Using instructional objectives in agronomic courses

Judith A. Wells, Diana G. Helsel, and David H. Trinklein

ABSTRACT

The writing of clear instructional objectives helps both instructors and students to focus the learning process in agriculture. Writing instructional objectives may be improved by a better understanding of the components of instructional objectives and by replacing vague verbs (such as "know" or "understand") with those that evoke a more specific, active response (e.g., "arrange" or "appraise"). According to Benjamin S. Bloom, a well-constructed instructional objective has three parts: i) Intended outcome statement (What is it that I must teach?), ii) Conditions statement (What materials and procedures will work best?), and iii) Criteria statement (To what extent do I expect the student to learn what I teach?) Bloom's Taxonomy of Educational Objectives can assist instructors in targeting instructional objectives at six levels ranging from simple learning to complex learning. The hierarchical structure of Bloom's Taxonomy may help instructors challenge student thinking to the higher, more complex levels of learning.

Additional index words: Hierarchical structure of learning, Student achievement, Improvement of instruction, Thinking at higher levels.

As instructors are expected to become more accountable for their teaching endeavors and teaching goals, the writing of meaningfully stated instructional objectives for each agronomy course takes on paramount importance. In fact, educational research has shown that one significant difference between the effective and ineffective instructor is how well each stated their expectations of student achievement (Good and Grouws, 1979; Brophy and Evertson, 1976, 1981).

One of the most fundamental steps in teaching is determining instructional objectives. These objectives allow the instructor to clearly delineate what to teach and how to assess progress in the teaching process. Objectives also enable the student to measure learning progress (Binkley and Tulloch, 1981).

Specifically defined objectives motivate students to work harder to attain them than do vaguely stated ones. Well-written objectives serve to clarify and crystallize the assigned learning task in the mind of the student. This clarification is necessary before the student can effectively learn.

Many adjectives describe objectives, including "instructional objectives" (Mager, 1962), "behavioral objectives" (Vargas, 1972), "terminal behavior objectives" (Burns, 1977), and "performance objectives" (Gagne and Briggs, 1979). Other commonly used terms are "educational objectives," "learning objectives," and "teaching objectives."

This paper presents: i) an explanation of instructional objectives in the context of Bloom's Taxonomy of Educational Objectives, ii) some guidelines for writing them effectively, emphasizing the higher levels of learning, iii) specific applications and examples of instructional objectives with accompanying examination questions apropos to the study of crop production, and iv) suggestions of how faculty may encourage students to use instructional objectives. Even though instructional objectives and Bloom's Taxonomy are not new topics, they continue to be relevant. In a survey of 40 College of Agriculture teaching faculty at the University of Missouri, none outside of the Agricultural Education Department had a knowledge of Bloom's Taxonomy.

BLOOM'S TAXONOMY OF EDUCATIONAL OBJECTIVES

The most widely used system of classification of educational objectives was developed by Benjamin S. Bloom and his colleagues (1956). They categorized objectives into three overlapping domains according to learning outcomes:

2. Psychomotor objectives concerning the learning of manipulative skills or physical movements.
3. Affective objectives concerning the learning of attitudes, feelings, and values.

In practical application, learning involves two or three of the above domains simultaneously.

For an instructor of a lecture-oriented course, the emphasis is on the cognitive domain. Bloom divides the cognitive domain even further into six levels, from the simplest learning at level 1.00 to the most complex learning at level 6.00 (Table 1).

The simplest form of learning, called "knowledge" (level 1.00), involves rote memorization of facts. The second level is "comprehension" in which the student is required to restate the meaning of the information just memorized. Next, and more complex, is "application" (level 3.00) that requires the student to use the information gained in levels 1.00 and 2.00 in an applied problem. "Analysis" (level 4.00) requires a student to separate information into its component parts and then to determine the relationship(s) between the component parts. Level 5.00 or "synthesis" asks a student to start with known pieces of knowledge and to assemble or integrate them in new ways. Consequently, this complex level 5.00 requires a student to think originally and creatively in order to generate new, and often abstract, ideas or answers. Usually grading becomes more subjective at this advanced level; therefore the instructor may find it more difficult to establish valid criteria or examination questions. The most complex level of learning is "evaluation" (level 6.00).

