify the faculty member's task of determining his/her ability to prepare students for careers. Many researchers have developed ways to categorize learning behaviors. One of the most popular and widely-used approaches of such a classification system is the **Taxonomy of Educational Objectives: The Cognitive Domain**, developed by Bloom, Englehart, Furst, and Krathwohl in 1956.

Categorizing Learning Behaviors

In developing the Taxonomy, the various behaviors associated with learning were examined and grouped into hierarchical levels. These levels ranged from the simplest to the most complex learning behaviors. Each level of behavior was designed to serve as a prerequisite and a basis for the next higher level.

The original hierarchy developed by Bloom et al. (1956) consisted of six levels of behavior — knowledge, comprehension, application, analysis, synthesis, and evaluation. For the purposes of simplifying the differences between these levels, the six levels have been restructured into four levels (Newcomb and Trefz, 1987). A brief description of these levels follows.

Levels of Learning

Remembering is the simplest of the cognitive levels, involving the memorization, recall, and identification of facts. The ability to recall many types of information is involved at this level, ranging from simple, specific facts to more complex concepts and abstract theories.

It is important to note that at the remembering level, all emphasis is placed on the mere **recall** of information; no understanding of the concepts or principles of the information is required or assumed.

Providing this background of facts, dates, theories, etc. is essential for the student beginning to learn new subject matter. Avoidance of such fundamental instruction would deprive students of a point of reference or foundation for further learning.

However, when educators fail to elaborate on such facts or do not assist students with developing a deeper understanding that will enable them to apply their knowledge in new and challenging situations, the full potential of education cannot be realized. The mere knowledge of facts is not a sufficient goal in education.

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Table 1. Vocabulary Useful in Developing Objectives and Test Items at Various Cognitive Levels

Remembering	Processing		Creating	Evaluating
acquire	analyze	infer	combine	appraise
cite	apply	interpolate	compose	argue
define	associate	intepret	constitute	assess
identify	categorize	outline	construct	conclude
label	change	paraphrase	create	consider
list	choose	point out	derive	decide
name	classify	predict	design	evaluate
recall	compare	prepare	develop	judge
recite	compute	rearrange	devise	standardize
recognize	contrast	relate	document	validate
reproduce	convert	reorder	formulate	weigh
state	deduce	rephrase	integrate	
	demonstrate	represent	modify	
	describe	restate	originate	
	detect	restructure	organize	
	determine	summarize	plan	
	differentiate	transfer	produce	
	discriminate	transform	propose	
	distinguish	translate	reorganize	
	draw	use	revise	
	estimate		rewrite	
	explain		specify	
	extend		synthesize	
	extrapolate		tell	
	generalize		transmit	
	illustrate		write	

Source. Adapted from:

Chamberlain, V.M. and Kelly, J.M. (1981). *Creative Home Economics Instruction*. New York: McGraw Hill Book Company.

Hall, K.S. (1983). "Content Structuring and Question Asking for Computer-based Instructional Objectives Classification Scheme." *Educational Technology*, 24(7), 21-26.

Only when students can make the transition from the curriculum to the career and can express their knowledge in ways relevant to the situations facing them has their education been truly beneficial to their professional growth and development.

Processing, the next level of learning, involves the use of known facts, principles, and theories in a procedural manner. An understanding of the material is required and abilities to relate this material to new situations as well as analyze existing circumstances to develop solutions are needed.

Creating, the third level, moves the student into divergent thinking. Creating is the ability to think in alternatives. It encourages students to think innovatively and make original conclusions.

Creative activity in the classroom and the career often involves the development of some type of product (Bloom, et al., 1981). This product could be in the form of a communication that expresses the unique ideas, feelings, and experiences of the learner, or a plan or solution to a particular situation.

Some processing level behaviors at times also require a student to **create a solution** to a problem or situation. The students are normally provided with the specifics of the situation and correct answers can generally be determined in advance by the instructor. This type of creativity should not be confused with the creating level, which requires the student to **create an entire product**. Correct answers to questions that are truly at the creating level cannot be determined in advance from the instructor; they come from within

thoughts and understandings unique to the student.

It is important to note here that the role of the educator changes when teaching and testing at the creating level of instruction. Bloom et al. (1981) maintain that the instructor

"...serves more as a coach or guide with the student. Rather than judging the student's work on the basis of a letter grade, they are directed to helping the student find aspects of their work which are adequate as well as aspects which can be improved or strengthened."

