

## Chapter 4

# Mastery Learning and Instructional Design<sup>6</sup>

Robert M. Gagné

*One of Gagné's major contributions to theory and practice alike was the Events of Instruction. The Events serve as a major vehicle for incorporating the conditions of learning into an instructional situation, and serve as a framework for the design of lessons. The Events were primarily discussed in Gagné's book-length publications. This article is one of the few shorter summaries of the Events of Instruction and their rationale. It was published in 1988 in the premier issue of Performance Improvement Quarterly, over 20 years after the original introduction of the Events of Learning in the first edition of Conditions. It provides Gagné an opportunity to compare his position, as well as the role of instructional design in general, with that of Benjamin Bloom.*



Recounting a little of my personal history, I was at one period strongly attracted to the idea of programmed instruction. I supervised a program of training research that included the advocates of both linear program design and branching program design. A little later, I conducted learning studies that utilized programmed materials as their principal content did. The reason I bring these things up is simply this: The idea of learning to mastery was (at least for me) first encountered in programmed instruction. It was quite clear that instructional programs, with their frames and small steps, were aiming for performance that was perfect. That is, the criterion of learning was complete learning, without error, with a criterion of 100%.

## Mastery Learning

It took the brilliant insight of Benjamin Bloom (1968) to raise this particular feature of planned instruction to a new level of generality. Using some of the distinctions of

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Carroll's model of school learning (1963), he proposed that learning to a criterion of 100%, or *learning for mastery*, should be not only a desirable, but also an attainable goal for all but a very small percent of students in school programs. Mastery should be achievable for virtually all students, provided suitable provisions can be made in the time allowed for learning and provided that the *quality of instruction* be held at a high level. This quality should include provision for formative evaluation testing (of the students) and for feedback to them.

In the writings of Bloom, then, mastery learning was transformed from a virtually adventitious feature of programmed instruction to a major desirable characteristic of instruction in general. There came to be strong reasons why instruction should abandon a standard like "70% is passing." Such a statement means that some things have been learned and some have not, whereas the aim should be that all of the objectives of instruction are mastered.

Still another source of influence on these ideas must surely have been the notion of criterion-referenced measurement, as described by Glaser (1963) and by Glaser and Klaus (1963). In this kind of assessment, measurement is made of the attainment of some defined performance. That is, the measurement of performance is related to some standard, or criterion. It is perhaps worth noting here that the clearest examples of criterion-referenced measurement come from kinds of learning outcomes called intellectual skills, such as those pertaining to the learning of mathematics, grammatical rules, science principles, and the like. Criterion-referenced measurement of such subjects as history and literature presents some considerable difficulty, which has not as yet been solved satisfactorily. That is an important point, for the following reason: Mastery learning means 100% learning. As long as the 100% criterion can be maintained, the concept of mastery learning is clear and strong. Once one departs from that standard (as is often suggested by scholars in the psychometric tradition), the fundamental meaning of "criterion-referenced" is lost, and the idea of mastery learning suffers severely. But consider these remarks, if you wish, only a footnote.

The next step in mastery learning, as I have perceived it, was to make it into a system of instruction. This effort was contributed to by the studies of Anderson (1976) and Block (1974), among others. These studies contributed the idea that large differences in achievement found in typical school classes could be substantially reduced by allowing slower students more time, and by assuring that all students received feedback coupled with corrective instructions. Thus, when teachers were committed to making these adjustments in their delivery of instruction and in their classroom procedures, the level of achievement in the whole class improved. Students who would otherwise be in the lower part of the distribution were allowed and encouraged to catch up, to restudy, to follow

new procedures, even when they took more time, and thus to become “good students” rather than poor ones.

Soon it was time for Bloom to lay it all out—to disclose the master plan. This he did in the book titled *Human Characteristics and School Learning* (1976). Here we are told that outcomes of learning are determined by two kinds of characteristics of students upon entry into instruction—*cognitive* capabilities and *affective* characteristics. Obviously these are influenced by prior instruction in the school, but in major respects by the extra-school environment—the home and the community. Then, we come to the influence of instruction itself, that is, to the quality of instruction.

Evidence collected and summarized by Bloom indicates that quality of instruction in such subjects as mathematics and foreign language has to do with the following variables: (a) the cues or directions provided to the learner, (b) the participation of the learner in the activity, (c) the reinforcement received by the learner, and (d) the provision of feedback that includes correctives. It is of interest to note that cognitive entry characteristics enter into the picture, also, in the specific sense of *prerequisites to the learning task*.

