TRANSFER OF LEARNING

FROM A MODERN MULTIDISCIPLINARY PERSPECTIVE

Edited by

Jose P. Mestre

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Transfer of Learning from a Modern Multidisciplinary Perspective

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INTRODUCTION

Framing The Transfer Problem

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The topic of how the transfer of learning occurs certainly has legs in the educational and psychological literature, where it has occupied center stage for over 100 years. *Transfer* is a term that describes a situation where information learned at one point in time influences performance on information encountered at a later point in time. The question attracted the interest of researchers shortly after the birth of psychology as an empirical science and has continued to be a topic of considerable interest, as evidenced by the chapters in this volume. Our purpose in this introductory chapter is to provide an historical context for the remaining content and to emphasize the unique contribution of each of the chapters to follow. There are many new and exciting ideas in this book and we hope readers enjoy them as much as we have.

Psychology as a scientific discipline began in the middle of the 1800s, and one of the first questions that concerned early researchers was the

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issue of how information learned at one time comes to influence learning and performance at a later time. An early analysis by Hoffding (1892) serves as a departure point for the discussion to follow. Hoffding was concerned with the problem of recall, and he suggested that the problem could be conceptualized as follows. Suppose that a learning event was represented by the letter *A*, and the stored internal representation of that event, when learned, was represented by the letter *a*. Now suppose that the internal representation of a response to the learned event was represented by the letter *b*, and the observable response made when *b* was activated was represented by the letter *B*. The chain of Hoffding's representation could then be characterized as *A-a-b-B*. Recall would occur when event *A* would again activate *a* and ultimately result in performance of the previously learned *B*.

Using Hoffding's representation, the question of transfer arises when *A* is no longer identical to its initial form, but rather, some variant of that form, *A'*. Will *A'* activate *a*, and what are the conditions that govern the likelihood that *a* will be activated? This is the central theoretical question contained in the transfer issue, and we will shortly unpack that question into some of its subparts.

Before doing so, however, we want to mention that the question of how transfer works, and how transfer can be facilitated, is a vitally important educational issue. Here the questions are, can we arrange educational experiences in an optimal fashion so that one learned event facilitates the acquisition of a later learned event, and can we teach in a manner that optimally extends the range of events to which initially learned material can be applied? As we will see shortly, these are also complicated questions that need to be decomposed before we can fully appreciate their complexity. In addition, these questions are the primary concern of the chapters in this volume.

Before we can adequately address both the question of the theory of transfer and the educational enhancement of transfer, we need to do some definitional housework. In the next section we introduce a number of the concepts that have been introduced to describe various aspects of transfer. The definitional section is followed by a brief history of both the theoretical and educational ideas that have dominated the transfer issues, which in turn leads into a discussion of the contributions of this volume.

DISTINCTIONS BETWEEN TYPES OF TRANSFER

The description of types of transfer is useful because it illustrates both the historical evolution of transfer research and the breadth and scope of the transfer issue.

Lateral and Vertical Transfer

The distinction between lateral and vertical transfer was made by Gagné (1965). Vertical transfer occurs when a skill or knowledge unit learned in one situation directly influences the acquisition of a more complex skill or knowledge unit learned at a later point in time. From Gagné's perspective, the simpler skill was a necessary precursor to the acquisition of the more complex skill and instruction should be arranged to take advantage of the hierarchical structure of information to be learned. The concept of vertical transfer was part and parcel of the whole mid-1900s movement that involved careful task analysis of educational content and the attempted assurance that lower-level knowledge be learned before higher-level material was attempted (e.g., mastery learning). The idea behind task analysis was that you could begin with terminal learning goals, ask the question of what content would have to be learned before the terminal material could be learned, and then proceed to move backward until you encountered what was referred to as "entering behaviors." Entering behaviors were skills that children have acquired before entering school. Having completed the task analysis you could then begin to design instruction that would systematically teach the identified skills, beginning with those coming immediately after the entering behaviors, and leading ultimately to the mastery of terminal learning goals.

Lateral transfer was less well defined in Gagné's (1965) system. He referred to lateral transfer as "a kind of generalization that spreads over a broad set of situations at roughly the same level of complexity" (pg. 231). As a presumed example, lateral transfer would refer to situations where a child would learn things like the correspondence between fractions and decimals, and the fact that letters can be the same even when their physical appearance changes, as in the case of font changes. These examples may not capture what Gagné had in mind, and it is safe to say that the distinction was not well defined. As we will see as we proceed with this section, this definitional fuzziness is symptomatic of a problem in defining one broad class of transfer situations.

