CONSTANCE R. MILLER

Scientific Literature as Hierarchy: Library Instruction and Robert M. Gagné

Too often, library use instruction for undergraduates has aimed at teaching high-level concepts, such as how to use an abstract or a citation index, before the essential lower-level skills have been acquired. R. M. Gagné's learning theory points out that emphasis must be placed on the often-ignored prerequisite of effective library use: an understanding of the systematic way in which scientific (including the social sciences) literature and knowledge is produced, organized, and accessed. This paper establishes the connection between the learning theories of Gagné and systematic patterns in scientific literature, and discusses the implications of this connection for instruction in library use.

EARLY ATTEMPTS at library instruction concentrated on quantity. Learning theories were virtually ignored in presentations that seemed to aim at teaching the entire curriculum of a two-year library school course in an hour. In the last decade, however, as instruction in the use of the library to college undergraduates has risen to the status of a discipline in its own right, librarians have begun to pay heed to the lessons embodied in the psychology of learning. For example, self-paced library workbooks designed by Mimi Dudley, Beverly Renford, and others, resemble programmed instruction, and a recent article by Kobelski and Reichel reminds instruction librarians to keep the cognitive theorists in mind.[1]

An interesting speculation, however, is that librarians and learning theorists have been attempting the same thing: to understand and to systematize the production of information. Confirmation for this speculation can be found by comparing the learning theory developed by Robert M. Gagné (b. 1916), a psychologist and instructional designer at Florida State University, with the way in which scientific (including the social sciences) information is produced, organized, and accessed. The accuracy with which Gagné's theory of learning reflects the structure of information has implications for library instruction and lends impressive credibility to Gagné's approach to learning.

R. M. Gagné emphasizes the influence of learning, rather than growth, on human behavioral development,[2] and his model of learning is cumulative. This means that progress, or development, results from acquiring capabilities that build on each other. Combinations of previously learned items result in new learning. Gagné sees the cumulative learning sequence as moving from lower-level capabilities to higher ones (see figure 1), and in his book *The Conditions of Learning*, he goes into detail about each type of learning in the sequence, giving examples, conditions for learning, and educational implications.[3] Within the sequence, transfer from lower to higher levels occurs because higher-level concepts or rules include elements identical to those at lower levels, plus at least one new element.[4] Learning anything new is relatively easy and natural,

Constance R. Miller is instruction librarian, St. John's University/College of St. Benedict, Collegeville, Minnesota.

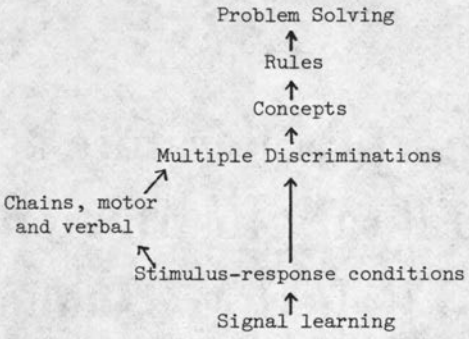

Fig. 1
Gagné's Cumulative Learning Model

therefore, if the prerequisite lower-level learning has occurred.

It is not only in terms of overall human behavioral development that Gagné views learning as sequential. He also believes that it is possible to represent, in a valid, ordered sequence, the instruction of any intellectual skill (i.e., a capability that makes it possible for an individual to execute an entire class of tasks).[5] Gagné calls these valid, ordered sequences "learning hierarchies": "Any high level skill has one or more immediate descendants which are subskills."[6] Learning hierarchies do not deal with how something should be taught. They are representations of the interrelations of intellectual skills (see figure 2).[7]

A learning hierarchy is designed by working backward from a goal or terminal objective with the subordinate skills at each level telling what the learner needs to know in order to move on to the superordinate, next higher skill. The lowest skill, or set of skills, in a hierarchy is/are one(s) that all learners can perform. For more advanced learners, instruction can begin at any point in the hierarchy.

Task analysis, according to Gagné, is the systematic description of a terminal objective in terms of prerequisite performance objectives. Each skill in a learning hierarchy must be stated in behavioral terms, and include an action verb, conditions for performance, and a means of measuring whether the performance has been achieved.[8] Designing instruction in terms of learning hierarchies, therefore, has several advantages: it establishes an instructional sequence; it focuses the instruction on the ability or level of each individual learner; and it builds evaluation of learner performance and of the instruction itself into the behaviorally described system.[9,10,11,12]

