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Lessons Illustrating Selected Theories and Models

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2 A Lesson Based on the Gagné-Briggs Theory of Instruction

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FOREWORD

History

The Gagné-Briggs theory of instruction was first developed in the 1960s, although its development has continued to date. It is affectionately known by many as the granddaddy of instructional theories. It was the first major attempt to integrate a wide range of knowledge about learning and instruction (from many theoretical perspectives) into a comprehensive theory of instruction. Its impact on the field has been immense.

Unique Contributions

One of the most outstanding features of the Gagné-Briggs instructional theory is that it is so comprehensive. It prescribes the nature of instruction for all three of Bloom's domains of knowledge: cognitive, affective, and psychomotor; and within the cognitive domain it prescribes methods for teaching verbal information (remember-level knowledge), intellectual skills (application of generalizable knowledge), and cognitive strategies (the higher thought processes).

This instructional theory is also comprehensive in the breadth of instructional strategies that it prescribes. The nine events of instruction include gaining the learners' attention, presenting objectives, and stimulating recall of relevant prior knowledge, all of which have tended to be overlooked by more recent instructional theories. In fairness, however, it should be pointed out that many of the more recent theorists have opted to sacrifice breadth in order to achieve greater

depth, that is, to provide more detailed guidance for instructional designers and teachers. The net result is that the Gagné-Briggs theory provides a comprehensive framework within which much of the more recent work can be subsumed.

In addition to the nine events of instruction, this theory provides unique prescriptions for the selection and sequencing of content. Once a terminal objective has been identified within the intellectual skills category, the designer/instructor should identify its learning prerequisites (simpler component skills) that the learners have not yet mastered, and those prerequisites should be taught. With respect to sequencing, Gagné-Briggs proposes a hierarchical sequence in which the simpler component skills are taught before the more complex skills of which they are a part.

Similarities

The Gagné-Briggs theory of instruction has a number of prescriptions in common with other instructional theories, such as presenting the stimulus material, providing learning guidance of various kinds, requiring overt responses (practice) from the learners, and providing feedback about those responses. These and other similarities are identified in the chapter with Editor's Notes.

Issues to Think About

One important issue is how to operationalize the prescriptions provided by this instructional theory. Because of its breadth, this theory offers few specific instructions for implementation. For example, how should one go about providing learning guidance? To what extent do the other instructional theories in this book provide such operationalization? And to what extent does this theory provide a vehicle for integrating all the diverse prescriptions of the theories in this book into a common knowledge base about instruction?

STUDY QUESTIONS

1. What are the five categories of human learned capabilities?
2. Why is it useful to distinguish the five categories?
3. What are the five types of intellectual skills?
4. What relationship exists among those five types of intellectual skills?
5. What prescriptions do Gagné-Briggs make with respect to the sequence in which instructional content should be presented to the learners?
6. What are the nine events of instruction?
7. For what situations does each event differ?
8. How does each of the nine events of instruction differ for each such situation?

C.M.R.

INTRODUCTION TO THE THEORY

Over the years, Robert Gagné and Leslie Briggs developed a wide variety of instructional prescriptions (Briggs, 1977; Briggs & Wager, 1981; Gagné, 1974, 1985; Gagné & Briggs, 1979). Taken together, these prescriptions constitute a theory of instruction, because different methods of instruction are prescribed for different situations. Gagné also developed a theory about how learning occurs, and Briggs developed many instructional development procedures; but neither of these two important contributions is the focus of this chapter. This chapter describes the Gagné-Briggs prescriptions about what instruction should be like for any given situation, and it illustrates those prescriptions in a lesson, along with commentary about which prescription is being implemented at each point in the lesson.

The Gagné-Briggs theory of instruction is comprised of three major sets of prescriptions: It prescribes different methods of instruction for each of five categories of **learned capabilities:** it identifies nine **events of instruction,** which should usually comprise the instruction intended to develop any desired capability; and it prescribes a way to **sequence** instruction based on intellectual skills. These three sets of prescriptions are described next, followed by the lesson and then by the commentary on the prescriptions used in the design of the lesson.

The Categories of Learned Capabilities

For the purposes of designing instruction, Gagné (1984, 1985) describes five categories of human learned capabilities, each of which requires different instructional prescriptions.* These are:

1. Verbal information.
2. Intellectual skills, which have five subcategories
   A. discriminations
   B. concrete concepts
   C. defined concepts
   D. rules
   E. higher-order rules (problem solving).
3. Cognitive strategies.
4. Attitudes.
5. Motor skills.

Before instruction can be designed and developed, it is necessary to identify the category into which the desired learned capability fits. This is because the

*The use of types of objectives as the basis for prescribing methods of instruction is also an important part of the theories of Merrill (p. 204) and Gropper (p. 52).

instruction differs for each category. The critical attributes of each category are described below.

Verbal Information. Individuals have learned verbal information when they are able to recall it. They may write, type, state, or recite such information as names, labels, sentences, arguments, single propositions, or groups of related propositions.*

Intellectual Skills. Individuals use an intellectual skill when they show competence or interact with the environment using symbols or language. They show they know how to do something of an intellectual sort. Details of Gagné's five intellectual skills follow.†

Discriminations. Learners discriminate when they state whether things are the same or different. The may discriminate along one or more physical dimensions. They may discriminate, for example, sizes, colors, shapes, and sounds. This is a very basic intellectual skill.

Concrete concepts. Learners have acquired a concrete concept when they can identify previously unencountered instances of a class of objects, class of object properties, or class of events by instant recognition. Concepts of this type are identified by pointing at them or marking them in some manner—they do not have to be, and usually cannot be, identified by means of a definition. "Ball," "wheel," "penny," "triangle," and "rectangle" are examples of concrete concepts.

Defined concepts. Learners have acquired a defined concept when they use a definition to put something they have not previously encountered into a class (or some things into classes). Their behavior shows that they know the parameters of the class or classes. Concepts such as "family," "alien," "nucleus," "igneous rock," and "electrical resistance" are defined concepts.‡

Rules. Learners have acquired a rule when they can demonstrate its application to previously unencountered instances. A rule is a relation between two or more concepts. An example is the use of "Ohm's law," represented by $V = IR$, to solve electrical circuit problems.§

Higher-order rules (problem solving). When learners use two or more previously learned rules to answer a question about an unfamiliar situation, they are attaining a higher-order rule by problem solving. Success with a problem-solving exercise involves mastery of a set of concepts and rules that must then be combined to solve the problem. In addition, because the situation itself is unfamiliar, the learners must search out and choose which rules to use. In physics, different "projectile motion" problems require the use of different combinations and sequences among the various "laws of motion" for their solution.*

*Verbal information is similar to Merrill's "remember-instance" and "remember-generality" (p. 203) and Gropper's "recall or apply facts" (p. 51).

†Intellectual skills are similar to Merrill's "use" level of performance (p. 203).

‡Concrete and defined concepts (and perhaps discriminations as well) are equivalent to Merrill's "use concepts" (p. 203) and Gropper's "apply definitions to examples or illustrate them with examples" (p. 51).

§Rules correspond to Merrill's "use procedures" and "use principles" (p. 203) and Gropper's "follow procedural rules" (p. 51).

Cognitive Strategies. Learners have acquired cognitive strategies when they have developed ways to improve the effectiveness and efficiency of their own intellectual and learning processes; when they can learn independently; when they can propose and solve original problems. Breaking a problem into parts, working backwards from the solution, summarizing text, and using mnemonics are examples of cognitive strategies.† Although Gagné (1985) describes cognitive strategies applicable to attending, learning, and remembering, the examples used in this section include only problem-solving strategies, following Gagné and Briggs (1979).