Specific and Nonspecific Transfer

Specific transfer involves a situation where there is a clear similarity between the stimulus complex encountered in one situation and the stimulus complex encountered in another situation. We can use Hoffding's representation to illustrate specific transfer. If A and A' are quite similar to one another, then it is very likely that the appearance of A' will activate the stored memory representation a, and thereby facilitate the attachment of a

previously learned response to the new learning event. As we will see in the later section on theories of transfer, the analysis of the conditions of specific transfer was particularly popular during the heyday of behavioral learning theories.

Nonspecific transfer refers to situations where there is no obvious relationship between the stimulus properties of two learning events, but the acquisition of one nonetheless influences the acquisition of the other. The classic example of nonspecific transfer in the behavioral learning era was "learning to learn" demonstrations where practicing one set of learning events could be shown to facilitate another set of learning events even though there was no obvious stimulus similarities between the two events. For example, Harlow (1949) analyzed experiments where monkeys were shown to become more adept at repeated problem solving even though there was no obvious relationship between the successive problems they were solving.

As was the case with lateral transfer, one cannot find a good definition of what nonspecific transfer is. Past researchers knew it when they saw it, but found it impossible to define in a formal fashion.

Near and Far Transfer

When discussing the idea of specific transfer we noted that learning events involving similar responses can be quite similar to one another in terms of their stimulus properties, but they can also be quite different from one another. In order to capture this distinction, some authors (e.g., Mayer, 1975) began to refer to transfer events as involving either near or far transfer. Near transfer referred to situations where there was a great deal of similarity between the conditions of original learning and the conditions involved in transfer learning, whereas far transfer involved little similarity between the two events.

One common way the difference between near and far transfer is discussed is in terms of school-learned events and out-of-school events (e.g., Royer, 1979). School-learned events are often described as involving near transfer since many of the conditions involved in learning one event are also present when another event is learned. In contrast, when school-learned material is applied to an out-of-school problem, it is said to involve far transfer since the stimulus complexes in the two situations are likely to be quite different.

Far transfer has also been difficult to define. Early on it was thought of as representing the far extreme of a stimulus generalization gradient (to be discussed in a following section) that will still activate an earlier learned response. However, usage by researchers in the later half of the 1900s soon

expanded this notion to one involving such ideas as the category of real-world problems that could be solved through the use of mathematical operation (e.g., multiplication). The class of such problems is obviously very large and very varied in form. Thinking of the class as involving a stimulus generalization gradient is simply not a very satisfactory way of defining far transfer.

Literal and Figural Transfer

Royer (1979) presented another distinction that he described as involving either literal or figural transfer. Literal transfer involved the application of an intact bit of knowledge to a new learning event. So, for example, the skill of calculating the area of a rectangle can be applied intact to the novel problem of determining the size of a rug necessary to carpet a room. In contrast, there are other situations that seem not to involve the transfer of an intact skill, but rather involve the application of a segment of world knowledge as a tool for thinking about or learning about a new problem or issue.

Royer (1979) mentioned figural language like metaphor and simile as the clearest examples of figural transfer. For example, when we hear phrases like "Encyclopedias are goldmines" or "Our brain is like a computer," we are being asked to use the world knowledge we have about the referent of the sentence as a tool for understanding or thinking about the subject of the sentence. Royer suggested, though, that activities like the use of analogy in teaching also involved the use of figural transfer, since invoking an analogy involves asking the learner to use their knowledge about one topic as an aid in understanding and learning about another topic.

The problem with Royer's notion of figural transfer is that it involves definition by example, never a very satisfactory way to formally define a psychological construct. In short, figural transfer suffers from the same shortcomings as definitions of lateral and far transfer.

Comparisons between the Distinctions

It is obvious that there is a great deal of similarity between some of the distinctions mentioned in the above sections. For example, the idea of vertical transfer is based on the notion that there is some systematic and obvious stimulus relationship between early learned skills and later learned skills. Typically these relationships are strong enough that they can be described as involving specific transfer. Likewise, there is a great deal of similarity between the ideas of near transfer, specific transfer, and vertical

transfer. Moreover, the examples that Royer (1979) used to describe literal transfer could also be thought of in terms similar to those used to describe near, specific, and vertical transfer.