It is these ideas about quality of instruction, specifically, that I shall want to return to again in reviewing the ideas of instructional design. It is these variables that Bloom designated as *alterable variables*. These are the factors that the designer of instruction, or the teacher, is able to alter, and in so doing, is able to affect the quality of instruction.

More recent verification of the effects of these variables of instructional quality has come in the article by Bloom on “the 2 Sigma Problem” (1984). In this article, studies by several of Bloom’s students examined the improvements in achievement over conventional classroom instruction of variables identified as (a) enhancement of prerequisites, (b) enhanced cues and participation, and (c) mastery learning feedback and correction procedures. The latter procedures were also tried in combination with other variables, including a total set that made up a complex called “tutoring.” While I do not wish to describe the results in detail, I would say with emphasis that every one of these “alterable variables” was shown to have a positive effect on achievement. Of course, some effect sizes were larger than others. Furthermore, their combined effects appeared to be additive.

What Bloom wishes us to note is that some of the most obvious quality features we can observe in a one-to-one tutoring situation are also useful quality features with classes of 30 students. If teachers make up their minds to do so, the features of enhanced prerequisites, enhanced cueing, student participation, and feedback providing reinforcement and correction, can all be done in the classroom. And if the designers of

instruction decide to do so, these same quality features can be built into the instruction delivered by virtually any of the media. These are the variables of instructional quality, and in combination with the procedures of mastery learning, they can raise achievement by an amount of two entire sigma.

## What About Instructional System Design?

In proceeding to a consideration of the features of instructional system design (ISD), I shall be speaking about the rational basis for this model of instructional design, not about the design procedures themselves. For example, I shall not be talking about “how to do a task analysis”; not “how to introduce a new concept,” but, “the ways in which instruction can influence the learning of a new concept.” As I proceed with the presentation of instructional design ideas, you will see, I think, the following points of comparison with learning for mastery:

1. There are some striking main ideas of mastery learning and instructional design that are identical (except for terminology).
2. There are a few key points of ISD that are not shared with mastery learning.
3. I can detect zero points of conflict in the instructional recommendations from the two systems.

## Instructional Design

Instructional design begins with what is called a needs analysis, the purpose of which is to determine what needs to be learned. (I shall not expand upon this subject here.) This is followed by a task analysis that states what is to be learned as a set of performance objectives. These are specifically stated descriptions of observable human performances. There may need to be many descriptions for any particular course of study, and almost certainly several for any given lesson. An example, for a course in science, might be: “Given a printed description of a body falling from a specified height, demonstrates the principle of gravity with an expression yielding the value of the force at earth’s surface.” A different kind of objective, also for a course in science, might be: “Describes the succession of steps in scientific knowledge and logic that led to the abandonment of the concept of the *ether*.”

Assuming that such objectives do exist, or that they can be stated, the next step is to classify the objectives. I need to say more about this later. At this point I simply note that objectives are classified as *types of learning outcomes*: verbal information, intellectual skills, cognitive strategies, attitudes, and motor skills. The reason for classifying objectives is not primarily because they have to be assessed (or measured) differently.

This is fairly obviously true. The main reason for classifying learning outcomes, though, is because *they require different instruction* for greatest effectiveness. This point comes up later, after I have outlined the tactics of instruction in general.

## Instructional Tactics and Their Sources

The tactics of instruction are derived from two different sources, two sources that are fortunately found to be compatible and even complementary. One source is simply observation of what instruction does—how it proceeds in its attempts to teach. This is not exactly “what an instructor does,” or “what a teacher does”—it is narrower in conception. It is “what a teacher does in delivering instruction,” or “what a textbook does in delivering instruction.” However limited these tactics may be in temporal duration, there is a series of steps—a procedure—in the structure of instruction.

A second source is learning theory. The model of information-processing proposed by Atkinson and Shiffrin (1968) some years ago identifies a number of conceptual structures involved in the process of taking in information and getting it transformed so that it is stored in long-term memory and later recalled as an observable human performance. This entire process, or set of processes, forms the basis of what I refer to when I speak of learning theory. The sequence of processing when something new is learned is briefly described in the following section.

## Information Processing for Learning

Following reception of incoming stimuli, information is *registered* very briefly in one or more sensory registers, then undergoes *feature analysis* or *selective perception*. The information next enters short-term memory where it can be stored in limited amounts for only about 20 seconds. Here it may be *rehearsed* and is also subject to *semantic encoding*, in which form it enters the long-term memory. Information from long-term memory may be *retrieved* back to a short-term form, which is in this case viewed as *working memory*. Working memory (conscious memory) is where various combinations of new and old information take place, and so provides a very important working function for new learning. The additional output of long-term memory, of course, is the response system itself, yielding performance that can be observed outside the individual.