Attitudes. Attitudes are complex mental states of human beings that affect their choices of personal action towards people, things, and events. Learners have an attitude when they choose to make consistent choices in repeated situations. Behavior in a single situation is not an indication of an attitude. Rather, consistent behavior in a variety of similar situations indicates that the attitude exists. Consistent choices of personal action such as preferring rock music to classical, driving within the speed limit, being honest, and being afraid of snakes reflect attitudes that have been learned.‡

Motor Skills. Learners have developed a motor skill when they perform a physical task utilizing equipment or materials according to a routinized procedure. Their behavior says nothing of their ability to recognize a need to apply the procedure to a specific problem; they can merely carry out the procedure correctly, with appropriate speed, accuracy, force, and smoothness. Driving a

*Problem solving is the same as Merrill's "find" (p. 203) and Gropper's "solving problems" (p. 51).

†Cognitive strategies are the same as Landa's "general, content-independent abilities" (p. 123) and Scandura's "higher-order rules" (p. 165) and are somewhat similar to Merrill's "find" level of performance (p. 203).

‡This theory is unique among the ones in this book in addressing methods for teaching attitudes and outcomes. Even Keller's prescriptions, which deal exclusively with affective considerations, address attitudes and motives only insofar as they are means for achieving cognitive ends rather than as ends in themselves for which optimal means need to be prescribed.

car, throwing a ball, climbing a rope, driving a golf ball, and correctly using a woodturning machine are examples of motor skills.*

Identifying the category of learned capability into which the desired learning fits is important because Gagné and Briggs prescribe different methods of instruction for each category of learned capability. For further descriptions of the learned capabilities, see Gagné (1984, 1985) and Gagné and Briggs (1979).

The Events of Instruction

Once the desired learning outcomes have been identified and classified as previously described, the instructional methods most appropriate for the desired outcomes can be prescribed. In learning theory, the information-processing model describes the act of learning as an internal process that has several stages. Gagné (1985) proposes that those stages are enhanced by means of a specific order of instructional methods he calls "the events of instruction." The events of instruction establish the internal and external "conditions of learning" essential for the various types of learned capability to be learned. More extensive accounts of the relationship between the learning theory, the internal and external conditions of learning, and the events of instruction can be found in Gagné (1985) and Gagné and Briggs (1979).

Gagné (1985) has identified nine events of instruction for any desired learning (see Fig. 2.1). He argues that these nine different events must always be considered as potential ways of providing external support for the internal act of learning. Furthermore, he proposes that the nature of the instruction in an event should differ depending on the category of learned capability expected as the outcome of the instruction. "Learning intellectual skills requires a different design of instructional events from those required for learning verbal information or those required for learning motor skills, and so on" (p. 245). The next section describes the different events in light of the various learned capabilities (adapted from Gagné, 1985; Gagné & Briggs, 1979; and Gagné, Wager, & Rojas, 1981).

1. Gaining Attention

For *all* learned capability outcomes the attention of the students is gained by introducing rapid stimulus changes. For group instruction, gesturing, raising the voice, and providing a highly visual demonstration may gain the students' attention. Use of words such as "Look!" or "Watch!" can help. For computer-assisted instruction, rapidly changing visual displays are useful. For individualized instruction, provide a variety of novel situations designed to appeal to the students' interest and curiosity. For all presentation forms, matching the stimulus to the content is also advantageous. For *problem solving*, raise the learners' curiosity by presenting a hypothetical situation or by asking a rhetorical question.*

*The only other theories in this book that address motor skills at all are Landa's and Gropper's. Neither addresses them to the extent that Gagné and Briggs do.

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

FIG. 2.1 The nine events of instruction.

2. Informing the Learner of the Lesson Objective(s)

"When learners comprehend the objective of instruction, they will acquire an expectancy that normally persists throughout the time learning is taking place and that will be confirmed by the feedback given when learning is complete" (Gagné, 1985, p. 247). Providing learners with the objective of the instruction helps them answer that very important question, "How will I know when I have learned?" Following is a summary of the different instructional techniques that inform the learner of the objective for each of the learning capabilities:†

Verbal information. State in simple terms what the learner will be able to say or do after he or she has learned.

Intellectual skill. Describe and demonstrate the activity to which the concept, rule, or procedure applies.

Cognitive strategy. Clarify the nature of the solution expected and describe or demonstrate the strategy. A verbal communication may be very effective.

Attitude. As providing the objective would defeat the purpose of the instruction, the learner should be informed later, after he or she has chosen to behave in the appropriate manner (see Event 5).

Motor skill. Demonstrate the expected performance.

*This strategy component is not directly addressed by any of the other theories in this book except for Keller's (p. 293), and there are even important differences there (see p. 293 for details).

†This strategy is similarly not directly addressed by any of the other theories in this book except for Keller's (p. 294).

3. Stimulating Recall of Prior Learning

Before engaging in the instruction, the learner is asked to recall some things previously learned. What is to be recalled should be naturally related to the new learning. The kinds of things recalled are different for each of the different learned capabilities desired as outcomes.*

Verbal information. Stimulate recall of well-organized and previously learned bodies of knowledge. This could be done by an "advance organizer" (Ausubel, 1960), by "adjunct questions" (Rothkopf, 1970), or by summaries and outlines.

Intellectual skill. Stimulate recall of prerequisite rules and concepts that are components of the problem, rule, or concept to be learned.

Cognitive strategy. Stimulate recall of similar task strategies and task-relevant rules and concepts.

Attitude. Stimulate recall of the situation and action involved in personal choice as well as relevant information and skills. Remind learner of the human model and the model's characteristics.

Motor skill. Stimulate recall of the "executive subroutine" and part skills, if appropriate.

4. Presenting the Stimulus Material with Distinctive Features

Any stimulus must have its distinctive features clearly delineated. Highlight important features of diagrams or charts; use headings or bold or italic print in printed text; use variety of tone, pitch, and volume in speech.†

Verbal information. Display printed or auditorially delivered verbal statements in an organized, systematic fashion. Present in propositional form and emphasize distinctive features.‡

Intellectual skill. Delineate distinctive features of objects and symbols to be formed into the concept or rule or problem to be solved. Present varied examples of the concept, rule, or problem.§

*This prescription has been integrated into Merrill's theory (p. 207) but without the level of guidance provided by Gagné-Briggs.

†This is very similar to Gropper's "eliciting stimuli" (p. 47).

‡Merrill provides a number of more detailed prescriptions about this (see Fig. 7.3).

§This appears to include primarily Merrill's "examples" (p. 204), Gropper's "examples" (p. 54), Landa's "demonstrations" (p. 121, footnote 12), and Collins' "positive exemplars" (p. 183). However, the nature of the examples is not prescribed to the level of guidance that characterizes Merrill's theory.

Cognitive strategy. Describe the novel problem; then describe and show what the strategy accomplishes.

Attitude. Have the human model describe and demonstrate the general nature of the choice of personal action to be presented.*

Motor skill. Display the situation in existence at initiation of skill performance; demonstrate executive subroutine; provide tools or implements.†

5. Providing Learning Guidance

This involves making the stimulus as meaningful as possible. In general, use concrete examples of abstract terms and concepts, and elaborate each idea by relating it to others already in memory.‡

Verbal information. Elaborate content by relating it to larger bodies of knowledge in memory;§ emphasize verbal links and provide concrete examples; use images, spatial arrays,‖ and mnemonics.

Intellectual skill. Give divergent concrete instances and noninstances of a concept or applications of a rule; provide verbal cues to the proper combining sequence.

Cognitive strategy. Provide verbal description of the strategy, followed by one or more concrete examples; provide prompts and hints to the novel solution.