It is also the case that there are readily available educational tools for promoting near, specific, vertical, and literal transfer. All of these transfer forms involve situations where there is an explicit stimulus similarity between the conditions of early learning and the conditions of later learning. If one wants to devise educational experiences that promote these kinds of transfer, it can be done by simply arranging the stimulus conditions of learning so as to emphasize the similarities of the learning events.

Whereas it is easy to classify types of transfer that are based on the concept of stimulus similarity, as we have seen, it is far more difficult to characterize types of transfer that are not based on the resemblance of stimulus events. As noted earlier, Gagné's (1965) notion of lateral transfer was poorly defined as are nonspecific transfer, far transfer, and figural transfer. We have long been able to show that these types of transfer do indeed occur. But what has been far more difficult is to identify and define the properties that govern them.

The notion that there is a vast realm of transfer problems that are poorly understood foreshadows the content of this book. Each of the chapters makes a contribution to either understanding or measuring transfer in situations not involving obvious stimulus resemblances between learning or problem-solving events. Before we turn to a description of the chapters to follow, we need to conduct a brief survey of historical theories that have been used to explain transfer. Describing the historical theories will allow us to bring the unique contributions of the chapters in this book into sharper focus.

HISTORICAL THEORIES OF THE TRANSFER OF LEARNING

Historical theories of the transfer of learning can be divided into two categories: those that emphasize the analysis of events external to the learner, and those that emphasize the analysis of events internal in the learner. We will call this first category of theories environmental theories, and the second, cognitive theories.

Environmental Theories of Transfer

The first serious theory of the transfer of learning was proposed by Thorndike and Woodworth (1901), and it was called the theory of identical elements. They proposed that transfer from one task to another would

occur only when both tasks shared identical elements. Furthermore, they proposed that as the number of shared elements increased, one would see either an increase in the amount of transfer occurring from task to task, or an increasing likelihood that transfer would occur at all. Shared elements, of course, referred to shared stimulus features in the two learning tasks. As the proportion of shared stimulus features between tasks increased, there was a corresponding increase in the degree of transfer between the tasks.

Thorndike and Woodworth's (1901) analysis implied a sort of stimulus similarity gradient between the stimulus features of learning tasks, but they did not offer any direct evidence that such a gradient existed. Such evidence was soon to come in the form of stimulus generalization research. Consider the example of a dog that has been classically conditioned to salivate to a 500 Hz tone. Now imagine an experiment where a conditioned dog was systematically presented with tones that varied from 500 Hz by increments of 25 Hz. The results of such an experiment that measured saliva flow would show that the maximum amount of flow would occur at 500 Hz, and there would be a near normal distribution of flow as the presented tone varied above and below the tone involved in original learning. This distribution would be symmetric, and the degree of saliva flow for increments above the original tone would be very similar to the flow for increments below the original tone.

Stimulus generalization research provided a nice confirmation of the theory of identical elements in that it showed that it indeed was the case that the response of new learning tasks varied systematically as a function of the stimulus relationship between the new task and the task of original learning. This confirmation lent theoretical credibility to the notion of transfer being governed by stimulus relationships and undoubtedly contributed to the popularity of educational movements that were based on the ideas embedded within identical elements theory.

We will not review the educational influence of identical elements theory but we will indicate that it served as the guiding notion behind a very large number of educational approaches that were especially popular from the period of about 1940 to 1970. Although these approaches were widely popular, they came to be seen as having shortcomings that could ultimately be traced to failings in the theory of identical elements.

Difficulties with Identical Elements Theory

The fundamental limitation of identical elements theory is that it has little to say about a number of forms of transfer that we have discussed previously. Since identical elements refers explicitly to stimulus features present in a learning environment, the theory would deny the possibility that trans-

fer would occur in situations where there obviously are not shared stimulus features between events. To use an example that was presented earlier, it is difficult to imagine two things that are more dissimilar from one another than encyclopedias and goldmines. Nonetheless, almost all native speakers of English would immediately recognize the metaphorical relationship between the two things and to perhaps even be able to learn something about encyclopedias by having them compared to goldmines. As an aside here, it is interesting to observe the curious asymmetric relationship between the referent and subject in almost all metaphors. Encyclopedias can be goldmines, but goldmines cannot be encyclopedias.

