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Principles of Learning: A Conceptual Framework for Domain-Specific Theories of Learning

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Principles of Learning: A Conceptual Framework
for Domain-Specific Theories of Learning

Christian J. Weibell (we'-bull)

A dissertation submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirement for the degree of
Doctor of Philosophy

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ABSTRACT

Principles of Learning: A Conceptual Framework for Domain-Specific Theories of Learning

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This study is predicated on the belief that there does not now exist, nor will there ever exist, any single theory of learning that is broad enough to account for all types of learning yet specific enough to be maximally useful in practical application. Perhaps this dichotomy is the reason for the apparent gap between existing theories of learning and the practice of instructional design. As an alternative to any supposed grand theory of learning—and following the lead of prominent thinkers in the fields of clinical psychology and language teaching—this study proposes a shift toward principles. It presents a principle-based conceptual framework of learning, and recommends use of the framework as a guide for creating domain-specific theories of learning.

The purpose of this study was to review theories of learning in the behavioral, cognitive, constructive, human, and social traditions to identify principles of learning local to those theories that might represent specific instances of more universal principles, fundamentally requisite to the facilitation of learning in general. Many of the ideas reviewed have resulted from, or been supported by, direct empirical evidence. Others have been suggested based on observational or practical experience of the theorist. The ideas come from different points in time, are described from a variety of perspectives, and emphasize different aspects and types of learning; yet there are a number of common themes shared among them regarding the means by which learning occurs. It is hypothesized that such themes represent universal and fundamental principles of learning. These principles were the objective of the present study. They have been sought through careful review and analysis of both theoretical and empirical literature by methods of textual research (Clingan, 2008) and constant comparative analysis (Glaser & Strauss, 1967). By way of textual research a methodological lens was defined to identify general themes, and by way of constant comparative analysis these themes were developed further through the analysis and classification of specific instances of those themes in the texts reviewed. Ten such principles were identified: *repetition, time, step size, sequence, contrast, significance, feedback, context, engagement, and agency*. These ten facilitative principles were then organized in the context of a comprehensive *principles-of-learning framework*, which includes the four additional principles of *potential, target, change, and practice*.

Keywords: principles of learning, domain-specific theories of learning, learning framework, learning theories, learning theory, learning principles, learning, principles, theory, theories

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Chapter 1: Introduction

Theories of Learning

While the process of learning is generally complex it is not entirely unpredictable. Throughout recorded history, learning has played an important role in cultures around the world and has been the subject of formal study—especially since the European Renaissance of the 14th – 17th centuries (Aspinwall, 1912; Compayre & Payne, 1899; Cubberley, 1904, 1920, 1922; Curoe, 1921; Graves, 1909, 1910, 1913; Monroe, 1905; Norton, 1909; Painter, 1917; Parker, 1912; Quick, 1890; Seeley, 1899; Shoup, 1891).

Over the past 125 years or so the study of learning has been approached from a variety of perspectives, some of the most prominent being (a) behavioral (observable performance), (b) cognitive (operational constructs, memory structures, and mental processes), (c) constructive (construction of mental representations by the learner rather than the teacher), (d) human (the learner as a whole person), and (e) social (the learner as a member of society). From these various approaches to the study of learning have emerged theories of learning, theories of instruction, theories of instructional design, and methods of teaching (see for example: Bower & Hilgard, 1981; Driscoll, 2000; Gredler, 2009; Mowrer & Klein, 2001; Olson & Hergenhahn, 2009; C. M. Reigeluth, 1983, 1999; C. M. Reigeluth, 1999; and Saettler, 1990).

The Impact of Learning Theory on Instructional Design

Each of these approaches and their ensuing theories has made an important contribution toward a better understanding of what it means to learn and the process by which learning takes place. Each theory is based on different assumptions, but each has offered a unique and valuable perspective. With all that has been done thus far, one might reasonably question the need for any

additional work toward an improved conception of learning. Such a question, however, overlooks the apparent gap between theory and practice (Christensen & Osguthorpe, 2004; South, 2008; Yanchar, South, Williams, & Allen, 2008; Yanchar & South, in press). Theories of learning seem to have relatively limited impact on the design of instruction. Perhaps a new way of thinking about learning theory itself might help to close this gap.

According to a survey conducted by Christensen and Osguthorpe (2004) only fifty percent of instructional designers regularly use theories when making instructional-strategy decisions. For those that do, the common practice seems to be one of eclectically drawing on methods and strategies from multiple theories of learning (Christensen & Osguthorpe, 2004; C. M. Reigeluth, 1999; Visscher-Voerman & Gustafson, 2004; B. G. Wilson, 1995, 1999; Yanchar et al., 2008; Yanchar & South, in press). One problem with this instructional design practice of "informed eclecticism" is that in the act of repurposing and combining fragments of multiple theories, instructional designers may be haphazardly generating new theories on the fly in a rather undisciplined manner. This is not to say that all ad hoc theories produced by eclectic assembly are necessarily flawed, but that may be true in some cases since "the combination of two instructional techniques from contradictory theories could lead to the dilution of the efficacy of both, if neither one were given the emphasis and structure needed for it to create its intended effect" (Yanchar & South, in press, p. 13).

Of even greater concern than the assumptive and structural integrity of the various theories taken in piecemeal amalgamation is the efficacy of the instruction that is produced on

such a foundation.¹ In my own experience, I have found that many instructional products, and many classroom methods and activities, are generally not effective per se—meaning that without a significant *independent* effort made by the student, the learning objectives are not met. The student who succeeds does so, in large part, because of the amount of time he or she spends outside of class or by referencing instructional materials other than those provided. This observation is consistent with the field experience of David Merrill, one of the most prominent and influential scholars in the field of instructional design today, who said, “A week does not go by that I don’t have the opportunity to review products that DO NOT TEACH” (Merrill, 1997, p. 1). So, while eclectic reference to learning theory appears to be a dominant trend in instructional design, it does not seem to be the most effective approach. Perhaps there is a better alternative.

A Shift toward Principles

When contemplating the issues in one’s own field, it is often useful to consider how similar issues have been addressed in other fields. This apparent trend of eclectic borrowing, copying, or assembly—in the maturation of a new discipline and the evolution of theoretical models and methods—has also been an issue in two fields closely associated with the field of instructional design: clinical psychology and language teaching. Suggestions from respected scholars in each of these disciplines provide insight on how both researchers and practitioners might advance the field of instructional design to close the gap between theory and practice and to increase the effectiveness of instructional products produced by instructional designers.

¹ Or, even worse, instruction that is produced in the absence of any sound theoretical basis at all.

In commenting on the practice of copying and borrowing of theories in American psychology in the mid 1900s, Kelly (1963) suggested that “instead of poking about in the neighbor’s backyards for methodological windfalls” we should “start abstracting the scientific principles that are beginning to emerge from our experiences” (p. 23). He further advised that we should “examine a variety of scientific theories, not to find one that can be copied concretely, but to discover common principles that can be applied to the building of brand new theories” (p. 23)—theories that are especially designed to fit the realm of events we wish to account for. To understand the direction of the present study, please note that Kelly's suggestion is not a push toward the practice of eclecticism, but rather toward the establishment of principles that might be applied in a very disciplined way.

In the field of language teaching, Kumaravadivelu (1994, 2003) described a “shift away from the conventional concept of method toward a ‘postmethod condition’ that motivates a search for an open-ended, coherent framework based on current theoretical, empirical, and pedagogical insights that will enable teachers to theorize from practice and practice what they theorize” (p. 27). He suggested a framework of macro strategies “derived from theoretical, empirical, and pedagogical knowledge related to L2 [second language] learning/teaching” (p. 32). His call is a move toward principled pragmatism.

The shift toward frameworks and principles in language teaching has also been pursued by others in the field. For example, Rod Ellis (2005) reviewed results from a variety of second language acquisition studies in order to identify general principles for language pedagogy. This effort resulted in the identification of ten specific principles to serve as the basis for instructed language learning. Another scholar, H. D. Brown (2001, 2007) summarized a history that has—in a very simplified view—been a search for the one ‘correct’ or ‘best’ method of teaching. This

search has been described as “changing winds and shifting sands” (Marckwardt, 1972), a rally to “banners and bandwagons” (Close, 1977), “a pendulum swinging back and forth” (Mitchell & Vidal, 2001, p. 26), and a “major river, constantly flowing, fed by many sources of water” (p.27). H.D. Brown (2001) noted that by the 1980s the profession of language teaching had “learned to be cautiously eclectic in making enlightened choices of teaching practices that were solidly grounded” (p. 39), but suggests that this enlightened practice should be guided by “overarching principles of second language learning” (p. 54) upon which language teaching should be based.

Inspired in part by the shift toward principles in the fields of psychology and language teaching, I believe that the identification of common principles found in existing theories of learning, as well as those that emerge from experience, may be an important step toward closing the divide between practice and theory. A framework of common principles of learning would be of great benefit to both instructional designers and educational practitioners. Instead of repurposing and combining popular theories for uses they were not specifically designed for, effective instruction could be developed based on principles that embody the meaningful substrate underlying the theories. Empowered with such a foundation, instructional designers would be free to focus their time and effort on creating good instruction.

The Purpose of this Study

The purpose of this study is to identify fundamental and universal principles of learning that are either explicitly stated or implicitly assumed in the theoretical foundations of learning that most commonly influence instructional design today: behavioral, cognitive, constructive, human, and social.

The identification of principles to guide instructional design practice has already begun with Merrill’s work to identify “first principles of instruction” (2002a; 2007; 2009). Going

beyond a mere statement of the theory, he has provided excellent, concrete examples that show how those principles can be applied in practice (2002b; 2002c; 2006; 2008a; 2008b; 2008c; 2009). Merrill characterizes his principles as relating “to creating learning environments and products rather than describing how learners acquire knowledge and skill from these environments or products” (Merrill, 2002a, p. 1). In contrast with Merrill’s principles of *instruction*, the principles to be identified in the present study are principles of *learning*. Principles of learning do not compete with principles of instruction, but are complementary to them, and may help explain the reasoning behind some of Merrill’s principles, providing further insight into why they are effective.

Note that use of the two adjectives *fundamental* and *universal* is specific and is intended to establish a very clear objective for this study. *Fundamental* principles are those that have a critical influence on learning—that is basic, vital principles upon which successful learning depends. *Universal* principles are those that might reasonably be construed to apply broadly to many different types of learning, including: changes in behavior, the acquisition of factual and conceptual knowledge, the mastery of complex motor skills, the development of intellectual capacity, and even changes in attitudes, desires, or beliefs.

Although a rational argument will be made to support claims of fundamentality and universality for the principles identified, I recognize that no such argument can ever be complete, and that the resulting ideas from this study will be, at best, tentative. Accepting this limitation, these two attributes together will serve as the criteria by which principles of learning will be identified from the theories reviewed. The justification for adopting these two particular attributes is that principles that meet, or at least have the clear potential of meeting, both criteria will provide the greatest utility in understanding the nature of learning in a variety of situations.

The resulting principles will be analogous to the “basic methods” Reigeluth (1999) described when he distinguished them from “variable methods” (p. 20). When Merrill (2002a) compared his own principles of instruction to Reigeluth’s basic methods, he clarified the difference between basic and variable methods as follows:

A principle (basic method) is a relationship that is always true under appropriate conditions regardless of program or practice (variable methods). A practice is a specific instructional activity. A program is an approach consisting of a set of prescribed practices. Practices always implement or fail to implement underlying principles whether these principles are specified or not. A given instructional approach may only emphasize the implementation of one or more of these instructional principles. (p. 1)

The same relation of Merrill’s *principles* to Reigeluth’s *basic methods* also applies to the present study. Principles of learning that are fundamental and universal, by definition, should hold true regardless of the method, practice, approach or program within in which they are applied. Principles that do not appear to be absolutely essential to learning, or principles that apply only to a localized learning situation or only to a specific type of learning, are not the end goal of this study. The expected result of the present study is a list of *descriptive* principles of learning² that will assist instructional designers and educational practitioners with understanding or analyzing learning in, and preparing instruction for, many different contexts.

Overview of Chapters

This chapter has described a gap between existing theories of learning and their use in applied instructional design. Following the lead of efforts that have been made in the fields of clinical psychology and language teaching to address similar problems, an alternative principle-

² i.e., describing learning rather than prescribing how to facilitate it (C. M. Reigeluth, 1983)

based approach to learning theory has been suggested as a possible solution to close this gap. The purpose for the present study has been defined as a search for universal and fundamental principles of learning that apply to all types of learning. Chapter two describes the method used to pursue this goal. In chapter three, 35 theories of learning that were selected for review and analysis are summarized. Chapter four reports on the themes identified. These themes are then organized into a coherent conceptual framework of learning in chapter five. In chapter six, concluding remarks are made, including: a review of what has been accomplished in the present study, limitations of the study, and directions for future application and research, building on the contribution of knowledge made by this study.

Chapter 2: Method

It is typical for the literature review to precede the method section in a dissertation report. However, following the advice of my dissertation committee and my own feelings toward the most logical organization for the present study, it seemed appropriate to first describe the method that will be used to analyze the literature and then to enumerate the ideas that will be brought under review.

Textual Research

The purpose of the traditional method section in any scientific research paper is to document the process used to conduct the study with enough detail so that readers are able to evaluate the credibility of the claims and conclusions made, and to repeat the study precisely. The primary method of research used for the present study is *textual research*. Textual research is a general term used by Clingan (2008) to describe research in which the principal data collection method used is the review and analysis of existing literature. This type of research is commonly applied in the social sciences, the humanities, philosophy, and linguistics. Data collection in textual research may be quantitative, qualitative, or a mixture of the two (Belsey, 2005; Fidel, 2008). Textual research methods include such things as concept network analysis (Carley, 1997), content analysis (Neuendorf, 2002; Weber, 1990), discourse analysis (G. Brown & Yule, 1983; Silverman, 1993), lexical analysis (Bybee & Hopper, 2001), semantic analysis (Goddard, 1998; Ziff, 1960), syntactic analysis (Green & Morgan, 1996; Moravcsik, 2006), and thematic analysis (Stone, 1997). *The analysis for the present study is primarily thematic, where the themes to be identified are principles of learning.*

Since scholarship and research typically begin with a review of existing theory and knowledge relevant to the topic of study, it is important to understand the distinction between a literature review and textual research. Clingan (2008) clarified this difference by saying,

What makes textual research result in a thesis—rather than just producing a literature review—is that the scholar/researcher will take the data gathered through reading the literature, analyze it according to whatever methodological lenses her work is based on, consider various opposing theorists and methodologies, and present an original hypothesis and conclusive interpretation. (p. 1)

Consistent with Clingan’s description, the general method and goals of the present study were to

1. *Collect* data through the reading of literature.
2. *Analyze* the data collected with the purpose of identifying themes (principles of learning) that transcend various theoretical positions on the nature of learning.
3. *Synthesize* the various themes into a single list.
4. *Present* an original hypothesis and conclusive interpretation in the form of a conceptual framework of learning that organizes the themes into a meaningful hierarchy of relationships.

The following three sections describe more specifically how sources of literature will be selected for review; how principles of learning will be selected from the ideas reviewed (i.e. the methodological lens I will be using); and the steps in the process that will be used to analyze, synthesize, and organize the principles identified into a conceptual framework.

Guidelines for Selecting Literature to Review

In my review of both printed and digital libraries, it has become quite apparent that a man could spend his entire life reading, at his swiftest pace, never visiting the same lines of text

twice, never stopping to rest, never stopping to eat, and never stopping to sleep, and still he could not possibly review all that has been written that bears interest on the subject of learning. It is therefore necessary that my review of ideas and theories be focused on a sampling of the most relevant sources of literature. To this end I have reasoned out five criteria to guide my selection of theories to review. Based on these criteria, those ideas that I shall consider worthy of analysis in this study are those that have passed the tests of

1. *Clarity* – meaning the theory has been articulated with enough clarity and precision so as to be distinct from other theories.
2. *Stability* – meaning the theory has been developed sufficiently so as to be relatively stable in its ideas.
3. *Utility* – meaning the theory provides greater insight and understanding of the process of learning than that which is readily apparent to the layman and that it might be of practical use in facilitating learning.
4. *Impact* – meaning the theory has attracted attention from people outside of the direct influence of the originator of the theory.
5. *Durability* – meaning the theory has endured as the subject of formal study or application for several years.

By these criteria I will make a list of theories and ideas to review in search of principles of learning. Guidelines for how principles will be identified during review of those sources are described next.

Guidelines for Selecting Principles (The “Methodological Lens”)

As stated above, the two criteria for selecting principles of learning from the theories to be reviewed are

1. *Fundamentality* – meaning the principle can justifiably be said to have a critical influence on learning, or in other words, it is a basic, vital principle upon which successful learning depends.
2. *Universality* – meaning the principle might reasonably be construed to apply broadly to many different types of learning, including: changes in behavior, the acquisition of factual and conceptual knowledge, the mastery of complex motor skills, the development of intellectual capacity, and even changes in attitudes, desires, or beliefs.

As noted in chapter one, although a rational argument will be made to support claims of fundamentality and universality for the principles identified, I recognize that no such argument can ever be complete, and that the resulting ideas from this study will be, at best, tentative. Accepting this limitation, these two attributes together will serve as the criteria by which principles of learning will be identified from the theories reviewed. I have tried to be very specific in describing what I mean by fundamental and universal. However, it is often easier to understand what something *is*, when the boundaries of what it *is not* are clearly defined. Thus, to further illuminate these two concepts, let us consider what they are not.

If a principle is not fundamental, what is it? There are two possibilities. A principle that is not fundamental is either (a) invalid, or (b) helpful, but not critical to learning. Supposed principles of the first type are typically perpetuated by tradition and include ideas such as, “students must attend a formal classroom in order to learn,” or “students must have a teacher in order to learn.” They are easily discredited since counter examples are abundant.

Principles of the second type are defensible principles that generally improve the learning process in some way, but are not critical to it. This does not mean they are not valuable. It only

means that successfully learning may occur whether or not the principle is implemented. For example, one of Merrill's first principles of instruction states that, "Learning is facilitated when learners are engaged in solving real-world problems" (Merrill, 2002a, p. 2). Presumably researchers and educators will generally agree that this is a defensible principle, which is of great value to those tasked with designing meaningful and effective instruction. However, it is not a critical principle of learning since learning may also occur when learners are engaged in solving contrived problems, or even when the learning activities are not problem-based at all. Fundamental principles, then, are principles that are both *valid* and not only helpful in the learning process, but *critical* to its success.

Now to the second question, if a principle is not universal, what is it? The concept of universality deals with the scope of applicability of the principle. Principles that are not universal are limited in their range of explanatory power to a specific domain of learning. For example, in the teaching of second language pronunciation we talk about positive and negative transfer, or the influence of one's native tongue for good or bad on the process of learning a second language. Generally, second language phonemes (sounds) that are either the same as or very different from first language phonemes are easier to acquire than those that are similar to, but critically different from, first language phonemes. This principle of linguistic transfer is an example of a local principle of learning specific to the domain of language learning, and more specifically to the sub-domain of learning pronunciation of a second language.

As part of the present study, many such principles—i.e. many non-universal principles—will be coded in the analysis inasmuch as they are instances of more general, universal principles. Once coded, these local principles will be mapped hypernymically to universal principles they are instances of, or by which they may be subsumed. A hypernym is an umbrella

term, or a word whose meaning encompasses the meaning of another more specific word. For example, the local principle of *linguistic transfer* noted above is an instance of a more general principle of learning that is universal to all types of learning, namely, *sequence*, which denotes the notion that what has been learned previously may be of advantage, or of disadvantage, in learning something new. More will be said on the principle of sequence in chapter four.

Categorical Development Through Constant Comparison

This section describes more precisely how theories selected for review will be analyzed to obtain a list of principles either explicitly stated or implicitly assumed in each, how the resulting lists of principles from the various theories will be synthesized into a single list, and how the final list will be organized into a conceptual framework of learning.

Analysis. It has already been stated that the method of research for this study is textual research, meaning data will be collected through the review of text-based sources. If this data collection was limited to something like the counting of syntactic or grammatical features in the text, the process would be one of quantitative analysis. However, the goal of this study is not to count features but to identify principles. In most cases this cannot be achieved merely through the objective tallying of typographical occurrences, but must be reasoned out through the subjective analysis of semantics underlying the language used to describe the theories. Where principles are clearly and obviously stated, they can be counted. Where they are not, they must be inferred by interpretive analysis of the text. Hence, the method of analysis used here is similar to what Glaser and Strauss (1967) called *constant comparative analysis*, which is an important component of *grounded theory*. The application of constant comparative analysis was described by Glaser and Strauss (as cited in Lincoln & Guba, 1985, p. 339) as having four stages:

1. Comparing incidents applicable to each category

2. Integrating categories and their properties
3. Delimiting the theory
4. Writing the theory

Glaser and Strauss are clear that these four stages are not carried out in an entirely linear and lock step fashion, but rather, each of the stages “remain in operation simultaneously throughout the analysis and each provides continuous development to its successive stage until the analysis is terminated” (p. 339). The first stage “combines inductive category coding with a simultaneous comparison of all social incidents observed” (Goetz & LeCompte, 1981, p. 58). The ‘incidents’ to be observed in the present study are not social incidents, but textual incidents. These textual incidents are either principles of learning explicitly stated or underlying assumptions that imply principles of learning. These textual incidents will hereafter be referred to as *local principles of learning*. The emerging list of categories, or themes, to which local principles are to be coded will hereafter be referred to as *universal principles of learning*.

As each local principle is encountered it will be coded by assigning it to one of the universal principles that has been identified previously in the analysis or by assigning it to a new universal principle of which it is the first instance. Bruner, Goodnow, & Austin (1972) explained this process of categorization by saying, “To categorize is to render discriminably different things equivalent, to group the objects and events and people around us into classes, and to respond to them in terms of their class membership rather than their uniqueness” (p. 16). Categories are the basis for organization and conceptualization of large amounts of data that would otherwise be difficult to interpret. Dey (1993) provided an excellent discussion on the creation and assignment of categories. As part of his discussion, he described the importance of active reading, using a checklist to direct one’s attention and therefore aid in alerting oneself to

themes that emerge from the text. Dey's checklist is comparable to Clingan's concept of methodological lens, in that it provides a framework to guide and focus the review and analysis of the data. Dey noted, however, that although checklists can help, they can also inhibit and cautioned that "reading the data means rethinking and redeveloping our ideas" (p. 86). This is similar to the observation of Corbin and Strauss (2008) that, "something occurs when doing analysis that is beyond the ability of a person to articulate or explain" (p. 9). They recommended care be taken to preserve the fluid and dynamic nature of a qualitative analysis:

No researcher should become so obsessed with following a set of coding procedures that the fluid and dynamic nature of qualitative analysis is lost. The analytic process, like any thinking process, should be relaxed, flexible, and driven by insight gained through interaction with data rather than being overly structured and based only on procedures. (p. 12)

Establishing a fixed methodological lens by focusing my study on the identification of principles that are *fundamental* and *universal* gives clear direction to my research. Allowing my list of categories (the universal principles) to evolve—simultaneously emerging from and providing guidance to the research process—gives me the kind of flexibility Corbin and Strauss recommend. This flexibility characterizes one of the strengths of qualitative inquiry, namely, that it allows for insight and interaction with the data. Another is that qualitative analysis builds upon natural ways of thinking:

Most of the time conceptualizing, asking questions, and making comparisons occur quite unconsciously. They are the tools that persons use to become acquainted with and understand the worlds they live in. The difference between everyday life and doing analysis is that in analysis researchers take a more self-conscious and systematic approach to knowing. (Corbin & Strauss, 2008, p. 20)

One of the key characteristics of grounded theory that makes it a valid method of research is the careful recording of notes (Williams, n.d., Chapter 3 - "Keeping a Record") and the goal-oriented analysis that drives the development of themes or concepts. Throughout the analysis of this study, careful notes will be kept listing each local principle of learning as it is encountered in the text, the source reference in which the principle was found, and a mapping to one or more universal principles that the local principle is an instance of.

Synthesis. The second stage of the method of constant comparison is the integration of categories. In contrast with the first stage of the method—which focuses on comparing incidents and making a decision as to whether a given incident is similar to or different from others already encountered—the second stage represents a subtle shift to making explicit the theoretical properties of each category (i.e., each universal principle of learning). In the words of Glaser and Strauss (1967),

This constant comparison of the incidents very soon starts to generate theoretical properties of the category. The analyst starts thinking in terms of the full range of types or continua of the category, its dimensions, the conditions under which it is pronounced or minimized, its major consequences, its relationship to other categories, and its other properties. (p. 106)

The realization of the second stage of the method in the present study is the active examination of properties of the individual local principles of learning in an effort to understand and explicate how they function as a class. It is through this activity that the dimensionality of each respective universal principle of learning might be more fully delineated. For example, it is this analysis that enables us to understand *repetition* as being much more than just the redundant drill and practice by which it is so often characterized. Beyond its application to learning by rote, repetition plays a significant role in the acquisition of knowledge and skills in the unplanned,

informal, experiential learning of our lives. Where there exists a similarity across events, there exists a pattern. Where there exists a pattern, there exists the possibility of anticipating reoccurrence of the event characteristics that make up the pattern. As we recognize these patterns we are able to respond to them in systematic—and automatic—ways, refining and improving our response over time. Thus, by the same principle of repetition that makes possible the rote memorization of discrete facts we might also develop higher order skills such as closing a complex sales transaction, managing personal or business finances, or delivering a public speech.

The various types of repetition mentioned above have emerged as a common theme in the preliminary research that was conducted to determine the feasibility of the present study. They are used here to illustrate how a category might be more fully understood by attending inductively to the properties of the individual incidents that belong to that category. Repetition will be discussed more fully in the Results section.

The synthesis effort of the present study will start with multiple lists of local principles of learning identified for each theory reviewed. These lists of principles will have already been mapped to categories (i.e. universal principles by which they are subsumed). Using the category mappings the local principles will be synthesized into a single list of universal principles. This synthesized list is the primary deliverable for the present study. Each universal principle on the list will be accompanied by a discussion of the dimensionality and range of application of the principle, drawn from the specific properties of the local principles from which it was derived as well as from relevant real-world examples.

Organization. A further contribution of the present study will be the application of original and creative thought to organize the list of principles according to meaningful relationships. This final step encompasses both stages three and four of Glaser and Strauss's

method of constant comparison (delimiting the theory and writing the theory). The expected result is a conceptual framework of learning presented in a very concise and intuitive way so as to facilitate easy understanding and application of the principles. Additionally it is expected that this conceptual framework might be a practically useful tool for the following activities:

1. *Communication* – communicating about the learning process as a whole, or about various specific parts of the process
2. *Evaluation* – evaluating educational products and instructional methods to determine the degree to which principles of learning have been attended to, and to predict whether or not the product or method will result in successful learning
3. *Diagnosis* – identifying, very specifically, why a particular product or method fails to result in effective or efficient learning
4. *Development* – developing effective instructional products and methods.
5. *Research* – investigating meaningful hypotheses suggested by the framework

In summary, this chapter has described the combined method of textual research and constant comparative analysis that was used to review theories of learning in search for common themes among them that are presumed to be universal and fundamental in nature. Criteria by which theories were selected has been explained, as well as the methodological lens used to identify, analyze, synthesize, and organize the themes. The next chapter will summarize the 35 theories of learning that were reviewed.

Chapter 3: Literature Review

The literature review conducted in concert with an experimental dissertation study is generally oriented toward reviewing prior research and results relevant to the question under examination. The goals of such a review are to (a) establish a theoretical basis for the study, (b) gain insight into data collection and analysis procedures previously used, and (c) establish informed hypotheses regarding the expected outcomes of the study. These goals are also applicable to the present study, but they have already been addressed in chapter two. Therefore, the additional literature reviewed in this chapter is to provide an overview of theories from the five general approaches to the study of learning that commonly influence the practice of instructional design today.

The first approach, *behavioral*, focuses on the experimental study of learning, accepting observable performance as the only valid source of evidence for learning, and motivates learning primarily through the use of reward or punishment administered according to carefully planned schedules of reinforcement. The second approach, *cognitive*, uses operational constructs to describe knowledge representation, memory structures, and mental processes. Under this approach learning is promoted by manipulating the presentation of knowledge, providing encoding strategies, and prescribing rehearsal schedules—in order to facilitate linking new information with existing knowledge structures. The third, the *constructive* approach, emphasizes the individual uniqueness of mental models and the need for learners to construct their own knowledge structures. Constructive learning theory promotes learning primarily through discovery. The fourth, the *human* approach, is based on the observation that human beings act with intentionality and are guided by values. Learning is promoted by understanding the whole person, his motives, and his goals. The fifth approach, *social*, emphasizes that “people

learn from one another, via observation, imitation, and modeling” (Social Learning Theory, 2008). The remainder of this chapter will give an overview of the history of research behind each of these approaches. Section titles provide the name of the theory, its primary proponent, and the approximate year or period in which it was first introduced, or when it was published in its most influential form. The list of theories that will be summarized is given in Table 1.

Table 1

Theories Reviewed Under Each Approach to the Study of Learning

Approach	Theories Reviewed
Behavioral	Associationism (Aristotle-350BCE) Connectionism (Thorndike-1898) Classical Conditioning (Pavlov-1928) Behaviorism (Watson-1913) Operant Conditioning (Skinner-1938) Mathematico-Deductive Theory (Hull-1943) Contiguous Conditioning (Guthrie-1930) Stimulus Sampling Theory (Estes-1950)
Cognitive	Associationism (Aristotle-350BCE) Memory and forgetting (Ebbinghaus-1885) Purposive Behaviorism (Tolman-1922) Insight Learning (Kohler-1925) Cognitive Information Processing (Atkinson & Shiffrin-1968) Subsumption Theory (Ausubel-1962) Schema Theory (Rumelhart & Norman-1976)
Constructive	Constructivist Learning in the Classroom (mid-1990's) Intellectual Development Theory (Piaget-1952) Discovery Learning (Bruner-1961)
Human	Hierarchy of Human Needs (Maslow-1943) Biological Motivation (Fuller-1962) Achievement Motivation (Atkinson & McClelland-1953) Attribution Theory (Weiner-1971) Self-Worth Theory (Covington-1976) Self-Efficacy (Bandura-1977) Self-Determination (Deci & Ryan-1985) Self-Regulation (Zimmerman & Schunk-1989) ARCS (Keller-1979) Freedom to Learn (Rogers-1969) Agentic theory of Self (Bandura-1997)
Social	Sociocultural Development Theory (Vygotsky-1934/1978) Social Cognitive Theory (Bandura-1977) Expansive Learning (Engestrom-1987) Cognitive Apprenticeship (Brown, Collins, & Duguid-1989) Communities of Practice (Lave & Wenger-1991) Dynamic, Distr., Bounded Communities (Wilson & Ryder-1996)

The Behavioral Perspective

Behavioral *psychology* is a branch of science devoted to identifying principles of behavior through experimental study. Behavioral *learning theory* is the application of those principles to learning. To speak of behavioral learning theory as if it has emerged from a single line of research in which each subsequent researcher were influenced by and built upon the work of his predecessors within a very narrowly defined program of study is a misrepresentation of history. O'Donohue and Kitchener (1999) noted that there are "at least fifteen" varieties of philosophical and psychological behaviorism (p. 2). While some have built very directly and explicitly on the foundation of those that have gone before them, others have acted fairly independent of both their predecessors and their contemporaries. Only a few have directly influenced education, and those few—although distinct in their original form—have been merged, not by their creators or any select organizing committee, but by practitioners,³ into a general theory of learning based on the behaviorist tradition. This practitioners' theory is founded primarily on the work of Burrhus Fredric Skinner (1904-1990), and it is Skinner's principles of operant conditioning, contingencies of reinforcement, and reinforcement schedules, which receive the greatest attention in behavioral learning theory chapters of contemporary educational psychology textbooks (see, for example, Bohlin, Durwin, & Reese-Weber, 2009; Driscoll, 2000; Eggen & Kauchak, 1999; Mowrer-Popiel & Woolfolk, 1998; O'Donnell et al., 2007; Ormrod, 2003; Sternberg & Williams, 2010; Woolfolk, 1998; Woolfolk, 2010). Skinner, however, does not anchor the foundation of contemporary behavioral learning theory alone. The

³ By who is applied learning theory created? If this case is representative of a larger phenomenon, I believe the answer (i.e., practitioners rather than theorists) is rather ironic.

contributions of several individuals will be discussed in the following section (including Skinner), roughly in the order in which their most influential publications relevant to behavioral learning theory were made. This ordering is in no way absolute, has been selected simply as a matter of organization, and should not be taken to present a concrete chronological evolution of ideas. As behavioral learning theory is only one of five theories that will be reviewed, this discussion will be necessarily brief. Many excellent books are readily available for more detail (especially informative are, Bower & Hilgard, 1981; Hilgard, 1948; Hilgard & Bower, 1966; O'Donohue & Kitchener, 1999; Olson & Hergenhahn, 2009).