Attitude. Have the human model describe or demonstrate the action choice; students observe positive reinforcement of model's behavior.¶

Motor skill. Require direct and continued practice; provide feedback of performance achievement.

*This prescription is unique among the theories in this book.

†This is also unique among the theories in this book.

‡This would include Merrill's "help," "alternative representation," "mnemonic" (p. 207), and perhaps even "generality" (p. 204), and it would include Gropper's "cues" (pp. 47 and 55). Gagné-Briggs provide somewhat less detailed guidance here than do Merrill and especially Gropper (pp. 54–56), although it should also be noted that Gagné-Briggs' prescriptions are considerably more comprehensive (broader) than Merrill's and Gropper's, as witnessed by prescriptions for such outcomes as attitudes and motor skills and such methods as gaining attention and stating objectives.

§This prescription comes from Ausubel's work and recent schema theory and is unique among the theories in this book, including the three cognitively based theories: Landa's and Scandura's, which both emphasize information-processing routines rather than memory structures, and Collins's, which emphasizes techniques for depth of processing. Clearly, all of these prescriptions are compatible with each other.

‖This is somewhat similar to Gropper's prescriptions for "display of information," especially "tabled formats" (p. 57).

¶Again, prescriptions for this category of outcomes are unique among the theories in this book.

6. Eliciting the Performance

Here the learner is required to demonstrate the newly learned behavior to show whether or not the learned capability has been stored in long-term memory.*

Verbal information. Ask for part or all of the information; require paraphase or learners' own words.

Intellectual skill. Ask the learner to apply the concept or rule to instances not previously encountered during the learning.

Cognitive strategy. Give the learner the challenge of an unfamiliar problem to solve using the strategy.

Attitude. Place the learner in a previously unencountered situation where choices must be made; ask the learner to indicate choice of action in such real or simulated situations or in a questionnaire.

Motor skill. Provide the opportunity for the student to perform the total learned procedure.

7. Providing Informative Feedback

Here the student is informed of the degree of correctness of his or her performance. Feedback can be "built in," as in computer-assisted instruction, programmed instruction, individualized instruction, and some practical activities. It can be student initiated and immediate, or provided by the instructor or similar agent, possibly after some delay. Appropriate remedial instruction should be provided if the performance is not correct (see Events 4 and 5).†

Verbal information. Confirm correctness of statement of information.

Intellectual skill. Confirm correctness of concept or rule application.

Cognitive strategy. Confirm originality of problem solution.

Attitude. Provide direct and vicarious reinforcement of the action choice.

Motor skill. Provide feedback on the degree of accuracy and timing of the performance.

8. Assessing Performance

To ensure that the learner has learned the new capability, it is necessary to require additional instances of the performance. Assessing performance serves two functions: It establishes whether or not the new learning has reasonable stability, and it provides additional practice.‡

*This is the same as Merrill's "practice" (p. 204) and Gropper's "practice" (p. 54).

†Feedback is also prescribed by Merrill (p. 207), Gropper (p. 47), and Collins (p. 185).

‡This is a testing prescription rather than an instructional prescription.

Verbal information. Require that the student paraphrase, or elaborate on, the learned information.

Intellectual skill. Require that the student apply the concept or rule to a number of new instances.

Cognitive strategy. Provide a variety of novel problems to be solved.

Attitude. Ask the learner to make a choice of personal action in a real or simulated situation.

Motor skill. Require the learner to perform the total skill.

9. Enhancing Retention and Transfer

Providing additional practice with a wide variety of instances is likely to increase *retention* of all learned capabilities. For *verbal information,* requiring that the student paraphrase, or elaborate on, the learned information is recommended to enhance retention. For *intellectual skills,* arranging practice in the form of spaced reviews is particularly effective for retention. If the practice involves a variety of divergent instances, then the learned capability is more likely to be *transferred* to new situations. Gagné and Briggs do not offer more detailed prescriptions for enhancing transfer, although further discussion about transfer and various cognitive models is available in Gagné (1985) and Gagné and White (1978).*

Having identified the desired learning outcome and classified it in terms of Gagné's learned capabilities, the instructional designer specifies a series of instructional events designed to activate, support, and maintain the internal act of learning. These events can take many forms, depending on the specific learning task and the characteristics of the learner(s). Further descriptions of the nine events of instruction can be found in Gagné (1985) and Gagné and Briggs (1979).

Sequencing Prescriptions

Although Gagné is most famous for his learning-task analsyis and hierarchical sequence, Gagné and Briggs (1979) recommend different sequencing strategies for different "levels" of sequencing in a course or curriculum. During the process of designing an instructional sequence, you should start by identifying and sequencing more general goals and objectives, and progress by levels down to increasingly specific objectives.†

*The prescriptions here are for use of strategy components that have already been prescribed (additional practice). The only new element here is the timing of the practice—spread out over time. Surprisingly, most instructional theories have not included any prescriptions for systematic review. Reigeluth provides considerable guidance for the format and timing of reviews (p. 257).

†This "top-down" approach to sequencing is not an instructional strategy, that is, it does not indicate what the instruction will be like. Rather, it is a development procedure—directions as to what the instructional designer should do and in what order.

After identifying end-of-course objectives, which state the performance expected after the course is completed, you identify major course units, each of which requires several weeks of study. For each unit you identify terminal objectives (to be reached by the end of the unit), and you sequence the units in the most appropriate sequence. Sequencing at this first level of analysis is done largely on the basis of expert opinion and intuition, although Bruner's (1960) spiral curriculum "appears to hold much promise" (Gagné & Briggs, 1979, p. 141).*

Next, you break the terminal objectives into performance objectives, which are the specific outcomes of the instruction and which are at a level appropriate for task analysis. These performance objectives, one or more of which may make up a lesson and which may require different capabilities, are sequenced primarily on the basis of expert consensus and common sense.†

Finally, a hierarchical task analysis is done on the performance objectives, and a hierarchical sequence, based on the intellectual skills, is designed. The hierarchical analysis breaks each performance objective down into "enabling objectives, each of which may have several subordinate objectives" (Gagné & Briggs, 1979, p. 137). The enabling objectives are either essential prerequisite skills required before the performance objectives can be learned, or they are objectives that help facilitate such learning. A sequence is then developed in which the component skills are taught in a parts-to-whole sequence; first the most elemental parts at the bottom of the hierarchy are taught, followed by progressively more complex combinations of the parts. Fig. 2.2 shows an example of a learning hierarchy and hierarchical sequence of skills.‡

Hierarchical analysis and sequencing are appropriate only for intellectual skills. As discussed previously, the very important category of *intellectual skills* has been divided into five subcategories. This was done for a very good reason. The learning of any one intellectual skill depends on the prior learning of one or more simpler intellectual skills.