Two other aspects of this information-processing model need to be mentioned. One is that an important component is *executive control*—a means by which the learner exerts control over the other processes of learning and memory. The learner may exercise executive control, for example, over the allocation of attention, or over the process of rehearsal, or over the way incoming information is encoded. A second additional feature

is the process called *reinforcement*. Although the model I have described doesn't tell us how reinforcement takes place, it assumes that it does take place. In other words, the *law of effect* is assumed to prevail in any act of learning. The after-effects of successful performance have their well-known effects on subsequent performances.

I emphasize again that the Atkinson-Shiffrin model of information processing—and there are other, contrasting, models—implies that learning involves a *sequence of steps—a sequence of transformations of information from one form to another*. Thus, this model conceives that learning is a *step-like series of processes*. All of them may occur in a few seconds, but they nevertheless constitute several identifiable stages.

What do these internal learning processes have to do with instruction? Instruction, after all, is a set of external events. Can these be thought of as bringing about the internal events we call learning processes? Well, not really. External events do not directly cause the internal processes. But they may be shown to *influence* them, to *support* them. This leads to the idea that instruction may be defined (to quote myself) as “a set of deliberately planned external events designed to support the processes of learning” (Gagné, 1985).

## The Events of Instruction

The two sources—empirical observations of the procedures of instruction, and the information-processing model of human learning and memory—are both involved in the formulation of the events of instruction. These events are as follows, arranged in the usual sequence of instruction:

1. Gaining attention
2. Informing the learner of the objective
3. Stimulating recall of prior learning
4. Presenting the stimulus
5. Providing learning guidance
6. Eliciting the performance
7. Giving informative feedback
8. Assessing performance
9. Enhancing retention and transfer

I hasten to point out two caveats about these nine events. First, the order of their presentation is not always followed exactly, even though in some ways it is inherent. (One cannot give feedback until the performance has been made.) Second, depending upon the age and experience of learners, not all the events are always overtly employed

in instruction. For example, for students of arithmetic who have been exhibiting the required performances of adding fractions, it would almost surely be a waste of time to go into detail about the next objective “subtracting fractions.” In general, however, my hypothesis about these events would run something like this: Each of the events of instruction is capable of supporting internal processes of learning. Unless such support is provided by the learner’s own executive control, the presence of each event adds to the probability of successful achievement.

## How These Events Relate to Mastery Learning

Let me now elaborate somewhat on some of these that appear to be relevant to learning for mastery.

### **Stimulating Recall of Prior Learning**

Certainly this is the same as what is meant in the studies of Bloom’s colleagues and students as *enhancement of cognitive prerequisites*. In my own writing, when I am dealing with instruction for intellectual skills (as they may occur in mathematics and foreign language learning), I say that the most important condition to assure is that prerequisite skills be retrieved so that they are in the forefront of memory, in other words, prominently attended to in working memory.

### **Presenting the Stimulus**

This event is considered to be the occasion for emphasizing or highlighting the distinctive features of what is to be learned. If learning is from a printed text, then key ideas may be underlined, printed in bold type, set off on the page, or whatever. If valves of the heart are being studied, then pictures showing these valves in bold outline may be employed. In general, features of what is presented are made distinctive in order that they may become cues. Here is one meaning for Bloom’s phrase “enhanced cues.”

### **Providing Learning Guidance**

In instructional design, learning guidance covers quite a lot of ground, depending on what kind of learning outcome is expected. In the simplest case, it can mean simply “hints” and “prompts,” and thus be another way of providing proper cues. More generally, learning guidance means *organizing and elaborating* the content. These activities may be done by the instruction itself (as designed by the instructional designer) or they may simply be suggestions that they be done by the learner. Advance organizers are an example of the former. An example of the latter might be a suggestion like “In learning the names of all the states, think of their locations in terms of the areas of an imagined map.” Questioning is another way of suggesting an organization to instructional content, and again this may be done by asking the student to construct questions to be

answered. In summary, the event called “providing learning guidance” has in it the ideas of cueing, or organizing, and of *student participation*.

### **Eliciting the Performance**

Of course this is done to verify that something has been learned. However, it probably also should be related to student participation. In a minimal sense, students need to participate by showing what they have learned.

### **Giving Informative Feedback**

Furnishing feedback is surely one of the critical events of instruction. The phrase “informative feedback” is used to reflect the research findings of Estes (1972) who demonstrated the superiority of information vs. reward as a form of reinforcement. This event is consistent with the feedback concepts of mastery learning. However, “corrective feedback” as employed in mastery learning, implies a somewhat more elaborate procedure in which the learner is instructed in ways of correcting his errors.