Associationism (Aristotle – 350 B.C.E). Aristotle asserted three Laws of Association and a Law of Frequency that are considered by many to be at the heart of most behavioral learning theories. These laws, summarized by Olson and Hergenhahn (1982, p. 35), are as follows:

1. Law of Similarity – the experience or recall of one object will elicit the recall of things similar to that object.
2. Law of Contrast – the experience or recall of one object will elicit the recall of opposite things.
3. Law of Contiguity – the experience or recall of one object will elicit the recall of things that were originally experienced along with that object.
4. Law of Frequency – the more frequently two things are experienced together, the more likely it will be that the experience or recall of one will stimulate the recall of the second.

These laws are cited by Olson and Hergenhahn and many other writers without specific reference, and it took some searching to trace them back to their exact origin. They are found in

Aristotle's *De Memoria Et Reminiscentia*⁴ (Ross & Aristotle, 1906, p. 111). Though these laws are “obviously merely principles governing the reinstatement of ideas previously experienced” (memory) and “their scope is much narrower than that assigned to them by modern psychology” (Ross & Aristotle, 1906, p. 39), because memory plays a central role in the acquisition of both knowledge and skill, they are clearly applicable to learning in general. Even though Aristotle's writings “in which he systematically developed his ideas on education have survived only in fragmentary form” (Hummel, 1993, p. 2) from these fragments it is possible to identify several ideas on learning. Based on my own reading of Ross's translation of *De Memoria*—and of *Ethics* and *Politics* translated by Burnet (Aristotle & Burnet, 1913)—I find that in addition to the well-known laws of association and the law of frequency, Aristotle's thinking also included ideas about

1. The nature of practice (that it should be hands-on, of good quality, and guided by instruction):

The things which we are to do when we have learnt them, we learn by doing them; we become, for instance, good builders by building and good lyre-players by playing the lyre....the material form from which and the means by which any form of goodness is produced and those by which it is destroyed are the same.... for it is by playing the lyre that both good and bad lyre-players are produced, and it is the same with builders and the rest. It is by building well that they will become good builders and by building badly that they will become bad builders. If it were otherwise, we should have no need of anyone to

⁴ Note that although Aristotle is commonly credited as the originator of these ideas, they are also evident in Plato's *Phaedo* (Cope, 1875). For example: “...lovers, whenever they catch sight of a lyre... or anything else which their favorites are in the habit of using...at the same time receive in their minds the image of the youth to whom the lyre belonged” (p. 31, Contiguity); “...is it possible for any one [sic] to recall to mind a man by seeing a picture of a horse or a picture of a lyre? or [sic] by seeing a portrait of Simmias to remember Cebes? Certainly it is.” (p. 31, Contrast); “Or again, by seeing a portrait of Simmias to call Simmias himself to mind” (p. 32, Similarity); “Does it not then happen in all these cases that recollection is derived at one time from similar and at another from dissimilar things?” (p. 32, Similarity and Contrast)

teach us; all would become good or bad as the case might be. (Aristotle & Burnet, 1913, p. 45)

2. The gradation of attainment over time:

It is better to practice from the very beginning every habit that can be produced by training—though the habituation should be a gradual process (p. 102)

3. The representation of concepts in memory through images:

Memory, even the memory of concepts, cannot exist apart from imagery (Ross & Aristotle, 1906, p. 103)

4. Readiness for learning and significance of new material:

When a stimulus occurs it imprints as it were a mould of the sense-affection exactly as a seal-ring acts in stamping (p.105)

Memory does not occur in those who are in a rapid state of transition, whether owing to some perturbing experience or their period of life; it is as if this stimulus, like the seal, were stamped on running water. Again in others their worn-out condition—like that of old buildings—and the hardness of the receptive structure, prevent the sense-affection from leaving an impression. Hence we explain why the very young and the aged have no memory; in the former growth, in the latter decay, cause rapid transition. (p. 105)

5. The need for repetition in varying degrees:

The same man may learn or discover the same thing twice. (p.109)

It so happens that some people receive a greater benefit from a single experience than others in whom the sequence has frequently taken place, and hence, in some instances, after seeing things once, we remember them better than others who have seen them frequently. (p. 111)

It is frequent repetition that produces a natural tendency (p. 113)

6. The value of orderly arrangement:

Those things are easily recalled which have an orderly arrangement...but things wanting in exactitude are with difficulty remembered. (p. 111)

7. The role of pleasure and pain in motivation:

For goodness of character has to do with pleasures and pains. It is pleasure that makes us do what is bad, and pain that makes us abstain from what is right. (Aristotle & Burnet, 1913, p. 49)

8. The increase of capacity and potential through education and habituation:

In all arts and crafts we require a preliminary education and habituation to enable us to exercise them (Aristotle & Burnet, 1913, p. 106)

9. The linking of mental concepts:

The occurrence of an act of recollection is due to the natural tendency of one particular change to follow another. (Ross & Aristotle, 1906, p. 109)

Suppose for instance one has a series of thoughts ABCDEFGH...in general the middle member also of a whole series of terms seems to be the starting point. (Ross & Aristotle, 1906, p. 113)⁵

For centuries, Aristotle's ideas have been debated and elaborated on by commentators and philosophers. Weimer (1973) noted that "the centrality of associationism as the mechanism of the mind is so well known as to require only the observation that *not one single learning*

⁵ Ross interprets this to mean:

E, then, will symbolize the central idea or nucleus of this group from which it is possible to pass, in more than one direction, to the idea lying in the outskirts of the group...Though Aristotle symbolizes his terms by the letters of the alphabet he is thinking not of a series following the direction of the time process but of a set of notions formed by those notions being frequently thought of together and grouped round one striking topic (p. 304)

theory propounded in this century *has failed to base its account on associative principles*” (p. 18).

Connectionism (Edward L. Thorndike – 1898). The prominent role of Aristotle’s laws of association in the 1900s may largely be due to the work of Edward L. Thorndike—the recognized founder of a “learning theory [that] dominated all others in America” for “nearly half a century” (Bower & Hilgard, 1981, p. 21). Thorndike’s theory was based initially on a series of puzzle box experiments that he used to plot learning curves of animals. In these experiments learning was defined as a function of the amount of time required for the animal to escape from the box. A full account of his experiments, including detailed descriptions of the puzzle boxes he used and examples of learning curves that were plotted, can be found in *Animal intelligence* (Thorndike, 1898).

In Thorndike’s view, learning is the process of forming associations or bonds, which he defined as “the connection of a certain act with a certain situation and resultant pleasure” (p. 8). His work leading up to 1898 provided “the beginning of an exact estimate of just what associations, simple and compound, an animal can form, how quickly he forms them, and how long he retains them” (p. 108).

Although his original experimental subjects were cats, dogs, and chicks, Thorndike clearly expressed his intention of applying his work to human learning when he said, “the main purpose of the study of the animal mind is to learn the development of mental life down through the phylum, to trace in particular the origin of human faculty” (1898, p. 2). From his work with animals he inferred “as necessary steps in the evolution of human faculty, a vast increase in the number of associations” (p. 108). A decade and a half later he expanded on the theme of human learning in a three volume series entitled, *Educational psychology*, with volume titles, *The*

original nature of man (1913a), *The psychology of learning* (1913b), and *Mental work and fatigue and individual differences and their causes* (1914b). The material in these books was very comprehensive and targeted advanced students of psychology. He summarized the fundamental subject matter of the three volumes in a single, shorter textbook entitled, *Educational psychology: briefer course* (Thorndike, 1914a). In these volumes Thorndike provided a formative culmination of his theory of learning in the form of three laws of learning:

1. Law of Readiness – The law of readiness was intended to account for the motivational aspects of learning and was tightly coupled to the language of the science of neurology. It was defined in terms of the *conduction unit*, which term Thorndike (1914a) used to refer to “the neuron, neurons, synapse, synapses, part of a neuron, part of a synapse, parts of neurons or parts of synapses—whatever makes up the path which is ready for conduction” (p. 54). In its most concise form, the law of readiness was stated as follows, “for a conduction unit ready to conduct to do so is satisfying, and for it not to do so is annoying” (p. 54). The law of readiness is illustrated through two intuitive examples given by Thorndike:

The sight of the prey makes the animal run after it, and also puts the conductions and connections involved in jumping upon it when near into a state of excitability or readiness to be made....When a child sees an attractive object at a distance, his neurons may be said to prophetically prepare for the whole series of fixating it with the eyes, running toward it, seeing it within reach, grasping, feeling it in his hand, and curiously manipulating it. (p. 53)

2. Law of Exercise – The law of exercise had two parts: (a) the law of use and (b) the law of disuse. This law stated that connections grow stronger when used—where

strength is defined as “vigor and duration as well as the frequency of its making” (p. 70)—and grow weaker when not used.

3. Law of Effect – The law of effect added to the law of exercise the notion that connections are strengthened only when the making of the connection results in a satisfying state of affairs and that they are weakened when the result is an annoying state of affairs.

These three laws were supplemented by five characteristics of learning “secondary in scope and importance only to the laws of readiness, exercise, and effect” (Thorndike, 1914a, p. 132). They are

1. Multiple response or varied reaction – When faced with a problem an animal will try one response after another until it finds success.
2. Set or attitude – The responses that an animal will try, and the results that it will find satisfying, depend largely on the animal’s attitude or state at the time.

The chick, according to his age, hunger, vitality, sleepiness, and the like, may be in one or another attitude toward the external situation. A sleepier and less hungry chick will, as a rule, be ‘set’ less toward escape-movements when confined; its neurons involved in roaming, perceiving companions and feeding will be less ready to act; it will not, in popular language, ‘try so hard to’ get out or ‘care so much about’ being out. (Thorndike, 1914a, p. 133)

3. Partial activity or prepotency of elements – Certain features of a situation may be prepotent in determining a response than others and an animal is able to attend to critical elements and ignore less important ones. This ability to attend to parts of a situation makes possible response by analogy and learning through insight.

Similarly, a cat that has learned to get out of a dozen boxes—in each case by pulling some loop, turning some bar, depressing a platform, or the like—will, in a new box, be,

as we say, 'more attentive to' small objects on the sides of the box than it was before. The connections made may then be, not absolutely with the gross situation as a total, but predominantly with some element or elements of it. (Thorndike, 1914a, p. 134)

4. Assimilation – Due to the assimilation of analogous elements between two stimuli, an animal will respond to a novel stimulus in the way it has previously responded to a similar stimulus. In Thorndike's words, "To any situations, which have no special original or acquired response of their own, the response made will be that which by original or acquired nature is connected with some situation which they resemble." (Thorndike, 1914a, p. 135)
5. Associative shifting – Associative shifting refers to the transfer of a response evoked by a given stimulus to an entirely different stimulus.

The ordinary animal 'tricks' in response to verbal signals are convenient illustrations. One, for example, holds up before a cat a bit of fish, saying, "Stand up." The cat, if hungry enough, and not of fixed contrary habit, will stand up in response to the fish. The response, however, contracts bonds also with the total situation, and hence to the human being in that position giving that signal as well as to the fish. After enough trials, by proper arrangement, the fish can be omitted, the other elements of the situation serving to evoke the response. Association may later be further shifted to the oral signal alone. (Thorndike, 1914a, p. 136)

Sixteen years after publishing his theory in the *Educational Psychology* series based on experiments with animals, Thorndike published twelve lectures that reported on experiments performed with human subjects between 1927 and 1930 (see Thorndike, 1931). The results of these experiments led Thorndike to make some modifications to his laws of connectionism.

The first change was to qualify the law of exercise. It was shown that the law of exercise, in and of itself, does not cause learning, but is dependent upon the law of effect. In an experiment in which subjects were blindfolded and repeatedly asked to draw a four-inch line

with one quick movement Thorndike discovered that doing so 3,000 times “caused no learning” because the lines drawn in the eleventh or twelfth sittings were “not demonstrably better than or different from those drawn in the first or second” (Thorndike, 1931, p. 10). He summarized this finding by saying,

Our question is whether the mere repetition of a situation in and of itself causes learning, and in particular whether the more frequent connections tend, just because they are more frequent, to wax in strength at the expense of the less frequent. Our answer is *No*. (p. 13)

However, in drawing this conclusion, Thorndike was not disproving the law of exercise, but merely qualifying it (by saying that repetition must be guided by feedback):

It will be understood, of course, that repetition of a situation is ordinarily followed by learning, because ordinarily we reward certain of the connections leading from it and punish others by calling the responses to which they respectively lead right or wrong, or by otherwise favoring and thwarting them. Had I opened my eyes after each shove of the pencil during the second and later sittings and measured the lines and been desirous of accuracy in the task, the connections leading to 3.8, 3.9, 4.0, 4.1, and 4.2 would have become more frequent until I reached my limit of skill in the task. (p. 12-13)

The second change was to recast the relative importance of reward and punishment under the law of effect. Through a variety of experiments Thorndike concluded that satisfiers (reward) and annoyers (punishment) are not equal in their power to strengthen or weaken a connection, respectively. In one of these experiments students learned Spanish vocabulary by selecting for each Spanish word one of five possible English meanings followed by the rewarding feedback of being told “Right” or the punishing feedback of being told “Wrong.” From the results of this experiment Thorndike concluded that punishment does not diminish response as originally stated in the law of effect. In his own words,

Indeed the announcement of “Wrong” in our experiments does not weaken the connection at all, so far as we can see. Rather there is more gain in strength from the occurrence of the response than there is weakening by the attachment of “Wrong” to it. Whereas two occurrences of a right response followed by “Right” strengthen the connection much more than one does, two occurrences of a wrong response followed by “Wrong” weaken that connection less than one does. (p. 45)

In another experiment a series of words were read by the experimenter. The subject responded to each by stating a number between 1 and 10. If the subject picked the number the experimenter had predetermined to be “right” he was rewarded (the experimenter said “Right”), otherwise he was punished (the experimenter said “Wrong”). Other than the feedback received from the experimenter, the subject had no logical basis for selecting one number over another when choosing a response. Each series was repeated many times, however, the sequence of words was long, making it difficult for the subject to consciously remember any specific right and wrong word-number pairs. From the results of this and other similar experiments Thorndike demonstrated what he called the “spread of effect.” What he meant by this was that “punished connections do not behave alike, but that the ones that are nearest to a reward are strengthened” and that “the strengthening influence of a reward spreads to influence positively not only the connection which it directly follows...but also any connections which are near enough to it” (Thorndike, 1933, p. 174). More specifically,

A satisfying after-effect strengthens greatly the connection which it follows directly and to which it belongs, and also strengthens by a smaller amount the connections preceding and following that, and by a still smaller amount the preceding and succeeding connections two steps removed. (p. 174)

In addition to these two major changes to the law of exercise and the law of effect, Thorndike also began to explore four other factors of learning that might be viewed as precursors

to cognitive learning research, which emerged in the decades that followed. They are summarized by Bower and Hilgard (1981):

1. Belongingness – “a connection between two units or ideas is more readily established if the subject perceives the two as belonging or going together” (p. 35).
2. Associative Polarity – “connections act more easily in the direction in which they were formed than in the opposite direction” (p. 35). For example, if when learning German vocabulary a person always tests themselves in the German-to-English direction it is more difficult for them to give the German equivalent when prompted with an English word than to give the English word when prompted with the German equivalent.
3. Stimulus Identifiability – “a situation is easy to connect to a response to the extent that the situation is identifiable, distinctive, and distinguishable from others in a learning series” (p. 36).
4. Response Availability – the ease of forming connections is directly proportional to the ease with which the response required by the situation is summoned or executed:

Some responses are overlearned as familiar acts (e.g., touching our nose, tapping our toes) which are readily executed upon command, whereas more finely skilled movements (e.g., drawing a line 4 inches as opposed to 5 inches long while blindfolded) may not be so readily summonable. (p.36-37)

Classical Conditioning (Ivan Petrovich Pavlov – 1928). Thorndike’s *psychological* research on learning was contemporary with the *physiological* studies of the nervous system made by Ivan Petrovich Pavlov. At the time he began writing on the conditioned reflex Pavlov was over fifty years old, having spent the earlier part of his life investigating the circulatory

system and digestive glands. It was during his study of the digestive glands that his attention turned to "psychical" stimulation of the glands:

While studying, over the course of many years, the normal activity of the digestive glands, and analyzing the constant conditions of this activity, I came upon facts (which had also been observed by others) of a psychical character, facts which could not rationally be neglected, as they participated constantly and prominently in the normal mechanism of the physiological process. I was obliged to consider them if I wished to make the most thorough possible study of my subject. (Pavlov et al., 1928, p. 47)

What Pavlov et al. (1928) observed is that “the activity of the digestive glands was called out not only when the food was in the mouth or had passed further along the digestive tube, but by agents acting from a distance, such as the sight, odor, etc., of the foodstuff” (p. 22). Before going farther, it’s important for the reader to note that Pavlov was not a psychologist and he was not investigating problems of learning. In his own preface to the only comprehensive, firsthand, report of his work, Pavlov made this clear when he said “this book concerns the investigation of the physiology of the cerebral hemispheres by the strictly objective method of conditioned reflexes” (p. 20). Although his study was focused on indentifying which nerves were connected to which digestive glands and the conditions under which these glands were innervated, as he turned to examine the psychical stimulation of the glands he noted that “similar experiments on animals had been performed in America, and indeed not by physiologists but by psychologists” (p. 39). He credited “the honor of having made the first steps along this path belongs to E. L. Thorndike” (p. 40) whose experiments had preceded those conducted in Pavlov’s lab by two or three years.

Though he was initially tempted to assume the role of a psychologist, Pavlov's decision to study the stimulation of nerves by agents acting from a distance through an objective physiological approach, was a very conscious and intentional one:

After persistent deliberation, after a considerable mental conflict, I decided finally, in regard to the so-called psychical stimulation, to remain in the role of a pure physiologist, i.e., of an objective external observer and experimenter, having to do exclusively with external phenomena and their relations. (p. 40)

Pavlov's ensuing research aimed at discovering the laws that govern the association between external objects and the secretion of the salivary glands. He called such associations conditioned reflexes to differentiate them from unconditioned reflexes, or reflexes which had a natural association with the salivary glands, such as the secretion produced by putting acid or sand in the dog's mouth. The initial association for a conditioned reflex was formed by the conditioned stimulus (e.g. the *sight* of dry bread) occurring in time with the unconditioned stimulus (e.g. the *sensation* of dry bread in the mouth). Today the process through which an association is made between a conditioned stimulus and an unconditioned response is commonly referred to as classical conditioning.

The observation that such associations are made—with or without intentionality on the part of the dog or the investigator—was Pavlov's basic starting point. The experiments that followed typically dealt with understanding how these associations were formed, maintained, terminated, strengthened or attenuated. For 25 years, many experiments were conducted in Pavlov's labs along these lines. So many, in fact, that even Pavlov was not able to tear himself away from his research to prepare a summative report of his work. In his own words, "How

could I halt for any comprehensive conception, to systematize the results, when each day new experiments and observations brought us additional facts!” (Pavlov et al., 1928, p. 42).

Though Pavlov described ‘psychic stimulation’ of salivary and gastric secretion in his 1897 book *Die Arbeit der Verdauungsdrusen*, the first report from his laboratory giving a systematic description of ‘natural’ conditioned reflexes was a thesis published by Dr. Wolfson entitled *Observations upon salivary secretion* (Petrograd, 1899, as cited in Rosenzweig, 1960, p. 313). The term ‘conditioned reflex’ was first used in print by Dr. Tolochinov, who completed the first experiments in Pavlov’s lab on the conditions under which psychical salivary secretion reflexes appear in 1901 and communicated his results to the Congress of Natural Sciences in Helsingfors in 1903⁶ (Pavlov et al., 1928). Many reports were published after that, but no comprehensive reports were available *Lectures on conditioned reflexes* by Pavlov et al. was published in 1928.

Olson and Hergenhahn (2009) summarized some of the most important concepts that were empirically founded through Pavlov’s experiments:

1. The process by which a conditioned reflex is developed.

To produce a CR [conditioned response], the CS [conditioned stimulus] and the US [unconditioned stimulus] must be paired a number of times. First the CS is presented and then the US. The order of presentation is very important. Each time the US occurs, a UR [unconditioned response] occurs. Eventually the CS can be presented alone and it will elicit a response similar to the UR. When this happens, a CR has been demonstrated. (p. 164)

⁶ Dr. Tolochinov delivered his paper in 1902 and it appeared in print the following year. (Rosenzweig, 1960, p. 313)

2. Experimental extinction. “If after a CR has been developed, the CS is continually presented without the US following the CS, the CR gradually disappears” (p. 164).
3. Spontaneous recovery. “After a period of time following extinction, if the CS is again presented to the animal, the CR will temporarily reappear” (p. 165).
4. Higher-order conditioning. “After a CS has been paired with a US a number of times...it can be paired with a second CS to bring about a CR” (p. 165). For example, a US (e.g. meat powder) causes a UR (e.g. salivation). If a light is presented just before the food powder a number of times, the light will come to cause a CR (i.e. salivation in response to the light). Once the light can elicit a CR, it can be paired with another CS, such as a buzzer, without presenting the meat powder. After a number of pairings of the buzzer, followed by the light, the buzzer alone will come to elicit the CR. In this example, the food powder is called a primary reinforcer, the light is a secondary reinforcer, and the buzzer is a tertiary reinforcer. Second-order conditioning (the buzzer), and third-order conditioning (e.g. a tone of 2,000-cps paired with the buzzer) were often achieved in Pavlov’s experiments. However, because second- and third-order conditioning must occur during extinction (i.e. the CS is presented without the meat powder) there is no reinforcement and the CS gradually loses its ability to call out the response. Because of this, it is very uncommon to go beyond third-order conditioning.
5. Generalization. Stimuli similar to the CS will also elicit the CR. For example:

Once [a dog has been conditioned to salivate in response to a 2,000-cps tone], we enter the extinction phase of the experiment, only this time we will expose the animal to tones other than the one it was trained on. Some of the new tones will have a frequency higher than 2,000 cps, and some will have a lower frequency. Using the number of drops of

saliva as our measure of the magnitude of the CR, we find that the CR has its greatest magnitude when the 2,000-cps tone is presented, but CRs are also given to other tones. The magnitude of the CR given to the other tones depends on the similarity to the tone the animal was actually trained on; in this case, the greater the similarity to the 2,000-cps tone, the greater the magnitude of the CR. (p. 166)

6. Discrimination. Discrimination is the opposite of generalization:

Generalization refers to the tendency to respond to a number of stimuli that are related to the one actually used during training. Discrimination, on the other hand, refers to the tendency to respond to a very restricted range of stimuli, or to only the one used during training. (p. 167)

Discrimination is developed through two methods: prolonged training and differential reinforcement.⁷ The greater the number of times a CS is paired with a US, the less likely there is to be a CR to a CS that is similar, but not identical to the one used for training. Through differential training, a variety of similar CSs are presented, but only the one of interest is followed by reinforcement. Through this process, the tendency for a CR to follow a non-reinforced CS is diminished and extinguished.

Behaviorism (John B. Watson – 1913). Thorndike and Pavlov provided important contributions to behavioral psychology, but it was John B. Watson (1878-1958) who championed the popular behaviorist movement. Pavlov's contribution was made from the discipline of

⁷ An interesting side note regarding the limits of discrimination possible when using the second method of training, differential reinforcement, is the account Pavlov gave of conditioning a dog to respond to the shape of a circle illuminated on a screen close in front of the dog, but to not respond to an ellipse. All circles were reinforced by feeding. No ellipses were reinforced. The first ellipse was very different from the circle. Over successive trials the shape of the ellipse was brought closer to the shape of the circle to the point where the axes were 9:8, or nearly circular. At this point, a salivary response was produced and all of the previous differential training was undone. The dog began responding to even the more elongated ellipses to which no response was previously made. Even more interesting, however, was the apparent development of experimental neurosis in the dog as a result of being presented with stimuli between which he could not discriminate. Where previously the dog would stand quietly on his bench, he would now struggle and howling constantly. (Pavlov, Gantt, & Volbort, 1928, p. 342)

physiology and was somewhat indirect. His connection with American behavioral psychology was initially made by Watson, who felt that Pavlov's experiments provided a good example of a sound experimental method used to observe the conditioning process of the secretory reflex, by monitoring the flow of saliva (Watson, 1916, p. 92; 1928, p. 35; 1930, p. 50). As for Thorndike, it is unlikely that he would have labeled himself a 'behaviorist', since it wasn't until 1913 that the term began to come into vogue. This new term, and the perspective on the study of psychology to which it referred, quickly became the dominating school of psychology in American universities. It was in his article entitled, *Psychology as the Behaviorist Views It*, that Watson (1913) positioned behavioral psychology as "a purely objective experimental branch of natural science" with a "theoretical goal" of "prediction and control of behavior" (p. 158).

Watson (1928) more plainly defined behaviorism by saying that,

Behaviorism is the scientific study of human behavior. Its real goal is to provide the basis for prediction and control of human beings: Given the situation, to tell what the human being will do; given the man in action, to be able to say why he is reacting in that way. (p. 2)

Later, in reflecting on the behaviorist movement, he wrote,

Behaviorism, as I tried to develop it in my lectures at Columbia in 1912 and in my earliest writings, was an attempt to do one thing—to apply to the experimental study of man the same kind of procedure and the same language of description that many research men had found useful for so many years in the study of animals lower than man. (Watson, 1930, p. v)

Watson's initial research focused on animal subjects such as rats (1903), rabbits (Watson & Watson, 1913), birds (e.g., 1907; 1908a; 1910), and monkeys (1908b; 1909). But by the year 1919 he had been able to apply the same experimental procedures to the study of man—the goal

he had established for himself in his 1913 article. This article has come to be referred to as the *Behaviorist Manifesto*.

Through his own efforts and through the reports of other researchers working in the same field, Watson collected data through “daily observation of several hundred infants from birth, through the first thirty days of infancy and of a smaller number through the first years of childhood” (Watson, 1930, p. 118). From this data he concluded that “young children taken at random from homes of both the poor and of the well-to-do do not make good subjects” (p. 149) because their behavior was too complex. His solution to this problem was to study hospital-reared children belonging to wet nurses. Perhaps his most famous experiments were those conducted to establish conditioned emotional responses in “Little Albert” by exposing him to various small animals and simultaneously sounding a loud noise that had been found to elicit crying. Through repeated pairing of the animals with the noise, the animals themselves came to elicit responses of fear, crying, and avoidance behavior—where previously they had not (Watson & Rayner, 1920). Several other experiments conducted with children are accounted in Watson’s 1930 publication entitled, *Behaviorism*.

Watson’s perspective on learning—i.e., his theory of habit formation—is illustrated in the following example generalized from his observations of several children in similar situations:

To make the whole process a little more concrete, let us put in front of the three-year-old child, whose habits of manipulation are well established, a problem box—a box that can be opened only after a certain thing has been done; for example, he has to press inward a small wooden button. Before we hand it to him, we show him the open box containing several small pieces of candy and then we close it and tell him that if he opens it he may have a piece of candy. This situation is new to him. None of his previously learned formed manipulation habits will completely and instantly work in this situation. None of his unlearned reactions will help him very much. What does he do? That depends upon his previous organization. If well organized by previous handling of toys, he goes at the problem at once—(1) he picks the box up, (2) he pounds it on the floor, (3) he drags it

round and round, (4) he pushes it up against the base-board, (5) he turns it over, (6) he strikes it with his fist. In other words, he does everything he has learned to do in the past in similar situations. He displays his whole repertoire of acts—brings all of his previously acquired organization to bear upon the new problem. Let us suppose that he has 50 learned and unlearned separate responses at his command. At one time or another during his first attempt to open the box, let us assume that he displays, as he will, nearly all of them before he pushes the button hard enough to release the catch. The time the whole process takes, we will say, is about twenty minutes. When he opens it, we give him his bit of candy, close up the box and hand it to him again. The next time he makes fewer movements; the third time fewer still. In 10 trials or less he can open the box without making a useless movement and he can open it in two seconds. (Watson, 1930, p. 204)

Watson explained this instance of learning---the ability to open the box with increasing speed and with fewer and fewer useless movements---as a function of *frequency* and *recency*. The act that is performed most frequently persists while the rest die away. The act that has been performed most recently is more likely to appear sooner in the next succeeding trial. Watson's explanation of recency and frequency as the basis for habit formation was criticized by some writers, and specific experiments were performed to demonstrate the inadequacy of these two factors alone to account for learning (Gengerelli, 1928). However, these factors do not form Watson's complete picture of learning. In his introduction to a republication of Watson's *Behaviorism* (Watson & Kimble, 2002, p. xii) Kimble lists nine hypothetical laws of learning identified by Watson.⁸ The first two are frequency and recency. The remaining seven are

3. Conditioning is a process of stimulus substitution: "The [conditioned stimulus] now becomes a substitute stimulus—it will call out the [response] whenever it stimulates the subject" (p. 21)

4. The process of conditioning is ubiquitous, "So far as we know we can substitute another stimulus for any stimulus calling out a standard reaction" (p. 22). Thus, learning never produces truly new responses. "The organism starts out life with more unit responses than it needs" (p. 24). The process that appears to establish new responses

⁸ The page number references used by Kimble are based on the 1925 printing of Watson's *Behaviorism*

“concerns itself really with stimulus substitutions and not reaction substitutions (pp. 25-26).

Laws 5-9 came from Pavlov, by way of G. V. Anrep (Watson does not give a reference).

5. “Conditioned responses [may be] temporary and unstable. After periods of no practice they cease to work [but they can] be quickly reestablished.”

6. “The substituted stimulus can be made [so specific that no] other stimulus of its class will then call out the reflex.” But, in apparent contradiction to this idea, Watson also noted that conditioned responses generalize (transfer) to similar conditioned stimuli.

7. “The magnitude of the response is dependent upon the strength of the [conditioned] stimulus”.

8. “There is a marked summation effect. If a dog is conditioned separately to [two stimuli], there is a marked increase in the [strength of the response] if the stimuli are given simultaneously.”

9. “Conditioned responses can be ‘extinguished’” (pp. 28-29).