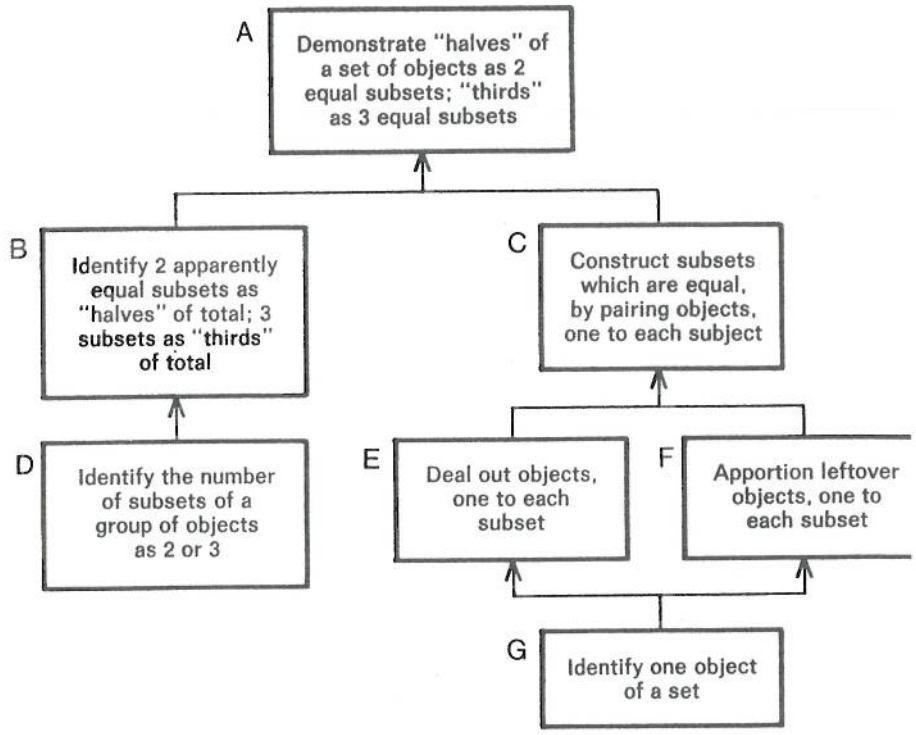
In order to learn to solve problems by using two or more rules, a learner must have already learned to use the various component rules. Because a rule relates two or more concepts, the learning of those concepts is an essential prerequisite to the learning of the rule. Similarly, defined concepts often have concrete concepts as critical attributes, and concrete concepts cannot be learned unless their common characteristics can be discriminated.

Most courses of instruction involve lessons having more than one type of

*This is the first sequencing prescription, but it is very vague. Reigeluth's "elaboration sequence" is similar to Bruner's "spiral curriculum" but provides much more detailed guidance to instructional designers.

†This is another sequencing prescription (albeit vague).

‡This is a very valuable sequencing strategy that many theorists have included in their theories, such as Gropper (p. 58) and Reigeluth (p. 253).



Hierarchical Sequence 1 (up a leg): D, B, G, E, F, C, A.
Hierarchical Sequence 2 (level by level): G, D, E, F, B, C, A.

FIG. 2.2. A learning hierarchy and hierarchical sequence.

learning outcome. The designer of a lesson will place emphasis on what the student can *do* as a result of instruction. Usually this implies a need to make an analysis of the *intellectual skills* involved in a lesson. Often lesson planning can best be done by making intellectual skills the major organizing factor. Verbal information, cognitive strategies, motor skills, and attitudes can then be added to the places where the most appropriate linkage occurs (Gagné & Briggs, 1979, p. 147). Regarding the sequencing of these various outcomes, the following loose "rules" apply (adapted from Gagné & Briggs. 1979, p. 144):

Verbal information. Order of presentation is not important; a meaningful context should be provided.

Intellectual skill. Subordinate skills must be mastered first. Skill sequence may be provided by verbal instruction.

Cognitive strategy. Problem situations require previously learned intellectual skills and the prior learning, or provision, of appropriate verbal information.

Attitude. Respect must be established for the human model. Verbal information relevant to choices must be previously learned or provided.

Motor skill. The executive routine must be learned, and also part skills. Intensive practice is provided on the total skill.

See Briggs (1977), Gagné and Briggs (1979), and Briggs and Wager (1981) for more detailed sequencing suggestions.

LESSON PREFACE

The remainder of this chapter illustrates how some of the Gagné-Briggs prescriptions can be applied in the design of a lesson for secondary students on basic optics and the use of the microscope. The content and objectives used in this lesson are the same as those used in other chapters of this book so as to facilitate easy comparison with the other theories and models of instruction.

This section begins with the presentation of three lessons based on different instructional strategies. In each of the lessons are circled numbers that correspond to comments presented in the following section. The comments relate specific parts of the lesson to specific prescriptions in the Gagné-Briggs theory and indicate which parts of the lesson were created solely according to the designer's discretion.

The Instructional Objectives

After completing the instruction within the three lessons, the students will be able to do the following:

1. Classify previously unencountered lenses as to whether or not they are convex lenses.
2. Define focal length.
3. Explain or predict what effect different convex lenses will have on light rays.
4. Explain the way in which the curvature of a lens influences both the magnification and the focal length of different lenses.
5. State from memory the three significant events in the history of the microscope (which are shown in the lesson).
6. Use a previously unencountered optical microscope properly.

According to Gagné and Briggs, the objectives belong to the following categories of learned capabilities: verbal information (Objectives 2 and 5); intellectual skills, specifically concepts and rules (Objectives 1, 3, and 4), and procedural learning, which involves motor skills and a sequential rule—an intellectual skill (Objective 6).

The organization of the lessons is as follows: Verbal information (Objective 5) is presented in Lesson 1; intellectual skills (Objectives 1–4) in Lesson 2; and an intellectual skill, or sequential rule (Objective 6), in Lesson 3. The reason for shifting Objective 2 to the category of intellectual skill is explained in Comment 12, and why Objective 6 is an intellectual skill rather than a motor skill is explained in the comments for Lesson 3.

Each lesson follows the guidelines for presenting the events of instruction for the particular category of learned capability. (The nine events of instruction are presented in Fig. 2.1.) The events of instruction are also referenced in the lessons themselves, at the beginning of each step in Lesson 1 between [brackets], and in the comments for Lessons 2 and 3.

The lessons provided in this chapter represent just one manner of utilizing the instructional principles of Gagné and Briggs. Because of the breadth of their work, Gagné and Briggs provide less detail regarding the selection of actual microstrategies for instruction. Therefore, many of the specific details of each lesson are left to the discretion of the individual designer.

LESSONS

LESSON 1

[1]

[2] Instructor: "What do these items have in common?" The following items are displayed:

1. Old wire-rim glasses.
2. Glass globes filled with water.
3. Two lenses combined on a pole (crude microscope).

[3] The instructor entertains answers from students, leading them to state that all are used for magnification.

[4] Instructor: "You will be learning about how lenses were invented and developed. In particular, you'll learn important names and dates in the development of magnification with glass. Pay close attention to the people and events presented in the slide presentation. You will have to know them for the final test."

The instructor presents slides that trace the development of magnification with glass and does the narration and elaboration on each slide, providing directed learning. The presentation includes:

1. 1000 B.C., engraver using globe.
2. 1200 A.D., people wearing glasses similar to those already shown.
3. 1590 A.D., eyeglass lenses put together on a pole, and made into a microscope, by Zacharias Jensenn in Holland.

Instructor: "Notice that these were presented in chronological order, beginning with a very crude method of magnification, leading to a more refined one. You'll find a graphic representation of this on your worksheet."

The instructor presents students with a worksheet (see Fig. 2.3).

Each student fills in the worksheet and discusses his or her answers with another student. The instructor asks for scores from the students, and provides additional feedback and discussion, answering questions and clearing up any remaining problems the learners express.

Students are asked to write a short history of the development of magnification as part of the final exam. They are instructed to include names and dates in their histories.

At later points in the curriculum, the instructor relates the history of the development of magnification to the history of the development of other technologies and bodies of knowledge. The names, dates, and events are all reviewed in the process.

IMPORTANT EVENTS IN THE HISTORY OF MAGNIFICATION

+	+	+	+	+
1000 B.C.	1 A.D.	1200 A.D.	1590 A.D.	1971–72 A.D.

1. Place the following events on this timeline by placing the letter of the event at the appropriate spot:
   A. First compound microscope invented
   B. Glass globes used for magnification
   C. Year of your birth
   D. Eyeglasses first used
2. Give a short history of the development of the first compound microscope. Include dates.

FIG. 2.3. Worksheet for Lesson 1.