### **Others**

There are a few more parallels that could be drawn, but they are less important than those I have mentioned. It appears to me that if instructional designers used the events of instruction properly, they would be incorporating into the lessons they design the ideas of (a) enhancing prerequisites, (b) providing content organization and cues to retrieval, (c) assuring student participation, and (d) using informative and corrective feedback. Thus, the instructional designer who follows this model would be taking advantage of the *alterable variables* identified in the studies of Bloom and his students. Such instructional design would be expected to make the most of the kinds of variables that lead to effectiveness of learning in the one-to-one tutoring situation.

## **Differences in the Two Systems**

There are, then, substantial similarities, or even identities, between the design implications desirable from the research on learning for mastery and those that are characteristic of instructional systems design. There are also differences, some that are probably minor in their effects, and one that is major.

An example of a minor difference, which I nevertheless believe is worth attention, is event No. 2, “informing the learner of the objective.” I realize that the evidence on this variable is mixed. Nevertheless, it is obviously the kind of event that would normally be a part of a tutor’s behavior. My guess is that it will be found to have an effect size of at least .30 in a properly designed study. The investigation of Rothkopf and Kaplan (1972) is one good example.

### Taxonomic Differences

But let me turn to the major difference. Curiously enough, this difference pertains to the taxonomy of objectives—the taxonomy of learning outcomes, and the implications this taxonomy has for instruction. Both Bloom and I have taxonomies of learning outcomes to propose, and there are some categories about which there are no differences in any major sense. I would surely agree there are domains of cognitive outcomes, affective outcomes (which I call attitudes), and psychomotor outcomes. Here, then, are the differences I see:

1. I think it is necessary to distinguish *three kinds of cognitive outcomes*. These arise from learned capabilities that are qualitatively, structurally, different from each other. They are called verbal information, intellectual skills, and cognitive strategies. Some relationships can be built between these and the six kinds of outcomes in Bloom's cognitive learning theory. These three types are called declarative knowledge; procedural knowledge, or productions; and self-management skills, or control processes. I will say in a moment why I think these distinctions are important.
2. Each of the five learning outcomes—intellectual skills, cognitive strategies, verbal information, attitudes, and motor skills—*requires a different specific content and configuration* of instructional events for effective learning. It is perhaps easiest to make this point by taking as examples two kinds of outcome that are most unlike—verbal information and motor skills. The provisions of the U.S. Constitution regarding the powers of the executive branch may be taught either by auditorially delivered speech, or by print on a page. But these media have extremely limited usefulness in teaching a motor skill. You do not teach letter-printing or ice-skating by talking about them or requiring someone to read about them. Surely everyone would agree that, in the case of these two types of learning outcomes, the instructional designer or teacher has to do different things so far as the operations of “enhancing prerequisites” and “providing cues for retrieval” are concerned. Feedback and correction also have to be quite different in the two cases—feedback for a motor skill must be very precise, whereas feedback for a passage of prose can be quite imprecise, so long as the “gist” is recalled.

### Different Learning Conditions for Different Outcomes

These differences in two contrasting kinds of learning outcome also imply a requirement for distinctive learning conditions. And so, upon further analysis, distinctive instructional conditions for each of the five different kinds of learning outcome becomes one of the major conceptions of instructional design theory (Gagné, 1985). These distinctive

conditions can be expressed in terms of the events of instruction previously mentioned. The differences show up primarily in the events numbered 3, 4, and 5—stimulating recall of prior learning, presenting the stimulus, and providing learning guidance.

**Recall of Prior Learning.** When intellectual skills are to be learned, the prior learning to be recalled consists of prerequisite skills. This, of course, is in accord with the idea of “enhancing prerequisites.” But when verbal information is being learned, the prior learning is not exactly prerequisite. It is, instead, a larger complex of organized knowledge. This is the meaningful structure spoken of by Ausubel (1968), or, in terms of modern cognitive theory, the schema. This knowledge is not precisely pre-requisite, and is much more generally related to verbal information than are the prerequisites of intellectual skills. When motor skills are the outcomes of interest, the relevant prior knowledge may be either the procedural skill called the executive subroutine, or part skills of some sort. But part skills, when they can be identified are not prerequisites. Then, when an attitude is being acquired, the prior learning is still different. It may include knowledge of the situation in which the attitude is to be displayed. Also, it needs to include reminders of a human model and the qualities that make such a person admirable.

So, what is meant by the prior learning which is to be stimulated, or enhanced, is very different depending upon the nature of the learning outcome.