The fact that the theory of identical elements has nothing to say about transfer between events that do not share obvious stimulus features means that the theory has little or nothing to say about lateral transfer, far transfer, and figural transfer. This is a fatal flaw since these are some of the most interesting kinds of transfer, particularly from an educational perspective. The fundamental idea behind education is to teach knowledge and skills that will allow one to function better outside the classroom. A theory that cannot explain out-of-school transfer, and that offers no guidelines for promoting the educational development of out-of-school transfer, is certainly not a theory that has broad educational applicability.

Cognitive Explanations of Transfer

One obvious limitation of identical elements theory is that it depends on an analysis of observable stimulus events to develop an explanatory system for the transfer of learning. As the cognitive revolution took hold in the later part of the 20th century, explanations for transfer began to emerge that were based on hypothesized events occurring in a learner's cognitive structure.

Rather than referring to a particular theory in this section, we present an amalgam of theories that were offered by a variety of researchers (e.g., Anderson, 1976; Anderson & Bower, 1973; Bransford & McCarrell, 1974; Collins & Loftus, 1975; Johnson, 1975; Mayer, 1975; Wittrock, 1974).

Cognitive theories of the transfer of learning were developed in the context of the presentation of ideas about how the human cognitive system was structured and about how it functioned. Specifically, it was assumed that the cognitive system was structured into the components of stimulus (iconic) memory, short-term memory, and long-term memory. Long-term memory was further conceptualized as a semantic network where the nodes in the network consisted of conceptual representations of semantic information. These nodes were connected by pathways that varied in strength and along which activation could spread in a manner that would

result in the firing of a node if sufficient strength were accumulated from activated connecting pathways. Moreover, the activation of sections of a network could often be activated by events in the environment. So, for example, if a person reads a section of text describing activities involving parachuting, a number of nodes in that person's semantic network begin to fire, thereby spreading activation to other nearby (semantically related) nodes, and soon there is a chunk of memory activated that can assist in the encoding of new information in the reading passage.

This sort of description of the cognitive system soon began to be used to describe the process of comprehension, and comprehension soon came to be used as a necessary condition for the transfer of learning. The idea was that comprehension was heavily dependent on the activation of prior knowledge that was related to the new learning. For example, when you read the sentence, "The haystack was important because the cloth ripped," chances are you don't have too much difficulty understanding the sentence because we have mentioned parachuting in the paragraph above. But now try "The trip was not delayed because the bottle broke," or "The notes were sour because the seam was split." Without the context of ship launching or playing bagpipes, both sentences may be very difficult to understand. (The sentence examples come from Bransford and McCarrell, 1974.)

The idea soon emerged that comprehension and transfer were very similar, if not the same, process. That is, in order for transfer to occur a section of long-term memory would have to be activated that contained material that was conceptually similar to the new material that was being learned. If a section of long-term memory was activated when new learning material was encountered, it could be used to facilitate the acquisition of the new material, and it is possible that the activated memory would also contain information that could be used in activities such as problem solving.

An elaboration on the theme of the relationship between comprehension and transfer occurred with the development of schema theory. The notion of activated semantic networks as a mediating structure for new learning was a powerful idea, but it seemed not to do a very good job of capturing differences between very frequently encountered events and less frequently encountered events. For example, imagine hearing a description from someone about attending a bullfight and then eating dinner at a nice restaurant. Chances are the bullfight description would be encoded as a series of episodic traces that would probably fade fast and that would be quite veridical in nature. In contrast, the restaurant description would tend to be encoded in a more narrative form. Moreover, the restaurant description upon recall might possibly even contain information that was not presented. In short, the listener might add content to the original story.

These differences described above seemed to be difficult to explain if one imagined that both involved activating segments of semantic memory.

However, if one imagined that the two stories activated different segments of memory that were qualitatively different from one another, then the differences in acquisition and recall become more understandable. This qualitative difference was exactly what was proposed and the memory structure encoding frequently encountered events came to be called schemas and the description of the formation and operation of schemas was described in schema theory (see Adams & Collins, 1978; Anderson, 1978; Rumelhart & Ortony, 1977, for early descriptions of schema theory).

Schemas were thought to be data structures that represented frequently occurring events that contained the same or similar elements. Activating the schema not only facilitated the acquisition of new information that could be encoded in the schema, but it also "added to" the information that was presented. So, for example, if someone mentions that they had dinner in a restaurant, the listener knows a lot about what happened without being told. In contrast, most people have never been to a bullfight and have read relatively few descriptions about what happens at a bull fight. Hence, relatively little information about a bullfight gets activated when the description begins.