[11] LESSON 2

[12] [This lesson is presented to the learner as a workbook, with each frame on a separate page.]

A LESSON ON LIGHT AND LENSES 1

In this lesson you will learn:

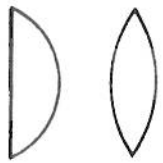
[13]
1. To identify any convex lens.
2. To define and identify focal length.
3. To graphically show the path of light as it passes through different parts of a convex lens.
4. To predict the relationship between focal length, lens curvature, and magnification, given a set of lenses.

[14] Have you ever used a magnifying glass? You may want to play with one before you do this lesson. Look at lots of different objects through the magnifying glass. What happens? Do you know why? This lesson will help you learn about the magnifying glass and why it works as it does. 2

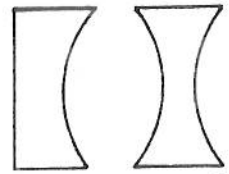
[15] Follow the directions in these self-instructional materials *exactly*. After you answer a question, turn the page. If your answer is correct, continue with the directions on that page. If you give a wrong answer, turn back a page and review the information. Then see if you can answer correctly. Work at your own pace and turn in the booklet when you've finished. 3

All convex lenses have at least one surface that bends out, so that the lens is thicker in the middle than at the edges. 4
These are cross-sectional side views of each lens:

[16] [17]



These are convex lenses.



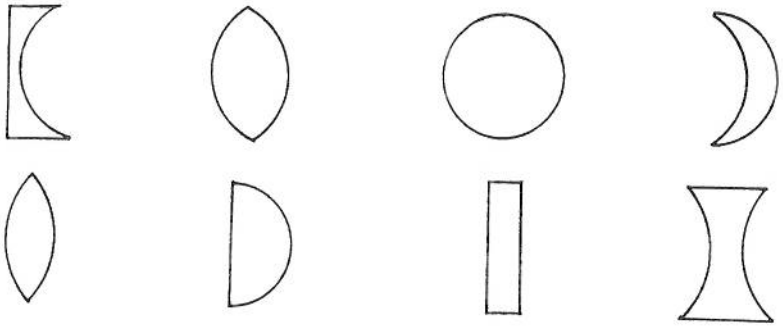
These are not convex lenses.

The middle of a convex lens is _____ than the edges. 5

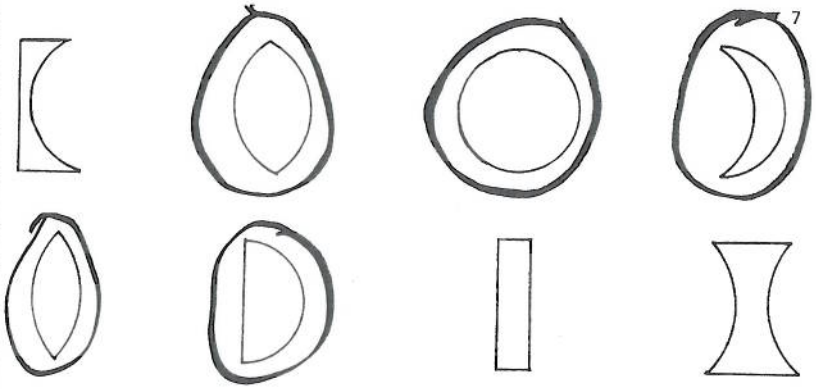
Turn the page

The middle of a convex lens is *THICKER* than the edges. 6

Circle the lenses below that are *CONVEX*.
Again, these are cross-sectional side views of each lens:



7



Your page should look like this because:

All convex lenses have at least one surface that bends OUT, and convex lenses are thicker in the middle than at the edges.

Turn the page.

[20] Do you remember what happens to light when it passes through a medium like glass? 8

It _____.

Light *BENDS* when it passes through a medium like glass. 9

When light rays pass through a CONVEX LENS

[21] Those that pass through the outer edges of the lens bend inward. and those that pass through the middle of the lens do not bend at all.

[21] Which way do the rays coming through the outer edges of a convex lens bend? 10

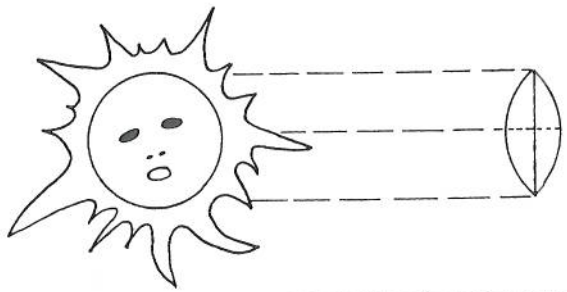
_____

Which way do the rays coming through the center of a convex lens bend?

_____

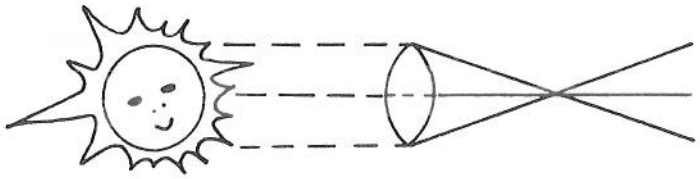
Rays passing through the edges bend *INWARD*. 11
Rays passing through the center *DO NOT BEND*.

[22] Draw the paths of light rays through this convex lens.



12

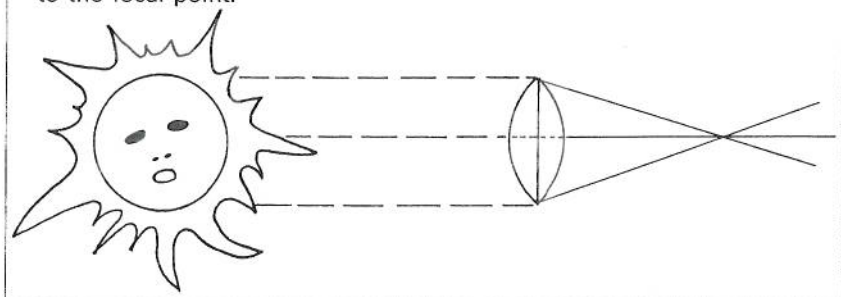
Your drawing should look like this:



Obviously, if some rays bend inward and others bend not at all, they will all intersect at some point. That point of intersection is called the FOCAL POINT.

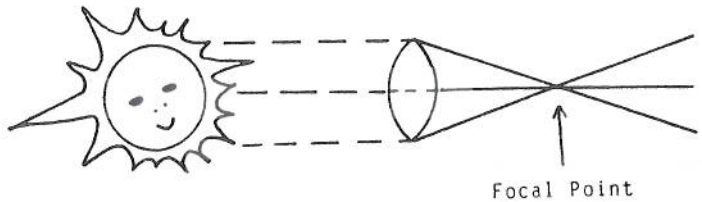
13

You've already seen this drawing, but now, add an arrow that points to the focal point.



14

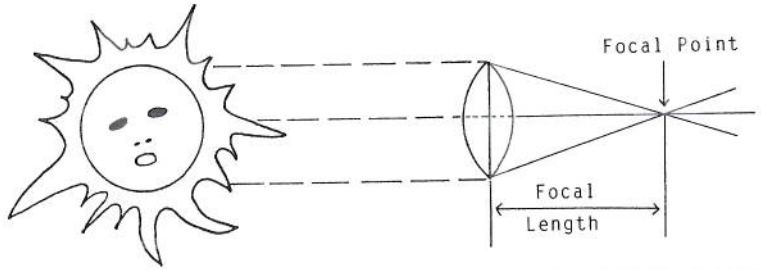
[27]



[28]

[29] The distance from the center of the lens to the focal point is called the FOCAL LENGTH.