Though Watson’s role as the recognized founder of behaviorism as a school of psychology is clear (Morris & Todd, 1999), his impact on educational learning theory is limited, as evidenced by the (at best) tangential coverage he is given in comprehensive books on learning theory (e.g., Bohlin et al., 2009; Bower & Hilgard, 1981; Driscoll, 2000; Eggen & Kauchak, 1999; Hilgard, 1948; O’Donnell et al., 2007; Olson & Hergenhahn, 2009; Ormrod, 2003; Sternberg & Williams, 2010; Woolfolk, 2010). Perhaps this is because his explanation of frequency and recency was never fully accepted as sufficient to account for learning, and because his other laws—as summarized by Kimble—weren’t really unique, with most of them having been adopted without change from Pavlov.

Operant Conditioning (Burrhus Fredric Skinner – 1938). In contrast to the minimal impact of Watson’s work on behavioral learning theory, it is the work of Burrhus Fredric Skinner that dominates textbook accounts and popular understanding of behavioral learning theory. Skinner’s studies of operant conditioning, contingencies of reinforcement, and schedules of reward and punishment have played a major role in the design of instruction for nearly a century. During his career, and following his retirement, Skinner published regularly (as evidenced by the

63-page bibliography compiled by Smith and Morris, 2003), producing over 20 books and nearly 200 articles between 1930 and 1993 ("Articles," 2009). Though Skinner wrote on a variety of topics, the primary focus of his research consistently centered on operant conditioning and contingencies of reinforcement. As a result of his relentless commitment to the experimental study of principles of behaviorism, and his enduring focus, Skinner is largely responsible for bringing behavior-based principles of learning into the American classroom.

Skinner's dogmatic and unrelenting approach to scientific inquiry of empirical principles can be understood, in part, by a prominent experience in his teenager years. While reading Shakespeare for one of his school classes, his father made a comment regarding the disputed authorship of the plays of Shakespeare. This in turn led Skinner to the writings of Francis Bacon (Skinner, 1967, p. 388-389), which he believed likely influenced his philosophical position, taken later in life as a scientist (p.409).

Skinner (1979) attributed his conversion to behaviorism to another philosopher named Bertrand Russell (p. 5), who had referred in a review article of *The Meaning of Meaning* by C. K. Ogden., to Watson's *Behaviorism* as "massively impressive." Skinner subsequently bought both Watson's *Behaviorism* and Russell's *Philosophy*. These two books, along with a copy of Pavlov's *Conditioned Reflexes*, formed the start of a small personal library that he kept in his rented room. He read the first third of *Philosophy*, but abandoned his reading in the middle third when he lost interest in Russell's rehash of his views on nature. Ironically, by doing so he missed the last third of the book in which Russell undertakes to disprove the behavioristic view expressed in the first third by talking about "man from within." The ironic result was that Skinner became converted to the behaviorist perspective and stayed true his course throughout his entire life. Additional influences in his persuasion were a weekly seminar in animal behavior

by Walter S. Hunter of Clark University, a graduate student by the name of Charles K. Trueblood, Fred Keller (who had particular sway in Skinner's resisting the mentalistic predispositions of his department and remaining a behaviorist), and most especially by Pavlov:

The International Congress of Physiology met at the Harvard Medical School in August 1929, and Ivan Petrovich Pavlov gave the principle address!...I heard Pavlov's address (in German) but did not try to shake his hand. I did get his autograph. A photographer was taking orders for a portrait and had asked Pavlov to write his name on a slip of paper so that his signature could appear on each print. I offered to buy a copy if I could have the slip of paper when the photographer was through with it, and he sent it to me. (Skinner, 1979, pp. 42-43)

While studying psychology at Harvard, Skinner seriously considered transferring to the physiology department (Skinner, 1979, pp. 25, 38) but his decision to stick with psychology was made firm by the availability of a machinist shop in the department of psychology. He was able to use the shop according to his pleasure and it was there in which he was able to build various apparatus (e.g., a silent release door) for use in his experiments (p.32). These experiments were not only the core of Skinner's research but also his primary source of learning since he claims to have "never learned how to read the 'literature' in psychology" (p. 34). What Skinner probably meant to say was that he did not take interest in the *contemporary* literature of psychology. He certainly did read though, since the background research for the experiments that laid the foundation for his life's work included a review of the experimental work on reflexes from the middle of the seventeenth century down through Magnus and Pavlov (p. 67). He also benefited from more practical books as he grew into his research through his experiments at Harvard:

If my rats were to get all their food in the apparatus, I could no longer go on using pearl barley. In a book on the breeding and care of the white rat I found a formula for a balanced diet: wheat, corn, flax seed, and bone meal, with a bit of salt, cooked in a double boiler. The mixture would have to be converted into pellets of uniform size, and I consulted a druggist, who showed me his pill machine. (Skinner, 1979, p. 59)

Through his experiments Skinner felt he had discovered a “new theory of conditioning” that was “different from Pavlov’s and much more like most learning in daily life” (p. 89). He differentiated his research from other studies of learning by focusing on the maintenance of behavior strength:

Up to that time the study of learning had been concerned almost exclusively with acquisition and forgetting, but I had stumbled onto the *maintenance of behavior in strength*. My rats acquired the response of pressing the lever with almost embarrassing speed. Thereafter I was looking at the conditions under which its strength was sustained. (p. 99)

In the *Behavior of Organisms* (1938) Skinner made a distinction between two types of behavior: respondent behavior, or involuntary reflex behavior elicited by a known stimulus, and operant behavior, or behavior that is simply emitted by an organism in response to a stimulus that is unknown to the observer. Respondent behaviors are reflex behaviors. Operant behaviors are those that appear to be spontaneous, because the stimulus is not known, and, according to Skinner, it is “not important to know its cause” (Hergenhahn, 1982, p. 84). Operant behaviors include most of the things we do in our daily lives.

Skinner (1938) also distinguished between two types of conditioning: Type S and Type R. Through Type S conditioning—identical to Pavlov’s classical conditioning—a stimulus to be conditioned (e.g. an assistant wearing a lab coat) is repeatedly paired with an unconditioned stimulus (e.g. acid) until it comes to elicit the same response (e.g. salivation) that is made when the unconditioned stimulus is presented. In Type S conditioning, the strength of conditioning is usually determined by the magnitude of the response. Type R conditioning refers to the conditioning of operant behavior in which responses (i.e. behaviors emitted in response to unknown stimuli) are reinforced. This type of conditioning is comparable to Thorndike’s law of

effect: “If the occurrence of the operant is followed by presentation of a reinforcing stimulus, the strength is increased” (p. 21). In Type R conditioning, the strength of conditioning is usually measured by response rate. Skinner’s operant conditioning is based entirely on Type R conditioning.

Though Skinner did not believe that theories of learning are necessary, and made an argument for why this is so (1961a), his practice of operant conditioning in the experimental analysis of behavior was based on a clearly defined set of principles:

1. Positive reinforcement – a response that is followed by the presentation of a satisfying stimulus tends to be repeated.
2. Negative reinforcement – a response that is followed by the removal of an aversive stimulus tends to be repeated.
3. Punishment – a response that is followed by the presentation of an aversive stimulus becomes less frequent.
4. Reinforcement removal – a response that is followed by the removal of a satisfying stimulus (i.e. a reinforcer) becomes less frequent.
5. Discrimination – discriminations are learned when a behavior is reinforced in the presence of one stimulus but not another, or when a behavior is punished in the presence of one stimulus but not another.
6. Shaping – a new behavior can be learned through the reinforcement of successive approximations to the goal behavior:

The whole process of becoming competent in any field must be divided into a very large number of very small steps, and reinforcement must be contingent upon the accomplishment of each step. (Skinner, 1961g, p. 153)

7. Chaining – complex behavior can be established by linking together a series of simple behaviors already known to the learner, where the response of each link brings the learner into contact with discriminative stimuli that serve as cues for subsequent responses.
8. Priming – various methods, such as showing or telling, can be used to get a learner to behave in a given way for the first time so that the behavior can be reinforced.
9. Prompting – certain discriminative stimuli may be used to provide a guide to prompt behavior that is to be learned.
10. Vanishing (i.e. Fading) – the concept of vanishing refers to the gradual fading out of discriminative stimuli initially used to prompt a behavior. Skinner (1986) provided a practical example:

My daughter Deborah once came home from school complaining that she had been assigned to learn 15 lines of Longfellow's "Evangeline." ("Those are very long lines," she said.) I told her I would show her how she could learn them quite easily. I wrote the lines on a chalkboard and asked her to read them. Then I erased a few words and asked her to read them again. She did so correctly in spite of the omissions. I erased a few more words, and she could still "read" them. After five or six erasures, she "read" them although there was nothing on the chalkboard. At first, the words were primes. By reading them, she engaged in the required behavior – but not yet for the right reasons. The words I left on the chalkboard functioned as slowly vanishing prompts. We do something of the same sort when we learn a poem by ourselves. We prime our behavior by reading a line, and then we turn away from the text and say as much of the line as we can, looking back and prompting ourselves if necessary. By looking back less and less often, we slowly vanish the prompts. (p. 107)

One of Skinner's greatest and most unique contributions to behavioral learning theory is his research around schedules of reinforcement. Skinner first became interested in schedules of reinforcement when the magazines used to automatically deliver food pellets in response to a bar press jammed or otherwise failed to operate. Under these conditions rats would continue to press

the bar even though food was not delivered with every bar press. Skinner took advantage of this as a way to reduce laboratory costs by using less food, and also to initiate a program of study of intermittent reinforcement schedules. Though only four schedules are well known (fixed ratio, fixed interval, variable ratio, and variable interval), Skinner also explored tandem schedules, differential reinforcement of rate, multiple schedules, mixed schedules, chained schedules, and concurrent schedules (Ferster & Skinner, 1957). His second major contribution is the practical implementation of behavioral principles of learning in the classroom using programmed instruction and teaching machines (Skinner, 1960; 1961i; 1961j; 1986). Skinner was not the first to conceive of a teaching machine, but his program of practical application and research paved the way for the modern era of computer-based instruction.

The contributions of three more individuals remain to be discussed in this section—the mathematico-deductive theory of Clark L. Hull (1884-1952), the contiguous conditioning theory of Edwin R. Guthrie (1886-1959), and the stimulus sampling theory of William K. Estes (b. 1919). All three are significant to the study of behavioral learning theory, but have virtually no direct influence on today's practice of instructional design. With the exception of a few inline citations they are completely absent from the sampling of college undergraduate educational psychology books reviewed as part of this study (e.g. Eggen & Kauchak, 1999; O'Donnell et al., 2007; Ormrod, 2003; Sternberg & Williams, 2010; Woolfolk, 1998; 2010). It is difficult to say conclusively why these theories have not influenced instructional design in the same way that the theories of Thorndike, Pavlov, Watson and Skinner have. It may be that practitioners were turned off by the mathematical basis of the theories of Hull and Estes, and Guthrie's theory may not have seemed a very good fit to the designing of goal-based curriculum, inasmuch as Guthrie was not concerned with the success or failure of achievements but rather with what he called

‘movements.’ Though not as influential as the foregoing theories, each provides an important perspective on learning, and provides valuable data to inform the identification of principles of learning for the present study. Each will be discussed briefly.

Mathematico-Deductive Theory (Clark L. Hull – 1943). The development of Hull’s theory can be divided into roughly three periods. From 1929 to 1943 the theory was published in several miniature formalizations in which portions of the projected theory were elaborated (see, for example Hull, 1942). The second period, from 1943 to 1949, began with the publication of *Principles of Behavior* (Hull, 1943), which contained perhaps the most influential formulation of the theory. This formulation was radically revised by a research memorandum distributed in 1945 (see Koch, 1954, p. 1). During the third period the postulates were further revised and were published in 1951 in *Essentials of Behavior* (Hull, 1951). Koch (1954) gives a very detailed analysis of Hull’s theory in each of these three periods that is comparable to, and in agreement with, the conclusions made in Hull’s own posthumous publication of *A Behavior System* (1952).⁹

Hull’s theory was expressed in the form of postulates based on the following methodology:

The typical procedure in science is to adopt a postulate tentatively, deduce one or more of its logical implications concerning observable phenomena, and then check the validity of the deductions by observation. If the deduction is in genuine disagreement with observation, the postulate must be either abandoned or so modified that it implies no such conflicting statement. If, however, the deductions and the observations agree, the postulate gains in dependability. By successive agreements under a very wide variety of

⁹ Hull's intention was to write a three volume series to cover "in an elementary manner the range of ordinary mammalian behavior" (Hull, 1952, p. vii). The first volume is *Principles of Behavior* (Hull, 1943), updates and revisions to which were published in *Essentials of Behavior* (Hull, 1951). The second volume is *A Behavior System* (1952), the manuscript for which was written by Hull, but the proofing and print of which occurred after he passed away. The third volume was never written.

conditions it may attain a high degree of justified credibility, but never absolute certainty. (Hull, 1943, p. 15)

The postulates, as presented by Hull (1943) in *Principles of Behavior*, are summarized below.¹⁰

1. Postulate 1 – Sensory input (the afferent neural impulse) and the stimulus trace

(afferent impulse decay):

When a stimulus energy (S) impinges on a suitable receptor organ, an afferent neural impulse (s) is generated and is propagated along connected fibrous branches of nerve cells in the general direction of the effector organs, via the brain. During the continued action of the stimulus energy (S), this afferent impulse (s), after a short latency, rises quickly to a maximum of intensity, following which it gradually falls to a relatively low value as a simple decay function of the maximum. After termination of the action of the stimulus energy (S) on the receptor, the afferent impulse (s) continues its activity in the central nervous tissue for some seconds, gradually diminishing to zero as a simple decay function of its value at the time the stimulus energy (S) ceases to act. (p. 47)

2. Postulate 2 – Interaction of afferent neural impulses:

All afferent neural impulses (s) active in the nervous system at any given instant, interact with each other in such a way as to change each into something partially different (s') in a manner which varies with every concurrent associated afferent impulse or combination of such impulses. Other things equal, the magnitude of the interaction effect of one afferent impulse on a second is an increasing monotonic function of the magnitude of the first. (p. 47)

3. Postulate 3 – Innate behavior tendencies:

Organisms at birth possess receptor effector connections (sU_R) which, under combined stimulation (S) and drive (D), have the potentiality of evoking a hierarchy of responses that either individually or in combination are more likely to terminate the need than

¹⁰ For convenience of reference I have labeled them with titles which briefly summarize the core idea of the postulate, for example, "Sensory input and the stimulus trace," "Interaction of afferent neural impulses," "Innate behavior tendencies," etc. However, the reader will please note that these titles are assigned by me, not Hull.

would be a random selection from the reaction potentials resulting from other stimulus and drive combinations. (p. 66)

4. Postulate 4 – Habit strength¹¹ as a function of the temporal relation of the conditioned stimulus to the reaction:

Whenever an effector activity ($r > R$) and a receptor activity ($S > s$) occur in close temporal contiguity (sCr), and this sCr is closely associated with the diminution of a need (G) or with a stimulus which has been closely and consistently associated with the diminution of a need ($Gdot$), there will result an increment to a tendency ($\Delta_s H_R$) for that afferent impulse on later occasions to evoke that reaction. The increments from successive reinforcements summate in a manner which yields a combined habit strength (${}_s H_R$) which is a simple positive growth function of the number of reinforcements (N). The upper limit (m) of this curve of learning is the product of (1) a positive growth function of the magnitude of need reduction which is involved in primary, or which is associated with secondary, reinforcement; (2) a negative function of the delay (t) in reinforcement; and (3) (a) a negative growth function of the degree of asynchronism (t') of $Sdot$ and R when both are of brief duration, or (b), in case the action of S' is prolonged so as to overlap the beginning of R , a negative growth function of the duration (t'') of the continuous action of $Sdot$ on the receptor when R begins. (p. 178)

5. Postulate 5 – Primary stimulus equivalence and stimulus generalization:¹²

The effective habit strength ${}_s Hbar_R$ is jointly (1) a negative growth function of the strength of the habit at the point of reinforcement ($Sdot$) and (2) of the magnitude of the difference (d) on the continuum of that stimulus between the afferent impulses of $sdot$ and s in units of discrimination thresholds (j.n.d.'s); where d represents a qualitative difference, the slope of the gradient of the negative growth function is steeper than where it represents a quantitative differences. (p. 199)

¹¹ Habit strength, one of Hull's most important concepts, refers to the strength of the association between a stimulus and a response. As the number of pairings between the two goes up, the habit strength goes up. The mathematical formula that describes this relationship is as follows, where N is the number of pairings between stimulus and response:

$${}_s H_R = 1 - 10^{-0.0305 N}$$

¹² c.f. Thorndike's theory of identical elements (Thorndike, 1914a, p. 268) and the transfer of training (p. 276).

6. Postulate 6 – Primary motivation:¹³¹⁴

Associated with every drive (D) is a characteristic drive stimulus (S_D) whose intensity is an increasing monotonic function of the drive in question. (p. 253)

7. Postulate 7 – Reaction potential:¹⁵

Any effective habit strength ($sHbar_R$) is sensitized into reaction potentiality (sE_R) by all primary drives active within an organism at a given time, the magnitude of this potentiality being a product obtained by multiplying an increasing function of sH_R by an increasing function of D . (p. 253)

8. Postulate 8 – Innate inhibition from primary negative drive:

Whenever a reaction (R) is evoked in an organism there is created as a result a primary negative drive (D); (a) this has an innate capacity (I_R) to inhibit the reaction potentiality (sE_R) to that response; (b) the amount of net inhibition (I_{dot_R}) generated by a sequence of reaction evocations is a simple linear increasing function of the number of evocations (n); and (c) it is a positively accelerated increasing function of the work (W) involved in the execution of the response; (d) reactive inhibition (I_R) spontaneously dissipates as a simple negative growth function of time (t''). (p. 300)

¹³ Hull (1943) explained that "significant empirical evidence...has led to the tentative conclusion that all primary drives produce their effects by the action of various chemicals in the blood" (p. 251):

Drive substances, such as the various endocrine secretions, are conceived either to be released into the blood by certain kinds of strong stimulation or as themselves initiating stimulation of resident receptors through their evocation of action by selected portions of the body, e.g., the intestinal tract and the genitalia. In both cases the energy effecting this receptor activation is called the drive stimulus (S_D). (p. 252)

¹⁴ Hergenhahn and Olsen (1982, p. 131-148) explained this postulate as follows:

Biological deficiency in the organism produces a drive state. Each drive state has specific stimuli associated with it (e.g. hunger pangs, dry mouth, etc...). The existence of specific drive stimuli make it possible to teach an animal to behave in one way under one drive and another way under another.

¹⁵ Hull's formula for reaction potential:

$$\text{Reaction Potential} = sE_R = sH_R \times D$$

9. Postulate 9 – Conditioned inhibition— the learned response of not responding:

Stimuli (S) closely associated with the cessation of a response (R) (a) become conditioned to the inhibition (I_R) associated with the evocation of that response, thereby generating conditioned inhibition; (b) conditioned inhibitions (${}_SI_R$) summate physiologically with reactive inhibition (I_R) against the reaction potentiality to a given response as positive habit tendencies summate with each other. (p. 300)

10. Postulate 10 – Inhibitory potentiality varies from instant to instance:

Associated with every reaction potential (${}_SE_R$) there exists an inhibitory potentiality (${}_SO_R$) which oscillates in amount from instant to instant according to the normal "law" of chance. The amount of this inhibitory potentiality associated with the several habits of a given organism at a particular instant is uncorrelated, and the amount of diminution in ${}_SE_{bar_R}$ at the time available. (p. 319)

11. Postulate 11 – Momentary effective reaction must exceed reaction threshold:

The momentary effective reaction potential (${}_SE_{bar\dot{R}}$) must exceed the reaction threshold (${}_SL_R$) before a stimulus (S) will evoke a given reaction (R). (p. 344)

12. Postulate 12 – Probability of striated-muscle reaction evocation:

Other things equal, the probability (p) of striated-muscle reaction evocation is a normal probability (ogival) function of the extent to which the effective reaction potential (${}_SE_{bar_R}$) exceeds the reaction threshold (${}_SL_R$). (p. 344)

13. Postulate 13 – The greater the momentary effective reaction potential, the shorter will be the latency between stimulus and response:

Other things equal, the latency (${}_st_R$) of a stimulus evoking a striated-muscle reaction is a negatively accelerated decreasing monotonic function of the momentary effective reaction potential (${}_SE_{bar\dot{R}}$), provided the latter exceeds the reaction threshold (${}_SL_R$). (p. 344)

14. Postulate 14 – Extinction:

Other things equal, the mean number of unreinforced striated-muscle reaction evocations (n) required to produce experimental extinction is a simple linear increasing function of the effective reaction potential (${}_sEbar_R$) provided the latter at the outset exceeds the reaction threshold (${}_sL_R$). (p. 344)

15. Postulate 15 – Amplitude of response:

Other things equal, the amplitude (A) of responses mediated by the autonomic nervous system is a simple linear increasing function of the momentary effective reaction potential (${}_sEbardot_R$). (p. 344)

16. Postulate 16 – Incompatible response:

When the reaction potentials (${}_sE_R$) to two or more incompatible reactions (R) occur in an organism at the same time, only the reaction whose momentary effective reaction potential (${}_sEbardot_R$) is greatest will be evoked. (p. 344)

In later work, Hull also described the following influential ideas:

1. Incentive Motivation. In 1943, Hull assumed that the greater the amount of reward the greater the amount of drive reduction.

From these considerations, coupled with the amount-of-reinforcement hypothesis, it may be inferred that the successful reaction will be more strongly conditioned to the stimulus aggregate arising from a large piece of food than to that from a small one. Therefore, given a normal hunger drive, the organism will execute the correct one of several acts originally evoked by the situation more promptly, more vigorously, more certainly, and more persistently when a large amount of food is stimulating its receptors than when they are stimulated by a small amount. (pp. 131-132)

Since the amount of need reduction presumably varies with the amount of the reinforcing agent consumed by the organism, it follows as a strong probability from the dependence of reinforcement upon the amount of need reduction that the increment of habit strength ($\Delta {}_sH_R$) per reinforcement will be an increasing function of the amount of the reinforcing agent employed. (p. 132)

Experiments (such as those by Crespi (1942, 1944) and Zeaman (1949), as cited in Hergenhahn, 1982, p. 140) led Hull to conclude that organisms learn just as rapidly

- for a small reward as for a large one, but *performance*, once the behavior is learned, varies according to the size of the reward.
2. Stimulus-Intensity Dynamism. "The greater the intensity of the stimulus, the greater the probability that a learned response will be elicited" (Hergenhahn, 1982, p. 141).
 3. Drive Reduction vs. Drive Stimulus Reduction. Hull's theory was originally termed a drive reduction theory of learning. He revised this terminology to *drive stimulus reduction* for two reasons. The first is because of the latency between the time a drive-satisfying reward is introduced and the actual reduction of the drive itself. Hull decided that drive reduction was too far removed from the presentation of the reinforcement to explain how learning was taking place. The second reason is that a 1950 study reported by Sheffield and Roby (cited in Hull, 1952, p. 153) found that hungry rats were reinforced by nonnutritive saccharine—a substance that could not possibly have reduced the hunger drive. Hull concluded that the ingestion of the saccharine-sweetened water reduces hunger tension (the drive stimulus) but not the drive itself, and thus served as a reinforcer.
 4. Fractional Antedating Goal Reactions. As Pavlov discovered, an organism can develop a conditioned response to stimuli experienced just prior to the behavior that is reinforced. It is this conditioned response to antecedent stimuli that Hull refers to as "anticipatory goal reactions" (1951, p. 24) or "fractional antedating goal reactions" (1952, pp. 124-155). This response is a fraction of the end goal response. This fractional response brings the organism closer to the end goal. As the response is made, the firing of kinesthetic receptors in the organism causes proprioceptive stimuli that simultaneously reinforce the response and stimulate an additional response.

Fractional antedating goal reactions were Hull's answer to how maze learning occurred, suggesting that chains are established not only through instrumental conditioning, as proposed by Skinner, but also through classical conditioning—i.e., in Hull's view, a combination of the two. The rat, having been rewarded in the end goal box of the maze, begins to associate, in anticipatory fashion, stimuli that it experienced just prior to entering the goal box with its own kinesthetic response that moved it into the goal box, and into contact with the reward. The reward reinforces the actions made in response to stimuli just prior to entering the goal box. The stimuli just prior to entering the goal box reinforce actions made just prior to encountering those stimuli. Similarly, each set of stimuli encountered on the way to the goal box becomes associated with the prior response that brought the rat into that state and each serves as a cue for action. This chain continues all the way back to the start of the maze so that the stimulus of the start box is linked through one fractional antedating goal response after another to the goal box.

The sixteen postulates and four additional ideas stated above leave out the very lengthy details typical in Hull's writing. As an example, *Mathematico-deductive theory of rote learning* (Hull, 1940), is filled with over three hundred pages of mathematical equations and proofs of theorems derived from the basic postulates. The ideas are conveyed primarily through symbols and symbolic relations more than the narrative prose common to the presentation of most learning theories, and familiar to most readers. Doubtless this resulted in the theory falling outside the grasp of, or beyond the limits of reasonable utility for, most educational practitioners.

In addition to the complexity of the theory, the fact that it had some fairly radical changes in a relatively short period of time, and the falling out of favor of 'systems' theories by the mid 1900s may also account for its lack of adoption in practical pedagogical application.

Contiguous Conditioning (Edwin R. Guthrie – 1930). In contrast to the complexity of Hull's theory, Edwin R. Guthrie proposed a theory that was intentionally simplistic:

It is here being suggested that the development of a scientific psychology requires that we investigate learning in its simplest forms. What happens as the result of one pairing of a stimulus pattern with a response that alters the previous effect of that pattern? (1946, p. 17)

Guthrie believed that the scientific research of Thorndike and others was wrongly influenced by social values such as economy of time. He felt that this was missing the mark, and was a distraction from the truly valuable search to understand learning itself. In his view, the central problem of learning had been neglected, namely, "what change occurs in behavior as the result of a single action" (1946, p. 16). By fitting the experimental science of learning to satisfy necessary assumptions for running statistical models of analysis, the true essence of learning was entirely overlooked:

In the laboratory we glory in experiments with fifty to fifteen hundred repetitions and their resulting curves. In nature these repetitions, as exactly duplicated as possible, simple do not occur. But learning does occur. The experimental results with a long series of repetitions have all the desirable characteristics of scientific fact...In the field of learning this very commendable effort to be scientific has led us toward studies of success, the trend of errors with repetition, the reduction of time with practice. But it is a characteristic of a score of total errors (in a maze, for instance) to omit examination of the successive changes that constitute learning (Guthrie, 1946, p. 16).

Guthrie was very much interested in getting at "the facts of learning" and used this phrase quite frequently in his writing (e.g., 1930, p. 416; 1946). These 'facts' were to be found not in the latches of the puzzle box, but by turning attention to the organism itself:

My first suggestion for directing our attention toward facts that will lead to the development of good theory applies chiefly to the field of learning. It is that we look for facts in the behavior of the organism rather than in the operation of a latch, an arrival at a

goal, the "learning" of a lesson. We should transfer our interest from the goal achievement to the behaving organism. It is the muscles of the organism that are innervated, and not the lever of the problem box. The machinery through which solutions are arrived at is contained within the skin of the solver (Guthrie, 1946, p. 6).

Guthrie was concerned not with goals and accomplishments but with movements (responses to stimuli), regardless of whether they led to success or failure.¹⁶ Guthrie posited that movements are learned in a single trial, and that "a stimulus pattern gains its full associative strength on the occasion of its first pairing with a response" (1942, p. 30). The idea that learning happens in only one trial runs counter to common intuition. Guthrie offered resolution to this apparent conflict by saying,

In the psychology of learning we often confuse the effects of repetition on a single association of stimulus and response with the effects of practice on the development of skill, which is something quite different. In learning any skill, what must be acquired is not an association or any series of associations, but many thousands of associations that will connect specific movements with specific situations. One lesson or trial is all that is necessary to learn to depress the brake pedal on a car. Learning to drive the car requires a varied experience which will cause the pedal to be depressed in many situations and left severely alone in many others. (p. 36)

Guthrie also stated that, "the subject will use that one of his practiced movements that was last in evidence when on some former occasion he solved his problem in circumstances like those now prevailing" (1940, p. 145). This came to be known as the recency principle (Hergenhahn, 1982, p. 199).

¹⁶ This, perhaps, is one reason Guthrie's theory does not commonly influence today's design of instruction, and is hardly, if ever, discussed in college-level learning psychology textbooks. In a world where educational achievement is defined in terms of measurable learning outcomes, a theory focused only on movements is of little utility to practitioners.

Practice, he acknowledged, does improve performance, but the performance improved is the performance of acts. He did not believe that practice plays any role in the learning of movements (Guthrie & Horton, 1946, as cited in Hergenhahn, 1982, p. 200):

We have taken the position that the acts are made up of movements that result from muscular contraction, and that *it is these muscular contractions that are directly predicted by the **principle of association***. We are assuming that such movements are subject to conditioning or associative learning and that this conditioning is in itself an “all or none” affair, and its degree is not dependent on practice. One experience is sufficient to establish an association.

But the learning of an act does take practice. We assume that the reason for this is that the act names an end result that is attained under varied circumstances and by movements varied to suit the circumstances. Learning an act as distinguished from a movement does require practice because it requires that the proper movement has been associated with its own cues. Even so simple an act as grasping a rattle requires different movements according to the distance and direction and position of the object. One successful experience is not sufficient to equip the infant with an act because the one movement acquired on that occasion might never again be successful.

Another important concept in Guthrie’s explanation of learning is movement-produced stimuli. Movement-produced stimuli are stimuli that are caused by the movements of the body. “If we hear a sound and turn toward it, for example, the muscles, tendons, and joints produce stimuli that are distinctly different from the external stimulation that caused us to move” (Hergenhahn, 1982, p. 199, cf. Aristotle's chains of recollection). Guthrie leveraged the idea of movement-produced stimuli to explain how an environmental stimulus might be connected to a response that is not manifest immediately following the stimulus. As an example he cited the sequence of events following a telephone ring (Guthrie, 1935, as cited in Hergenhahn, 1982, p. 199):

The movement, once started, maintains itself by the stimuli it furnishes. When the telephone bell rings we rise and make our way to the instrument. Long before we have reached the telephone the sound has ceased to act as a stimulus. We are kept in action by

the stimuli from our own movements toward the telephone. One movement starts another, then a third, the third a fourth, and so on. Our movements form series, very often stereotyped in the form of a habit. These movements and their movement-produced stimuli make possible a far-reaching extension of association or conditioning.

One point on which Guthrie differed greatly from Skinner, and the practitioner's general theory of behaviorism today, is the role of reward in learning. Rather than intensifying the behavior preceding the reward, he felt the reward protected the behavior from being unlearned by removing the opportunity for interfering associations to be made:

What I am here urging is that the food reward does not intensify the latch opening. This is the erroneous assumption made by Thorndike in his argument for a law of effect. *What encountering the food does is not to intensify a previous item of behavior but to protect that item from being un-learned.* The whole situation and action of the animal is so changed by the food that the pre-food situation is shielded from new associations. (Guthrie, 1940, p. 144)

It was under this same reasoning that Guthrie accounted for forgetting. In his words, "Forgetting is not a passive fading of stimulus-response associations contingent upon the lapse of time, but requires active unlearning, which consists in learning to do something else under the circumstances" (Guthrie, 1942, p. 29)

Based on his ideas of learning, Guthrie suggested three methods for breaking a habit. The *threshold method* is executed by "introducing the stimulus at such weak strengths that it will not cause the response and then gradually increasing the intensity of the stimulus" (1938, p. 60). Using the *fatigue method* the undesirable behavior is allowed, or forced, to continue to the point that it is no longer fun. The third method, the *incompatible response method*, establishes a condition in which the stimulus or stimuli for the undesirable response are presented in conjunction with other stimuli that produce a response that is incompatible with the undesired

response. To break a habit, not only must one avoid the cues that elicit the undesirable behavior, but they must become associated with other behavior.