Schema theory added to the power of cognitive explanations of transfer because it provided a way of describing and making distinctions between various kinds of transfer events. One could now explain and make predictions about transfer in situations involving both frequently and infrequently encountered events.

The Contribution of Cognitive Theory to the Transfer Literature

When we ended the section on environmental theories, we noted their fatal flaw involved an inability to explain transfer in situations where there was no obvious similarity between the stimulus complex involved in original learning and the stimulus complex involved in the transfer event. The theory could explain things like vertical transfer, specific transfer, and literal transfer, but could not explain other forms of transfer.

Cognitive theories went a long way toward providing us with the conceptual tools we needed to think about these other forms of transfer. Rather than transfer being dependent on stimulus similarity, cognitive theory proposed that transfer was dependent on conceptual similarity. Two learning events might appear to be quite different from one another, but if they have underlying conceptual similarities, one could very well influence the performance on the other.

Whereas the conceptual tools provided by cognitive theory advanced our ability to think about and describe transfer circumstances, those tools

were still impoverished and inadequate in many respects. It proved to be difficult, for example, to translate cognitive theory into educational experiences that could be shown to facilitate later learning and to facilitate transfer to a broad range of possible transfer situations. Moreover, even though semantic network theory and schema theory proved to be useful devices for understanding topics like reading comprehension, they were clunky devices for dealing with learning and performance in subject-matter areas such as mathematics and science.

What was needed was a new set of conceptual tools for examining transfer and that could also be used to create important educational experiences and to measure important learning outcomes involving transfer. That is precisely the purpose of this volume. We believe that the chapters contained in this book present a new and exciting set of conceptual tools that will not only allow us to think about transfer in more productive ways, but will also enable the development of educational and measurement tools that will greatly facilitate our ability to educate the children in our schools.

Expanded View of Transfer

Historically, the perspective taken in psychological studies of transfer consists of defining/identifying some common similarity across two tasks and then seeking evidence (or lack thereof) for transfer. When viewed from this researcher-centered perspective, results from transfer experiments are binary—either transfer happened or it didn't, with many arguing that positive evidence for transfer is rare indeed (Detterman, 1993). Yet, assuming that participants in transfer studies were not daydreaming throughout the experiments, they were transferring something to reason and make sense of the tasks given to them to perform. Focusing on researcher-defined transfer objectives imposes limitations on the study of transfer, perhaps the most salient limitation being that we miss out on trying to understand the mental processes that individuals employ in transferring prior learning—that is, we make little effort to understand what it is that individuals are actually attempting to transfer.

Expanded views of transfer (Beach, 1999; Bransford & Schwartz, 1999; Dyson, 1999; Greeno, Smith, & Moore, 1993; Lave, 1888; Lave & Wenger, 1991) differ from traditional views by investigating the mediating factors by which individuals activate and apply prior learning, both productively and unproductively, during transfer tasks. At a more practical level, by understanding the factors that mediate both productive and unproductive transfer, one can begin to think about instructional strategies that may be more conducive toward fostering productive transfer.

These views are nicely summarized by Lobato (2003), who has proposed an "actor-oriented" model for investigating transfer in which the researcher attempts to identify how participants in a transfer task (i.e., the "actors") see different situations as similar, thus shifting the emphasis from researcher-centered definitions of successful transfer to actor-generated creations of similarities between previous and new situations. Within this view, the success or failure of transfer in any given task is immaterial—what matters is understanding how learners make connections between learning that took place in previous situations to new situations that they now encounter. Lobato's model, and other recent views of transfer, go further in considering sociocultural influences on transfer (Beach, 1999; Greeno, Smith & Moore, 1993; Lave, 1888; Lave & Wenger, 1991); that is, transfer is not simply something that an individual does in isolation but rather depends on environmental and social factors as well. For example, within a situated cognition perspective, Greeno and colleagues (1993) suggest that transfer is also mediated by factors such as interactions with the environment, peers, teachers, and other external influences that lead the individual to become attuned to the affordances of the context. By way of summary, Table I.1 from Lobato (2003) highlights important contrasts between traditional views of transfer and the expanded view (in Lobato's terminology, "actor-oriented transfer") along various dimensions.

THE CONTENT OF THIS BOOK

Many of the chapters of this volume reflect the expanded view of transfer discussed in the previous section. This volume is eclectic in bringing together researchers from psychology and physics education—who would not normally present their ideas under the same forum—to share their views and perspectives on transfer. What we believe has emerged is a fresh look at transfer issues from a multidisciplinary perspective.