**Presenting the Stimulus.** This instructional event is obviously going to differ depending on what learning outcome is expected. For example, if the aim is learning conversational Spanish, the stimulus must comprise orally produced Spanish speech, and it would be a mistake to present printed text in its place. But, beyond this, the differential aspects of stimulus presentation pertain to emphasis on *distinctive features*, and therefore on the means of providing *cues*. Cues for the recall of meaningful prose passages are probably quite different from cues for the recall of concepts and rules. Distinctive features of printed discourse would appear to be key words and phrases, topic sentences, and the like. For intellectual skills, in contrast, distinctive features are likely to be cues of the *sequence of steps* involved in procedures to be recalled. For example, cues for the successive steps in long division are usually given emphasis in the stimulus presentation for this skill.

**Learning Guidance.** What is meant by learning guidance is also different for different kinds of learning outcome. According to most theoretical accounts, verbal information learning may best be enhanced by procedures called elaboration, that is, by relating new knowledge to be learned to larger masses of organized knowledge that are already familiar. Learning about a particular event of a political campaign is acquired and stored

in relation to a larger set of knowledge, a schema, pertaining to political campaigns in general. However, it is not at all clear that elaboration is the way to deal with intellectual skills. Concepts and rules must yield performances of great precision, and it is possible that such a quality is not promoted by elaboration. Learning guidance for procedures usually means making their steps distinctive.

Images also appear to have different functions in the cueing of verbal information and intellectual skills. It is notable that images have been shown to be useful in recalling disparate, non-meaningful items or lists of verbal information, whereas their use as cues to intellectual skills is much less well established.

**Summary of Differential Instructional Events.** The general point, therefore, is that the alterable variables called enhancing prerequisites, stimulus organization, and cueing, are entirely compatible whether one follows the principles of learning for mastery or those of instructional systems design. The latter theory, however, requires that attention be given to the differential qualities required for the events of instruction called “stimulating recall of prior learning,” “presenting the stimulus,” and “providing learning guidance.” Distinctions between the cognitive outcomes called verbal information and intellectual skill are of critical importance.

As for other instructional events of instructional design, they appear to be quite identical with those advocated by the mastery learning conception. Here I speak particularly of reinforcement, informative feedback, and corrective information. Mastery learning has continued to emphasize these features of effective instruction. Bloom and his students have verified their worth in a number of studies of classroom instruction.

## A Noteworthy Area of Agreement

I want to point out one aspect of learning on which there is a marked measure of agreement, because it seems so important. This is the idea of skill automaticity. Bloom has written about this conception (1986), and I have too (Gagné, 1983). Intellectual skills that are highly practiced come to be performed automatically, that is, they demand little conscious attention. The skilled student of geometry doesn't have to “stop and think” about how to find the value of the complementary angle of 100 degrees—instead, its value of 80 degrees is known automatically once its direction and origin are perceived. The skilled reader does not slow his comprehension in order to pay conscious attention to the differences between *welcome* and *winsome*, because the differences in their sounds are automatically processed. The skilled writer doesn't stop to attend to the form of a past participle of the verb go, but writes automatically, “I have gone.”

By definition, a skill becomes automatic when it can be performed without interfering with a second simultaneous task. In practice, automaticity is achieved by repeated performances in different examples. For instruction, one of the best procedures appears to be involving learners in game-like exercises in which they strive to beat their previous times in performance of a skill.

The main importance of automatization of skills lies in the freeing of attention for other tasks, particularly those that require problem solving. Thus, reading comprehension depends on the automatization of decoding skills, so that the “thinking” part of reading can be done. The solving of arithmetic word problems depends on the automatization of skills of mathematical translation in order that attention be made available for problem solving activity. Skillful automobile driving likewise requires the presence of automatized component skills of acceleration, braking, and steering. Here is the way I would state the most important hypothesis in this area:

*The principal factor* affecting the development of higher level thinking in learners is the release of attention by automatization of basic skills.

## Conclusion

I conclude by saying that the principles of instructional design have a great deal in common with those procedures advocated and validated for mastery learning. There are scarcely any important conflicts between the two systems that I can detect. Both are concerned that designers and teachers make use of the alterable variables for which there is much evidence: enhancing prerequisites, providing good stimulus organization and cues, assuring learner participation, giving feedback with correction. Their similarities even extend to a mutual appreciation of another kind of variable whose importance has not always been given sufficient emphasis—automatization of intellectual skills. This might, I suppose, be classified as an additional example of the need for learner participation—a participation that goes beyond initial learning, and perhaps also beyond what is usually considered “mastery.”

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