In spite of the usefulness of Gagné's hierar-

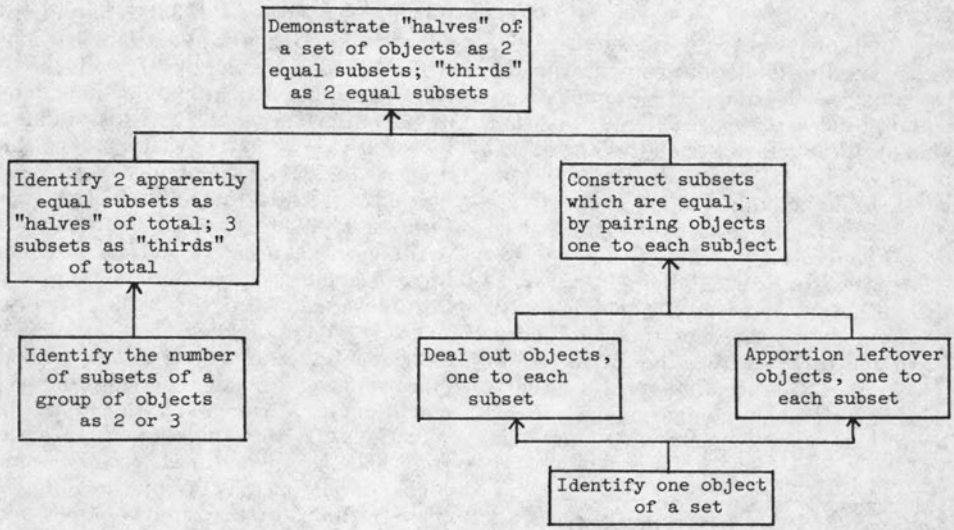

Fig. 2
Example of a Learning Hierarchy

chical theory for instructional design, there has been significant opposition to his concept of superordinate-subordinate skill units. The inclusion hypothesis, held by Gagné's opponents, suggests that optimal learning occurs by moving from the understanding of a total task to its composite parts. Ausubel's subsumption theory and Norman's web theory maintain that mastery of an overview, or supporting structure, should occur first.[13] Perhaps the major problem with hierarchical learning, however, has been stated by Gagné himself. The validity of learning hierarchies, which is established by proving that learning a subordinate skill implies transfer to learning a superordinate skill, has been difficult to demonstrate.[14] Although relatively recent attempts at validation have been somewhat more successful,[15] many studies cast significant doubt on the whole learning hierarchy concept.[16] This validation problem, however, results primarily from a mistaken approach. An analysis of the organization of scientific literature and of the way in which this organization can be systematically used to obtain information reveals an interesting similarity between library research and Gagné's hierarchical theory of learning. This mirroring of Gagné's theory and the process of accessing knowledge validates the hierarchical learning model in a way that proving a transfer from lower-level to higher-level capabilities can never do.

W. D. Garvey describes science as a "social system of which communication is a salient feature."[17] This scientific communication is far from random. It consists, rather, of a complex system[18] of scientific literature, which is organized into networks of interrelated citations.[19] These networks connect various types of sources on related subjects: there are primary sources, which constitute the unchanging component in a body of scientific knowledge; there are secondary sources, which are the changing, revising component—the edge of growth; and there are the intermediary or reference sources, which serve as the glue that holds the mass of information together.[20] These latter sources are the keys to accessing scientific information.

There are two separable but interconnected parts to the structure of a body of scientific literature, each of which provides a means of conveying what is known. The substantive part provides content, and the bibliographic part provides bibliographic location.[21] Figure 3 illustrates the relationships among various sources along a content-bibliographic continuum.[22]

To locate primary information on a topic of interest, the content and/or bibliographic sources cannot be used randomly. In the sense that the use of certain sources leads to the use of other sources (e.g., the location of a key source in an encyclopedia bibliography is a precursor to using a citation index), the systematic way in which scientific literature must be searched to most effectively yield the needed information is hierarchical. Additionally, as Friedes points out, a researcher can "tune in on the scholarly discussion at the level of generality corresponding to his [sic] familiarity with the subject."[23] The process of developing an understanding of the organization of information is hierarchical, as is Gagné's model of human behavioral development (see figure 1). To reach the problem-solving stage (i.e., the ability to conduct a complex search for information on a topic), a number of lower-level capabilities must first be achieved. Figure 4 is a representation of the cumulative learning sequence of library research. Equivalent stages from Gagné's cumulative learning model are in parentheses opposite the relevant boxes.