[30]



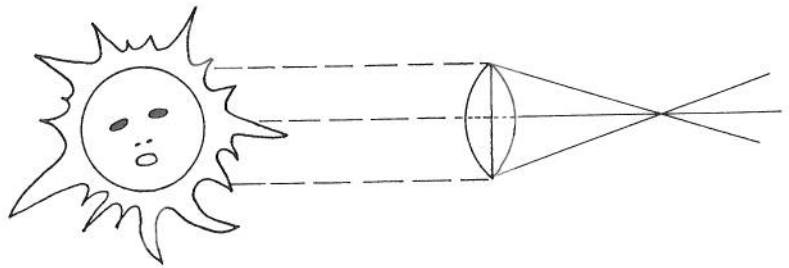
15

[31] What is focal length?

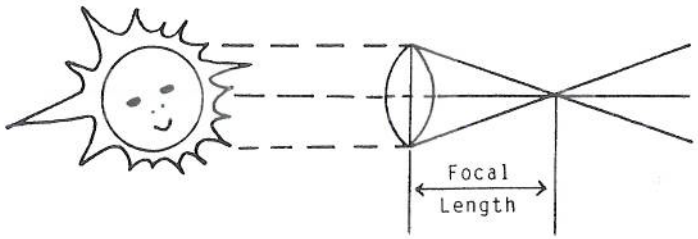
16

[32] The focal length is the distance from the center of the lens to the focal point.

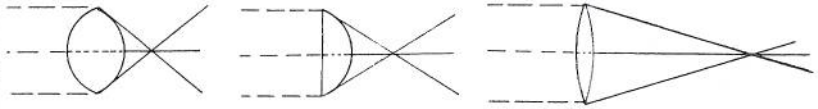
[33] On the diagram below, label the FOCAL LENGTH.



17



Here are some lenses that have light rays passing through them. The focal length has been labeled. What kinds of relationships do you see between the focal length and how sharply the lens curves?



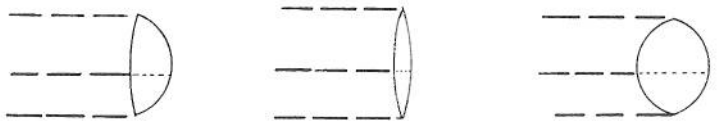
The greater the lens curvature, the _____ the focal length.

The lesser the lens curvature, the _____ the focal length.

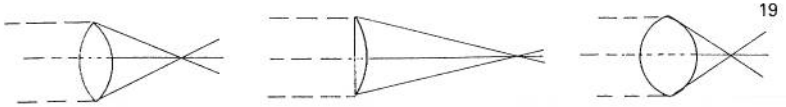
18

The greater the lens curvature, the *SHORTER* the focal length.
The less the lens curvature, the *LONGER* the focal length.

On the lenses below, draw in the path of the light rays. remembering how lens curvature affects focal length. Label the focal point and the focal length.



19



[37]

The whole point of having a convex lens is to magnify an image, to make it bigger.
If a lens has a longer focal length, it will have less magnifying power.
If a lens has a shorter focal length, it will have greater magnifying power.

20

To achieve the greatest magnifying power, use the lens with the _____ focal length.

21

To achieve the greatest magnifying power, use the lens with the *SHORTEST* focal length.

[38]

Since you know that
less magnification = longer focal length
greater magnification = shorter focal length
and that
less lens curvature = longer focal length
more lens curvature = shorter focal length
What is the relationship between lens curvature and magnification?

_____ magnification = _____ lens curvature

_____ magnification = _____ lens curvature

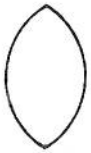
greater magnification = greater lens curvature
less magnification = less lens curvature

22

Which of these lenses would you use to achieve the greatest magnification?

a. _____

b. _____



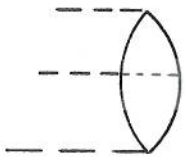
c. _____

d. _____

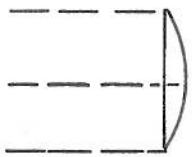
23

d. because it is thickest in the middle.

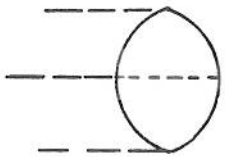
On the lenses below, draw in the path of the light rays, remembering how lens curvature affects focal length. Label the focal point and the focal length, and rank in order of magnifying power.



rank _____



rank _____



rank _____

The teacher gives the learners a quiz upon completion of this workbook. Its items are similar to the ones that elicited student performance in this workbook. Note: Later in the course, students are given a worksheet that presents

[41] various lenses, concave and convex, and are asked to identify the convex lenses and their focal lengths, draw paths of light through them, and state their relative magnifying powers. They will also be asked to use real lenses and objects that contain lenses (e.g., microscopes) in a variety of situations.

[42] LESSON 3

Students are seated in pairs, each pair sharing a microscope and four clean slides. The instructor presents an old pair of blue jeans, rips them, and passes them around, inviting each set of students to place a few threads on
[43] one of the slides in front of them. The instructor also passes around an orange and tells students to pick off a piece of skin and place it on a slide. Students are also told to place some strands of their own hair on a slide and, finally, to place a piece of a leaf on a slide.

Instructor: "By placing these specimens on your slides, you've learned how to *dry mount* a slide. During the rest of this class you will learn another, more
[44] complex skill: how to use a microscope, not only the one in front of you but any microscope in this room. Each one is slightly different from the others. Some use mirrors rather than light bulbs for the light source. In addition, the adjustment knobs can be in different places on each microscope. You will learn to correctly place a slide, direct light onto the stage, and focus the microscope in order to examine the specimens on the slide in front of you." The instructor projects a slide that shows students what they will see through their own microscopes when they correctly complete the procedure. The slide remains visible throughout the rest of the class.

Instructor: "I will now take you on a 'guided tour' of your microscope, to help
[45] you recall the parts of the microscope that we have already learned. Many of the microscopes in this room are different, so you will have to examine yours and discover how each part works. Don't worry now about the order in which each part will be adjusted; just find the parts that you already know." Instructor then has students identify and manipulate each of the following:

objectives	light source
eyepiece	diaphragm
stage and clips	coarse and fine adjustment knobs

The instructor now demonstrates the correct use of a microscope. Depending
[46] on the size of the group, students may gather around as the instructor demonstrates on a real microscope, or a videotape could be shown that displays the procedure.

The instructor distributes the "Memo on the Microscope" worksheet (see
[47] Fig. 2.4) and says, "This list will help you to remember the correct sequence

MEMO ON THE MICROSCOPE

1. Direct the light source onto the stage.
2. Adjust the light coming through the diaphragm.
3. Place and secure a prepared slide on the stage.
4. Select the appropriate objective.
5. Adjust the coarse focus knob.
6. Adjust the fine focus knob.
7. Repeat steps 4–6 with other objectives as needed.

FIG. 2.4. Worksheet for Lesson 3.

of steps necessary for using a microscope. Use the microscope in front of you and the slide with the blue jean fabric on it for your first time through the procedure."

Students are then allowed to work through the entire procedure at their own pace with their partner. While one student performs the procedure, the partner will provide guidance and feedback using the "Memo on the Microscope" sheet.

As the students work their way through the procedure, the teacher circulates, answering questions and giving whatever guidance is necessary for students to get through the exercise. The following questions ought to be raised during this time:

With which objective do you want to start looking at your specimen? Why?
When do you know that the light is correctly adjusted?
How do you know when you've adjusted the coarse focus enough?

As each pair of students finishes, the students are instructed to make sure that the view through their eyepiece corresponds with the slide shown on the wall, and to record their success on their score sheet for this unit. If they are not successful, they have another chance to correct it by going back over their handout and trying the procedure again.