The core of Guthrie's theory was simple and was surrounded by many excellent observations on learning. It was motivated by the desire to understand how learning occurs by looking at the acquisition of movements rather than focusing on the success or failure of acts. Guthrie felt that "we shall never learn how skills are acquired if we confine our-attention to 'improvement' in behavior" (Guthrie, 1946, p. 5). It was a call to look for answers in "the behavior of the organism rather than in the operation of the latch" (Guthrie, 1946, p. 6).

Stimulus Sampling Theory (William K. Estes – 1950). Guthrie's call was answered by William K. Estes. His stimulus sampling theory, which started as a form of stimulus-response associationism, attempted to formalize many of the ideas of Guthrie (Bower & Hilgard, 1981, p. 213). Estes believed that the interplay between theory and experiment was hindered "by the fact that none of the many current theories of learning commands general agreement among researchers," that progress toward a common frame of reference would be slow "so long as most theories are built around verbally defined hypothetical constructs which are not susceptible to unequivocal verification," and that while awaiting resolution of the disparities among competing theories it would "be advantageous to systematize well established empirical relationships at a peripheral, statistical level of analysis" (W. K. Estes, 1950, p. 94). He felt that the possibility of agreement on a theoretical framework would be maximized by defining concepts in terms of variables that could be experimentally manipulated and by developing consequences of assumptions through strict mathematical reasoning.

Estes, like Hull, developed a mathematical model of learning. His model treated learning and performance as a stochastic¹⁷ problem, and aimed to quantify the likelihood of a correct response—for example, the chance of a rat turning left in a T-maze. Initially, the probability of the rat turning to the left is assumed to be .5. However, unlike a coin toss, in which each toss has a 50/50 chance of resulting in heads or tails, as a result of the learning process, the rat becomes progressively more biased to turning left. This learning, he assumed, takes place over the course of successive trials.

An important assumption in the model is that the learning situation is made up of a large, but finite, number of stimulus elements. These elements include all things that the experimental subject experiences at the onset of a learning trial, including, “the experimenter, the room temperature, extraneous noises inside and outside the room, and conditions within the experimental subject, such as fatigue, or headache” (Hergenhahn, 1982, p. 222).

Estes’ model began with the basic premise of experimental behaviorism, namely, that a response, R , is a function of a stimulus, S :

$$R = f(S)$$

He then applied to this equation a mathematical expression of probability and restated this relationship to say that the probability of the occurrence of a response class, R_k , is a function of the ratio of x to S , where S represents the total number of stimulus elements effective in the stimulus situation, and x represents the number of those elements that are conditioned to the response class, R_k :

¹⁷ i.e., as though learning were a random process for which all possible response outcomes might be assigned a probability of occurrence.

Probability of $R_k = x/S$

In other words, “the probability of any response is assumed to be equal to the proportion of sampled elements on that trial that are connected to that response” (Bower & Hilgard, 1981, p. 217).

It is important to understand how Estes’ concept of R and S were a departure from traditional definitions, and that his function was probabilistic rather than deterministic. Instead of considering R to represent a single response, he broke the concept of response into two parts: the R -class, and the R -occurrence. Each R -occurrence is a member of some R -class, and manifests the necessary characteristics required to satisfy some experimental definition of a ‘correct’ response. For example, in a bar-pressing experiment, the R -class might be defined to include any act that depresses the bar. “Any movement of the organism which results in sufficient depression of the bar to actuate the recording mechanism is counted as an instance of the class” (W. K. Estes, 1950, p. 96). Estes also noted that the response class might be further broken down into finer subclasses, e.g., one that includes bar presses made with the right forepaw, and one that includes bar presses made with the left forepaw. Reinforcement of right-paw bar pressing will increase the probability that instances of that subclass will occur, and will also increase the probability that responses of the more general class, bar-pressing, will occur.

Even more important than his definitions of response is Estes’ interpretation of the stimulus, for it is this interpretation that forms the defining core of his model, and from which it gets its name. Unlike the traditional behaviorist model in which the stimulus was regarded as a singular entity to which a response is conditioned, the stimulus condition in Estes’ model was regarded as “a finite population of relatively small, independent, environmental events, of which only a sample is effective at any given time” (W. K. Estes, 1950, p. 96). By “effective” Estes

meant those stimulus elements that are experienced by the organism. Although all stimulus elements may be present “the experimental subject does not experience all of [them] on any given trial, but only a small proportion of them” (Hergenhahn, 1982, p .223). Bower and Hilgard (1981) attributed this fluctuation in momentary effective stimuli to both internal and external sources:

Two sources of random variation in stimulation may be indentified: the first arises from incidental changes in the environment during the experiment (extraneous noises, temperature fluctuations, stray odors, and so on); and the second arises from changes in the subject, either from changing orientation of her receptors (what she is looking at or listening to), from changes in her posture or response-produced stimuli, or from fluctuations in her sensory transmission system. When verbal stimuli are presented to human subjects, variability may occur due to different implicit associations or interpretations aroused by the material upon different occasions. (p. 215-216)

The phenomenon of *momentary effective stimuli* explains why multiple trials are necessary for each of the stimulus elements to become conditioned to the response.

The conditioning process can be illustrated by a hypothetical, simplified, example. Suppose that the total stimulus situation is made up of 100 possible stimulus elements. At the onset of the first trial, the experimental subject experiences 5 of the possible 100 stimulus elements. At the end of the trial—terminated by execution of the desired response—each of these five stimulus elements will become associated with whatever response is made. Any previous association of a given stimulus element to a different response class is thereby replaced by the new association. During the second trial, another five stimulus elements are experienced, each of which may or may not already be associated with the response to be made. After the trial-terminating response is made, any stimulus elements not previously associated with the exhibited

response class now become so. This process continues from one trial to the next, until all stimulus elements in the situation become conditioned to the desired response.

To model learning across a series of trials, Estes set up an equation to predict the number of new elements that could be expected to become conditioned on any given trial. This equation was expressed in terms of (a) S_0 , a subpopulation of stimulus elements that may be manipulated independently of the remainder of the situation; (b) s_0 , the mean number of stimulus elements from the subpopulation that are effective on any one trial; and (c) x , the number of elements from the subpopulation that are conditioned to R at any given time:

$$\Delta x = s_0[(S_0 - x)/S_0]$$

To provide intuitive access to the meaning behind this function, consider the following example. Suppose the subpopulation contains 100 stimulus elements, 20 of which are already conditioned to R . Then, if an average of 8 of those 100 elements are effective during any one trial, we can expect that the number of elements that will be conditioned during a trial is $8[(100 - 20)/100] = 8(80/100) = 640/100 = 6.4$. Assuming that the change in x per trial is relatively small, the derivative of this function can be taken with respect to T , where T represents the number of trials. After taking this derivative, Estes substituted p for x/S_0 to describe the probability of R_k as a function of the number of reinforced trials T :¹⁸

$$p = 1 - (1 - p_0)e^{-qT}$$

¹⁸ In this equation p_0 represents the probability of a response other than a response of type R_k

He also derived a function to describe the probable duration of a trial in terms of the strength of R_k , and a function to predict the expected rate of occurrence of R_k as a function of time (for these derivations see W. K. Estes, 1950, pp. 100-103).

To summarize, in Estes' model, learning is the successive association of stimulus elements to a response class, which occurs over multiple trials. When a response occurs, all stimulus elements effective at the time of the response, or just prior to it, become conditioned to the response. Learning takes place in an experimental situation by controlling the sampling of momentary effective stimulus elements to ensure that the desired response will take place on every single trial, while still introducing stimulus elements not yet conditioned to R in the stimulus element subpopulation so that they will also become conditioned to R .

This concept behind Estes' model of learning is simple, and it has a defensibly intuitive practical utility. However, Estes' model, which has come to be known as stimulus sampling theory,¹⁹ is given no attention whatsoever in present day books on educational psychology (see, for example, Bohlin et al., 2009; Driscoll, 2000; Eggen & Kauchak, 1999; Mowrer-Popiel & Woolfolk, 1998; O'Donnell et al., 2007; Ormrod, 2003; Sternberg & Williams, 2010; Woolfolk, 1998; Woolfolk, 2010). Perhaps, like Hull's theory, this is because of the mathematical basis of the model. Or, perhaps it is because of the almost revolutionary turning of attention by practitioners to cognitive learning theory shortly after the publication of *Toward a Statistical Sampling Theory* (W. K. Estes, 1950).

¹⁹ Though Estes specifically stated that "No attempt has been made to present a 'new' theory" (W. K. Estes, 1950, p. 106) his statistical model of learning has come to be referred to as such.

The Cognitive Perspective

Cognitive science is a broad, multidisciplinary term that encompasses both the human science of cognitive psychology, and the computer science of artificial intelligence and machine learning. Though in casual reference I have heard mention that the cognitive perspective is a mechanistic view of the mind—one in which the head is envisioned to be full of cogs and springs—this is not consistent with the historical use and linguistic root of the word.²⁰ Such misconception is possibly based on articles such as Turing’s *Computing Machinery and Intelligence* (1950) and Waldrop’s *Machinations of Thought* (1985\1991). A careful reading of these articles, however, reveals that they are not about putting cogs in the mind, but rather, putting thought into the machine. In contrast, cognitive psychology is concerned with how information is represented and transformed in the brain. It is a study of perception, and of how knowledge is acquired, how it is stored, and how it is purposively used. Cognitive learning theory is the application of this psychology to learning.

²⁰ The first written record of the term “cognitive” is attributed to Thomas Bowes in 1586 in *De La Primaudaye's French academie*, who, quoting Plato, said, “there are three vertues in the soule belonging to knowledge and understanding, called cognitive and knowing vertues: namely, reason, understanding, and phantasie [sic]” (as cited in Cognitive, n.d.). Consistent with this use, it is generally accepted that “cognitive” comes from the Latin word “cognoscere,” meaning “to become acquainted with.”

²¹ While it is true that computer analogies have been used to illustrate cognitive theories, for example, to “help illustrate the distinction between memory structure and control processes” (R. C. Atkinson & Shiffrin, 1968, p. 14), they should not be over interpreted as an attempt to mechanize the mind, but simply accepted as illustrative analogies. The advent of computers provided “both a credible metaphor for human information processing and a significant tool for modeling and exploring human cognitive processes,” (Bruning, Schraw, Norby, & Ronning, 2004, p. 5), but it was the process of knowledge acquisition that was modeled.

The modern popularization²² of the cognitive approach to learning began in the mid 1900s as an almost revolutionary reaction to the behavioral approach.²³ It was driven by research in both linguistics and computer science—research that was motivated, in part, by global war (H. D. Brown, 2001; Slobodin, 1977). Of particular influence was Chomsky’s work on linguistic theory (1953; 1955; 1956; 1957) and—even more especially—his harsh criticism of B. F. Skinner and the misappropriation of radical behaviorist principles to language learning (1967; 1971). When the U.S. found itself thrust into the middle of a worldwide conflict there was a sudden need for Americans to have oral proficiency in the languages of “both their allies and their enemies” (H. D. Brown, 2001, p. 22). This spawned a language teaching revolution, and the U.S. military provided funding for special intensive language courses that focused on developing oral skills. As a result, national interest in foreign languages was revived, and educational institutions quickly adopted what came to be known as the Army or Audio Lingual Method. The

²² Chomsky (2005, para. 3) noted that the so-called cognitive revolution was more of “a second cognitive revolution, reviving and extending important insights and contributions of the cognitive revolution of the 17th and 18th centuries, which had regrettably been forgotten.”

²³ Many theorists previously conducting research in the behaviorist paradigm shifted to a cognitive view, but the transition was not necessarily an easy one. Consider, for example, the experience of William K. Estes (1982a):

The shift from a stimulus-response to an informational frame of reference may sound simple and straightforward in hindsight, but it was very difficult to achieve in the climate of the learning theories of the 1940s. Behavior was the proper study of psychology; the mind was simply a subjective and fictitious entity....During my own training as an investigator, I absorbed the prevailing frame of reference thoroughly, and, in my first theoretical paper (Estes, 1950), I subscribed wholeheartedly to the idea that laws or principles of learning could be expected to take their simplest form when expressed in terms of stimulus-response relationships (even while I myself was deviating from the paradigm by introducing abstract theoretical concepts not strictly definable in terms of observable stimulus or response variables). It was only many years later that I began to see the possibility that expressing laws of learning in terms of relations between behavior and observable determining conditions might not, in any significant sense, be the simplest or most parsimonious approach. Rather, the laws might take on simpler forms when expressed in terms of concepts of information or memory (Estes, 1975, 1978)....As will be apparent in subsequent chapters of this book, memory, rather than learning, was the central concept in my research and theoretical efforts from about 1960 down to the present." (pp. 17-19)

method was grounded in structural linguistics and behavioral psychology, and was experienced by the learner as a practice of patterned mimicry drills. Though the method enjoyed many years of popularity it ultimately declined due to its failure to teach long-term communicative proficiency (Rivers, 1964). In Brown's words:

We discovered that language was not really acquired through a process of habit formation and overlearning, that errors were not necessarily to be avoided at all costs, and that structural linguistics did not tell us everything about language that we needed to know. (p. 23)

In the aftermath of World War II language learning remained a strong focus of both U.S. government and university education. Chomsky (1967), however, was very direct in pointing out that behavioral learning theory was not the answer to effective language learning. His review of Skinner's *Verbal Behavior* (1957) was intended "not specifically as a criticism of Skinner's speculations regarding language, but rather as a more general critique of [behaviorist speculation] as to the nature of higher mental processes" (Preface, para. 2).

Skinner's thesis is that external factors consisting of present stimulation and the history of reinforcement (in particular, the frequency, arrangement, and withholding of reinforcing stimuli) are of overwhelming importance, and that the general principles revealed in laboratory studies of these phenomena provide the basis for understanding the complexities of verbal behavior. He confidently and repeatedly voices his claim to have demonstrated that the contribution of the speaker is quite trivial and elementary, and that precise prediction of verbal behavior involves only specification of the few external factors that he has isolated experimentally with lower organisms.

Careful study of this book (and of the research on which it draws) reveals, however, that these astonishing claims are far from justified. It indicates, furthermore, that the insights that have been achieved in the laboratories of the reinforcement theorist, though quite genuine, can be applied to complex human behavior only in the most gross and superficial way, and that speculative attempts to discuss linguistic behavior in these terms alone omit from consideration factors of fundamental importance that are, no doubt, amenable to scientific study, although their specific character cannot at present be precisely formulated. Since Skinner's work is the most extensive attempt to accommodate human behavior involving higher mental faculties within a strict behaviorist schema of

the type that has attracted many linguists and philosophers, as well as psychologists, a detailed documentation is of independent interest. The magnitude of the failure of this attempt to account for verbal behavior serves as a kind of measure of the importance of the factors omitted from consideration, and an indication of how little is really known about this remarkably complex phenomenon. (para. 6-7)

Chomsky's criticism, combined with the advent of the first experimental computer in the 1940s and the first commercially available computers in 1950, provided the necessary impetus to displace the behavioral stronghold on psychology and learning research.²⁴ Experimental studies of behavior-based learning, of course, did not cease²⁵ but there was a definitive shift in the emphasis of psychology and learning research. The computer model of input, output, storage, and processing was quickly latched onto as a metaphor for talking about and studying human learning.

Three major characteristics that distinguish the cognitive perspective from the behavioral perspective, and define its essence were stated by Howard (1983) as follows:

²⁴ Perhaps even more influential than any of the events already described, or at least certainly a possible contributing factor, is the mass media scare of behavioral control championed by the broadcasting industry—attacking behavioral psychology in general, and Bandura's research on transmission of aggression through modeling in specific (Bandura, 2006a, pp. 57-61, 64-65):

The popular media were deluging the public with repugnant imagery of brainwashing and the frightful scenarios of *1984* and *Brave New World* dominated by social engineers wielding powerful methods of behavioral control. The hit movie, *A Clockwork Orange*, graphically portrayed the fiendish nature of behavior modifiers physically shocking people into submission. In his movie *Sleeper*, Woody Allen amusingly outwits the ironclad control by despotic social engineers who reduce humans to mindless zombies. Skinner's publication, *Beyond Freedom and Dignity* (1971), alarmed the public that the application of these new psychological methods would strip people of their dignity and deprive them of their freedom....At the height of this media frenzy, I began my term as president of the APA. (p. 64)

²⁵ See, for example, the reference list in O'Donohue and Kitchener (1999), and journals such as *Adaptive Behavior*, *Advances in Child Development and Behavior*, *Advanced in Cognitive-Behavioral Research and Therapy*, *Advances in the Behavioral Measurement of Children*, *Advances in the Study of Behavior*, and *The Behavior Analyst Today*.

1. It emphasizes *knowing*, rather than responding. The major emphasis is not on stimulus-response bonds, but on mental events (p. 5).
2. It emphasizes *mental structure* or organization. An individual's knowledge is organized and new stimuli are interpreted in light of this knowledge (p. 6).
3. It defines a view of *the individual* as being *active*, *constructive*, and *planful*, rather than as being the passive recipient of environmental stimulation. (p. 6)

While these differential characteristics are generally accepted, the line between behavioral psychology and cognitive psychology is not so clear, as has been expressed by Leahey and Harris (1997):

Although it is common to sharply contrast cognitive psychology and behavioral psychology, we believe things are not quite so simple. Clearly, cognitive psychology and radical behaviorism are quite different, since Skinner does not tolerate the postulation of any inner psychological entities, whether it be Freud's ego or the cognitive psychologists long-term memory. However, both Tolman and Hull postulated inferred entities that controlled behavior—for example, cognitive maps²⁶ and mediating responses.... Influenced by the computer metaphor, cognitive psychology has created an entirely new vocabulary for discussing learning. Stimulus becomes input, behavior becomes output, and response mediators are now levels of information processing. (p. 103)

And if the roots of behavioral learning theory seemed somewhat disjoint, it is even more the case with cognitive learning theory. In June, 1977, the NATO International Conference on Cognitive Psychology and Instruction was organized to “explore the extent to which theoretical and methodological developments in cognitive psychology might provide useful knowledge with regard to the design and management of instruction” (Lesgold, Pellegrino, Fokkema, & Glaser,

²⁶ It is for this reason that I have chosen to include Tolman's work in this section on cognitive learning theory rather than in the previous section which reviewed behavioral learning theory. Tolman's unique contribution was primarily cognitive, not behavioral.

1978, p. v). The submission of papers for the conference gave evidence to a huge diversity of research efforts being made in several countries, all under the umbrella of cognitive research. Many of the selected papers were included in Lesgold's report of conference proceedings. In order to provide some semblance of structure to the report they were organized under six general topic areas that the authors felt best represented a high-level survey of the landscape of contemporary cognitive psychology research: (a) learning, (b) comprehension, (c) perceptual and memory processes in reading, (d) problem solving and components of intelligence, (e) cognitive development, and (f) approaches to instruction.

A more recent view was provided by Honeck, Case and Firment (1991), who took the position that there is no paradigm—i.e., “a particular set of assumptions, methods, and theories” (p. xiv)—by which the field might be characterized. They described cognitive psychology as “an undulating mass rather than a fixed target” (p. xiv) and felt it was best defined by examples of general questions that cognitive psychologists might typically ask:

What happens to an environmental stimulus when it is first received by the senses?
Does knowledge affect perception of a stimulus?
What is memory? Are there different memory systems?
What form does memory/knowledge take?
What facilitates or hinders remembering?
How is language understood?
How do people reason?
How do people recognize patterns and categorize things?
What factors influence problem solving?
Are cognition and emotion separable systems?
What happens when people read?
Are people aware of what their minds do?
(p. xiv)

These questions represent areas of cognitive research such as sensory perception, echoic memory, feature extraction and interpretation, top-down processing, memory models, knowledge

structure, transfer, interference, and metacognition. Honeck, et al. also noted the proliferation of cognitive “mini-theories”:

Even though there are no overarching, all-encompassing theories in cognitive psychology, there are many specific theories about a restricted range of phenomena—for example, short-term memory, categorization, syllogistic reasoning, and the like.... There are also mini-theories to explain [for example] why recall is generally different than recognition, how people discover analogies between things, why people tend to overlook misspelling of the word *the*, why pictures tend to be remembered better than words, how mental images are constructed, what makes for an expert in physics, what young infants tend to notice, and so on. If anything, this set of mini-theories, the phenomena they address, the methods used to study the phenomena, and the assumptions brought to bear, is what characterizes the field. (Honeck et al., 1991, pp. xiv-xv)

To provide a more coherent, organized picture of the field they cited three general points of view, under which these mini-theories may be grouped: (a) the information processing view, (b) the ecological view, and (c) the parallel distributed processing view (i.e., connectionism). Of these three, they noted that the ecological view is “a radical view, one that most cognitivists either reject or feel uncomfortable with” (p. xv).²⁷ The remaining two views—the information processing view and the connectionist view—are the predominantly accepted views, with the connectionist view gaining increasing popularity since the mid 1990s.

Based on a review of several books dealing exclusively with cognitive psychology,²⁸ the categorization by Lesgold (1978), and the sample questions, mini-theories, and general points of view given by Honeck, Case and Firment (1991); appear to be a fair representation of the field at

²⁷ Aside from this reference in Honeck, Case, and Firment (1991) I have not seen any other mention of the ecological view in the piles of literature on cognitive psychology that have been reviewed for the present study. It seems to be more on the philosophical, rather than the practical, side of cognitive theory.

²⁸ For example, including but not limited to: Bruning (2004), Honeck, Case, and Firment (1991), Howard (1983), Martindale (1991), Neisser (1967), Reed (1988), and Reynolds (1983).

large. The remainder of this section will summarize contributions to cognitive learning theory, based on my own review of the literature, to provide additional perspective.

Associationism (Aristotle – 350 B.C.E). Aristotle’s writings on learning—already covered in the foregoing review of behavioral learning theory—could very arguably be considered a much better fit for cognitive learning theory, especially with the focus of his learning-related writings on memory and recall. Ultimately, it was the predominant application of his laws of association²⁹ to habit formation in the mid-to-late 1800s and the early 1900s that led me to include his ideas with those of the behaviorists. However, the same laws of association, and many of his other ideas that have been preserved through history, are also deeply embedded within the core of contemporary cognitive learning theory. His thoughts on the nature of practice, the gradation of attainment over time, the representation of concepts in memory through images, and the seal-ring stamping of memories, all clearly apply to the acquisition of knowledge—as do his ideas on the need for repetition in varying degrees, the value of orderly arrangement, the role of pleasure and pain in motivation, the increase of capacity and potential through education and habituation, and the linking of mental concepts. Since these have already been discussed, the reader is referred to the review of behavioral learning theory in the preceding section for further detail, source quotations, and references.

Memory and forgetting (Hermann Ebbinghaus – 1885). As generally accepted methods of inquiry transitioned from philosophical reasoning to quantitative scientific inquiry in the latter half of the 19th century, Hermann Ebbinghaus built on Aristotle’s foundation of the

²⁹ Both by Aristotle himself, and by behavioral psychologists since the time of Thorndike (as evidenced by his opening statement in the intro to *Animal Intelligence* (1898, p. 1)).

association of ideas by conducting the first recorded experimental studies of memory.³⁰ His desire was “to go a step farther into the workings of the mind and to submit to an experimental and quantitative treatment the manifestations of memory” (1913, p. v). The experiments were conducted from 1879 to 1880 and from 1883 to 1884. In his study he explored “the rapidity of learning series of syllables as a function of their length,” “the increase in rapidity of learning in the case of meaningful material,” “retention as a function of the number of repetitions,” “the effect of a decided increase in the number of repetitions,” “retention and obliviscence as a function of time,” “retention as a function of repeated learning,” and” retention as a function of the order of succession of the members of the series.”

Though his experiments were conducted using himself as the only subject of experimentation, and though he acknowledged and qualified many times in his writing, that the results of the tests are of limited individual significance, his findings are nevertheless very interesting, and have been applied quite broadly.

In the process of conducting his experiments, one of the first things he noticed is that, for him at least, a series of seven³¹ or fewer syllables required only a single reading in order to recite

³⁰ Though often cited unequivocally as the first experimental studies of memory, given the inquisitive nature of man, and evidence of man’s methodological inspection of both the external and internal realm since the time of the early Greeks, it is unlikely that it actually *is* the first. That said, until some predating study is identified, comparable in clarity and coherence, we accept it as such.

³¹ In 1956, George A. Miller published *The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information* (Miller, 1956). Though he didn’t specifically cite Ebbinghaus’s study, he was not unaware of its existence (p. 94). In his article Miller cited several examples in which the unidimensional channel capacity—operationally defined based on information theory as the number of *bits* a person was able to take as input which varied along a single scale and then pass on as output, usually in a verbal absolute judgment or report—was found to be sufficient to represent 7 distinct elements, plus or minus two. For absolute judgments of tones it was found that listeners never confused two or three distinct tones, rarely confused four, but with five or more confusions were frequent. Psychologists “have been using seven-point rating scales for a long time, on the basis that trying to rate into finer categories does not really add much to the usefulness of the ratings” (p. 84). Channel

it perfectly (Ebbinghaus, 1913, p. 48). Multiple readings were required before the first unaided reproduction was possible for lists of length greater than seven. The significance of this observation is that the capacity of immediate memory is clearly limited to active retention of a rather small number of items, and that learning generally happens through repeated experience:

Under ordinary circumstances, indeed, frequent repetitions are indispensable in order to make possible the reproduction of a given content. Vocabularies, discourses, and poems of any length cannot be learned by a single repetition even with the greatest concentration of attention on the part of an individual of very great ability. By a sufficient number of repetitions their final mastery is ensured, and by additional later reproductions gain in assurance and ease is secured. (Ebbinghaus, 1913, p. 4)

He found that neither an excess nor an insufficiency of repetition was harmful to learning, or entirely wasteful:

capacity for absolute judgments of loudness average 2.3 bits, or enough to represent about five discriminable alternatives. For taste discrimination, 1.9 bits, or four distinct concentrations can be identified—less distinctive than auditory stimuli, but not far off. Visual capacity seems to have a much higher capacity, ranging from 3.2 to 3.9 bits, meaning 10 to 15 distinct positions along a linear interval can be uniquely identified. Channel capacity for the skin was found to have “about four intensities, about five durations, and about seven locations” (p. 86).

Miller’s conclusion was that “there seems to be some limitation built into us either by learning or by the design of our nervous systems, a limit that keeps our channel capacities in this general range” (p. 86). Miller also notes, however, that in everyday experience we are able to “identify accurately any one of several hundred faces, any one of several thousand words, any one of several thousand objects, etc.” (p. 87) This he attributes to our ability to make simultaneous and successive discriminations. With simultaneous discriminations “we can make relatively crude judgments of several things simultaneously” (p. 88) thereby increasing our total capacity. Language is made up of sequences of phonemes, so we are able to make several judgments successively as we process the input. Our span of immediate memory exhibits a similar trait in that it seems to be limited to about seven items in length. Miller is quick to point out that while the limits of absolute judgment and immediate memory are similar, we should not jump to the conclusion that they are rooted in the same source, although that may be the case.

In his article several years later, entitled, "The Magical Number Seven: Still Magic After All These Years?," Baddeley (1994) concluded that:

In emphasizing the importance of recoding, Miller pointed the way ahead for the information-processing approach to cognition, and in developing the concept of chunking, he provided a concept that continues to be fruitful in the analysis of learning and memory. The article, if not the number seven, retains its magic. (p. 356)

What will happen, it may be asked, if the number of repetitions actually given to a certain series is less than is required for memorization or if the number exceeds the necessary minimum?

The general nature of what happens has already been described. Naturally the surplus repetitions of the latter alternative do not go to waste. Even though the immediate effect, the smooth and errorless reproduction, is not affected by them, yet they are not without significance in that they serve to make other such reproductions possible at a more or less distant time. The longer a person studies, the longer he retains. And, even in the first case, something evidently occurs even if the repetitions do not suffice for a free reproduction. By them a way is at least opened for the first errorless reproduction, and the disconnected, hesitating, and faulty reproductions keep approximating more and more to it. (Ebbinghaus, 1913, p. 52)

This phenomenon he described metaphorically, as a process of engraving and fading:

These relations can be described figuratively by speaking of the series as being more or less deeply engraved in some mental substratum. To carry out this figure: as the number of repetitions increases, the series are engraved more and more deeply and indelibly; if the number of repetitions is small, the inscription is but surface deep and only fleeting glimpses of the tracery can be caught; with a somewhat greater number the inscription can, for a time at least, be read at will; as the number of repetitions is still further increased, the deeply cut picture of the series fades out only after ever longer intervals. (Ebbinghaus, 1913, pp. 52-53)

He found that increased repetition during a period of study provided a savings in relearning at a later period. Specifically, he found that for each three additional repetitions that he spent on a given day on the study of a series, he saved, in learning that series 24 hours later, on the average, approximately one repetition (Ebbinghaus, 1913, p. 57). But he also learned that this was of limited effect. The savings of relearning did not continue to increase proportionally with an increased number of repetitions above a certain limit:

I have made some trial tests partly with shorter series, and partly with familiar series, all of which confirmed the result that the proportion in question gradually ceases to hold with a further increase of repetitions. Measured by the saving of work after 24 hours the effect of the later repetitions gradually decreases. (pp. 59-60)

The effect of increasing the number of repetitions of series of syllables on their inner fixedness in the above defined sense grew at first approximately in proportion to the number of repetitions, then that effect decreased gradually, and finally became very slight when the series were so deeply impressed that they could be repeated after 24 hours, almost spontaneously. (p. 61)

In addition to looking at the effect of an increased number of repetitions during a given period of study, he also examined the effect of multiple periods of study on retention of what has been learned. He found that each subsequent relearning of a series strengthens its retention:

The series are gradually forgotten, but—as is sufficiently well known—the series which have been learned twice fade away much more slowly than those which have been learned but once. If the relearning is performed a second, a third or a greater number of times, the series are more deeply engraved and fade out less easily and finally, as one would anticipate, they become possessions of the soul... (Ebbinghaus, 1913, p. 81)

In conjunction with his investigation on the effect of repeated learning, he also asked whether it was better to study all at once, or to break the task down into multiple periods of study. He found that for the relearning of a 12-syllable series, “38 repetitions, distributed in a certain way over the three preceding days, had just as favorable an effect as 68 repetitions made on the day just previous” (p. 89). Though based on a limited data set, Ebbinghaus felt that the difference was significant enough to warrant a conclusion in favor of spaced practice:

Even if one makes very great concessions to the uncertainty of numbers based on so few researches, the difference is large enough to be significant. It makes the assumption probable that *with any considerable number of repetitions* a suitable distribution of them over a space of time is decidedly more advantageous than the massing of them at a single time.