In the first chapter, Daniel Schwartz, John Bransford, and David Sears argue that the varied positions on transfer can be seen as pieces of the truth that can be reconciled through a broader theoretical foundation. They seek to redirect the focus of transfer in terms of what phenomena to study and how transfer is measured. More specifically, Schwartz and colleagues take the stance that classic views of transfer tend to measure transfer in ways that make people look dumb. They propose different ways of designing studies and assessments of transfer that measure the effect of previous learning on performing new tasks. They differentiate between what classic studies of transfer measure, namely, what people "transfer out" (whether or not people directly apply what they learned in one context to another), and what is not measured in classic studies of transfer, namely,

Table I.1. Theoretical Assumptions of Actor-Oriented Transfer Compared to Traditional Transfer.

Dimension	*Traditional transfer*	*Actor-oriented transfer*
1. Definition	The application of knowledge learned in one situation to a new situation.	The personal construction of relations of similarity across activities (i.e., seeing situations as the same).
2. Perspective	Observer's (expert's) perspective.	Actor's (learner's) perspective.
3. Research method	Researchers look for improved performance between learning and transfer tasks.	Researchers look for the influence of prior activity on current activity and how actors construe situations as similar.
4. Research questions	Was transfer obtained? What conditions facilitate transfer?	What relations of similarity are created? How are they supported by the environment?
5. Transfer tasks	Paired learning and transfer tasks share structural features but differ by surface features.	Researchers acknowledge that what experts consider a surface feature may be structurally substantive for a learner.
6. Locations of invariance	Transfer measures a psychological phenomenon.	Transfer is distributed across mental, material, social, and cultural planes.
7. Transfer processes	Transfer occurs if two symbolic mental representations are identical or overlap, or if a mapping between them can be constructed.	Multiple processes, such as an attunement to affordances and constraints, assimilation, language use, and "focusing phenomena," influence transfer.
8. Metaphor	Static application of knowledge.	Dynamic production of "sameness."

Source: From J. Lobato (2003), *Educational Researcher, 32*(1), 20. Copyright 2003 by the American Educational Research Association; reproduced with permission from the publisher.

what people "transfer in" to a new situation from previous learning. They argue that the latter is equally if not more important than the former. They also point out that classic transfer studies follow a "sequestered problem-solving" paradigm where participants are tested isolated from any "contaminating" influences or information (e.g., other colleagues, or text or electronic resources); the alternative proposed is an expanded definition of transfer that includes assessments of "preparation for future learning," where the aim is to study whether or not individuals' previous learning serves as an asset in helping them learn new material and solve novel problems. They review research findings from several studies, showing, with this expanded definition, how transfer is not as rare as some argue. They end by proposing a two-dimensional "space" for learning and performance, which consists of innovation and efficiency, and discuss what optimal learning trajectories, as well as research, might look like in the innovation-efficiency space.

The second chapter by Christopher Wolfe, Valerie Reyna, and Charles Brainerd is from the psychology tradition and discusses the implications of fuzzy trace theory for transfer. Fuzzy trace theory is a dual-process theory of memory that was introduced to explain surprising findings about the relation between memory and cognitive processes. The theory posits two independent memory systems: gist and verbatim. Verbatim memory is used to answer questions about literal representations of knowledge, whereas gist memory is used to reason and problem solve and contains more nebulous patterns, impressions, and essences of the situation. Both gist and verbatim representations are formed in parallel, with verbatim memories accounting for surface details and gist memories accounting for underlying meaning or patterns; verbatim and gist memories, however, are encoded, retrieved, and stored separately. The authors discuss how this theory has been used to both predict and explain a wide range of experimental findings in terms of which type of memory is retrieved. They then discuss two transfer experiments designed to test various predictions based on manipulations of the conditions for encoding information, and on the use of gist and verbatim information. The authors conclude that transfer of learning depends much more on gist memories than it does on verbatim memories.

The next four chapters are from the physics education research (PER) tradition and build on a mix of theoretical constructs. The perspective taken in Chapter 3 by David Hammer, Andrew Elby, Rachel Scherr, and Edward Redish is that transfer is a concept that they do not find very useful since they have difficulty drawing any kind of boundary around it. Instead, they find it more useful to explore the construct of "activation of resources." They argue that the term "transfer" as it is traditionally used describes knowledge as a unitary entity—something that an individual learns in one context and either applies, or not, in another context.