Evaluating is the final level of learning. Evaluation involves the ability to make a judgment or critical analysis for a given set of data that is based on a standard or specific criterion (Bloom, et al., 1956). Decisions at this level of learning involve some risk taking — the answers are not obviously correct or incorrect.

The decisions at this level can be based on either the accuracy, consistency and logic of the material or its application to a set of criteria. Criteria may either be taken from established standards or from those determined by the student.

Making the distinction between these various levels of learning can be the first step toward improved teaching and enhanced student learning.

Use of the Levels of Learning

How can this information about the levels of learning be used to improve the effectiveness of educational programs? To gain the greatest benefit, it is necessary to put this information into practice in all areas of instruction: (1) in the development of objectives; (2) in the design of learning activities for use

in the classroom and outside of class; and (3) in the development of test items and student assignments.

Development of Objectives. Educational objectives provide students with a "blueprint" of what is considered to be important in a given course. Carefully developed objectives can also create a common understanding between the instructor and student as to what information will be provided through instruction as well as what is expected of the student. They also give the student direction as where best to devote learning efforts.

As professors develop objectives that describe what they want their students to know and be able to do after a unit has been taught, it is important that they develop objectives at each of the levels of cognition. If all of the objectives call for behaviors like list, define, or name, all of which are at the remembering level, then for most courses the level of content and the expectations for students will not be appropriate. If the objectives do not include learning at the various levels of cognition, it is unlikely that students will develop proficiency in all levels.

Vocabulary lists based on the levels of cognitive learning have been developed (Chamberlain and Kelly, 1981, and Hall, 1983) to assist instructors in designing course objectives as well as test items. A compilation of these lists, adapted to represent the four levels of learning, is provided in Table 1. The behaviors associated with the various items in each category are representative of the type of learning required in each level. Although this list is by no means exhaustive, it can serve as a basic guideline for educators.

Using this list as a catalyst for ideas, professors can readily design their instructional objectives so as to include learning at the various levels of cognition. The following objectives related to beef cattle production illustrate the use of objectives at the various levels of cognition.

Remembering — List the advantages and disadvantages of a commercial cow-calf operation for the southeastern United States.

Processing — When developing a beef cattle production plan for a cow-calf enterprise, indicate what the most important characteristics would be for the sale product as determined by the market demand and explain each of these characteristics.

Creating — Considering the breeds to be used in developing the maternal side of the cross, propose a series of matings that is most likely to result in a maximum preweaning rate of gain.

Evaluating — Given a set of production records, determine which dams should be culled and explain why.

Designing Learning Activities

Sound instructional design demands that professors develop student learning activities for both in-class and out-of-class assignments which enable students to accomplish the objectives for each unit of

instruction. These learning activities must be designed so as to cause students to operate at the appropriate level of cognition. If a professor only recites basic facts in a lecture mode and there are no supplementary out-of-class learning activities, it will be unreasonable to expect that students will develop the ability to use higher order cognitive processes. Also, if students are not required to practice operating at each of the levels of cognition as a part of their experiences with the course, then it is unlikely that they will learn to create and evaluate on their own.

Therefore, as professors develop their teaching strategies, they should make liberal use of a wide range of teaching techniques and learning activities that will help students develop higher order abilities. Certainly one must go beyond dependence on lecture.

There needs to be carefully planned and executed class discussion which requires students to process basic facts and concepts. Such discussion can also cause students to evaluate.

Case studies can be used in ways that cause students to operate at all four levels of cognition. When carefully chosen writing assignments are used, it is likely that the learning will quickly move beyond the remembering level.

The use of experiments, the doing of science, will also help students to learn at the higher levels of cognition. Similarly, lab activities which require application and testing of theory, not only clarify what may be abstract to the student but also cause students to process and perhaps evaluate.

Thus, by using a variety of approaches to teaching, professors can greatly enhance the probability that the learning that occurs as a result of their course will go well beyond remembering.

Development of Test Items and Student Assignments. Once objectives are written and learning activities are designed and used, then professors need to be sure to test at the higher levels of cognition. If the objective calls for the students to be able to process, then the test items designed to determine if the objective has been met must measure processing, and so on for each level of cognition.

Like behavioral objectives, test questions can be written in a subject matter area to provide a progression through the four levels of cognition.

Remembering — "What are the advantages of a commercial cow-calf operation for the southeastern United States?" or "What concerns does one face with a cow-calf operation in the southeastern United States?"

Processing — "What is the influence of market demand on the sale of a product?"

Creating — "Design a breeding program that will optimize pre-weaning rate of gain."

Evaluating — "Using the attached set of records, provide recommendations as to which heifers should be kept. State the reasons for your recommendations."