With this result, found here for only very limited conditions, the method naturally employed in practice agrees. The schoolboy doesn't force himself to learn his vocabularies and rules altogether at night, but knows that he must impress them again in the morning. A teacher distributes his class lesson not indifferently over the period at his disposal but reserves in advance a part of it for one or more reviews. (p. 89)

He also noted, however, that an important factor which affected his ability to learn was the time of day at which he studied, with morning hours being more productive than the later hours of the day:

In the later hours of the day mental vigor and receptivity are less. The series learned in the morning and then relearned at a later hour, aside from other influences, require more work for relearning than they would if the relearning were done at a time of mental vigor equal to that of the original learning. (Ebbinghaus, 1913, p. 66)

Ebbinghaus is perhaps most well known for his description of what is commonly referred to as the *forgetting curve*:

Left to itself every mental content gradually loses its capacity for being revived, or at least suffers loss in this regard under the influence of time. Facts crammed at examination time soon vanish, if they were not sufficiently grounded by other study and later subjected to a sufficient review. But even a thing so early and deeply founded as one's mother tongue is noticeably impaired if not used for several years. (1913, p. 4)

He discovered that the rate of forgetting could be approximated quite accurately by a negatively accelerated, exponential logarithmic function where the amount remembered, b , is calculated as a function of time (in minutes), t , which have passed, counting from one minute before the end of learning (pp. 76-79), where the constants k and c are given values of 1.84 and 1.25, respectively:

$$b = \frac{100 k}{(\log t)^c + k}$$

In addition to repetition and forgetting, Ebbinghaus also had something to say about individual differences, content-type effects of learning, attention and interest, meaningfulness, content-length effects on learning, the influence of recollection on reproduction, capacity, and order effects on the association of ideas learned in series. In regard to individual differences, he

simply noted that individuals vary in their ability to memorize, and that the capacity of a given person varies with age and time of day (1913):

How differently do different *individuals* behave in this respect! One retains and reproduces well; another, poorly. And not only does this comparison hold good when different individuals are compared with each other, but also when different phases of the existence of the same individual are compared: morning and evening, youth and old age, find him different in this respect. (p. 3)

He also noted that the type of content to be learned is of great influence on the amount of effort required to learn it (1913):

Melodies may become a source of torment by the undesired persistency of their return...Forms and colors are not so importunate; and if they do return, it is with noticeable loss of clearness and certainty...It is with something of a struggle that past states of feeling are realized; when realized, and this is often only through the instrumentality of the movements which accompanied them, they are but pale shadows of themselves. (p. 3)

Furthermore, the combination of content type and individual differences is the source of great variation in the work required to learn (1913):

If the two foregoing points of view are taken together—differences in individuals and differences in content—an endless number of differences come to light. One individual overflows with poetical reminiscences, another directs symphonies from memory, while numbers and formulae, which come to a third without effort, slip away from the other two as from a polished stone. (p. 3)

Additionally, he noted that the intensity of attention and interest play a significant role:

Very great is the dependence of retention and reproduction upon the intensity of the *attention* and *interest* which were attached to the mental states the first time they were present. The burnt child shuns the fire, and the dog which has been beaten runs from the whip, after a single vivid experience. People in whom we are interested we may see daily and yet not be able to recall the color of their hair or of their eyes. (pp. 3-4)

That which carries greater meaning for the learner is more easily acquired. In comparing the learning of series of nonsense syllables to the learning of a poem, Ebbinghaus found a very large difference between the number of repetitions required to learning nonsense material and the number of repetitions required to learn that which was meaningful:

In order to keep in mind the similarities and differences between sense and nonsense material, I occasionally made tests with the English original of Byron's "Don Juan." These results do not properly belong here since I did not vary the length of the amount to be learned each time but memorized on each occasion only separate stanzas. Nevertheless, it is interesting to mention the number of repetitions necessary because of their contrast with the numerical results just given.

[When learned to the point of the first possible reproduction] each stanza required hardly nine repetitions; or, if the errorless reproduction is abstracted, scarcely eight repetitions.

If it is born in mind that each stanza contains 80 syllables (each syllable, however, consisting on the average of less than three letters) and if the number of repetitions here found is compared with the results presented above, there is obtained an approximate numerical expression for the extraordinary advantage which the combined ties of meaning, rhythm, rhyme, and a common language give to material to be memorised [sic]. If the above curve is projected in imagination still further along its present course, then it must be supposed that I would have required 70 to 80 repetitions for the memorisation [sic] of a series of 80 to go nonsense syllables. When the syllables were objectively and subjectively united by the ties just mentioned this requirement was in my case reduced to about *one-tenth of that amount* [italics added]. (Ebbinghaus, 1913, pp. 50-51)

The curve referred to is that which resulted from plotting "the number of repetitions necessary for the memorisation [sic] of series in which the number of syllables progressively increased" (p. 48). Where the length of the series was seven or less, only one reading was necessary before the list could be recited perfectly, with lists of fewer than seven items requiring less and less attention. As the length of the series was increased, the number of repetitions required to learn the series increased non-linearly, with the ascent of the curve at first being very steep, but gradually flattening out.

The increased number of repetitions required to learn the series initially also had the side effect of establishing it more firmly in the mind:

...the effect of this need of more numerous repetitions in the cases investigated consists not merely in making the series just reproducible, but also in the firmer establishment of the longer series. After an interval of 24 hours they could be relearned to the point of being just reproducible with a saving both absolutely and relatively greater than with the shorter series.” (p. 84)

As a result of this “firmer establishment” longer lists could be more easily relearned:

On each day the average number of repetitions necessary for the committing of a given series is less than on the preceding day. With the longer series, in whose case the first output of energy is great, the decrease in the amount of work each time necessary to reach the first possible reproduction is proportionally rapid. With the shorter series, where the first output is small, the decrease is proportionally slow. (p. 85)

Another very interesting yet subtle observation was that whether or not he could remember studying a series of lists on a previous day made no difference in the effort required to master the series (1913):

When the series were repeated 8 or 16 times they had become unfamiliar to me by the next day. Of course, indirectly, I knew quite well that they must be the same as the ones studied the day before, but I knew this only indirectly. I did not get it from the series, I did not recognise [sic] them. But with 53 or 64 repetitions I soon, if not immediately, treated them as old acquaintances, I remembered them distinctly. Nothing corresponding to this difference is evident in the times for memorisation [sic]and for savings of work respectively. They are not smaller relatively when there is no possibility of recollection nor larger relatively when recollection is sure and vivid. The regularity of the aftereffect of many repetitions does not noticeably deviate from the line that is, so to speak, marked out by a smaller number of repetitions although the occurrence of this after-effect is accompanied by recollection in the first case just as indubitably as it lacks recollection in the second case. (pp. 58-59)

In the final chapter of his book, Ebbinghaus reported his findings regarding the mental association between members of a series, measured by the savings observed when learning a new

series methodically constructed from a series previously learned through the omission of 1, 2, 3 or seven intermediate members. His findings provide empirical support in favor of Aristotle's law of contiguity. The new series formed by leaving out intermediate members from the original series were learned with a time savings that was greatest where fewer intermediate members were omitted (1913):

There seems to be an association not merely in direct but also in indirect succession. The strength of these connections decreases with the number of the intervening numbers; with a small number it was, as will be admitted, of surprising and unanticipated magnitude. (p.101)

In contrast to this observed savings—yet still consistent with the idea that mental concepts are associated with one another, and that the order of succession is one of the characteristics learned when learning a series—he also found that when a new series was constructed not by omitting intermediate members of the original series but by permutation of the members (i.e., changing the order) there was an increase in the expenditure of time required to learn the new series, suggesting that the ordering of the original list interfered with the learning of the new list (1913):

By derivation of the transformed series by skipping 1, 2, 3, 7 intermediate syllables, the derived series were therefore learned with an average saving of 110, 79, 64, 40 seconds. On the contrary with derivation of the series by permutation of the syllables the learning required an average *increase* in expenditure of 5 seconds. (p. 104)

He also found that there was a present, yet weaker, reciprocal association formed between the members of a series. When the transformed series is formed by mere reversal of the syllable sequence, there is a time savings in learning of the transformed series, as compared to learning an unrelated, arbitrary series of the same length:

As a result of the learning of a series certain connections of the members are therefore actually formed in a reverse as well as in a forward direction...The strength of the predispositions thus created was again a decreasing function of the distance of the members from each other in the original series. It was, however, considerably less for the reverse connections than for the forward ones, the distances being equal. (pp. 112-113)

The studies that Ebbinghaus conducted were rooted in the ideas of association, but were clearly mentalistic, in contrast with the contemporary behavioristic S-R theories of Pavlov and Thorndike. As such, Ebbinghaus's studies provided a precedent on which much of the cognitive learning research conducted during the 20th century was based.

Purposive Behaviorism (Edward Chance Tolman – 1922). Another contribution to cognitive learning theory, which somewhat smudged the line between cognitive and behavioral learning theory, was the work of Edward Chance Tolman. Tolman was a behaviorist, but he was a *purposive* behaviorist (McDougall, 1925a, p. 278).

Purpose is held to be essentially a mentalistic category...[but] it will be the thesis of the present paper that a behaviorism (if it be of the proper sort) finds it just as easy and just as necessary to include the descriptive phenomena of "purpose" as does a mentalism. (Tolman, 1925a, pp. 36-37)

For Tolman, a "proper sort" of behaviorism was "not a mere Muscle Twitchism of the Watsonian variety" (1925a, p. 37), but was broad enough to cover "all that was valid in the results of the older introspective psychology" (1922, p. 47). In his view, the Watsonian variety of behaviorism was "an account in terms of muscle contraction and gland secretion" and "as such, would not be behaviorism at all but a mere physiology" (p. 45).

In contrast to the limiting notions of physiological behaviorism, Tolman (1922) suggested a new formula of behaviorism that would "allow for a more ready and adequate treatment of the

problems of motive, purpose, determining tendency, and the like” (p. 53). He defined purpose quite simply as persistence in behavior:

Purpose, adequately conceived, it will be held, is itself but an objective aspect of behavior. When an animal is learning a maze, or escaping from a puzzle-box, or merely going about his daily business of eating, nest-building, sleeping, and the like, it will be noted that in all such performances a certain *persistence until* character is to be found. Now it is just this *persistence until* character which we will define as purpose. (1925a, p. 37)

As an example he gave the following:

When a rat is running a maze and is exhibiting trial and error, such trials and errors, we discover, are not wholly identifiable in terms of specific muscle contraction A, followed by specific muscle contraction, B, etc. They are only completely describable as responses which "persist until" a specific "end-object," food, is reached. An identification of these trial-and-error explorations has to include, in short, a statement of the end-situation (i.e., the presence of food) toward which they eventuate. Such a behavior is, therefore, in our terminology a case of purpose. (p. 38)

It is of interesting note that Tolman spoke frequently of *purpose* and *cognition*— going so far as to call them out as the “determiners of animal learning” (1925b, p. 285)—but simultaneously went to great lengths to establish and hold his conception of these terms as distinct from a mentalistic view of the same.³²

³² I find Tolman’s use of cognitive terms (e.g., cognitions, cognitive hunches, initial cognitions, and cognition intent) to be excessive and unusual. Though he says repeatedly what they are not (mentalistic) he never says exactly what they are. The possibility seems likely that he was, in fact, referring to cognition in the ‘thinking’ sense, but to avoid being side-lined or benched by the mainstream behaviorists of the day, he refused to admit any supposition of hypothetical mental activity. Of course, if he was not referring to thinking, why would he have used the term ‘cognition’ at all?

I recently found that this same point is brought up by McDougall (1925b, p. 298):

Tolman seems inclined to attach much importance to the fact that by using the words of common speech (such words as desire, purpose, striving, cognition, perception and memory and anticipation) you can

The present paper will offer a new set of concepts for describing and interpreting the facts of animal learning. These new concepts will differ from the usual ones in not being restricted to the customary physiological notions of stimulus, neural excitation, synaptic resistance, and muscle contraction (or gland secretion). They will rather include such immediate and common sense notions as purpose and cognition. These latter, however, will be defined objectively and behavioristically, not 'mentalistically.' (p. 285)

Tolman's efforts to establish himself apart from the physiological behaviorism of Pavlov, Thorndike, and Watson, and from the introspective, mentalistic practices of clinical and human psychology are products of the time in which his research took place. When he began, introspection had largely been discredited among its opponents as a valid means of fact finding, and displaced by the methodology of the early, physiologically grounded, experimental behaviorists. However, Tolman did not agree with their "molecular" view of behavior—the contraction of muscles, the firing of nerve receptors, or the secretion of glands. In contrast, he viewed behavior as a molar phenomenon, larger than what happens inside the cells of the nervous system:

Behavior...is more than and different from the sum of its physiological parts. Behavior, as such, is an "emergent" phenomenon that has descriptive and defining properties of its own. And we shall designate this latter as the *molar* definition of behavior. (Tolman, 1932, p. 7)

As a molar phenomenon, behavior's immediate descriptive properties appear to be those of: getting to or from goal-objects by selecting certain means-object-routes as against others and by exhibiting specific patterns of commerces with these selected means-objects. But these descriptions in terms of gettings to or from, selections of routes and patterns of commerces-with imply and define immediate, immanent purpose and cognition aspects in the behavior. These two aspects of behavior are, however, but objectively and functionally defined entities. (p. 21)

describe the event and yet can avoid what he calls the 'mentalist' implications, if you carefully explain that you don't mean to use the words in the ordinary sense, but merely as words which are convenient for the description of the objective event you observe.

Tolman was not the first to suggest that behaviorism was larger than its physiological roots,³³ but in defining behavior as purposive, he was faced with the two-fold challenge of (a) reintroducing the notions of purpose, goal, and motive without being dismissed as a mentalist, and (b) securing for his views a place apart from those of Thorndike. As has already been mentioned, the first he did by simply defining purpose as the persistence of behavior, and by merely stating that his use of the term ‘cognition’ was not mentalistic but behavioristic. More importantly, in accomplishment of the second challenge—finding a place of light in Thorndike’s shadow—his most valuable contributions to cognitive psychology were made, namely the phenomenon of latent learning and the development and use of cognitive maps. In reference to Thorndike’s theory he said,

I have quite a number of quarrels with this theory. I would like to say first, however, that it seems to me that this theory of Thorndike’s either in its present or in its earlier form, is *the* theory relative to which the rest of us here in America have oriented ourselves. The psychology of animal learning—not to mention that of child learning—has been and still is primarily a matter of agreeing or disagreeing with Thorndike, or trying in minor ways to improve upon him. Gestalt psychologists, conditioned reflex psychologists, sign-gestalt psychologists—all of us here in American seem to have taken Thorndike, overtly or covertly, as our starting point. And we have felt very smart and pleased with ourselves if we could show that we have, even in some very minor way, developed new little wrinkles of our own. (Tolman, 1932, p. 152)

Tolman’s first “wrinkle”—latent learning—refers to the type of learning that occurs through casual, non-goal-directed interaction with the environment. That which is learned in this way is not manifest until needed:

³³ Tolman notes Holt, Perry, Singer, de Laguna, Hunter, Weiss, Lashley, and Frost as offering alternative views to the Watsonian brand of behaviorism (Tolman, 1932, pp. 4, 8-10).

Let me recall again the facts of “latent learning.” During latent learning the rat is building up a “condition” in himself, which I have designated as a set of “hypotheses,” and this condition—these hypotheses—do not then and there show in his behavior. S’s are presented but the corresponding R’s do not function. It is only later, after a goal has been introduced which results in a strong appetite, that the R’s, or as I would prefer to say, the B’s, appropriate to these built-up hypotheses appear. (Tolman, 1938, p. 161)

As evidence of latent learning, Tolman (1948) cited experiments that were mostly “carried out by graduate students (or underpaid research assistants) who, supposedly,” he said, “got some of their ideas from me” (p. 189).³⁴ In each of these experiments it was found that when rats were allowed to explore a fourteen unit T maze for a period of a few days, without any reward of food in the goal box, they consistently showed a sudden drop in errors and time required to reach the goal box once food was discovered there,³⁵ matching or exceeding the performance of rats that had been trained in the customary behaviorist fashion, in which food was present in the goal box for the duration of the training.

³⁴ In *Purposive Behavior in Animals and Men*, Tolman (1932, p. 343) lists four specific experiments conducted by: Blodgett in 1929, Williams in 1924, Elliott in 1929, and Tolman and Honzik in 1930. The term “latent learning” comes from Blodgett.

³⁵ One might wonder what is meant by a sudden drop in errors and time required to reach the goal box if previously there was no reward. Why would the rats even go to the goal box? The answer is that in the process of exploring the maze the rats would eventually end up in the goal box. Once there, they were confined in the goal box for a period of two minutes, without food, and then returned to their cages. Some have argued that because the rats were removed from the maze and returned to their cages, “that reward was, in fact, not removed from the situation” Hergenhahn (1982, p. 307). Even though this may be true (as I personally believe is the case, based on the obvious perturbation I observed in the subjects of my own maze learning experiments to plot the learning curve of a hamster in a variety of maze configurations) there is no question that the rats showed a very sudden, and very significant decrease in errors and time in making their way to the goal box once it was discovered that food was to be found there. To use Tolman’s terms, the rats moved very purposely and directly to the goal box when a “more demanded goal-object” was present (Tolman, 1932, p. 48).

Results of these experiments provided evidence for the phenomenon of latent learning,³⁶ and simultaneously provided evidence against the law of effect, which evidence Tolman used to establish his position as an improvement upon Thorndike:

My second objection is that the theory as stated by Thorndike does not allow for the facts of “latent learning,” of the complementary phenomenon of a sudden shoot-up in errors when a goal is removed, and of the utilization of alternative habits under different motivations. (Tolman, 1932, p. 153)

Tolman also viewed the latent learning experiments as one type of experiment that provided evidence in favor of cognitive maps. In my review of his writings it has been somewhat difficult to pin down precisely his conception of cognitive map, given the religious efforts he has made to avoid any association with mentalism. However, in his most direct treatment on the topic, *Cognitive Maps in Rats and Men* (1948), he referred to cognitive maps as “something like a field map of the environment” that “gets established in the rat’s brain” and once established, is then employed by “intervening brain processes” in the selective attention to stimuli by the nervous system, and the execution of responses (p. 192). Even in making this definition, of course, Tolman abstracted himself away from and diminished any assumed association that the reader might make with mentalism by following it up with a metaphorical reference to a “central control room” and a qualifying term, “cognitive-like:”

³⁶ Latent learning was experimentally defined by Tolman as the sudden decrease in errors made in a maze when a reward was placed in the end-goal box, as compared to the number of errors made when there was no reward present. The complement of latent learning, also proved out by Tolman in maze experiments with rats, was that when the end-goal reward was removed, there was a sudden increase in errors, presumably because the rats were now looking elsewhere for the food.

The incoming impulses are usually worked over and elaborated in the central control room into a tentative, cognitive-like map of the environment. And it is this tentative map, indicating routes and paths and environmental relationships, which finally determines what responses, if any, the animal will finally release. (p. 192)

Tolman's vague, and someone inconsistent, use of terminology notwithstanding, it seems a fair assumption that Tolman's cognitive maps were, in fact, assumed by him to be contents of the mind. These cognitive maps were built up in latent learning maze experiments during non-rewarded trials. The rats were then presumed to use this knowledge to quickly navigate to the goal box, once they found food there, just as quickly—and with just as few errors—as rats that had been trained over many trials.

In addition to the experiments demonstrating latent learning, Tolman also cited four other types of experiments that provide evidence for cognitive maps. The second type, VTE, or Vicarious Trial and Error experiments, investigated the “hesitating, looking-back-and-forth, sort of behavior which rats can often be observed to indulge in at a choice-point before actually going one way or the other” (pp. 196-197). VTE experiments support the theory of cognitive maps by showing that “the animal's activity is not just one of responding passively to discrete stimuli, but rather one of the active selecting and comparing of stimuli” (p. 200).

The third type Tolman referred to as “Searching for the Stimulus” experiments. In these experiments rats were observed to, anthropomorphically speaking, “look around *after* the shock to see what it was that had hit them” (p. 201). It was found that rats who received a shock when attempting to eat out of a food cup set in front of a striped visual pattern, would avoid going near the cup, or even try to hide the cup and striped pattern with sawdust, even months after only one shocking encounter. In contrast, when the conditions of the experiment were modified so that the lights would briefly go out coincidental to the shock—during which time the pattern and food

cup dropped out of sight—a large percentage of the rats that were put back into the cage only 24 hours later showed no avoidance of the striped pattern. These experiments reinforced the notion of “the largely active selective character in the rat’s building up of his cognitive map” (p. 201).

The fourth type of experiment, the “Hypothesis” experiments involved a four-compartment discrimination box in which the correct door at each choice point (between boxes) could be determined by the experimenter to be left or right, light or dark, or a combination of these. By randomizing the 40 correct choices made in 10 runs of each day’s test, the problem became insoluble—meaning, there was no pattern or basis for decision that the rat could take advantage of to know in advance which of the doors was correct. It was found that rats in this condition began to systematically test the system, for example, by always choosing the door at the right, then giving up and always choosing the door on the left, or choosing all the dark doors, or choosing all the light doors, etc. These “relatively persistent, and well-above-chance systematic types of choice” (p. 202) were referred to by Krech (as cited by Tolman, 1948, p. 202) as hypotheses. Tolman viewed Krech’s hypotheses as being equivalent to what he had been calling cognitive maps, and noted that from the results of Krech’s experiments it appeared that cognitive maps “get set up in a tentative fashion to be tried out first one and then another until, if possible, one is found which works” (p. 202).

The fifth type of experiment was one of spatial orientation. Experiments of this type demonstrated that rats not only learn how to navigate a maze in order to obtain food in the exit box, but that they simultaneously develop a wider spatial map that includes more than just the specific trained paths. Evidence of this was reported as early as 1929 by Lashley when two of his rats after having learned an alley maze, “pushed back the cover near the starting box, climbed out and ran directly across the top to the goal-box where they climbed down in again and ate” (as

cited in Tolman, 1948, p. 203). Tolman also noted that other investigators have reported similar findings.

In a series of radial path experiments, Tolman, Ritchie, and Kalish (also cited in Tolman, 1948, p. 203) found that rats not only develop a narrow map of the correct route, but a very wide map of the overall layout. When the known path is blocked, this map enables them to circumvent the problem and return as close as possible to the point at which they last received food. It was shown that even when the maze was rotated by 180 degrees rats were able to return to the original point of food by turning in the opposition direction than that which was previously learned.

Another experiment, which provided evidence against Thorndike's law of effect, was Tolman's experiment with human subjects (introductory psychology students) that involved a punchboard maze, a metal stylus, a bell, and a shock (Tolman, Hall, & Bretnall, 1932, as cited in Leahey & Harris, 1997, p. 57). In this study students learned a punchboard maze by inserting a metal stylus into one of two holes, one of which was "correct" and one of which was "incorrect." The punchboard "maze" consisted of several pairs of holes. The students were required to pass through the maze repeatedly until they were able to do it without choosing a "wrong" hole. The students were divided into a variety of experimental groups, four of which were:

Bell-right—when the subject inserted the stylus into the correct hole of each pair, an electrical circuit closed and rang a bell.

Bell-wrong—when the subject inserted the stylus into the incorrect hole of each pair, the bell rang.

Bell-right-shock—when the subject chose the correct hole, not only did the bell ring, but the subject also received a painful electric shock through the stylus.

Bell-wrong-shock—when the subject chose the incorrect hole, not only did the bell ring, but the subject was shocked.
(p. 57)

The results of the experiment are quite interesting. First, the effect of the bell—supposedly a neutral stimulus with no reinforcing value—appeared to reinforce whatever response it followed, since both bell-wrong groups learned more slowly than the bell-right groups. Subjects in the bell-wrong group had trouble learning to choose the hole that did not ring the bell. Students in the shock groups faced a similar challenge:

Subjects in the bell-right-shock group were learning to receive shocks, not avoid them, as suggested by the law of effect. Indeed, their rate of learning was not significantly different from the bell-right group. On the other hand, the bell-wrong shock group was learning to avoid shocks, since for them every error resulted in a shock. But the shock did not make them learning faster; in fact, they were the slowest of all the groups. The shock seemed to act as an emphaziser that impeded learning rather than helped it. (p.58)

Leahey and Harris explained these results by citing an article entitled, "Reinforcement in Human Behavior" (W. K. Estes, 1982b), which describes every reinforcing event as having both an affective and a cognitive dimension. The affective, or emotional, dimension identifies the reinforcer as either pleasurable or painful. The cognitive dimension provides information about whether the response was correct or incorrect.

Tolman's experiment separated the affective and cognitive values of the reinforcers he used. A bell has no affective value by itself; it changes behavior solely by telling the subject he or she had chosen the correct move in the pegboard maze. In the shock-right groups, the affective value of the reinforcer was brought in conflict with its cognitive value. While the shock was painful, it told the subject that he or she had chosen the correct move. (Leahey & Harris, 1997, p. 58)

In *Determiners of Behavior at a Choice Point* (1938), Tolman attempted a theory of intervening variables to describe "why rats turn the way they do, at a given choice point in a

given maze at a given stage of learning” (p. 1). He believed that all factors determining the choice the rat would make at any point in the maze could be envisioned as a causal function of both *independent* variables and *intervening* variables.

The independent variables of the general model were of two types: environmental variables and individual difference variables. Tolman’s environmental variables were (a) maintenance schedule [M], (b) appropriateness of goal object [G], (c) types and modes of stimuli provided [S], (d) types of motor response required [R], (e) cumulative nature and number of trials [Σ (OBO)], and (f) pattern of preceding and succeeding maze units. The individual difference variables were (a) heredity [H]; (b) age [A]; (c) previous training [T]; and (d) special endocrine, drug or vitamin conditions [E]. He viewed these as “possible modifiers” (p. 8) between the independent variable and the dependent variable. Tolman presented this as a general model that he supposed to account for theories such as those of Hull and Thorndike. The difference between one theory and another, he said, was simply the intervening variables chosen by the theorist:

A theory, as I shall conceive it, is a set of “intervening variables.” These to-be-inserted intervening variables are “constructs” which we, the theorists, evolve as a useful way of breaking down into more manageable form the original [f_I function which relates independent variables to the dependent variable]....In place of [f_I], I have introduced a set of intervening variables, I_a , I_b , I_c , etc., few or many, according to the particular theory. (p. 9)

For his own theory, he defined the function, f_I , to consist of six intervening variables: (a) demand, (b) appetite, (c) differentiation, (d) skill, (e) hypotheses, and (f) biases. Each of these intervening variables was, by Tolman’s definition, a measurement of change in the corresponding independent variable while all the others are held constant. Unfortunately, what he

presented was, in his own words, an “oversimplified and incomplete version” of his theory “because [he had] not as yet completely thought the whole thing through.” (pp. 15-16). Because of this, much interpretation and assumption is required to take these concepts any further. Similarly, in one of the final chapters of *Purposive Behavior in Animals and Men* (1932), Tolman enumerated what he called, “The Laws of Learning, Envisaged by Purposive Behaviorism” (p. 372). Disappointingly, the title of the list held much more promise than the content of the list itself. Like much of Tolman’s writing, it was on the verge of saying something really important, but in the end said nothing much at all.

Just as Tolman’s writing is filled with concatenated terms (e.g., means-object, means-end-capacities, means-end-relation, alternativeness, roundaboutness, and food-demandingness) the ideas expressed in many of his promises-not-quite-fulfilled chapters seem to be nothing more than the concatenation of disparate ideas that have apparent but not actual value in providing truly useful perspective in learning. Still, his persistence to explore latent learning, cognitive maps, purpose behind behavior, and cognitive control in directing attention and behavior, served as a platform on which later cognitive research could be established, and thereby provided a valuable contribution to the emergence of cognitive learning theory. The legacy of his ideas is that they called into question the need for reinforcement in order to learn, and positioned the locus of control of action within the individual, who selects from a previously learned set of alternatives according to his needs at any given moment:

Our final criticism of the trial and error doctrine is that it is its fundamental notion of stimulus-response bonds, which is wrong. Stimuli do not, as such, call out responses willy nilly. Correct stimulus-response connections do not get “stamped in,” and incorrect ones do not get “stamped out.” Rather learning consists in the organisms’ “discovering” or “refining” what all the respective alternative responses lead to. And then, if, under the appetite-aversion conditions of the moment, the consequences of one of these alternatives

is more demanded than the others—or if it be “demanded-for” and the others be “demanded-against”—then the organism will tend, after such learning, to select and to perform the response leading to the more “demanded-for” consequences. But, if there be no such difference in demands there will be no such selection and performance of the one response, even though there has been learning. (Tolman, 1932, p. 364)

Insight Learning (Wolfgang Kohler – 1925). Another contribution that provides evidence of cognition in learning is the fascinating study reported by Kohler (1951) in his book entitled, *Mentality of Apes*. The study was conducted by Kohler off the coast of Africa at the anthropoid station maintained by the Prussian Academy of Science in Tenerife during the years 1913 to 1917. The majority of observations were made in the first six months of 1914 (p. 7). Kohler’s report on these experiments was published in 1917 in *Intelligenzprüfungen an Anthropoiden*. The English version, *The Mentality of Apes*, was published in 1925.

Anthropoids were selected as the subjects of Kohler’s experiments both because of their similarity to man in intelligence and behavior, but simultaneously—and more importantly—because of their subordinate state of intelligence, which makes it possible to observe in the act of learning that which is not possible when observing the human adult:

Even assuming that the anthropoid ape behaves intelligently in the sense in which the word is applied to man, there is yet from the very start no doubt that he remains in this respect far behind man, becoming perplexed and making mistakes in relatively simple situations; but it is precisely for this reason that we may, under the simplest conditions, gain knowledge of the nature of intelligent acts. The human adult seldom performs for the first time in his life tasks involving intelligence of so simple a nature that they can be easily investigated; and when in more complicated tasks adult men really find a solution, they can only with difficulty observe their own procedure. (Kohler, 1951, pp. 1-2)

Kohler operationally defined intelligence as the utilization of roundabout methods—“detours, roundabout ways, paths or routes, circuitous routes and indirect ways” (p. 11)—to overcome obstacles:

As experience shows, we do not speak of behaviour as being intelligent, when human beings or animals attain their objective by a direct unquestionable route which clearly arises naturally out of their organization. But we tend to speak of "intelligence" when, circumstances having blocked the obvious course, the human being or animal takes a roundabout path, so meeting the situation. (Kohler, 1951, pp. 3-4)

All of his experiments were set up in this way, the direct path to the objective—usually a banana—being blocked, but a roundabout way being left open. Kohler was careful to set his experiments so as to require something beyond the roundabout way a chimpanzee might take in its normal behavior:

No one expects a chimpanzee to remain helpless before a horizontal opening in a wall, on the other side of which his objective lies, and so it makes no impression at all on us when he makes as horizontal a shape as he can of himself, and thus slips through. It is only when roundabout methods are tried on the lower animals, and when you see even chimpanzees undecided, nay, perplexed to the point of helplessness, by a seemingly minor modification of the problem—it is only then you realize that circuitous methods cannot in general be considered usual and matter-of-course conduct. (Kohler, 1951, p. 13)

He also set the experiments in such a way as to be able to distinguish between chance behavior that brings the subject in contact with the objective, and genuine achievement:

As chance can bring the animals into more favourable spots, it will also occasionally happen that a series of pure coincidences will lead them from their starting-point right up to the objective, or at least to points from which a straight path leads to the objective. This holds in all intelligence tests (at least in principle: for the more complex the problem to be solved, the less likelihood is there that it will be solved wholly by chance); and, therefore, we have not only to answer the question whether an animal in an experiment will find the roundabout way (in the wider meaning of the word) at all, we have to add the limiting condition, that results of chance shall be excluded. (Kohler, 1951, p. 16)

The genuine achievement takes place as a single continuous occurrence, a unity, as it were, in space as well as in time; in our example as one continuous run, without a second's stop, right up to the objective. A successful chance solution consists of an agglomeration of separate movements, which start, finish, start again, remain independent of one another in direction and speed, and only in a geometrical summation start at the starting-point, and finish at the objective. The experiments on hens illustrate the contrast in a particularly striking way, when the animal, under pressure of the desire to reach the

objective, first flies about uncertainly (in zigzag movements which are shown in Fig. 4a but in not nearly great enough confusion), and then, if one of these zigzags leads to a favourable place, suddenly rushes along the curve in one single unbroken run. (Kohler, 1951, pp. 16-17)

To separate problem solving behavior from normal or chance behavior, Kohler designed series of experiments that required the use of implements such as strings, sticks and boxes in order to obtain the objective. In these experiments, the banana could not be reached by making a detour, or by the body of the animal being adapted to the shape of its surroundings, but instead required the chimpanzee to make use of available objects as intermediaries. For example, in one series of experiments food was placed outside of the animal's reach, but a string was fastened to it, the end of which was placed within reach. In this simple case, none of the animals ever hesitated to pull the string to draw the food to them (Kohler, 1951, p. 26). In a more complicated variation, multiple strings were used, sometimes crossing each other, with only one of the strings attached. In these experiments no conclusion could be drawn as to whether or not the chimpanzee actually recognized the "right" string or not. Consistently the animal would take a position behind the bars of the cage as close as possible to the objective, and begin pulling in rapid succession, starting with the closest string, until the food was obtained. In another variation, where only one string was used, but was not attached to the food, only placed in a position closer or farther from it, it was found that the animal would always pull the string if it visibly touched the objective. If the distance between the objective and the end of the string was wide, the chimpanzee would generally not pull the string, unless he was interested in the string itself, or wanted to use it in some other way (p. 30).