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The student is required to make specific value judgments from previous knowledge and, often, to explain why he or she made these judgments. As in level 5.00, the instructor may be prone to grade answers at the most complex level more subjectively and qualitatively.

Bloom's Taxonomy of Educational Objectives is hierarchical, the higher or more complex levels of learning being based on knowledge obtained in the lower or simpler levels. It is easiest and most common for an instructor to generate instructional objectives originating from the two lowest levels of learning: knowledge and comprehension. More instructional objectives involving the higher learning levels need to be used to challenge students to think in terms of application, analysis, synthesis, and evaluation. One teaching aim should be to encourage complex, higher level thinking whenever possible, even with beginning students. A good starting place would be to direct more instructional objectives at the higher levels of Bloom's hierarchy.

A GUIDE TO WRITING INSTRUCTIONAL OBJECTIVES

The instructor must focus on three major concerns about teaching (Mager, 1962):

1. Intended outcome statement: What is it that I must teach?
2. Conditions statement: What materials and procedures will work best to teach what I must teach?
3. Criteria statement: To what extent do I expect the student to learn what I teach?

At the onset, the instructor must formulate a clear and specific set of intended learning outcomes to be accomplished by the end of the instructional period. The change in student behavior or performance as a result of instruction must be measurable. Generally designed to guide learning over a short time span, instructional objectives enable the student to know what to expect from examinations and from the course as a whole, as well as to evaluate personal progress in the learning process. These objectives may also be used to develop individualized instruction or self-study materials if they are very specific in their focus (Crunkilton and Krebs, 1982).

Intended Outcome Statement

All instructional objectives should state specifically what the learner must be able to do or perform after the learning experience. Hence, instructional objectives may contain few or many sentences, depending on the scope of the learning involved.

When choosing verbs for the instructional objectives, avoid those having many potentially different interpretations, such as "know," "be aware of," or "gain an appreciation of." For instance, contrast these two sample instructional objectives:

1. Be aware of the structures and pigments inside the plant cell which are responsible for absorbing light.
2. List the structures and pigments inside the plant cell which are responsible for absorbing light.

The verb "list" is more explicit than the verb "be aware." The student has a tendency to look at objective 1 and tell himself that he knows the answer. No action is elicited. The verb "list," on the other hand, calls for action. The student must write out or verbalize the answer. A specific action verb is the key to writing effective instructional objectives. Some examples of effective action verbs for the various cognitive learning levels are given in Table 1.

Table 1. Bloom's Taxonomy of Educational Objectives with verbs useful in stating cognitive outcomes in the study of agriculture.†

<table>
<thead>
<tr>
<th>SIMPLE LEARNING</th>
<th>Level 2.00</th>
<th>Level 3.0</th>
<th>Level 4.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1.00</td>
<td>Knowledge</td>
<td>Comprehension</td>
<td>Analysis</td>
</tr>
<tr>
<td>Define</td>
<td>Repeat</td>
<td>Record</td>
<td>Distinguish</td>
</tr>
<tr>
<td>Recall</td>
<td>List</td>
<td>Name</td>
<td>Analyze</td>
</tr>
<tr>
<td>Name</td>
<td>Relate</td>
<td></td>
<td>Differentiate</td>
</tr>
<tr>
<td>Relate</td>
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<td>Calculate</td>
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<td></td>
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<td>Examine</td>
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<td>Compare</td>
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<td>Contrast</td>
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<td></td>
<td></td>
<td></td>
<td>Criticize</td>
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<td></td>
<td></td>
<td></td>
<td>Diagram</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Examine</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Categorize</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMPLEX LEARNING</th>
<th>Level 5.00</th>
<th>Level 6.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluation</td>
<td>Judge</td>
<td>Appraise</td>
</tr>
<tr>
<td></td>
<td>Evaluate</td>
<td>Rate</td>
</tr>
<tr>
<td></td>
<td>Value</td>
<td>Revise</td>
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<tr>
<td></td>
<td>Score</td>
<td>Select</td>
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<tr>
<td></td>
<td>Choose</td>
<td>Assess</td>
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<tr>
<td></td>
<td>Estimate</td>
<td>Measure</td>
</tr>
</tbody>
</table>