Professors know that it is what appears on the test more than anything else that determines the "kind of learning" to which students pay attention. When the test calls for students to process knowledge, they become very adept at demonstrating that behavior. The same is true for behaviors associated at each of the levels of cognition.

Remembering

- A. Students offer the answer from their memory. They are not required to understand, compare, relate, or make any independent reasons in providing the answer.
- B. A question at this level is worded in a manner identical to the way the information was originally learned. Items should not use terms which are new to the student.
- C. Any question, regardless of its presumed complexity, which can be answered through mere recall of information previously discussed in class or in the text should be categorized as a remembering level question.

An example of an agricultural economics question that tests the ability to remember a formula is: "Marginal cost is equal to _____ divided by _____" (Erven, 1986). A question used in the area of plant pathology to test the ability to remember a definition is: "The 'gene for gene' theory states that _____" (Rhodes, 1986).

Hunkins (1972) states that questions at the remembering level are easy to develop and are used most often. Professors need to ask themselves why they ask such questions. How are student responses going to assist them in achieving a greater understanding of the material?

Processing

Students must be able to:

- A. translate ideas or concepts into their own words or in a form useful in solving the problem;
- B. select an approach (out of several possibilities) to solve a problem or situation that is new to the student (Hunkins, 1972); or
- C. identify, classify, discriminate, or relate particular qualities or characteristics of the material.

The following are examples of questions that require students to use understood information in a procedural manner. The first question asks an agricultural engineering student to interpret the reading on a voltmeter. The second question requires a natural resources student to use a known formula to calculate the age of a tree, given a set of criteria.

1. In the circuit shown, what would be the reading of the voltmeter? (Lichtensteiger, 1986).
2. What is the total age of the following tree?
Given: Increment core at D.b.h., seven inches long, having a count of 63 rings, with 8 of those rings being on the innermost one inch of the core. The core was drilled straight toward the center of the tree of 24 inch D.b.h. with 0.75 inches bark thickness (Kasile, 1986).

The material used in testing at the processing level should either be new to the student or be different from that used in instruction, but with similar characteristics in terms of words used, content, etc.

Creating

- A. Students may identify the task or problem for themselves, or at least have considerable freedom in interpreting it (Bloom et al., 1981).
- B. Students may have the option to attack the problem with a variety of references or other material. Problems at the creating level are often utilized in open-book examinations.
- C. The problem, task, or situation involving creating should be new or in some way different from those used in the instruction.

The following creating level questions require students to use their own ideas and knowledge in different ways. The first question asks dairy science students to formulate a plan for utilizing a computer in dairy production. The second question, dealing with agricultural economics, requires students to present their views on the future of part-time farming in Ohio.

1. As a manager of a 200-cow dairy herd, including calf and heifer raising and forage production, you are interested in buying a computer to aid your decision making. Outline how you would use the computer and why. (The question will be graded primarily on how convincingly you answer the "why" part of the question.) (Schmidt, 1986).
2. State your conclusion relative to the survival of part-time farming in Ohio. Base your conclusion on the overall content of this course. Be specific in identifying the reasons for your conclusion using principles, theory, guidelines, procedures, and/or practices discussed in this course (Erven, 1986).

Evaluating

- A. Students make judgments about the worth or value of an idea, solution, method, etc. using a set of criteria as a basis for judgment.
- B. The problem situation or material to be evaluated should be available to the students as they make the evaluation, and they should be able to refer to it as they attempt to answer the question or problem (Bloom et al., 1981).

The following evaluating level questions ask students to take a stand on a given issue and support their position through information learned in the course.

1. The role of ruminant animals and their contribution to solving the world food problem will most likely be restricted to the temperate regions of the world (i.e., the so-called "developed" regions). Do you agree? Why or why not? Be specific! (Henderlong, 1986).
2. John Schmidt from the North Central Computer Institute predicted that on-farm

microcomputers would be a "boom" to the increased use of computer programs available only from main-frame computers via telephone linkage. Do you see an increase in the use of these main-frame computer programs? Why or why not? (Schmidt, 1986).

Summary

Given the complexity of the current and emerging body of knowledge in agriculture and the demands placed on graduates of colleges of agriculture, professors will increasingly need to examine at what level of learning (lower versus higher levels of cognition) they are teaching. Unless students learn to operate proficiently at the higher levels of the cognitive domain, they probably will not be well prepared to serve in an ever-changing industry. It is the responsibility of all professors of agriculture and natural resources to be sure their instruction is planned and delivered in such a manner that these higher order cognitive abilities are developed.

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