In yet another series of experiments, the objective was not connected in any way with the animals' room but was only obtainable by means of pulling it in with a stick. Kohler's

description of one of his subjects, Tschego, is representative of the pattern he observed with other chimpanzees:

Tschego first tries to reach the fruit with her hand; of course, in vain. She then moves back and lies down; then she makes another attempt, only to give it up again. This goes on for more than half-an-hour. Finally she lies down for good, and takes no further interest in the objective. The sticks might be non-existent as far as she is concerned, although they can hardly escape her attention as they are in her immediate neighbourhood. But now the younger animals, who are disporting themselves outside in the stockade, begin to take notice, and approach the objective gradually. Suddenly Tschego leaps to her feet, seizes a stick, and quite adroitly, pulls the bananas till they are within reach. In this maneuver, she immediately places the stick on the farther side of the bananas. She uses first the left arm, then the right, and frequently changes from one to the other. She does not always hold the stick as a human being would, but sometimes clutches it as she does her food, between the third and fourth fingers, while the thumb is pressed against it, from the other side. (Kohler, 1951, pp. 31-32)

Another of Kohler's examples clearly demonstrated how knowledge of the lay of the land known beforehand might be used to plan an indirect circuit through it:³⁷

One room of the monkey-house has a very high window, with wooden shutters, that looks out on the playground. The playground is reached from the room by a door, which leads into the corridor, a short part of this corridor, and a door opening on to the playground. All the parts mentioned are well known to the chimpanzees, but animals in that room can see only the interior. I take Sultan with me from another room of the monkey-house, where he was playing with the others, lead him across the corridor into that room, lean the door to behind us, go with him to the window, open the wooden shutter a little, throw a banana out, so that Sultan can see it disappear through the window, but, on account of its height, does not see it fall, and then quickly close the shutter again (Sultan can only have seen a little of the wire-roof outside). When I turn round Sultan is already on the way, pushes the door open, vanishes down the corridor, and is then to be heard at the second door, and immediately after in front of the window. I find him outside, eagerly starching underneath the window; the banana has happened to fall into the dark crack between two boxes. Thus not to be able to see the place where the objective is, and the

³⁷ cf. Tolman's notion of cognitive maps. Note also that Kohler's experiments were published prior to Tolman's and that Tolman, as evident by his many references to Kohler in *Purposive Behavior in Animals and Men* (1932), was well aware of Kohler's experiments.

greater part of the possible indirect way to it, does not seem to hinder a solution; if the lay of the land be known beforehand, the indirect circuit through it can be apprehended with ease. (Kohler, 1951, pp. 20-21)

Kohler also found that an increase in motivation could be used to help the tiring chimpanzee persist and succeed:

The improvement of the objective by the addition of further items is a method which can be employed over and over again with success when the animal is obviously quite near to a solution, but, in the case of a lengthy experiment, there is the risk that fatigue will intervene and spoil the result. (pp. 42-43)

Some of the most well-known experiments in the study were those involving boxes, which the animals must use in order to obtain access to an objective fastened high above the ground and unobtainable by any circuitous routes. In setting up these experiments Kohler noted that “the possibility of utilizing old methods generally inhibits the development of new ones” (p. 39) and directed that all sticks should be removed before experiments with boxes were conducted. One such experiment is described as follows:

The six young animals of the station colony were enclosed in a room with perfectly smooth walls, whose roof—about two metres in height—they could not reach. A wooden box (dimensions fifty centimetres by forty by thirty), open on one side, was standing about in the middle of the room, the one open side vertical, and in plain sight. The objective was nailed to the roof in a corner, about two and a half metres distant from the box. All six apes vainly endeavored to reach the fruit by leaping up from the ground. Sultan soon relinquished this attempt, paced restlessly up and down, suddenly stood still in front of the box, seized it, tipped it hastily straight towards the objective, but began to climb upon it at a (horizontal) distance of half a metre, and springing upwards with all his force, tore down the banana. About five minutes had elapsed since the fastening of the fruit; from the momentary pause before the box to the first bite into the banana, only a few seconds elapsed, a perfectly continuous action after the first hesitation. Up to that instant none of the animals had taken any notice of the box; they were all far too intent on the objective; none of the other five took any part in carrying the box; Sultan performed this feat single-handed in a few seconds. (pp. 39-40)

Not all of the apes employed the boxes so quickly. For example, Koko took several weeks to learn to use the box (Kohler, 1951, pp. 39-45). However, once he figured it out, and successfully obtained the banana several times using the box as a platform, he would “turn towards the box and seize it as soon as anyone came in sight carrying edibles” (p. 45).

Kohler’s (1951) experiments also included situations in which the objective was obtained through use of a ladder or box brought in by the ape from outside the room in which the objective had been hung (p. 51); situations in which the apes positioned and climbed swinging doors to reach the objective (pp. 53-57); and even situations in which the apes used other apes, their keeper, or the observer as a means to reach the objective (p. 48). There were also experiments in which the apes could only reach the fruit by moving a large box (pp. 59-66), or by detouring from their purpose to obtain a stick, a piece of wire, a stone, or a rope that can be used as a tool (pp. 101- 119). In some situations the apes had to remove stones from boxes to make them light enough to move (pp. 119-120) or connect two short sticks together to make one stick long enough to reach the banana (p. 125). Problems were also set in which the apes must stack multiple boxes on top of each other (pp. 135-154), and combine this with the use of a reaching stick in order to get the fruit.

The purpose behind all of Kohler’s experiments was to determine whether or not apes “behave with intelligence and insight” and “to ascertain the degree of relationship between anthropoid apes and man” (1951, p. 1). His conclusion was that chimpanzees do, in fact, “manifest intelligent behavior of the general kind familiar in human beings,” so long as the experimental test are carefully designed to include only those limits of difficulty and functions within which “the chimpanzee *can possibly* show insight” and cautioned that “in general, the

experimenter should recognize that every intelligence test is a test, not only of the creature examined, but also of the experimenter himself” (p. 265).

Cognitive Information Processing (Atkinson & Shiffrin – 1968). The ideas of Ebbinghaus, Tolman and Kohler represent early foundations of cognitive research and cognitive theory that were influential in opening the way for broad acceptance of a more general theory of cognitive learning. Leahey and Harris (1997, p. 104) cite the three-stage, multi-store model of memory proposed by Atkinson and Shiffrin (1968)³⁸ as laying the ground work for this theory. Atkinson (in Izawa, 1999) described the initial realization of the three stage model and the academic context of this effort as follows:

An invitation to contribute a chapter to *Psychology of Learning and Motivation* provided an opportunity to pull the various empirical and theoretical strands together into a larger framework. In the process, Shiffrin and I realized that the short-term buffer process that we were using in our various models was merely a stand-in for a more complicated set of processes representing short-term memory, leading us to broaden the conception of short-term memory to “control processes,” a term standing for “active memory” or “working memory.” This conception in turn allowed us to put together a theoretical framework with relatively autonomous sensory processing, controlled processing in short-term memory, and a permanent long-term memory upon which control processes could operate to produce retrieval. The field was obviously ready to embrace this approach, and the publication of the chapter seemed to act like the nucleus that causes a solution in delicate equilibrium to precipitate. (p. x)

Atkinson attributed the success of the model to “more than just a matter of a publication arriving on the scene at a propitious moment” and rather because it provided a good “quantitative fit” to “a wide array of experimental paradigms and conditions” (Izawa, 1999, p. x). Not many

³⁸ Atkinson first met Shiffrin in 1964 while serving on the faculty at Stanford. At the time he was working on mathematical models of memory, using a computer-controlled system to conduct experiments. Their collaboration began when Shiffrin’s graduate advisor, Gordon Bower, left on sabbatical and asked Atkinson to take over as Shiffrin’s research advisor.

years after the publication of their chapter, just as Skinner and radical behaviorism proved to be the star of the behavioral stage, cognitive learning theory came to be dominated by one central model based on the ideas of Atkinson and Shiffrin. This model is commonly referred to as the information processing model.³⁹

The information processing model has three major components (Eggen & Kauchak, 1999, pp. 243-244):

1. Information stores – repositories used to hold information. Three types of storage are assumed: sensory, short-term (working), and long-term.
2. Cognitive processes – intellectual actions that transform information and move it from one store to another. Processes include: attention, perception, rehearsal, encoding, and retrieval.
3. Metacognition – knowing about and having control over cognitive processes; a form of self-regulation. Metacognition controls and directs the processes that move information from one store to another.

In this model of memory, a depiction of which can be found in Eggen and Kauchak (1999, p. 244), new information is assumed to flow from left to right, entering through the senses and moving through the processes of attention, perception, rehearsal, and encoding into long term memory, where it is then available for later retrieval and use.

Information from the environment is temporarily stored in sensory memory so that it can be selectively attended to—i.e., brought into short term (or working) memory—and further

³⁹ The review of the Information Processing Model given here is based primarily on the overviews by Bruner, Goodnow and Austin (1972), Driscoll (2000), Eggen and Kauchak (1999; 2007), and Leahey and Harris (1997).

processed. Information in sensory memory decays rapidly and disappears in only a few seconds if it is not transferred into working memory.

Strong evidence supporting the existence of sensory memory was presented by Sperling (1960) when he demonstrated that subjects were able to consistently recall about 75 percent of 12 letters arranged in a 3x4 matrix and flashed on screen for only 50 milliseconds. Using a “partial-report” method, subjects were not told in advance which portion of the matrix to attend to, but instead were signaled after the presentation by a high, middle, or low tone to report only the top, middle, or bottom line of the matrix.

Sperling also found that decay of information brought in through the visual system—in cases where no further attention and processing is involved—is complete in one second or less. He replicated his study with the auditory system and found that decay took place in under four seconds. More recent research suggests that it may last as long as ten seconds (Samms, Hari, Rif, & Knuutila, 1993, as cited in Leahey & Harris, 1997, p. 107). Regardless of the exact number, however, it is well known that sensory memory does not persist for more than a very brief period. This temporary trace is sufficient to enable the aggregation of fragmented images (for visual information) and echoes (for auditory information) into meaningful units that can then be processed further in working memory, but short enough to prevent clutter and confusion. Leahey and Harris (1997) expressed their belief that the “fact that information decays so rapidly from sensory memory is actually an adaptive feature of our information-processing system,” and that it prevents “double images in the visual system or confusing echoes in the auditory system” (p. 107).

Sensory information selected for further processing is brought into working memory through attention and perception (or pattern recognition).⁴⁰ Attention has been conceptualized as a “filter” that selects from among different information input “channels” (Broadbent, 1958); a “tuner” that selectively attenuates, or raises the thresholds for accepting signals from non-relevant or non-interesting sources (Treisman, 1960); and as “mechanisms that control the significance of stimuli” through the allocation of limited resources or capacity (Kahneman, 1973, p. 2).⁴¹ Attention can be thought of as having three dimensions: (a) voluntary vs. involuntary, (b) locus of interest, and (c) intensity.

Although attention may be voluntary (conscious) or involuntary (sub- or pre-conscious), cognitive psychologists have generally been most interested in voluntary attention, in which a subject attends to particular stimuli because they are relevant to a task he has chosen to perform. Attention may also be described in terms of the locus of interest—e.g., inputs from a particular source, targets of a particular type, a particular attribute of objects, or outputs in a particular category (Treisman, 1969, as cited in Kahneman, 1973, p. 3). Whether voluntary or involuntary, and regardless of focus, attention may also vary in intensity, or level of arousal. “Collative properties”⁴² of stimuli, such as novelty, complexity, and incongruity cause some stimuli to be

⁴⁰ Eggen and Kauchak (1999, p. 256) use the term “perception,” defining it as “the process by which people attach meaning to their experiences.” Leahey and Harris (1997, p. 113) emphasize “pattern recognition” and define it as the process by which we “recognize environmental stimuli as exemplars of concepts already in memory.”

⁴¹ Kahneman’s *Attention and Effort* (1973) provides an excellent review of the study of attention.

⁴² Berlyne introduced the term “collative properties” in 1960 to describe “the effects of comparisons among elements which are presented either simultaneously or in succession” (Cupchik & Berlyne, 1979, p. 94). Collative properties refer to the structural relations between individual elements in a stimulus. For example, in a work of art the individual elements might be the “colour, texture, and medium of a visual work, the tones of a musical passage, or the words and rhyme of a poem” (p. 93). The collative properties would include “the degree of similarity or difference among the elements and intercorrelations among them” (p. 93).

more arousing than others (Cupchik & Berlyne, 1979; Berlyne, 1951, 1960, and 1970, as cited in Kahneman, 1973, p. 3).

In Kahneman's (1973) capacity or effort model of attention "transient variations in the effort a subject invests in a task determine his ability to do something else at the same time" (p. 4). When attention is voluntary the level of intensity corresponds to effort rather than to mere wakefulness or alertness. Ulric Neisser, whose theoretical contributions will be discussed further under our review of constructive learning theory, followed in the lead of the Gestalt theorists' notion of autochthonous⁴³ forces, and emphasized "pre-attentive" processes that "produce the objects which later mechanisms are to flesh out and interpret" (Neisser, 1967, p. 86). This view of "pre-attentive" processes resolves, in part, the apparent conflict between the contradictory observations that (a) "man often performs several activities in parallel, such as driving and talking, and apparently divides his attention between the two activities" but, (b) "when two stimuli are presented at once: often, only one of them is perceived, while the other is completely ignored; if both are perceived, the responses that they elicit are often made in succession rather than simultaneously" (Kahneman, 1973, p. 5). Kahneman's resolution to this conflict is a model of capacity, in which total capacity of attention may be apportioned among multiple potential sources of input or activity. In his model, capacity of attention is finite and will be consumed more by some activities than others since "the ability to perform several mental activities concurrently depends, at least in part, on the effort which each of these activities demands when

⁴³ "Autochthonous Gestalt: A perceptual pattern induced by internal factors rather than by external stimulus" (Corsini, 1999, p. 83). "Autochthonous idea (E. Bleuler) A thought that originates within the mind, usually from an unconscious source, yet appears to arise independently of the person's stream of consciousness, such as fantasies, dreams, delusions, inspirations, insights as well as repetitious thoughts of obsessive-compulsive individuals.

performed in isolation” and “not all activities of information-processing require an input of attention” (p. 9). Schneider and Shiffrin (1977) described the distinction between activities that demand attention and those that do not as a difference of controlled vs. automatic processes.⁴⁴

Automatic processing is learned in long-term store, is triggered by appropriate inputs, and then operates independently of the subject's control. An automatic sequence can contain components that control information flow, attract attention, or govern overt responses. Automatic sequences do not require attention, though they may attract it if training is appropriate, and they do not use up short-term capacity. They are learned following the earlier use of controlled processing that links the same nodes in sequence. In search, detection, and attention tasks, automatic detection develops when stimuli are consistently mapped to responses; then the targets develop the ability to attract attention and initiate responses automatically, immediately, and regardless of other inputs or memory load.

Controlled processing is a temporary activation of nodes in a sequence that is not yet learned. It is relatively easy to set up, modify, and utilize in new situations. It requires attention, uses up short-term capacity, and is often serial in nature. Controlled processing is used to facilitate long-term learning of all kinds, including automatic processing. In search, attention, and detection tasks, controlled processing usually takes the form of a serial comparison process at a limited rate. (pp. 51-52)

To summarize, attention may be voluntary or involuntary, focused on one or more sources of input or tasks either simultaneously or alternating serially, varied in level of intensity, and is of limited capacity. Sensory information may be brought into working memory when an individual chooses to attend to it, or when it simply catches his attention. While he is only able to attend to a limited amount of information, automaticity enables him to engage in multiple intellectual activities simultaneously.

The next step in the information processing model is perception. Through the process of perceiving, sensory input becomes meaningful. As we perceive, we recognize either familiar

⁴⁴ Neisser (1967) referred to “responses that can also become preattentive with sufficient practice” as “automatisms” (p. 101).

patterns or novel entities. Hoffding (1891) described pattern matching as the attachment of an input sensation to consciousness:

Whatever states and farther effects it may be able to call up afterwards, the first condition is that there shall be an instinctive recognition, in other words that the sensation shall have a point of attachment in consciousness. This point...then forms the starting-point of further operations. (p. 153)

Neisser (1967) elaborated on Hoffding's view, calling it out as the missing step in theories of the association of ideas:

To say that the sight of bread gives rise to the idea of butter "by virtue of previous association," as was (and is) so commonly assumed, is to miss a crucial step. The present sight of bread, as a stimulus or a perceptual process, is not generally associated with butter; only stored memories of bread are associated in this way. Hence we must assume that the present event is somehow identified as bread first, i.e., that it makes contact with "memory traces" of earlier experiences with bread. Only then can the preexisting association be used. Association cannot be effective without prior pattern recognition. (p. 50)

Pattern recognition models are generally grouped under three classes: (a) template matching, (b) prototypes, and (c) feature analysis (Leahey & Harris, 1997, p. 114). Template matching is perhaps the most intuitive of the three models. This model assumes that incoming sensory images are compared against previously stored mental copies that serve as exact-match templates. This model has been criticized for lack of plausibility, i.e., because of inefficient storage and search time to determine a match. Under the second model, the prototype model, it is assumed that only an abstracted general instance is stored rather than an enormously large number of exact-match templates. The third model, feature analysis, takes the approach that rather than templates or even prototypes, what is stored are specific perceptual features of sensory input. Feature profiles extracted from sensory input are matched with existing profiles in

memory by identifying features that are shared in common. The larger the number of common features the more likely the match.

Working memory, “variously called short-term memory, short-term store, working memory, immediate memory active memory, or primary memory” (Eggen & Kauchak, 1999, p. 123), is limited in capacity and is subject to relatively rapid decay. One effective strategy that can be used to extend the amount of information held in working memory is chunking (Miller, 1956). *Chunking* is a process of recoding multiple bits of information into a meaningful representation that contains the same amount of information, but takes up fewer slots⁴⁵ in memory. Driscoll (2000, p. 89) gave the example of recoding seventeen individual letters (JFKFBIAIDSNASAMIT) into five meaningful acronyms (JFK, FBI, AIDS, NASA, and MIT), thereby reducing the number of chunks from seventeen to five. Leahey and Harris (1997) provided an example of using mental visualization to chunk three bits of information, the words *rabbit*, *hat*, and *hamburger*, into one bit of information in the form of a coherent image of “a rabbit wearing a baseball cap and chomping on a Big Mac” (p. 124). In Miller’s original study (1956), subjects chunked streams of binary digits into their decimal or octal equivalents (for example, 10 becomes 2, 1010 becomes 10, 0111 becomes 7, 101000 becomes 20, etc.).

⁴⁵ From Leahey and Harris (1997, p. 123):

The metaphor of a series of slots (called the rehearsal buffer) in working memory has been useful. As the central executive processes new material and/or old material retrieved from long term memory, these slots are filled one-by-one until there is no remaining space in the rehearsal buffer. Once this happens, in order for new material to be added to working memory, something currently there must be “bumped,” either through forgetting or encoding and transfer to long-term memory, out of immediate consciousness. This slot metaphor reflects the intuitive feeling we often have that our mind is so full that there is no room for even one more piece of information without something already there being pushed out.

Automaticity is an important factor that determines the effectiveness of chunking. To produce a significant savings the re-encoding process itself needs to be automatic:

The recoding schemes increased their span for binary digits in every case. But the increase was not as large as we had expected on the basis of their span for octal digits. Since the discrepancy increased as the recoding ratio increased, we reasoned that the few minutes the subjects had spent learning the recoding schemes had not been sufficient. Apparently the translation from one code to the other must be almost automatic or the subject will lose part of the next group while he is trying to remember the translation of the last group. (Miller, 1956, p. 94)

The effort expended in learning the recoding scheme to a point of automaticity, however, may be well worth the investment, not just for parlor tricks, but for useful, everyday tasks:

It is a little dramatic to watch a person get 40 binary digits in a row and then repeat them back without error. However, if you think of this merely as a mnemonic trick for extending the memory span, you will miss the more important point that is implicit in nearly all such mnemonic devices. The point is that recoding is an extremely powerful weapon for increasing the amount of information that we can deal with. In one form or another we use recoding constantly in our daily behavior. (Miller, 1956, pp. 94-95)

Through chunking we are able to extend the capacity of our working memory. Through maintenance rehearsal we are able to prevent the rapid decay of information in working memory. *Maintenance rehearsal* is “the process of repeating information over and over, either aloud or mentally, without altering its form” (Eggen & Kauchak, 1999, p. 257). A household example of maintenance rehearsal is when we repeat a phone number silently or out loud until we are able to write it down or dial it.

Maintenance rehearsal may be adequate for information that need only be retained temporarily, but it is not the best strategy for more permanent encoding. For long-term encoding to be successful, information must become meaningful to the learner through organization and elaboration. Organization is “the process of clustering related items of content into categories or

patterns” (Eggen & Kauchak, 1999, p. 259). Research evidence suggests that we naturally organize information as we encode it in long term memory. During a study in which subjects were asked to list items in specified categories Bousfield and Sedgewick (1944) discovered that responses tended to cluster according to various types of categorical and spatial contiguity—for example, “groups of domesticated animals, commonly exhibited species, and various zoological phyla” (p. 153). Although this phenomenon was noted in their report, clustering of categories was not the focus of their study. As a follow up, Bousfield (1953) later presented a technique for quantifying such clustering, the theoretical significance of which is “a means for obtaining additional information on the nature of organization as it operates in the higher mental processes” (p. 229). His experiment demonstrated that “subjects, when given, a list of randomly arranged items will in their recall show a greater-than-chance tendency to group the items in clusters containing members of the same general category” (p. 237). It has also been found that repetition plays an important role in the organization of new material, that “subjective organization increases with repeated exposures and recall of the material, and that there is a positive correlation between organization and performance” (Tulving, 1962, p. 352).⁴⁶ In other words, with repeated exposure comes greater organization, and with greater organization comes higher levels of performance.

Another important factor of encoding is the context in which it takes place. According to the principle of encoding specificity (Thomson & Tulving, 1970), the probability of later recall depends on the similarity of context during initial learning and the context during later recall.

⁴⁶ Tulving’s study is an extension of Bousfield’s work, taking it “from on trial recall and experimentally organized materials...to a learning situation, with several successive trials, and experimentally unorganized materials” (Tulving, 1962, p. 352).

Context is defined by the material being learned, the mental set derived from the material, the environmental surroundings, and the mood or prevalent emotion and feeling of the individual during learning and retrieval (Leahey & Harris, 1997, pp. 147-149).

Craik and Lockhart (1972, as cited in Bower & Hilgard, 1981, p. 434) distinguished between maintenance rehearsal (“superficial recycling” of the material) and elaborative rehearsal. The organization and encoding of new information into long-term memory is facilitated by elaborative rehearsal. Elaborative rehearsal is “any form of rehearsal in which the to-be-remembered information is related to other information” (Bruning et al., 2004, p. 67). New information becomes meaningful when it is understood in the context of existing knowledge or when it becomes sufficiently well known so as to be familiar, easily recalled, and useful. Elaborative encoding strategies include mediation, imagery, mnemonics, guided questioning, and deep processing.

Mediation “involves tying difficult-to-remember information to something more meaningful” (Bruning et al., 2004, p. 67). For example, Montague, Adams, and Kiess found that subjects were better able to recall pairs of nonsense syllables such as RIS-KIR when they were tied to a natural language mediator such as *race car* (as cited in, Bruning et al., 2004, p. 68).

Imagery is the encoding of simple or complex information, such as the meaning of the German word *das buch* or the concept of *abiogenesis*, respectively. In the first case, a single mental picture of an old leather-bound bible with yellowed pages and the smell of old print will do nicely. In the second case, a more elaborate, complex, and detailed picture, or possibly an entire *set* of images might be needed—such as one representing simple chemicals, one representing polymers, one representing the replication of polymers, one for the hypercycle, one for the protobiont, and finally, one for bacteria—all tied together by a summative mental image

containing a directed graph with the words “simple chemicals,” “polymers,” “replicating polymers,” “hypercycle,” “protobiont,” and “bacteria” linked by arrows.

Mnemonics involve attaching new information to well-known information—in possibly a very artificial way⁴⁷— to facilitate elaboration, chunking or retrieval from memory. Mnemonic techniques include the use of rhymes such as “*i* before *e* except after *c*,” sayings like “thirty days has September, April, June, and November;” gestures as in the “right-hand rule” in physics to demonstrate the flow of electrical current in a magnetic field; and imagery (Bruning et al., 2004, p. 69). Common mnemonic methods include (a) the peg method, in which “students memorize a series of ‘pegs’ on which to-be-learned information can be ‘hung;’” (b) the method of loci, in which new information is mentally attached to familiar or present locations; (c) the link method, in which an image is formed for each item in a list to be learned and the image is pictured as interacting with the next item on the list (e.g., one can remember to take the dog to the groomer, pick up a roasted chicken for Sunday dinner, mail a letter, and pick up some two-inch light fixture screws by imagining the dog chasing a chicken with a letter in its beak and wearing two-inch screws as earrings); (d) stories, constructed from a list of words to remember; (e) the first-letter method, using the first letters of words to be learned to construct acronyms; and (f) the keyword method, which involves identifying a keyword that sounds like the vocabulary word to be remembered and an imagery link in which the keyword is imagined to interact with the word to be remembered (e.g., a 6th grade student remembers the word “captivate” by selecting the

⁴⁷ Mnemonics attachment is often, perhaps typically, made where there is no intrinsic relation between the new information and what it is being attached to. For example, using the method of loci one might mentally place items to be purchased at the grocery store in various locations around one’s home. Although you would not normally find an oversized stick of butter melting on the keys of your piano and running down into the cracks, this appalling visual image is very memorable.

keyword “cap,” and visualizing their Uncle Bob who tells fascinating stories and always wears a cap (Bruning et al., 2004, p. 73)). Leahey and Harris (1997) summarized the value of mnemonics in learning as follows:

Mnemonics take advantage of our natural information-processing tendency to impose structure and organization on material that we process. It is natural, not exceptional, to try to make meaningful something that does not have much meaning. The more links we can establish between the material we are trying to learn and information already in our long-term memory, the more potential avenues we have available to retrieve the information later. (p. 145)

Once encoded, information can become more permanently affixed in long-term memory through elaborative rehearsal. Methods for promoting elaborative rehearsal include schema activation, guided questioning, and deep processing (Bruning et al., 2004, pp. 67-77). Schema activation refers to the activation of students’ relevant existing knowledge prior to engaging in a learning activity. The fundamental assumption of methods based on the idea of schema activation is that “students at any age will have some relevant knowledge to which new information can be related” (p. 75). For example, in a pre-school lesson on living things the children might be asked to describe animals and plants they have observed or interacted with. They might also be asked to describe objects that don’t eat, breath, or move. These examples will then serve as anchoring points or exemplars of living vs. non-living objectives.

Another method to promote elaborative rehearsal is that of teacher, self, or peer *guided questioning* (Bruning et al., 2004, p. 76). Using this method, questions are asked and answered as new material is presented. King (1994) found that questions which prompted “comparing and contrasting, inferring cause and effect, noting strengths and weaknesses, evaluating ideas, explaining, and justifying” (p. 340) were especially effective.

Elaborative rehearsal is also promoted through *deep processing*. According to Craik and Lockhart (1972) the ease with which items are recalled from memory depends on what learners do as they encode new information. Information processed at only a superficial or surface level will be less well remembered than information that is analyzed or processed at a much deeper level.⁴⁸ Bruning, et al. (2004) gave an example to contrast shallow versus deep processing:

These two levels of processing may be seen in two common classroom assignments. In the first, students are asked to underline a set of vocabulary words in a brief essay. In the second, students are asked to read the same essay and be prepared to tell the class about it in their own words. If the students follow directions, the first assignment is a clear example of shallow processing; all they have to do is find the words in the essay and underline them. To perform this task, students do not have to think about the meaning of the essay and perhaps not even with the meaning of the words. Not surprisingly, if we tested these students for their understanding of the contents of the essay, the odds are they would remember relatively little.

In contrast, if the students who were asked to explain the essay to their classmates followed instructions, we would likely see a very different outcome. Putting an essay into one's own words requires thinking about the meaning of the content. In so doing, the students would have had to carefully analyze and comprehend the material. If we were to surprise these students with a test measuring their understanding of the essay, they almost certainly would remember far more of its contents than could the group that underlined vocabulary words. (p. 77)

The third type of storage in the Atkinson and Shiffrin model (1968) is long-term memory.

Long-term memory was distinguished from sensory and short-term memory as follows:

The last major component of our system is the long-term store. This store differs from the preceding ones in that information stored here does not decay and become lost in the same manner. All information eventually is completely lost from the sensory register and the short-term store, whereas information in the long-term store is relatively permanent (although it may be modified or rendered temporarily irretrievable as the result of other

⁴⁸ Craik and Tulving (1975) later indicated that *elaboration* or *spread* might be a better descriptive term than *depth*.

incoming information). Most experiments in the literature dealing with long-term store have been concerned with storage in the a-v-l mode [auditory-verbal-linguistic], but it is clear that there is long-term memory in each of the other sensory modalities, as demonstrated by an ability to recognize stimuli presented to these senses. There may even be information in the long-term store which is not classifiable into any of the sensory modalities, the prime example being temporal memory. (pp. 17-18)

In regards to the form of long-term memory, or *how* information is stored, Atkinson and Shiffrin (1968) generally accepted the prevailing view that memories are stored as a *trace*, in varying sense modalities, and of varying strength (pp. 25-30). The strength of the trace depends on the amount of rehearsal, which both increases “the length of stay in short-term store (during which time a trace is built up in LTS)” and gives “coding and other storage processes time to operate” (p. 35).

While the sensory trace model of memory gives an account for basic memory representation, others have been interested in accounting for relationships between knowledge units in memory and have developed *network models*, *feature comparison models*, *connectionist* and *parallel distributed processing models*, and *dual systems models*. The earliest, and best known hierarchical network model is the semantic network model of Collins and Quillian (1969). In this model, the structure of memory is a branching network of subordinate and superordinate nodes, with each node representing a concept such as *bird*. Attributes of the node are stored in the node itself and apply to all nodes below it in the hierarchy. For example, *has wings*, applies to both CANARY and OSTRICH, but not to ANIMAL or FISH.