† Adapted from Bloom et al. (1956) and Johnson and Johnson (1973).
Conditions Statement

Next, the instructor must decide on relevant conditions to accompany the subject matter to be taught. Usually a fairly detailed set of conditions, describing the circumstances surrounding the expected learning outcome, is required so that the student may fully comprehend the teacher's intent regarding the course content. The instructor must inform the student of what tools (e.g. references, materials, equipment, procedures, etc.) are needed to accomplish the learning task (Owen, 1983).

Criteria Statement

Finally, the student's mastery of the instructional objective is measured by an examination on the subject matter, taking into consideration any specific conditions pertinent to the intended outcome statement. Before the examination the instructor indicates to the student how well or to what extent he or she must learn the subject matter. Consequently, the instructional objective must state the criteria or the minimum acceptable amount of learning or performance expected of the student after receiving instruction. The instructor must let the learner know how much learning is adequate by specifying i) the minimum number of correct responses that will be acceptable, ii) the precision of answers required for acceptance, and iii) the length of time, if appropriate, for the examination.

POSSIBLE STUDENT REACTIONS TO POORLY WORDED VS. WELL-STATED OBJECTIVES

Different verbs define the level of the objective and elicit different student responses as illustrated by a series of agronomic examples.

Example 1.

Objective: Know why organic matter is an important component of the soil.

Explanation: Since “know” is an ambiguous verb, the student’s response to this objective is likely to be vague, such as “It improves the fertility.” Or the student may respond “Yes, I heard that term in lecture” or “I saw it in the text”. However, in reality the student does not fully comprehend the entire answer. Using a different verb for this instructional objective would enhance the learning outcome.

Improved Objectives: Analyze at least four ways in which organic matter influences soil productivity.

Explanation: In moving to a level 4.00 or analysis objective, the student must define soil organic matter and, using this knowledge, analyze its impact on at least four facets of soil productivity. The student is faced with a two part learning task: i) What is soil organic matter? and ii) What factors influence soil productivity? First, the student may define soil organic matter (a level 1.00 activity). Second, a list of factors influencing soil productivity (e.g. water holding capacity, water infiltration rate, cation exchange capacity, etc.) must be recalled (a level 1.00 activity). To completely understand the improved objective, the student must analyze the relationship between organic matter and soil productivity. To do so the student may pose a series of questions such as “Does organic matter improve or detract from water holding capacity?” Notice that the improved objective specifies the minimum number of acceptable responses required—analysis of at least four components of soil productivity relating to organic matter (refer to section on Criteria Statement).

Example 2.

Objective: Review the major organelles of a plant cell.

Explanation: Student response to this objective might be: “Nucleus, ribosome, and mitochondria.” Reviewing cell parts is a relatively passive activity: the student must only associate organelles with names. If this objective is stated differently, the student’s response would be different.

Improved Objective: Diagram and label the major organelles of a plant cell.

Explanation: Changing the verb “review” to “diagram” moves the level of the instructional objective from 2.00 to 4.00 (refer to Table 1). Diagramming the cell involves comprehending spatial relationships, as well as reviewing the names of plant cell organelles. First, the student must visualize and recognize by name the cell parts from memory. Second, the cell must be broken down spatially into its various organelles so that the cell's organizational structure may be understood. Third, the student must draw the cell with its major organelles correctly placed. Fourth, the student must write down the correct name of every organelle. Note that more involved and complex thinking is called for by the verb “diagram” as compared to the verb “review”.

Example 3.

Objective: List three attributes of a good seedbed.

Explanation: The student response to this level 1.00 instructional objective might be: “Water, aeration, and good seed-to-soil contact.” Listing requires only rote memorization. This objective could be changed to a level 6.00 objective by changing the verb.