Gagné applied learning hierarchies not only to behavioral development but also to

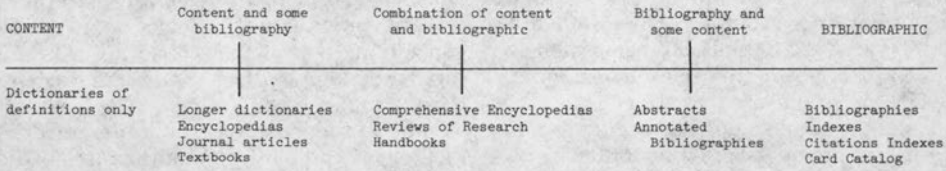

Fig. 3
Continuum of Content and Bibliographic Sources

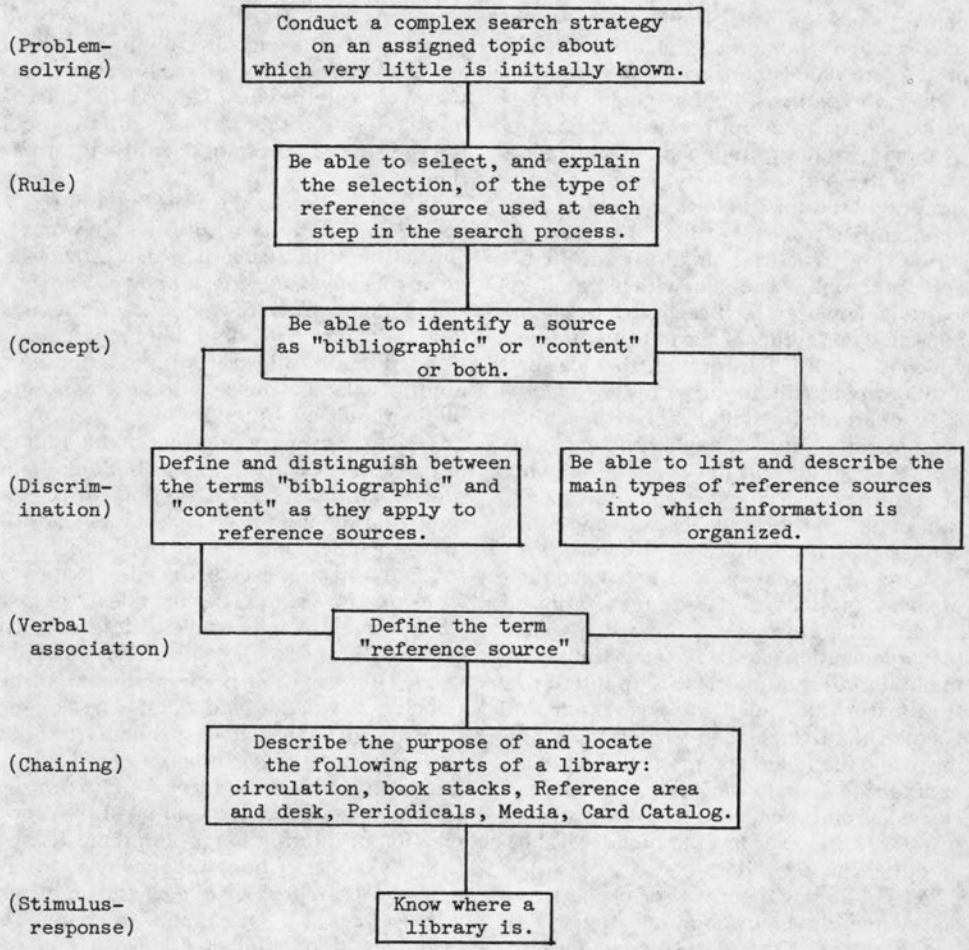

Fig. 4
Cumulative Learning Sequence of Library Research

the instruction of specific intellectual skills. In the same way, a specific search for information using content and bibliographic reference sources can be represented as a hierarchical process. Figure 5 is a learning hierarchy for conducting library research to locate primary information. The hierarchy specifies the systematic order in which sources are used to build an increasingly sophisticated body of information on a topic.

The correspondence between Gagné's theory and the organization and accessing of information provides validation for the hierarchical, cumulative model of learning. To the extent that information sources reflect the structure of the system of knowledge in which they exist,[24] what applies to the organization of information also applies to the system of knowledge. The ability to hierarchically gather information on a topic suggests the hierarchical accumulation of knowledge in a field. Scientific literature, from the progress of its production, to its organization, to its methods of access, is structured around prerequisite, subordinate steps leading to superordinate steps. The fact that scientists produce and use the literature of their fields cumulatively and hierarchically offers tangible support for Gagné's learning theory.