Collins and Quillian provided experimental support for the semantic network model by testing the speed at which subjects were able to verify sentences such as “canary is yellow” or “A canary is an animal.” To verify the first sentence only one level of dereferencing is required (i.e., having located canary, the subject need only search first order attribute connections to

verify the truth of the statement). To test the second, two levels of dereferencing are required, verifying first that a canary is a bird, and second that a bird is an animal. Collins and Quillian confirmed the predicted timing of such operations, but also received some unexpected results. Subject were able to identify that a canary was a bird more quickly than they were able to identify that a penguin was a bird, suggesting that the model did not account for typicality of concepts. The more typical, or perhaps the more familiar, the concept, the more quickly statements about the concept are able to be verified.

The inconsistency in access times for typical vs. non-typical concepts was addressed by feature comparison models of memory that assume concepts in memory are not stored in hierarchical networks but instead represented by sets of defining features. Building on Meyer's (1970) two-stage model for comparing attributes to verify statements of the form "*ALL S ARE P*" and "*SOME S ARE P*," Smith, Shoben and Rips (1974) presented a feature model for making semantic decisions. Using Meyer's model, the statement *All robins are birds* would be evaluated as follows:

Verification of the proposition *A robin is a bird* is based on a comparison process that determines whether every attribute of bird is also an attribute of robin. Note that this model determines semantic classification correctly only if the attributes associated with bird are necessary and sufficient criteria for category membership. Other attributes which we characteristically associate with bird (e.g., that they can fly) cannot be included in this set of attributes, for otherwise a proposition like *A penguin is a bird* will be incorrectly disconfirmed.... In the first stage of Meyer's model, a set is retrieved which contains the names of all categories that have some members in common with the category of the predicate noun (bird in the previous example). Then this set of intersecting categories is searched for the subject noun.... If the subject noun is found in this set of intersecting categories, the second-stage attribute comparison is executed. Thus, structurally, the model represents each lexical item in two different ways—by the names of the item's intersecting categories and by the item's defining attributes—while processing involves comparison mechanisms that operate on this information. (E. E. Smith et al., 1974, p. 215)

In the model proposed by Smith et al., semantic information is represented only by semantic features (rather than both nouns and attribute sets). Their model also considered both characteristic and defining features, and proposed a two-stage comparison process in which the second stage will only be executed if the result of the first stage—a measure of similarity calculated by comparing all features, both characteristic and defining—simultaneously falls below a predetermined level of confidence, above which the statement could be classified as true, and above a second predetermined level of confidence, below which the statement could be classified as false. In the second stage only defining features of the category (e.g. bird) are compared with features of the instance (e.g. robin) and a positive response can be made if: “(a) each defining dimension of the category is also a defining dimension of the instances, and (b) the particular values (features) on these dimensions which the instance possesses are within the range of allowable values for the category” (p. 223).

A third type of memory model is the *connectionist* or *parallel distributed processing model*. This model is also a type of network model, but it is not tied to linguistic concepts. In the connectionist network model of memory, each node is a generic processing unit, and the form of the representation in memory is “not a passive recording or data structure but rather a pattern of activation, either excitatory or inhibitory, and cognitive processing occurs through the propagation of activation patterns” (Leahey & Harris, 1997, pp. 140-141). Knowledge is not encoded in a particular location in the brain, but is made up of connection strengths between nodes. Learning is the process of strengthening or weakening these connections. The connectionist model is a direct model of the neural interconnections in the brain and is the predominately accepted view of memory at present.

In addition to the question of *how* information is stored in long-term memory, cognitive scientists have also been interested in *what* is stored. Although the network models cited above are based primarily on a verbal encoding of information, proponents of *dual-code systems* assume that information may be simultaneously encoded in both verbal and image forms. Paivio (2006) cites empirical evidence suggesting that it is much easier to encode concrete information that is easily represented as an image than it is to encode it in verbal form. He suggested that “a substrate of nonverbal representations and imagery derived from the child’s observations and behaviors related to concrete objects and events” (p. 7) is the foundation for all ensuing cognitive development. Investigators of human memory have also proposed other distinctions between different types of memory, such as acoustic versus verbal, and episodic versus semantic (Bower & Hilgard, 1981). Although the debate is far from settled, and the true nature of long term memory remains a mystery, based on the various accounts of empirical evidence already cited it does seem that information may be encoded in different forms.

Another question regarding long-term memory concerns the process of retrieval. Leahey and Harris (1997, pp. 141-144) listed two types of retrieval: *recognition* and *recall*. In a recognition task, the subject is required only to identify an item as familiar or not. A positive recognition depends on three factors: (a) the strength of the memory, (b) the match of the presented item to the memory trace, and (c) the criterion level set by the subject (how sure the subject needs to feel in order to give a positive response). The stronger the memory trace, and the closer the match of the presented item to the stored memory, the more likely an item will be identified as familiar. The criterion level set by the subject, however, may override the other two when the consequences of a false positive are severe—such as when a “yes” decision may result in sending an innocent man to prison. A variation on the general recognition task is the forced-

choice recognition task. In this variation—most commonly experienced in a multiple choice test—the subject must choose from one among several possible answers. The difficulty of the task depends greatly upon the alternative answers that the correct answer is embedded within.

Since recognition is possible with a very low strength memory trace, it is generally not considered to be as valid a measure of learning as a recall task. In a free recall task retrieval is entirely unaided and the subject must remember the desired information without any clues or hints. It is generally accepted that when information is retrieved from long-term memory under these circumstances the memory trace is fairly strong, and that the subject really knows the information. A variation is the cued recall task. In a cued recall task the desired information is prompted or teased out with a hint. It is somewhat similar to a recognition task, in that it is not as demanding, but is still held to be a more valid estimate of how well something is known, since the provided cue is removed one or more links from the information to be recalled. Because of this, cued recall can be an effective mode of learning to promote encoding as links are established with existing information (cf. Skinner's concept of vanishing (1986, p. 107)).

A final question about long-term memory is how and why information is forgotten. Forgetting, is generally attributed to one of four primary causes (Driscoll, 2000, pp. 104-106; Leahey & Harris, 1997, pp. 149-150). They are

1. Failure to encode – the material was never encoded properly to begin with, meaning there may not have been enough elaborative rehearsal or active rehearsal strategies to transfer it to long-term memory.
2. Retrieval failure – the material has been encoded and stored but has not been properly indexed and therefore cannot be retrieved (e.g., like a misplaced book on library

shelves)⁴⁹ or alternatively, in the Freudian tradition, the memory has been repressed, and hidden from oneself through the erection of defensive mental barriers.

3. Decay – over time the memory trace loses strength.⁵⁰
4. Interference – “other events or information get in the way of effective retrieval” (Driscoll, 2000, pp. 104-105). Interference may be retroactive, in which material learned later interferes with the recall of material learned earlier, or proactive, in which previous learning interferes with later learning (e.g. the type of interference a long-time tennis player deals with when trying to learn racquetball).

Subsumption Theory (David P. Ausubel – 1962). One of the strongest criticisms of the information processing model was that it did not account for variation in the effort necessary to acquire knowledge of different content types or by different learners.⁵¹ The prominent champion of this view was David P. Ausubel (1918-2008), who dedicated much of his professional career to defining and promoting the idea of *meaningful* cognitive learning. His theory was first presented in *A Subsumption Theory of Meaningful Learning and Retention* (Ausubel, 1962) and *The Psychology of Meaningful Verbal Learning* (Ausubel, 1963). It was later expanded in two editions of *Educational Psychology: A Cognitive View* (Ausubel, Novak, & Hanesian, 1968; Ausubel, Novak, & Hanesian, 1978). The 1978 edition was a revision of Ausubel's ideas based

⁴⁹ Leahey and Harris (1997) make note that “the selection of an appropriate retrieval cue is critical to the retrieval process,” and that “what is an effective retrieval cue for one person might be ineffective to another person trying to retrieve the same information.

⁵⁰ Because this is difficult to unequivocally demonstrate (Leahey & Harris, 1997, p. 150), forgetting is more popularly attributed to failure to encode, retrieval failure, or interference. For a particularly strong argument against Thorndike's law of disuse—the original hypothesis behind the concept of forgetting as a process of decay—see McGeoch's *Learning and the Law of Disuse* (1932).

⁵¹ Individual differences in retention and acquisition, as well as differences based on different content types was noted at least as early as 1913 by Ebbinghaus (1913, p. 3).

on research and feedback from students and colleagues. It was this edition that was selected as the primary text to review in the present study for local principles of learning according to Ausubel's theory, along with *A Subsumption Theory of Meaningful Learning and Retention* (Ausubel, 1962).

In 1978 Ausubel was formally referring to his theory as *assimilation* theory in order to "emphasize a major characteristic; the important interactive role that existing cognitive structures play in the process of new learning" (Ausubel et al., 1978, p. v). To contextualize his theory, Ausubel et al. distinguished between two types of learning, *rote* and *meaningful*, and argued that—contrary to some popular claims⁵²—most school learning was not rote, but meaningful:

The rote learning of lists of nonsense syllables and arbitrarily paired adjectives is representative of few defensible learning tasks in modern classrooms. It is also difficult to find supportive evidence for Underwood's assertion that "much of our educational effort is devoted to making relatively meaningless verbal units meaningful" (11, p. 111). Brute memorization of representational equivalents (e.g., lists of vocabulary in foreign language study, the values of various constants in mathematics and science) tends to form a very small portion of the curriculum, especially beyond the elementary school years, once children have mastered the basic letter and number symbols. Meaningful learning of verbally presented materials constitutes the principal means of augmenting the learner's store of knowledge, both within and outside the classroom. Hence, no research program purporting to advance this objective can avoid coming to grips with the fundamental variables involved in meaningful learning. (Ausubel, 1962, p. 215)

According to Ausubel et al. (1978) both rote and meaningful learning could occur in two different modes, *reception* and *discovery*. Though not completely against them, Ausubel et al. felt that "discovery methods of teaching hardly constitute an efficient *primary* means of transmitting the *content* of an academic discipline" (p. 26). This inefficiency was due to the extra

⁵² Ausubel specifically cites Underwood, B. J. (1959) *Verbal learning in the educative processes*. Harvard Educational Review., 29, 107-117.

effort required by the learner. Where in reception learning "the entire content of what is to be learned is presented to the learner in its final form" (Ausubel, 1961, p. 16), discovery learning requires a much greater effort in which learners must "rearrange a given array of information, integrate it with existing cognitive structure, and reorganize or transform the integrated combination in such a way as to create a desired end product or discover the missing means-end relationship" (p. 17). In the end "the discovered content is internalized just as in reception learning" (p. 17).

In verbal reception learning, presented material is merely "internalized," i.e., made available (functionally reproducible) for future use... Reception learning is meaningful provided that the learner adopts a set to relate the material to cognitive structure, and that the material itself is logically, i.e., non-arbitrarily, relatable thereto. In other words, pupils do not independently have to discover concepts or generalizations before they can understand or use them meaningfully. (Ausubel, 1962, p. 213)

Ausubel assumed a model of cognitive organization that supposed "the existence of a cognitive structure that is hierarchically organized in terms of highly inclusive conceptual traces under which are subsumed traces of less inclusive sub-concepts as well as traces of specific informational data" (1962, p. 216). Ausubel et al. (1978) later described three learning processes by which new knowledge is assimilated into existing cognitive structure:

1. *Subordinate* learning (there are two types):

In *derivative* subsumption, new information is linked to superordinate idea *A* and represents another case or extension of *A*. The critical attributes of the concept *A* are not changed, but new examples are recognized as relevant. (p. 68)

In *correlative* subsumption, new information *y* is linked to idea *X*, but is an extension, modification, or qualification of *X*. The critical attributes of the subsuming concept may be extended or modified with the new correlative subsumption. (p. 68)

2. *Superordinate* learning:

In superordinate learning, established ideas a_1 , a_2 , and a_3 are recognized as more specific examples of new idea A and become linked to A . Superordinate idea A is defined by a new set of critical attributes that encompass the subordinate ideas. (p. 68)

3. *Combinatorial* learning:

In combinatorial learning new idea A is seen as related to existing ideas B , C , and D but is neither more inclusive nor more specific than ideas B , C , and D . In this case, new idea A is seen to have some critical attributes in common with preexisting ideas. (p. 68)

In all three types of assimilation learning "new information is linked to relevant, preexisting aspects of cognitive structure and both the newly acquired information and the preexisting structure are modified in the process" (Ausubel et al., 1978, p. 68). The "major principle of organization" that makes this possible is one of "progressive differentiation" (p. 62), whereby "the most general and inclusive ideas of the discipline are presented first. Then they are progressively differentiated in terms of detail and specificity" (pp. 189-190). Three variables determine the extent to which assimilation through progressive differentiation is possible: (a) available subsumers, (b) discriminability, and (c) stability and clarity of subsumers. This was described as follows:

One important variable affecting the incorporability and longevity of new meaningful material is the availability in cognitive structure of relevant subsuming concepts at an appropriately proximate level of inclusiveness to provide optimal anchorage. If appropriately relevant and proximate subsumers are not present, the learner tends to utilize the most relevant and proximate ones that are available. But since the latter subsumers do not provide optimal anchorage, and since it is highly unlikely that the most relevant and proximate subsuming concepts are typically available to learners in most learning situations, it would seem desirable to introduce the appropriate subsumers and make them part of cognitive structure prior to the actual presentation of the learning task. The introduced subsumers would thus constitute efficient advance "organizers" or anchoring foci for the reception of new material.

A second important factor presumably affecting the retention of a meaningful learning task is the extent to which it is discriminable from the established conceptual systems that subsume it. A reasonable assumption here, borne out by preliminary

investigation (6), would be that if the distinguishing features of the new learning material were not originally salient and clearly discriminable from stable subsuming foci, they could be adequately represented by the latter for memorial purposes, and would not persist as dissociable entities identifiable in their own right. In other words, only discriminable categorical variants of more inclusive concepts would have long-term retention value. The discriminability of new materials could be enhanced by repetition or by explicitly pointing out similarities and differences between them and their presumed subsumers in cognitive structure.

Lastly, the longevity of new meaningful material in memory has been shown to be a function of the stability and clarity of its subsumers (6). Ambiguous and unstable subsumers not only provide weak anchorage for related new materials, but also cannot easily be discriminated from them. Factors probably influencing the clarity and stability of subsuming concepts include repetition, their relative age, the use of exemplars, and multi-contextual exposure.

(Ausubel, 1962, pp. 219-220; see also the restatement of these ideas in Ausubel et al., 1978, pp. 168-169)⁵³

In describing subsumption theory in 1962, Ausubel provided an interesting and very plausible explanation for the phenomenon of forgetting. His explanation centers on the concept of memorial reduction, which is, the least common denominator capable of representing cumulative prior experience:

Although the stability of meaningful material is initially enhanced by anchorage to relevant conceptual foci in the learner's cognitive structure, such material is gradually subjected to the erosive influence of the conceptualizing trend in cognitive organization. Because it is more economical and less burdensome to retain a single inclusive concept than to remember a large number of more specific items, the import of the latter tends to be incorporated by the generalized meaning of the former. When this second or obliterative stage of subsumption begins, the specific items become progressively less dissociable as entities in their own right until they are no longer available and are said to be forgotten.

⁵³ Note the reference here to advance "organizers." Though Ausubel supposed one could supply the necessary anchoring points just in time for instruction, (Anderson, Spiro, & Anderson, 1978, p. 439) cite Barnes & Clawson (1975) as stating that the research to support this claim "has proven inconclusive." Anderson et al., further state that "it is difficult to see why outlining subsequent material in abstract, inclusive terms should help readers...when the reader does *not* possess relevant schemata, there is no good reason to suppose that they can be acquired from a few abstractly worded sentences."

This process of memorial reduction to the least common denominator capable of representing cumulative prior experience is very similar to the reduction process characterizing concept formation. A single abstract concept is more manipulable for cognitive purposes than the dozen diverse instances from which its commonality is abstracted; and similarly, the memorial residue of ideational experience is also more functional for future learning and problem-solving occasions when stripped of its tangential modifiers, particularized connotations, and less clear and discriminable implication. Hence, barring repetition or some other special reason [e.g., primacy, uniqueness, enhanced discriminability, or the availability of a specially relevant and stable subsumer (see below)] for the perpetuation of dissociability, specific items of meaningful experience that are supportive of or correlative to an established conceptual entity tend gradually to undergo oblitative subsumption. (pp. 217-218)

Ausubel (1962) further explained that the common factor between learning and forgetting is that they both represent a "change in the availability or future reproducibility of the learning material," with learning representing an "increment in availability" and forgetting representing a "decrement in availability" (p. 218).

In addition to the principles of learning found in his exposition of assimilation theory, Ausubel et al. (1978) provided a fairly comprehensive discussion of several other ideas regarding the nature of learning. These include statements—some based only on theory, others based on empirical evidence—regarding cognitive aspects of learning such as: concept formation, criteria attributes, multi-contextual learning, stages in concept acquisition, integrative reconciliation, sequential organization, transferability, the role and significance of practice and drill in a non-stereotypical sense, the role of feedback, the nature of practice, frequency of practice, early vs. delayed review, prompting and guidance, autonomous unguided discovery, differential practice schedules, and the context of practice vs. context of performance. Although these are far too numerous to discuss here, they have been coded according to the method outlined in chapter two.

Schema Theory (Rumelhart & Norman –1976). Rumelhart and Norman (1976)

described schemata as the means by which generic concepts are represented and then applied in specific situations:

Generic concepts are represented by schemata. These schemata contain variables: references to general classes of concepts that can actually be substituted for the variables in determining the implications of the schema for any particular situation. Particular information is encoded within the memory system when constants—specific values or specific concepts—are substituted for the variables of a general schema. (p. 10)

They further posited that “learning is not a unitary process” (p. 24) and proposed three modes of learning to account for how schemata are acquired and modified: accretion, tuning, and restructuring. *Accretion* refers to “the normal kind of fact learning, daily accumulation of information in which most of us engage” in which “your knowledge base is merely incremented by a new set of facts” (p. 3):

One basic mode of learning is simply the accumulation of new information. We analyze the sensory events of our current experience, match them with some appropriate set of schemata, form a representation for the experience, and tuck the newly created memory structures away in long-term memory. The newly created data structures are instantiations of the previously existing ones; changed only in that the representations for particular aspects of the current situation have been substituted for the variables of the general schema.

This is learning by accretion: learning by adding new data structures to the existing data base of memory, following the organization already present. Learning by accretion is the natural side effect of the comprehension process. In it, we store some interpretation of the actual experience. If later we retrieve the stored information, we use the instantiated schemata to reconstruct the original experience, thereby “remembering” that experience. The schemata guide reconstruction in much the same way that they guide original comprehension. (Rumelhart & Norman, 1976, p. 13)

Accretion happens when the incoming information is consistent with schemata currently available. When the incoming information does not fit existing schemata, the need for change arises. And “the more discrepant the arriving information from that described by the available

schemata, the greater the necessity for change” (Rumelhart & Norman, 1976, p. 21). When the discrepancy is mild, *tuning* comes into play:

Existing schemata can often serve as the base for the development of new ones by minor changes; by “fine tuning” of their structure. We call this process tuning. We restrict the use of the term “tuning” to those cases where the basic relational structure of the schema remains unchanged, and only the constant and variable terms referred to by the schema are modified. (Rumelhart & Norman, p. 16)

Rumelhart and Norman also explained that the constants and variables of the schema can be changed in four ways (pp. 16-17):

1. Improving the accuracy: The constraints of the variable terms of the schema can be improved to specify the concepts that fit the variables with more accuracy.
2. Generalizing the applicability: The range of a given variable can be generalized to extend its range of applicability. Either the constraints on a variable can be relaxed, or a constant term can be replaced with an appropriately constrained variable term.
3. Specializing the applicability: The range of a given variable can be constrained by adding to the constraints of the variable or, in the extreme, by effectively replacing the variable with a constant term.
4. Determining the default values: The values of the variable that normally apply can be discovered and added to the specification of the schema. Whenever a particular variable is not specified, the default values provide intelligent guesses that can be used in making inferences and guiding further processing.

Restructuring becomes necessary when “existing memory structures are not adequate to account for new knowledge” (Rumelhart & Norman, 1976, p. 14) and the discrepancy is large. Restructuring refers to the creation of brand new schema, through either patterned generation (building a new schema based on an existing schemata, for example by replacing a constant term with a set of variable terms) or schema induction (building a new scheme by combining

recurring patterns of existing schemata). Through tuning an existing schema is modified.

Through restructuring new schemata are created.

Anderson, Spiro, and Anderson (1978) presented another model that they viewed as an improvement on, and clarification of, both Bartlett's (1932) ideas on schemata and Ausubel's (1963; 1968) ideational scaffolding:

Ausubel (1963, 1968) proposed that a reader's abstract cognitive structures provide the "ideational scaffolding" for the detailed information contained in text. In his words (1968, p. 153), ". . . [N]ew ideas and information are learned and retained most efficiently when inclusive and specifically relevant ideas are already available in cognitive structure to serve a subsuming role or to furnish ideational anchorage." Bartlett (1932) suggested a similar notion. However, research in the tradition of Bartlett and Ausubel has proved inconclusive. One reason is that until recently schema notions were hopelessly vague. The purpose of this paper is to provide a clearer formulation of schema theory, and then provide an experimental test of some hypotheses that follow from the theory. (Anderson et al., 1978, pp. 433-434)

One classic example of the role of schema in understanding a reading passage was illustrated by Pichert and Anderson (1977) in a study in which subjects were asked to read the following passage, from the perspective of either a burglar or a homebuyer:

The two boys ran until they came to the driveway. "See, I told you today was good for skipping school," said Mark. "Mom is never home on Thursday," he added. Tall hedges hid the house from the road so the pair strolled across the finely landscaped yard. "I never knew your place was so big," said Pete. "Yeah, but it's nicer now than it used to be since Dad had the new stone siding put on and added the fireplace."

There were front and back doors and a side door which led to the garage which was empty except for three parked 10-speed bikes. They went in the side door, Mark explaining that it was always open in case his younger sisters got home earlier than their mother.

Pete wanted to see the house so Mark started with the living room. It, like the rest of the downstairs, was newly painted. Mark turned on the stereo, the noise of which worried Pete. "Don't worry, the nearest house is a quarter of a mile away," Mark shouted. Pete felt more comfortable observing that no houses could be seen in any direction beyond the huge yard.

The dining room, with all the china, silver and cut glass, was no place to play so the boys moved into the kitchen where they made sandwiches. Mark said they wouldn't

go to the basement because it had been damp and musty ever since the new plumbing had been installed.

"This is where my Dad keeps his famous paintings and his coin collection," Mark said as they peered into the den. Mark bragged that he could get spending money whenever he needed it since he'd discovered that his Dad kept a lot in the desk drawer.

There were three upstairs bedrooms. Mark showed Pete his mother's closet which was filled with furs and the locked box which held her jewels. His sisters' room was uninteresting except for the color TV which Mark carried to his room. Mark bragged that the bathroom in the hall was his since one had been added to his sisters' room for their use. The big highlight in his room, though, was a leak in the ceiling where the old roof had finally rotted. (p. 310)

The point of the study was to provide an initial test of the idea that “more significant than the structure that is in some sense contained in a text is the structure the reader imposes on the text” (Pichert & Anderson, 1977, p. 309). The results of the study demonstrated support for two hypotheses:

1. Schemata aid learning by highlighting important elements:

If, for whatever reason, people take divergent perspectives on a text—that is, impose different high-level schemata—the relative significance of text elements will change. Elements that are important on one view may be unimportant on another. By definition, an important element “fits in” to an organized structure of information and is thereby, we hypothesize, more learnable. (p. 309)

2. Schemata aid recall by providing a structure of expectations that serves to cue remembering:

Perspective may have further independent effects on the accessibility of text elements that have been learned. A high-level schema can serve as a retrieval plan, so to speak outlining the questions one should ask of oneself. The schema is bound to provide implicit cues for important elements but is less likely to do so for unimportant ones. Therefore, among those idea units that are stored, the important units will be more accessible and, it is predicted as a consequence, better recalled. (p. 309)

In their general discussion of the results of the study, Anderson et al. (1978) summarized schema theory by saying:

A schema is an abstract description of a thing or event. It characterizes the typical relations among its components and contains a slot or place holder for each component that can be instantiated with particular cases. Interpreting a message is a matter of matching the information in the message to the slots in a schema. The information entered into the slots is said to be subsumed by the schema....Schema theory also provides a reason for supposing that subsuming structures will have effects on memory independent of those on learning. A high-level schema provides a retrieval plan....The idea is that the parent schema from which an instantiated representation of a text originally is constructed can later furnish implicit retrieval cues or specific text information (see Bower, in press). (p. 314)

A year after publication of the study by Pichert and Anderson (1977), Anderson et al. (1978) presented findings from a similar study that they believed provided “unambiguous confirmation that high-level schemata play a role in the learning and remembering of text information” (p. 437). In the same paper they made the following claims regarding the nature of schemata (p. 434):

1. A schema will contain slots into which some of the specific information described in a message will fit.
2. To interpret a particular situation in terms of a schema is to match the elements in the situation with the generic characterizations in the schematic knowledge structure.
3. The schemata a person already possesses are a principal determiner of what will be learned from a text.

4. The information that matches slots in the schema would be said to be significant, whereas information that does not would be called unimportant, irrelevant, or—in the limiting case—incongruous.
5. Information that fits the superordinate schema is more likely to be learned and remembered, perhaps precisely because there is a niche for it.
6. One schema can provide slots for more of a certain fixed body of information than other schemata.
7. If the knowledge domain were specified, it should be possible to make qualitative as well as quantitative predictions about just which details will be learned.

Schemata, as described by the foregoing authors, have been assumed to apply to the storage of declarative knowledge. They may also be used to store expectations of procedural knowledge. Procedural knowledge is knowledge concerning how to perform certain activities or processes. A classic example is what to do when ordering food in a restaurant. Through prior experience we learn to expect the waiter or waitress to do and say certain things, and we also know what is expected of us. Rumelhart (1980) compared schemata to plays, which have characters and roles, lines, settings, and actions. Schemata that store procedural knowledge are generally referred to as scripts (see, for example, Schank & Abelson, 1977).

Bower, Black and Turner (1979) published the results of a handful of studies in which they investigated the organization of knowledge of routine activities, such as eating at a restaurant or visiting a dentist, and how that knowledge is used to help people understand and remember narrative texts. In two of the studies they asked subjects to describe the details of what happens during familiar activities. They found that the various accounts collected largely agreed with each other regarding the nature of the characters, objects present, actions, and the order of

those actions. They also found agreement on the level of granularity at which the action sequences might be divided into “scenes,” that they interpreted to infer a hierarchical organization in memory of the activity. In other studies they investigated memory based on a script. Their results showed that subjects tended to confuse actions that were stated with actions that were unstated but implied by the script. They also found that subjects preferred to recall script actions in their familiar order. When a text presented actions that were scrambled, subjects would tend to recall them in canonical, rather than presented, order. An additional finding was that subjects reading a text would have to slow down to read statements that deviated from expectations, but that goal-relevant deviations were remembered better than script actions, suggesting that goal-relevant deviations held more significance. Though a later study (Mandler & Murphy, 1983) using the same scripts brought into question the strength of some of the claims made by Bower et al., both studies showed substantial agreement between subjects suggesting the use of schema in organizing knowledge.

The Constructive Perspective

Cognitive learning theory and constructive learning theory are sometimes spoken of by present day instructional designers in diametrical contrast to one another and as completely separate theories. However, untangling the two in my review and analysis of learning theory literature was no straightforward task. Sources often cited as the foundational literature of cognitive learning theory are also cited elsewhere as the foundation for constructive learning theory—for example, Ulric Neisser’s *Cognitive Psychology* (1967). Neisser's publication is often noted as the seminal work that marks a shift from prominence of behavioral learning theory to a focus on cognitive learning theory. As it turns out, although Neisser set out to write “a dispassionate survey of cognitive psychology” he ended up with something that was not “as

neutral or eclectic as had been planned” (p. vii). In the act of writing he discovered that he had “a definite commitment to a particular kind of psychology” and that his view of learning was one of construction rather than absorption (p. vii).

Rather than speaking of cognitive and constructive learning theory as two separate theories, it seems more accurate to say that constructive learning theory is a type or subset of cognitive learning theory, and not a true alternative to the same. O'Donnell, Reeve, and Smith (2007) go so far as to suggest that all cognitive theories are constructive in nature:

Cognitive theories include a variety of approaches to understanding the relationship between the individual and his or her environment. At the heart of most cognitive approaches to understanding learning is the notion that knowledge is constructed by the learner and affected by the learner's prior experiences. All cognitive theories are constructivist in nature in that they all emphasize the active role of learners in making meaning out of their experience. (p. 241)

While the above statement might be a bit of an overgeneralization, it is obvious that what is, or is not, a constructive theory of learning is not always so clear. College-level educational psychology texts generally note two types of constructive learning theory: individual constructivism⁵⁴ and social constructivism (see, for example, Bohlin et al., 2009, p. 119; Eggen & Kauchak, 1999, p. 279; Ormrod, 2003, p. 231; Woolfolk, 2010, p. 311). Bohlin et al. defined these two types of constructivism as follows:

In **individual constructivism**, a person constructs knowledge by using cognitive processes to gain knowledge from experience rather than by memorizing facts provided by others. In **social constructivism**, individuals construct knowledge through an interaction between the knowledge they bring to the situation and social/cultural exchanges within that context. (p. 119)

⁵⁴ Also referred to as "psychological" or "cognitive" constructivism.

Although individual constructivism is typically associated with the ideas of Piaget and social constructivism is typically associated with the ideas of Vygotsky,⁵⁵ Bohlin noted that the line between the two "can easily become blurred" (p. 119) for although Piaget was interested primarily in construction of meaning by individuals, he acknowledged social experiences as an important factor in individual cognitive development. Similarly, while Vygotsky's ideas focused on social and cultural interactions as catalysts of cognitive change, his theory emphasized internalization of knowledge as both spurred on through social interaction and individually mediated. Moshman (1982), made a similar distinction, dividing constructivist learning theories into three categories, summarized here by Harris and Graham (1994):

1. Endogenous constructivism – similar to individual constructivism in which the construction of new knowledge comes from within, and is based on existing knowledge. This paradigm "emphasizes internal construction of holistic knowledge structures, or the construction of new knowledge from old" (p. 234).

⁵⁵ Ratner (2004) argues against certain neo-Vygotskian beliefs and their misunderstandings of the concept of sociogenesis—arguing that their concept of "co-constructionism" is, in fact, diametrically opposed to Vygotsky's "emphasis on the social formation of psychology" (pp. 408, 409). Langford (2005) put it this way:

Contemporary psychologists are often keen to broadcast the idea that one of the most celebrated founders of the modern discipline, Vygotsky, agrees with them. In many cases they are quite justified in doing so. However, in others, the combination of their poor grasp of Vygotsky's texts and their desire to have him support their ideas, when he really does not, results in falsification of his ideas. Both originated in the West and make him into a constructivist. 'Constructivism' is a term that contrasts with realism and means that gaining knowledge is not a process of getting to know about an objective world, but one in which the world is invented... Vygotsky, as previously stressed, was a moderate realist who thought that children come to have an approximate understanding of the world as it really is. There are numerous passages where he says this and none where he says he is a constructivist (Vygotsky, 1925a, Ch. 1, 1927d, Chs. 1, 4, 1930a, 1930b, 1930h, 1931b, Chs 1, 2, 1931d, 1932c, 1934c, Ch. 2)... A constructivist view stressing language is among the most popular in the West... [however] the linguistic-constructivist thesis is wrong, simply because Vygotsky was not, as we have seen, at any time a constructivist. (pp. 152-153)

2. Exogenous constructivism – in contrast with endogenous constructivism, this category denotes theories in which constructed knowledge mirrors objects in the environment. "These theories...to some extent have an underlying empiricist view—that knowledge is derived from one's environment and thus can be seen as 'learned.'" (p. 235)
3. Dialectical constructivism – similar to social constructivism in which the construction of knowledge lies in the continual interaction between the individual and the environment. Dialectical constructivism "exists both separately from and within the tension between endogenous and exogenous constructivism" and the source of knowledge is seen "as lying in continuing interactions between the child and the environment" (p. 236).