Improved Objective: Select three attributes for good germination in a seedbed. Rate them in importance from greatest to least, justifying your rating in each instance.

Explanation: Selecting the seedbed attributes requires that the student understand the various attributes and bring them together in new ways as he synthesizes this information in formulating an answer. The student must rank the attributes in order of importance. In addition, the student must write or ver-
Table 2. A comparison of instructional objectives and appropriate sample examination questions concerning row crop production practices for the six levels of Bloom's Taxonomy of Educational Objectives.

<table>
<thead>
<tr>
<th>Level</th>
<th>Intended outcome statement</th>
<th>Conditions statement</th>
<th>Criteria statement</th>
<th>Sample examination question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>Name different methods of row crop production relative to soil preparation.</td>
<td>Information from textbook and lecture notes.</td>
<td>100% accuracy required in naming two production methods.</td>
<td>Two different production methods relative to soil preparation for row crops include _________ and _________ .</td>
</tr>
<tr>
<td>2.00</td>
<td>Identify the merits of no-till versus conventional tillage in row crops.</td>
<td>Information from textbook and lecture notes.</td>
<td>(a) The question may have more than one correct response. (b) 100% accuracy required in selecting all correct responses to questions.</td>
<td>When compared with conventional tillage practices, no-till production of row crops a) helps to preserve our valuable topsoil, b) requires less energy, c) reduces insect and disease problems, d) requires a greater use of herbicides.</td>
</tr>
<tr>
<td>3.00</td>
<td>Demonstrate an appropriate application of no-till methodology for row crop production.</td>
<td>Information from textbook and lecture notes.</td>
<td>100% accuracy required in employing the most desirable soil preparation/planting.</td>
<td>Given a field of wheat growing on class III land to be double cropped with soybeans, which soil preparation/planting method would you employ?</td>
</tr>
<tr>
<td>4.00</td>
<td>Calculate the pesticides needed for the production of 100 acres of corn using no-till techniques.</td>
<td>Information from textbook, lecture notes, and handouts from chemical companies.</td>
<td>(a) Assume the only insecticides used will be banded by the planter. (b) Assume that all pesticides will be applied at minimum rates specified on their labels. (c) 100% accuracy required in calculating the exact amount (in pounds or gallons, according to formulation) of all pesticides required.</td>
<td>Given the conditions presented in the instructional objectives, the pesticides needed to produce 100 acres of corn using no-till techniques include:</td>
</tr>
<tr>
<td>5.00</td>
<td>Plan a production schedule for corn using no-till production techniques.</td>
<td>Information from textbook, lecture notes and class handouts.</td>
<td>(a) Assume a planting date of April 15. (b) Assume supplemental irrigation available as needed. (c) Assume a soil test has been taken and the soil was brought to maintenance level analysis. (d) Show all practices to be considered during the course of production and set tentative dates for their implementation. (e) 100% accuracy required in establishing a production plan (on a per acre basis) that includes: planting rate, fertilizer application (analysis and rate), herbicide and insecticide types and rates and tentative harvest date.</td>
<td>Given the conditions presented in the instructional objective, propose a production plan using no-till for this corn crop.</td>
</tr>
<tr>
<td>6.00</td>
<td>Evaluate the economics of production for corn comparing no-till with conventional tillage systems.</td>
<td>Information from textbook, lecture notes and class handouts.</td>
<td>(a) Assume the yield for both tillage systems will be the same: 200 bushels per acre. (b) Assume planting date and rate to be the same for both systems. (c) Assume supplemental irrigation available as needed. Assume a soil test has been taken and the soil has been brought to maintenance level analysis. (d) 100% accuracy required in establishing a production plan (on a per acre basis) that includes: planting date and rate, fertilizer application (analysis and rate), insecticide and herbicide types and rates, and tentative harvest date. (e) 100% accuracy required for calculation of overhead expenses, labor costs, material costs, harvesting and marketing expenses. (f) 100% valid comparisons should be made between cost-effectiveness of the two production methods.</td>
<td>Given the conditions presented in the instructional objectives, appraise the crop production methods listed and judge which is the most desirable from an economic point of view. Justify your choice.</td>
</tr>
</tbody>
</table>