Students then repeat the entire procedure with the slide of the orange peel. After that, students move to another microscope and perform the procedure again, using that microscope and the slide with the hair on it.

Finally, students will bring the leaf slide into focus on yet another microscope, with the instructor present so that he or she can assess the learner's performance.

[53] Later in the course the students will be required to use microscopes as a part of subsequent learning tasks.

COMMENTS

LESSON 1

Objective 5

1. The first section of this lesson serves to present the events of instruction necessary for a student to learn Objective 5, stating important events in the history of the microscope, which is verbal information. For the purposes of this chapter, the events have been included in as close as possible to the exact order as they are presented by Gagné and Briggs. Often, these events will not occur in this order, and some may be excluded, depending on the learner's needs and characteristics.

2. *Event 1.* The *learner's attention* is gained by providing a change of stimulus in the environment. Presenting the real objects will pique the learner's interests.

3. *Event 3.* The use of objects that are familiar to the learners helps them to *recall information* they may already have learned and stimulates the recall of the context in which they will place the newly learned information (one of the conditions of learning verbal information).

4. *Event 2.* The learners are told exactly what they will have to do to show that they have met the standards for performance. Stating the *objective* serves to answer the learner's question, "How will I know when I have learned?"

5. *Event 4.* The *stimulus material* that is presented is the information that must be learned by the student. An incorrect stimulus would be to provide a list of other devices that were invented in 1920. Although that is also information, it would not help the student to master this objective.

6. *Event 5.* The instructor's narration can include answering questions from the learner and providing *learning guidance*. Gagné states that just telling the learners the answer to their questions is the correct form of learning guidance when the objective is verbal information.

7. *Event 6.* The *performance* that is elicited is a paraphrase of the information that has been given ("a short history . . ."), which is Gagné-Briggs' prescription for the acquisition of verbal information. A timeline was also added to elicit the performance, contributing to learning guidance (Event 5). Although

based primarily on designer discretion, this is also an alternative *spatial* representation of what is usually simply verbal information. It presents the stimulus in a different manner that can help students perform according to their own learning style (Dunn, 1978).

8. *Event 7.* In order to be effective, all *feedback* must inform the learner of the correctness or degree of correctness of the performance. Here the learner receives feedback that is immediate and indicates correctness, following the Gagné-Briggs prescriptions. In this instance, the designer of the lesson has decided that the feedback will come from a peer and be supervised by the instructor. Peer feedback is usually motivational to both the student and the peer. It can be an effective management strategy for the instructor. As the students report on their performances, the instructor can monitor overall performance.

9. *Event 8.* Assessment of the learners occurs here in the form of a typical essay test question. Multiple-choice, true-false, fill-in-the-blank, or matching questions could have been used instead.

10. *Event 9.* Retention and transfer of learning are aided by a spaced review that is a paraphrase of the information that was presented in this lesson. Designer discretion has placed this review at the final exam.

LESSON 2

11. *Sequencing.* Objectives 1 through 4 deal with the acquisition of intellectual skills. According to Gagné, there is a hierarchical relationship between concepts and rules. Certain simpler skills must be mastered before superordinate skills can be mastered. Identification of these prerequisite skills results in a learning hierarchy. A learning hierarchy for Objectives 1 through 4 is shown in Fig. 2.5. A proper instructional sequence is derived from the learning hierarchy by teaching the objectives from the bottom up in the hierarchy. Such a sequence for Objectives 1 through 4 is used in this lesson. It is assumed that all students have mastered entry-level behaviors and are starting instruction on the same level.

12. Self-paced instructional materials were chosen at the discretion of the designer to present these objectives (1–4). The events of instruction are handled differently in an individualized setting than they are for large-group instruction. According to Gagné, this approach allows for a greater degree of precision in the management of instructional events. Presented here on full-size pages, the booklets would best be printed on smaller pages or index cards with one frame per page.

13. *Event 2* (for all four objectives). The learners are told exactly what they will be learning and what behaviors they will have to exhibit to show that they have learned. All four objectives are presented together for this lesson (designer discretion).

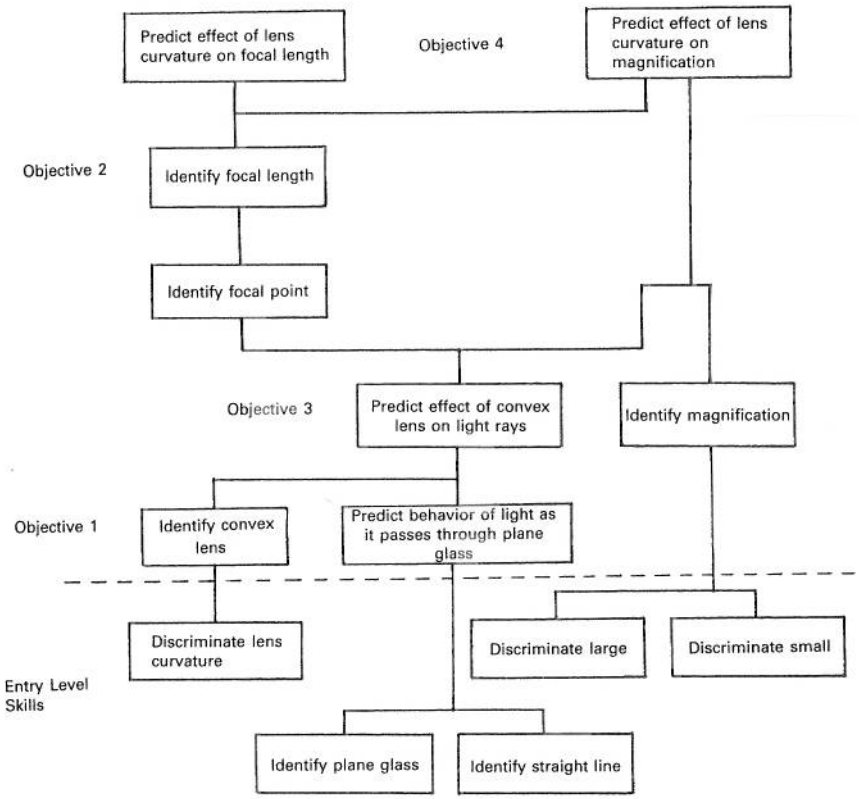


FIG. 2.5. Learning Hierarchy.

Objective 1

14. *Event 1.* This activity helps to gain the learner's attention and also informs the learner of the lesson's objectives.

15. These are simply directions to the student, having no direct relation to the events of instruction.

16. *Event 4.* Gagné states that as the stimulus material is presented, a variety of examples should be shown. Without this variety a student might not be able to identify the many different shapes and sizes in which convex lenses can be found.

17. *Event 5.* Learning guidance is provided by the examples, nonexamples, and verbal cues.

18. *Event 6.* Here a performance is elicited for the objective to classify a convex lens by definition. Examples that have already been presented, as well as

previously unencountered examples, are used, according to Gagné's prescriptions.

19. *Event 7.* The learner receives immediate, informative feedback regarding the performance "identify convex lenses."

Objective 3

20. *Event 3.* While this may be obvious information to many students, it stimulates recall of the prerequisite to the principle of how light behaves. This allows the learners to more easily acquire the new skill.

21. *Event 5.* Here, the intellectual skill (rule) to be learned is presented via a verbal communication. This stimulus material is presented in frame 9 and quizzed in frame 10. Note that frame 10 does *not* elicit the desired performance; it merely elicits recall of the stimulus material.

22. *Event 6.* The performance is elicited in frame 11.

23. *Event 7.* Feedback about performance correctness is provided in frame 12.