R. M. Gagné expressed, in explicit psychological terms, a theory of development and learning that accurately reflects a structure implicit in scientific literature. The accuracy of this reflection has implications for library instruction. A student cannot be expected to use an abstract effectively if the student doesn't understand the exact purpose it can serve. Teaching, in detail, the use of *Psychological Abstracts* to students in a junior-year class will not result in superior research projects. If, however, the students are taught that an abstract, as a type of source, will be useful at the point where their topics are well defined and narrowed, and if they have located a number of articles, the best of which they need to select, the research projects are likely to represent a creative synthesis of ideas. That is, a student will more effectively use a reference tool of any type by first understanding the prerequisite concepts: that scientific literature is hierarchically organized,

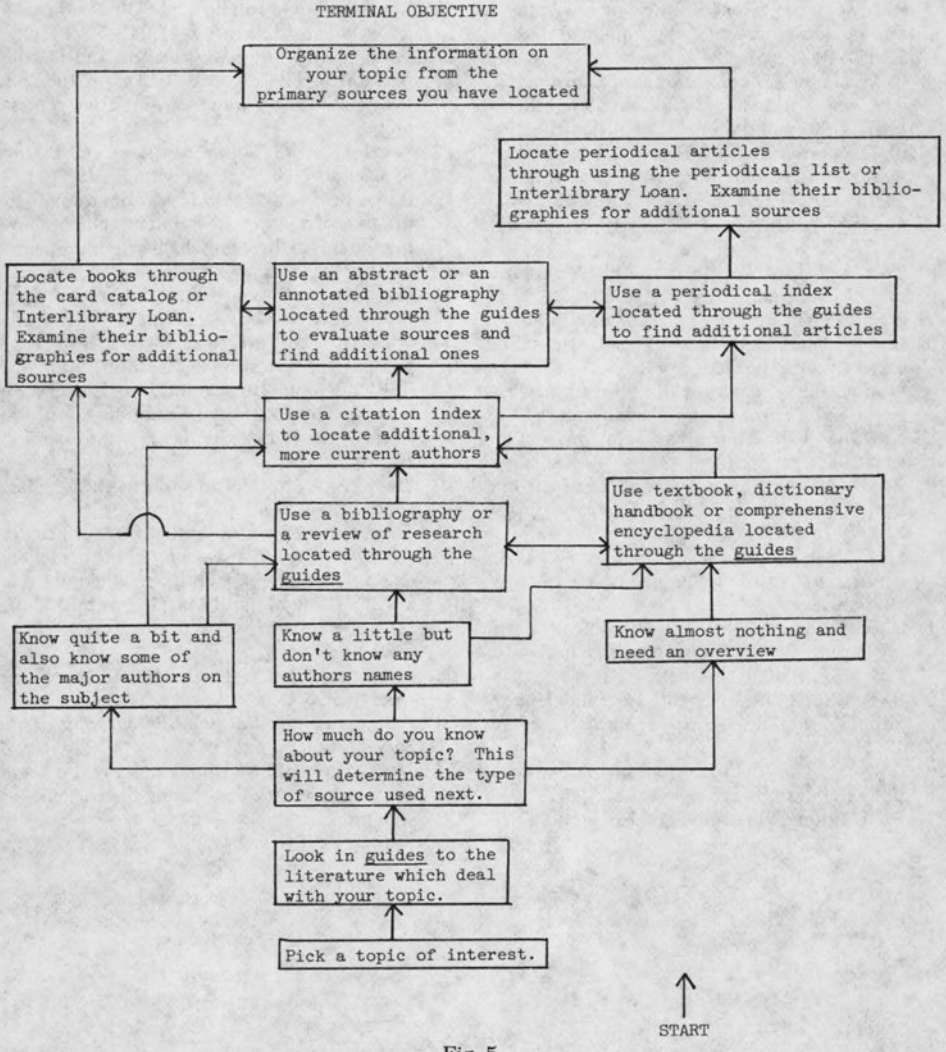

Fig. 5
Learning Hierarchy for Locating Primary Sources on a Specific Topic

and that the various elements interrelate.

What librarians have to say in support of Gagné, therefore, is that he has described a learning theory that reflects, with great accuracy, the way scientists acquire, produce, and access systems of information. In return, what Gagné has to say to librarians is that the key to accessing information lies in utilizing the hierarchical organization of the literature to build a cumulative body of knowledge.

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18. Ibid., p.134–35. Garvey has diagramed the progress of scientific research in a chart, showing the stages through which original research must proceed. Interestingly enough, the chart reveals a hierarchical structure made up of prerequisite objectives leading to the terminal objective, the "text, treatise" box.
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21. This idea is expressed by both T. K. Freides, *Literature and Bibliography of the Social Sciences* (Los Angeles, Calif.: Melville Pub. Co., 1973), p.259–65; and MacGregor and McInnis, "Integrating Classroom Instruction," p.23–25.
22. MacGregor and McInnis, "Integrating Classroom Instruction," p.24.
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24. MacGregor and McInnis, and Freides spend considerable time illustrating the truth of this statement.

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