These examples illustrate that the selection of verbs, especially those aimed at the higher levels of learning in the context of Bloom's Taxonomy, is the key to writing effective instructional objectives that stimulate students to higher levels of thinking.
APPLICATIERS OF INSTRUCTIONAL OBJECTIVES

Table 2 presents a comparison of objectives on the topic of row crop production practices written at the six different levels of learning complexity. In practice, however, it is customary to write an individual objective on only one level.

The table also illustrates the flexibility in approach afforded the instructor when formulating instructional objectives. It is mandatory to teach basic definitions and facts (concrete thinking) via the lower levels. Instructors may need to rely primarily on the lower levels for beginning students. When teaching more advanced students, emphasis is shifted to applying previously learned knowledge and to problem solving. The use of higher level objectives prompts the development of these higher level skills (abstract thinking). This type of learning should be encouraged in students whenever possible.

Instructional objectives should be written for each topic in a course and given to the students prior to the first lecture on a new topic. Generally, the set of objectives for each new subject should be limited to one or two typewritten pages.

Instructors should review and emphasize the importance of instructional objectives with their students. For maximum benefit, students should be encouraged to become familiar with the instructional objectives for each topic before it is covered in lecture. Assigning sample examination questions as homework can be an effective method for motivating students to make use of objectives. This method is most effective when instructors take a given percentage of examination questions directly from the sample questions.

Unfortunately, instructional objectives are not used as frequently by students as professors would like. In a survey of a two agronomy classes (n=159), it was found that only 9% of the respondents used instructional objectives before lectures. Of course, this is one of the best ways for students to make use of instructional objectives. Reading them before class helps develop an appropriate frame of reference so students can perceive important information as it is presented. Use of instructional objectives improves after lectures. In this sample. 43% of the students used them at some point after the lecture. This usage pattern is altered minimally if scrutinized by class rank or GPA.

The most frequent time for use of instructional objectives is just prior to an examination. This is certainly an appropriate time to use them, since many instructors write exam questions from their instructional objectives. Eighty-one percent of the students in our survey used instructional objectives prior to major examinations. Seniors were slightly less likely to use them than other classes (74% vs. 94% for sophomores, for example). Seniors develop a sensitivity for the material, because most of it is concentrated in their major area of study and since they have had more experience in classes than the other groups of students.

The frequency with which students use instructional objectives in other classes reflected the above mentioned trends. Nineteen percent of the students never used instructional objectives in any of their classes. Only 9% always used them when they were made available. This points out the necessity for instructors to reinforce the usefulness of instructional objectives in mastering classroom material. Fifty-two percent of the students used instructional objectives in their other classes only part of the time. Perhaps the reason we had better use of instructional objectives in the agronomy classes used in the survey was that both professors referred to instructional objectives frequently during the early parts of the semester. We also stressed that examinations were based on instructional objectives. After the first examination, this method of developing exam questions was apparent, and use of objectives may have increased.

SUMMARY

Learning is a complicated process. Simple learning by rote memorization serves as a base from which all subsequent learning is built. More complex learning involves moving up through the levels of knowledge, comprehension, application, analysis, synthesis, and evaluation.

Instructional objectives encompassing all six levels of learning in Bloom’s Taxonomy of Educational Objectives serve to focus the efforts of both the instructor and the student on the task of learning. All instructional objectives should include: i) an intended outcome of learning statement, ii) a conditions statement, and iii) a criteria statement. Proper verb choice in writing instructional objectives helps to direct the thought processes of the student to more complex, higher levels of learning in the context of Bloom’s hierarchical structure.

The goal of every teacher should be to instill in students the desire to achieve scholastic excellence by utilizing their talents to the fullest extent possible. The formulation of relevant instructional objectives represents a significant “first step” in challenging students to become better thinkers, thus helping them to attain higher academic achievement.

REFERENCES