24. *Sequencing.* It can be seen here that Objective 3 is prerequisite for learning the concept "focal point." One has to understand that the rays bend inward in order to understand that they intersect at some point. It occurs to us that many complex concepts in science are defined by the kinds of "relationships among concepts" that characterize the kind of rules often referred to as principles (cause-and-effect relationships and natural processes). Also note (as shown in Fig. 2.5) that focal point is taught here because it is prerequisite to the concept "focal distance," which in turn must be taught before Objective 4 (a rule).

25. *Event 4.* This frame presents the stimulus materials for a new objective.

26. *Event 6.* This elicits the performance.

27. *Event 7.* This provides feedback about performance correctness.

Objective 2

28. Objective 2 (defining focal length) entails learning the definition, which is actually the acquisition of verbal information. However, the *concept* of focal length is a prerequisite for Objective 4. Therefore, focal length must be taught as both verbal information and an intellectual skill (concept).

29. *Event 4.* This frame presents the stimulus material for both the verbal information and the intellectual skill.

30. *Event 5.* This visual representation of an example provides learning guidance both for the verbal information (as an elaboration that makes the verbal information more meaningful) and for the intellectual skill (as an example of the defined concept).

31. *Event 6.* This elicits the performance for the verbal information.

32. *Event 7.* This provides feedback.

33. *Event 6.* This elicits the performance for the intellectual skill.

34. *Event 7.* Feedback.

Objective 4

35. *Events 4 and 5.* Gagné has indicated that a discovery approach can be utilized through the same events of instruction. The stimulus material is of a slightly different nature (it does not tell the learners the relationship), but the learning guidance is quite similar (primarily examples). There is some evidence that a discovery approach enhances motivation, retention, and transfer.

36. *Event 6.* This elicits the performance.

37. *Event 4.* This is the stimulus material for the other part of Objective 4 (see Fig. 2.5).

38. Frame 21 involves stimulating the recall of prerequisite learnings (Event 3). Although these prerequisites were just learned in this lesson, they are essential to the relationship between magnification and lens curvature and should be recalled. To the extent that this frame requires a review of the intellectual skills presented in earlier frames in a different application, it can be viewed as an enhancement of retention and transfer (Event 9). On such a small scale, however (within one lesson), it may also be viewed as simply eliciting another performance of the task (Event 6). It can be seen that any given portion of the instruction may implement several events of learning.

39. *Event 6.* Frames 22 and 23 elicit the performance.

40. *Event 8.* This assesses the learners' performance for all of the objectives taught in this workbook (including objectives 1–4).

41. *Event 9.* This enhances retention and (to the extent that different lenses and representations of lenses are used) transfer.

Lesson 3

42. Lesson 3 teaches the steps for using a microscope properly. Each step includes motor skills, but the final objective is still classified as a rule. At this level, students will presumably not have to learn the necessary motor skills (e.g., turning on a switch, adjusting knobs) but instead must learn the proper *procedure* for combining these skills. Each step of the procedure could be seen as a rule by which the student must respond with a class of relationships among classes of objects and events (Gagné & Briggs, 1977, p. 67). For example, the student must bring the specimen into focus by first selecting the appropriate objective and then using the coarse and fine adjustment knobs, in that order. Gagné

classifies procedures as a type of chaining. There are four conditions that must be met in order for the learner to be successful. First, the learner must be able to perform each step in the chain in the *proper order*. Second, the steps must be performed in a *contiguous manner*, one after another. This condition concerns time lapses between successive steps of the procedure; they must be minimal. In order for the learner to be able to perform each link in the chain in the proper sequence and at the proper moment the sequence must be *repeated* by the learner. Finally, completion of the sequence must result in immediate satisfaction on the student's part (i.e., seeing the magnified object through the eyepiece). This *reinforcement* has been found to be important for the learning of chains, and delay of reinforcement makes learning more difficult. These conditions are further explained in the following comments.

43. *Event 1*. The objects presented are familiar to students but will be seen in an unfamiliar manner (i.e., magnified through a microscope), thus appealing to the students' interest. The arrangement of students in pairs represents a real school situation where equipment may be at a premium, as well as enhancing motivation for students by allowing them to work together (designer discretion).

44. *Event 2*. A complete performance objective for this lesson following Gagné's prescriptions reads: Given any microscope in the classroom and a prepared slide (situation), the student will demonstrate the correct procedure (learned capability) for using a microscope (object), by arranging the lighting apparatus and focusing the lenses (action) of any microscope in this room (tools/constraints). The essential elements of this objective are communicated to students at this time.

45. *Event 3*. It is assumed that students have already learned the actual parts of the microscope in a previous lesson. The recall of these prerequisite concepts is especially important for rule learning. Gagné's necessary internal condition for rule learning is that each concept that is a part of the rule must be previously learned. In this lesson, the instructor begins with a "guided tour" of the instrument itself, so that students may both familiarize themselves with the microscope and recall each of the various parts.

46. *Event 4*. The instructor presents the stimulus material by modeling the procedure that students will learn, using the same equipment. This stimulus is a demonstration of the procedure that students will be expected to perform themselves.

47. *Event 5*. The use of the handout for the microscope provides guidance for the learners by meeting the "correct order" condition necessary for learning a chain.

48. *Events 6 and 7*. By allowing students to perform the procedure at their own rate with prompting (if necessary) by the partner, students are able to achieve the continguity requirement for performing a chain. The steps of the procedure must follow each other without hesitation, and students will do this on their own without waiting for the rest of the class. The partner provides feedback as needed by each student.

49. *Event 5*. This line of questioning by the instructor provides learning guidance for the students. Instead of explicitly stating the rules that must be learned (e.g., use the lowest power objective when first examining a specimen), the instructor suggests a line of reasoning that will lead students to combine the subordinate rules and concepts for themselves. This contributes to the efficiency of learning.

50. *Event 7*. If the view through their microscope corresponds to the projected slide, the students will know that they have successfully performed the procedure. When each student is successful, immediate reinforcement occurs for the entire procedure and enhances learning for the student.

51. *Event 6*. Once the procedure for using a microscope has been learned, the student's performance must have a kind of "regularity" over a variety of specific situations (Gagné & Briggs, 1979, p. 67). In this case, the learner must be able to use different styles and types of microscopes. Therefore, once the learner has successfully completed the task on one microscope, he or she must also successfully perform the task on others. This repetition is an essential element for learning a procedure. Furthermore, all conditions for chain learning are rarely present on the first time through a procedure. Repeated practice allows students to work out problems they may encounter, as well as helping them to remember the procedure.

52. *Event 8*. This allows the learner's performance to be assessed.

53. *Event 9*. This facilitates transfer and retention.

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3 A Lesson Based on A Behavioral Approach to Instructional Design

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FOREWORD

History

When instructional theory was born, about 1960, a behavioral orientation dominated learning theory and instructional practice. Skinner's programmed instruction and teaching machines were highly popular. Gropper's theory of instruction is a creative synthesis of the vast majority of the knowledge about instruction that arose out of the behavioral tradition.

Unique Contributions

Part of the creative aspect of that synthesis is Gropper's conceptualization of three kinds of treatments (methods of instruction): routine treatments, which should always be used; shaping treatments, which should precede the routine treatments whenever the conditions pose learning difficulties; and specialized treatments, which supplement the other two types of treatments to meet special learning problems. This is a very useful conceptualization for instructional designers and teachers.

Another unique feature of Gropper's theory is the amount of detailed guidance its prescriptions provide for designers (see, e.g., his prescriptions for the size of the unit of behavior, the mode of the stimulus or the response, and exaggeration

*The views expressed in this chapter are those of the author and are not necessarily those of the Digital Equipment Corporation.