In their preface to *Constructivism in Education*, Steffe and Gale (1995) noted six alternative paradigms of constructivism: “social constructivism, radical constructivism, social constructionism, information-processing constructivism, cybernetic systems, and sociocultural approaches to mediated action” (p. xiii).

Driscoll (2000) described a similar theoretical polymorphism:

There is no single constructivist theory of instruction. Rather, there are researchers in fields from science education to educational psychology and instructional technology who are articulating various aspects of a constructivist theory. Moreover, constructivism is only one of the labels used to describe these efforts. Its use probably stems from Piaget's reference to his views as “constructivist” (see Chapter 6) and Bruner's conception of discovery learning as “constructionist” (see Chapter 7). Other labels include generative learning (CTGV, 1991a, 1991b; Wittrock, 1985a, 1985b), embodied cognition (Johnson, 1987; Lakoff, 1987), cognitive flexibility theory (Spiro et al., 1991, 1995), and postmodern and poststructural curricula (Hlynka, 1991; Culler, 1990). (pp. 375-376)

The efforts to simplify or categorize constructivist learning theory, and the various constructivist paradigms mentioned above, are clear evidence that there is an obvious lack of consensus on what constructive learning theory really is. This confusion made the task of setting scope for my review of constructive learning theory rather difficult. In the end, I settled on approaching constructivist learning theory, first and foremost, by looking at how it has impacted the practice of teaching and how it is being implemented in the classroom, and second, by reviewing the ideas of two key figures who are commonly credited as supplying the foundational ideas behind the movement: Jean Piaget (developmental learning) and Jerome Bruner (discovery learning).

Constructivist Learning in the Classroom (mid-1990s). In practice, constructivist learning theory is often manifest in the form of⁵⁶ a variety of teaching methods and techniques that are considered to be revolutionary or enlightened improvements upon old school traditional education in which knowledge is simply imparted by teachers to students. Sternberg and Williams (2010), reflecting what appears to be the common perception in both public and private educational institutions of the present day, equated "constructivist" teaching with "student-centered" teaching, and described constructivism as bringing "an increased awareness of the roll of individual differences" and "a renewed emphasis in learning on the role of student motivation" (p. 449). They listed five ways in which "expert teachers think about creating student-center learning situations" (pp. 449-450):

1. Accepting complexity

⁵⁶ Or perhaps better said, "confused to be"

When engaging in student-centered learning, expert teachers create complex learning environments instead of deliberately simplified ones, as is often the case for traditional methods of instruction. Student-centered teaching involves giving students real-world problems to solve, with all of the confusion inherent in such problems. The idea is that students should work on ecologically meaningful problems (in other words, problems that they might encounter in their daily lives, and that have some personal meaning for them), the solutions for which represent workable real-world solutions, rather than simply being expected to memorize and then restate correct answers on tests. (p. 449)

2. Learning through social interaction

Student-centered learning often involves social interactions with other students in varied formats, including **group instruction**, in which students learn, process, and discuss material in groups. Group discussions are conversations among students in which students pose and answer their own questions; the teacher does not play the dominant role. Thus learning becomes a socially mediated and facilitated activity. (pp. 449-450)

3. Presenting content in several contexts

Student-centered approach involve using multiple representations of content to help students generalize and transfer what they learn. This richer and more varied approach attempts to give students information they can use. It is also intended to help students develop realistic, flexible, and useful mental representations of knowledge that are not artificially limited as a function of having been learned in a particular context. (p. 450).

4. Using psychological principles to structure teaching

Student-centered teaching requires teachers to sue the principles and findings of cognitive and educational psychology to structure instruction to it best enhances the intellectual development of the student. Teachers must be aware of what it really means to learn as well as how the process of learning is affected by different factors. As this point suggests, student-centered teaching places high demands on teachers who use this approach. (p. 450)

5. Recognizing meaningful learning

It is...difficult to recognize when meaningful learning is taking place—sometimes students may talk animatedly about a subject and be learning nothing. At other times,

students take the opportunities of group work to gossip or joke around. You have less control, and it can be difficult to monitor what is going on. (p. 450)

In addition to these five ways of creating student-centered learning situations, Sternberg and Williams list, in complete detail, fourteen learner-centered psychological principles produced by a task force of the American Psychological Association assigned to develop a set of guidelines for school redesign and reform. The principles are divided into four groups: (a) cognitive and metacognitive, (b) motivational and affective, (c) developmental and social, and (d) individual difference factors in learning. They are written with the intent that they should "apply to all learners—to children, to teachers, to administrators, to parents, and to community members involved in our educational system" (Learner-Centered Work Group of the American Psychological Association's Board of Education Affairs, 1997, para. 9). The principles, in brief, state the following:

Cognitive and Metacognitive Factors:

Principle 1. Nature of the learning process. The learning of complex subject matter is most effective when it is an intentional process of constructing meaning from information and experience.

Principle 2. Goals of the learning process. The successful learner, over time and with support and instructional guidance, can create meaningful, coherent representations of knowledge.

Principle 3. Construction of knowledge. The successful learner can link new information with existing knowledge in meaningful ways.

Principle 4. Strategic thinking. The successful learner can create and use a repertoire of thinking and reasoning strategies to achieve complex learning goals.

Principle 5. Thinking about thinking. Higher-order strategies for selecting and monitoring mental operations facilitate creative and critical thinking.

Principle 6. Context of learning. Learning is influenced by environmental factors, including culture, technology, and instructional practices.

Motivational and Affective Factors:

Principle 7. Motivational and emotional influences on learning. What and how much is learned are influenced by the learner's motivation. Motivation to learn, in turn, is influenced by the individual's emotional states, beliefs, interests and goals, and habits of thinking.

Principle 8. Intrinsic motivation to learn. The learner's creativity, higher-order thinking, and natural curiosity all contribute to motivation to learn. Intrinsic motivation is stimulated by tasks of optimal novelty and difficulty, is relevant to personal interests, and provides for personal choice and control.

Principle 9. Effects of motivation on effort. Acquisition of complex knowledge and skills requires extended learner effort and guided practice. Without the learner's motivation to learn, the willingness to exert this effort is unlikely without coercion.

Developmental and Social:

Principle 10. Developmental influences on learning. As individuals develop, there are different opportunities and constraints for learning. Learning is most effective when differential development within and across physical, intellectual, emotional, and social domains is taken into account.

Principle 11. Social influences on learning. Learning is influenced by social interactions, interpersonal relations, and communication with others.

Individual Differences:

Principle 12. Individual differences in learning. Learners have different strategies, approaches, and capabilities for learning that are a function of prior experience and heredity.

Principle 13. Learning and diversity. Learning is most effective when differences in learners' linguistic, cultural, and social backgrounds are taken into account.

Principle 14. Standards assessment. Setting appropriately high and challenging standards and assessing the learner as well as learning progress—including diagnostic, process, and outcome assessment—are integral parts of the learning process.

(Learner-Centered Work Group of the American Psychological Association's Board of Education Affairs, 1997)

Sternberg and Williams (2010) also noted that “as was the case with direct instruction, good teaching from a constructivist perspective depends on the effective combination of specific techniques to reach the widest possible audience” (p. 451). They listed several methods for “teaching constructively” (pp. 451-465):

1. Individualized instruction – individualized instruction plans allow for variations in time to complete objectives, learning activities engaged in, and the instructional materials used by each student.
2. Discovery approaches – students construct their own understanding based on available or supplied information.

Unstructured discovery occurs when students make discoveries on their own. **Guided discovery** occurs when the teacher assists the students in making discoveries. Guided discovery is more practical and effective; unstructured discovery often leads students to become confused and frustrated and may result in students' drawing inappropriate conclusions. (p. 455)

3. Group discussion – "in group discussion, students do not just respond to teacher-initiated questions; they also respond to one another's questions in an open discussion format" (p. 455).
4. Inquiry methods – teachers begin by asking students a question. The students formulate multiple hypotheses that are possible answers to the question, then collect information to evaluate the various hypotheses and draw appropriate conclusions.
5. Group work – "student groupwork entails small groups of students working together on tasks in relatively informal settings" (p. 457). One of the main

advantages of groupwork is that every student has more of a chance to actively participate.

6. Cooperative learning – similar to groupwork, but more highly structured by the teacher and under tighter teacher control. Cooperative learning generally involves competition between groups to complete the goal, evaluated by time to completion or group performance on post-learning assessments.
7. Reciprocal teaching – students are first taught four steps to improve understanding of what they read: summarizing, asking a question about an important point in the text, clarifying the difficult portions of what was read, and predicting what is likely to come next. Once they have learned the method, students take turns teaching and leading the class or group.
8. Computer-assisted learning – "a type of individualized instruction administered by a computer" (p. 461).

Computer-assisted instruction can become a part of a technology-enhanced student-centered learning environment that encourages the students' manipulation of information and that roots the learning process in concrete experience and extended investigation. (p. 461)

Another example of how constructive learning theory has manifest in the practice of education is Brooks and Brooks' *In Search of Understanding: The Case for Constructivist Classrooms* (1993). Although this text presents many very good ideas on effective teaching and learning, it also demonstrates how the concept of constructivism has been stretched far beyond the simple boundaries of the fundamental concept that learners construct their own knowledge, and is now a change catalyst "serving as the basis for many of the current reforms in education"

(p. vii). While such extremism may not be warranted, the constructive movement is now one of the mainstream "banners and bandwagons"⁵⁷ around which frustrated educators find opportunity for expression and action:

Constructivism stands in contrast to the more deeply rooted ways of teaching that have long typified American classrooms. Traditionally, learning has been thought to be a "mimetic" activity, a process that involves students repeating, or miming, newly presented information (Jackson 1986) in reports or on quizzes and tests. Constructivist teaching practices, on the other hand, help learners to internalize and reshape, or transform, new information. Transformation occurs through the creation of new understandings (Jackson 1986, Gardner 1991b) that result from the emergence of new cognitive structures. Teachers and parents can invite transformations, but can neither mandate nor prevent them. (Brooks & Brooks, 1993, p. 15)

Brooks and Brooks suggested five guiding principles of constructivism (pp. 33-98):

1. Posing problems of emerging relevance to students

Teacher mediation is the key factor: The structuring of the lesson around questions that challenge students' original hypotheses presents students with the initial sparks that kindle their interest. Students must be given time and stimulation to seek relevance and the opportunity to reveal their own points of view. Students need opportunities to ponder the question, form their own responses, and accept the risk of sharing their thoughts with others. (pp. 37-38)

2. Structuring learning around primary concepts

Structuring curriculum around primary concepts is a critical dimension of constructivist pedagogy. When designing curriculum, constructivist teachers organize information around conceptual clusters of problems, questions, and discrepant situations because students are most engaged when problems and ideas are presented holistically rather than in separate, isolated, parts. Much of traditional education breaks wholes into parts and then focuses separately on each part. But many students are unable to build concepts and skills from parts to wholes. These students often stop trying to see the wholes before all

⁵⁷ Close (1977)

the parts are presented to them and focus on the small, memorable aspects of broad units without ever creating the big picture. (p. 46)

When concepts are presented as wholes, on the other hand, students seek to make meaning by breaking the wholes into parts that *they* can see and understand. Students initiate this process to make sense of the information; they construct the process and the understanding rather than having it done *for* them.(p. 47)

3. Seeking and valuing students' points of view

Students' points of view are windows into their reasoning. Awareness of students' points of view helps teachers challenge students, making school experiences both contextual and meaningful. Each student's point of view is an instructional entry point that sits at the gateway of personalized education. (p. 60)

4. Adapting curriculum to address students' suppositions

The adaptation of curricular tasks to address student suppositions is a function of the cognitive demands implicit in specific tasks (the curriculum) and the nature of the questions posed by students engaged in these tasks (the suppositions)...we don't know what ideas are within students' reach unless we do something specific to find out. (p. 72)

5. Assessing student learning in the context of teaching

Tests, then, particularly multiple-choice tests, are structured to determine whether students know information related to a particular body of knowledge—usually a curriculum guide or syllabus. The focus is outward, not inward, on material, not personal constructions. Therefore, the overarching question asked by the test is "Do you know this material?" Authentic activities (tasks and problems already relevant or of emerging relevance to students) also relate to a particular body of knowledge, but rather than structuring assessment around specific bits of information, they invite students to exhibit what they have internalized and learned through application. (pp. 96-97).

Brooks and Brooks (1993) also listed twelve descriptors of constructivist teaching behaviors as a guideline for how teachers can become constructivist teachers:

1. Encourage and accept student autonomy and initiative. (p. 103)

2. Use raw data and primary sources, along with manipulative, interactive, and physical materials. (p. 104)
3. When framing tasks, use cognitive terminology such as "classify," "analyze," "predict," and "create." (p. 104)
4. Allow student responses to drive lessons, shift instructional strategies, and alter content. (p. 105)
5. Inquire about students' understandings of the concepts before sharing [your] own understandings of those concepts. (p. 107)
6. Encourage students to engage in dialogue, both with the teacher and with one another. (p. 108)
7. Encourage student inquiry by asking thoughtful, open-ended questions and encouraging students to ask questions of each other. (p. 110)
8. Seek elaboration of students' initial responses. (p. 111)
9. Engage students in experiences that might engender contradictions to their initial hypotheses and then encourage discussion. (p. 112)
10. Allow wait time after posing questions. (p. 114)
11. Provide time for students to construct relationships and create metaphors. (p. 115)
12. Nurture students' natural curiosity through frequent use of the learning cycle model. (p. 116)

These guiding principles, and the methods listed above by Sternberg and Williams are a good reflection of how constructivist teaching is typically brought into the present day classroom. We now turn to the source behind many of these guidelines and practices: the ideas of Jean Piaget and Jerome Bruner, on which these methods are based.⁵⁸

⁵⁸ The work of Les Vygotsky is also of great influence to constructivist learning theory, although perhaps mistakenly so (Langford, 2005, pp. 152.153). His ideas will be included in our review of social learning theory.

Intellectual Development Theory (Jean Piaget – 1952). The contribution of Jean Piaget to constructivist learning theory was well stated by von Glasersfeld's (1995) when he said, “Although I do not continually cite Piaget, I sincerely hope one realizes that almost everything I write herein can be written only because Piaget spent some 60 years establishing the basis for a dynamic constructivist theory of knowing” (p. 6).

In learning theory and learning psychology textbooks, most accounts of Piaget’s theory summarize four stages of development—sensorimotor, preoperational, concrete operational, and formal operational—but fail to even mention the six sub stages of which the sensorimotor period⁵⁹ is comprised. This is unfortunate since the core substance of Piaget’s ideas regarding the mechanism and progression of development are revealed and developed in his description of these six sub stages (Piaget, 1963). One notable exception, is Brainerd’s undergraduate textbook entitled, *Piaget’s Theory of Intelligence* (1978), the entire content of which is devoted to a synopsis of Piaget’s theory.

From Piaget’s own writings I found two texts to be particularly useful in my search for local principles of learning: *The Origins of Intelligence in Children* (Piaget, 1963) and *The Psychology of the Child* (Piaget & Inhelder, 1969). The first is among Piaget’s earlier writings, originally published in French as *La Naissance de l’Intelligence Chez l’Enfant* (Piaget, 1936), and is Piaget’s most complete and detailed exposition of the six sub stages of the sensorimotor period. It is filled with quotations from Piaget’s original observations of children, which are cited as evidence of his conclusions about the mechanism of progression and the state of development

⁵⁹ In the translated works of Piaget “period” and “stage” are used interchangeably.

at various ages and stages in the child's development. The second text, *The Psychology of the Child* (Piaget & Inhelder, 1969), is intended as a synthesis of previous publications by Piaget up to that point (p. v). It summarizes both the sensorimotor period with its six sub stages and also the preoperational, concrete operational, and formal operational periods of development. These two books were selected as the main sources for studying the ideas of Jean Piaget, and the following summary is based on the content of these two books.

According to Piaget (Piaget & Inhelder, 1969), development occurs as a succession of three⁶⁰ great periods:

The mental development of the child appears as a succession of three great periods. Each of these extends the preceding period, reconstructs it on a new level, and later surpasses it to an ever greater degree. This is true even of the first period. (p. 152)

During the first great period (sensorimotor) "the evolution of the sensorimotor schemes extends and surpasses the evolution of the organic structures which takes place during embryogenesis" (p. 152). During the second great period (comprising both preoperational and concrete operational), "semiotic relations, thought, and interpersonal connections internalize these schemes of action by reconstructing them on the new level of representation, and surpass

⁶⁰ In reviewing Piaget's own writings, I have noticed that although the number of stages is commonly accepted among educators to be four, Piaget himself (Piaget & Inhelder, 1969) seemed to be in some conflict as to whether the number should be three or four. On the one hand he noted the existence of a delay between the development of the semiotic function (just after the initial establishment of sensorimotor schemes between age 0 to 24 months) and the internalization of actions into operations (age 6 or 7). He felt this was proof that there is "another level" between the two which "is not merely transitional" (p. 93). However, on the other hand, in the same text he later referred to the mental development of the child as appearing in "a succession of three great periods" (p. 152), lumping what are commonly referred to as the pre-operational and the concrete-operational stages into one. Brainerd (1978, p. 95) called attention to this same discrepancy and cited additional references in which "the pre-operational stage is treated somewhat equivocally in Piaget's own writings" but chose to treat the pre-operational and concrete-operational as two distinct stages in his own coverage of Piaget's theory.

them until all the concrete operations and cooperative structures have been established” (p. 152). Finally, in the third great period (formal, preadolescent operational) “nascent formal thought restructures the concrete operations by subordinating them to new structures whose development will continue throughout adolescence and all of later life (along with many other transformations as well)” (pp. 152-153).

Piaget did not see the progression from one period to the next as abrupt or discontinuous, but rather as a very smooth transition from spontaneous movements and reflexes to acquired habits, and from acquired habits to intelligence:⁶¹

What one actually finds is a remarkably smooth succession of stages, each marking a new advance, until the moment when the acquired behavior presents characteristics that one or another psychologist recognizes as those of “intelligence”...There is a continuous progression from spontaneous movements and reflexes to acquired habits and from the latter to intelligence. (Piaget & Inhelder, 1969, p. 5)

Perhaps in response to Bruner’s criticism that he was “deeply concerned with the nature of knowledge” and “less interested in the processes that make growth possible” (J. S. Bruner, 1966a, p. 7) Piaget and Inhelder (1969) emphasized that “the real problem is not to locate the first appearance of intelligence but rather to understand the mechanism of this progression” (p. 5). This mechanism, he described as one of *assimilation* (the fitting of new information into existing schemes) and *accommodation* (the creation of new schemes to organize information that cannot be assimilated into existing schemes):

⁶¹ It seems that Sternberg and Williams' (2010, p. 39) classification of Piaget's theory as discrete and discontinuous with “sharp gains at some points of development and virtually no gains” does not agree with Piaget's own view of either continuity or attainment through the progression of stages.

The organizing activity of the subject must be considered just as important as the connections inherent in the external stimuli, for the subject becomes aware of these connections only to the degree that he can assimilate them by means of his existing structures....that is to say, the input, the stimulus, is filtered through a structure that consists of the action-schemes (or at a higher level, the operations of thought), which in turn are modified and enriched when the subject's behavioral repertoire is accommodated to the demands of reality. The filtering or modification of the input is called assimilation; the modification of internal schemes to fit reality is called accommodation. (Piaget & Inhelder, 1969, pp. 5-6)

Through assimilation “reality data are treated or modified in such a way as to become incorporated” and “every newly established connection is integrated into an existing schematism” (Piaget & Inhelder, 1969, p. 5). In other words, through assimilation the data of life's experiences become part of our mental framework:

Intelligence is assimilation to the extent that it incorporates all the given data of experience within its framework. Whether it is a question of thought which, due to judgment, brings the new into the known and thus reduces the universe to its own terms or whether it is a question of sensorimotor intelligence which also structures things perceived by bringing them into its schemata, in every case intellectual adaptation involves an element of assimilation, that is to say, of structuring through incorporation of external reality into forms due to the subject's activity. (Piaget, 1963, p. 6)

The process of assimilation is intertwined with a second process, that of accommodation:

There can be no doubt either, that mental life is also accommodation to the environment. Assimilation can never be pure because by incorporating new elements into its earlier schemata the intelligence constantly modifies the latter in order to adjust them to new elements. Conversely, things are never known by themselves, since this work of accommodation is only possible as a function of the inverse process of assimilation. We shall thus see how the very concept of the object is far from being innate and necessitates a construction which is simultaneously assimilatory and accommodating. (Piaget, 1963, pp. 6-7)

In other words, accommodation is the process of adapting oneself to the universe by constructing schemata to fit reality data. Assimilation, on the other hand, is the process of

adapting the universe to oneself by interpreting reality data in terms of one's pre-established schemata. The balance between the two is controlled by a self-regulating function of equilibration:

An internal mechanism (though it cannot be reduced to heredity alone and has no preestablished plan, since there is in fact construction) is observable at the time of each partial construction and each transition from one stage to the next. It is a process of equilibrium, not in the sense of a simple balance of forces, as in mechanics, or an increase of entropy, as in thermodynamics, but in the sense—which has now been brought out so clearly by cybernetics—of self-regulation; that is, a series of active compensations on the part of the subject in response to external disturbances and an adjustment that is both retroactive (loop systems or feedbacks) and anticipatory, constituting a permanent system of compensations. (Piaget & Inhelder, 1969, p. 157)

In *Play, Dreams and Imitation in Childhood* Piaget (1962) described this equilibrium in the child as a balance between imitation and play:

If every act of intelligence is an equilibrium between assimilation and accommodation, while imitation is a continuation of accommodation for its own sake, it may be said conversely that play is essentially assimilation, or the primacy of assimilation over accommodation. (p. 87)

This balance is necessary not only for the intellectual development of the child, but also to satisfy his affective needs:

Obliged to adapt himself constantly to a social world of elders whose interests and rules remain external to him, and to a physical world which he understands only slightly, the child does not succeed as we adults do in satisfying the affective and even intellectual needs of his personality through these adaptations. It is indispensable to his affective and intellectual equilibrium, therefore, that he have available to him an area of activity whose motivation is not adaptation to reality but, on the contrary, assimilation of reality to self, without coercions or sanctions. Such an area is play, which transforms reality by assimilation to the needs of the self, whereas imitation (when it constitutes an end in itself) is accommodation to external models. Intelligence constitutes an equilibration between assimilation and accommodation. (Piaget & Inhelder, 1969, pp. 57-58)

Sensory-motor intelligence is defined by the activities of assimilation and accommodation of which it is made:

Sensory-motor intelligence is, in our view, the development of an assimilating activity which tends to incorporate external objects in its schemas while at the same time accommodating the schemas to the external world. A stable equilibrium between assimilation and accommodation results in properly intelligent adaptation. (Piaget & Inhelder, 1969, p. 5)

Through assimilation and accommodation during the sensorimotor period, the initial cognitive substructures on which all subsequent intellectual development is based are established.

It is because the baby begins by constructing, in coordinating his actions, schemata such as those of the unchanging object, the fitting in of two or three dimensions, rotations, transpositions, and superpositions that he finally succeeds in organizing his "mental space" and, between preverbal intelligence and the beginnings of Euclidean spatial intuition, a series of "topological" intuitions are intercalated as manifested in drawing, stereognosis, the construction and assembling of objects, etc.; that is to say, in the areas of transition between the sensorimotor and the perceptual...It is primarily preverbal sensorimotor activity that is responsible for the construction of a series of perceptual schemata the importance of which in the subsequent structuring of thought cannot, without oversimplification, be denied...The sensorimotor substructure is necessary to the conceptual for the formation of the operational schema which are destined to function finally in a formal manner and thus to make language consistent with thought. (Piaget, 1963, Forward)

The six sub stages of which the sensorimotor period is comprised are (Piaget, 1963)

1. The Use of Reflexes
2. The First Acquired Adaptations and the Primary Circular Reaction
3. The "Secondary Circular Reactions" and the Procedures to Make Interesting Sights Last
4. The Coordination of the Secondary Schemata and Their Application to new Situations
5. The "Tertiary Circular Reaction" and the "Discovery of New Means Through Active Experimentation"
6. The Invention of New Means Through Mental Combinations

Piaget described mental growth as being connected to, and building upon physical growth:

Mental growth is inseparable from physical growth: the maturation of the nervous and endocrine systems, in particular, continues until the age of sixteen. This implies that in order to understand mental growth it is not enough to start with birth; there is an embryology of reflexes (E. Minkowski) dealing with the movements and responses of the fetus, and the preperceptive behavior of the fetus, for instance, is relevant to the study of the perception of tactilo-kinesthetic causality (Piaget & Inhelder, 1969, p. vii)

He also described mental development during the first several months of life as providing the foundation for all subsequent intellectual development:

Mental development during the first eighteen months of life is particularly important, for it is during this time that the child constructs all the cognitive substructures that will serve as a point of departure for his later perceptive and intellectual development, as well as a certain number of elementary affective reactions that will partly determine his subsequent affectivity. (Piaget & Inhelder, 1969, p. 3)

These cognitive structures he called action-schemes, which he defined as “the structure or organization of actions as they are transferred or generalized by repetition in similar or analogous circumstances” (Piaget & Inhelder, 1969, p. 4, footnote).

Development of action-schemes begins in stage one with repeated exercise of the reflex, by which “the reflex is consolidated and strengthened by virtue of its own functioning” (Piaget, 1963, p. 32). Such repeated exercise, he said, is the beginning of assimilation:

This need for repetition is only one aspect of a more general process which we can qualify as assimilation. The tendency of the reflex being to reproduce itself, it incorporates into itself every object capable of fulfilling the function of excitant. (p. 33)

This tendency toward repetition or, as Piaget called it, “cumulative repetition” (Piaget, 1963, p. 33) results in both generalized assimilation—e.g. “at nearly five months his hands will

carry all objects to his mouth and he will end by using these behavior patterns to recognize bodies and even to compose the first form of space” (p. 35)—and in recognitory assimilation—e.g. distinguishing the nipple from other objects and rejecting the latter when trying to satisfy needs of hunger (p. 36). Thus, it is through repetitive use of the reflex, applied to different objects and in different circumstances that it is generalized, and through which recognition is acquired:

The reflex must be conceived as an organized totality whose nature it is to preserve itself by functioning and consequently to function sooner or later for its own sake (repetition) while incorporating into itself objects propitious to this functioning (generalized assimilation) and discerning situations necessary to certain special modes of its activity (motor recognition). (Piaget, 1963, p. 38)

In stage two “circular reactions” (Piaget, 1963, p. 49) appear. The circular reaction is “an acquired functional exercise which prolongs the reflex exercise and has the effect of fortifying and maintaining” (p. 66). Two examples are the systematic protrusion of the tongue and the sucking of the thumb or fingers:

Putting out the tongue and finger sucking thus constitute the first two examples of a behavior pattern which prolongs the functional use of the reflex (sucking-like movements), but with the acquisition of some element external to the hereditary mechanisms. The new use of the tongue seems to go beyond the simple reflex play involved in sucking. (Piaget, 1963, p. 55)

Also formed during stage two are a variety of sensorimotor associations—e.g. the “setting in motion of sucking by various signals: position, noises, optical signals, etc” (Piaget, 1963, p. 49)—and the coordination between sucking and vision. Piaget (1963) cites the following observation:

Three stages in the child's behavior may be distinguished. The first stage comprises the first week: the nursling attempts to suck only when his lips are in contact with the breast or the bottle....The second stages extends from the second to the eighth or ninth week: the nursling seeks the breast as soon as he finds himself in situations which regularly precede the meal (dressing, diaper changing, a stretched-out position, etc.). Finally the third stage begins between 0;3 and 0;4 and can be recognized by the appearance of visual signals. It is enough that the child sees the bottle or the objects which remind him of the meal for him to open his mouth and cry. (p. 56)⁶²

Stage one, the use of reflexes, and stage two, the first acquired adaptations and the primary circular reaction, are categorized by Piaget as *elementary* sensorimotor adaptations. During these two stages, "by constantly renewing his acts through reproductive and generalizing assimilation, the child surpasses simple reflex use, discovers circular reaction and thus forms his first habits" (Piaget, 1963, p. 153). In contrast, stages three, four, five, and six he categorizes as *intentional* sensorimotor adaptations. In the descriptions that follow, we shall see why.

In stage three, Piaget describes a *secondary circular reaction* and *procedures to make interesting sights last*; beginning also to differentiate means from ends:

We can call the circular reactions of the second stage "primary." Their character consists in simple organic movements centered on themselves (with or without intercoordination) and not destined to maintain a result produced in the external environment. So it is that the child grasps for the sake of grasping, sucking, or looking, but not yet in order to swing to and fro, to rub, or to reproduce sounds. Moreover the external objects upon which the subject acts are one with his action which is simple, the means being confused with the end. On the other hand, in the circular reactions which we shall call "secondary" and which characterize the present stage, the movements are centered on a result produced in the external environment and the sole aim of the action is to maintain this result; furthermore it is more complex, the means beginning to be differentiated from the end, at least after the event. (Piaget, 1963, p. 157)

⁶² Note that the three stages mentioned in this citation are different from, and should not be confused with, Piaget's six sub stages of the sensori-motor period.

And so it is that in stage three, rather than simple repeating of an action for the sake of repetition, the child begins to notice the results of his actions and to repeat actions in order to reproduce the result:

The simple example is doubtless that of the objects the child simply shakes as soon as he has grasped them. From this elementary schema, which is almost “primary,” the following is immediately derived: if the objects brandished produce a sound this is enough to make the child attempt to reproduce it. (Piaget, 1963, p. 166)

The child also begins to apply previously acquired schema, such as that of shaking the arm to produce a sound from an object held in the hand, as a generalized *procedure*, or means to prolong interesting events observed by the child from afar. From example,

He looks at a tin box placed on a cushion in front of him, too remote to be grasped. I drum on it for a moment in a rhythm which makes him laugh and then present my hand (at a distance of 2 cm from his, in front of him). He looks at it, but only for a moment, then turns toward the box; then he shakes his arm while staring at the box (then he draws himself up, strikes his coverlets, shakes his head, etc.; that is to say, he uses all the “procedures” at his disposition). He obviously waits for the phenomenon to recur (....)

It therefore seems apparent that the movement of shaking the arm, at first inserted in a circular schema of the whole, has been removed from its context to be used, more and more frequently, as a “procedure” to make any interesting spectacle last. (Piaget, 1963, p. 201)⁶³

Stage four is marked by the intentional coordination of schemata with one another into a single act, and their application to new situations. Piaget considers this the stage in which we see the appearance of “the first actually intelligent behavior patterns” (Piaget, 1963):

⁶³ cf. Vygotsky's example of the development of pointing, in which a previously "object-oriented movement...becomes a movement aimed at another person, a means of establishing relations" (Vygotsky, 1978, p. 56)

From the point of view of the functioning of intelligence this fourth stage marks considerable progress over the preceding one. The behavior patterns of the third stage, as we have seen, only consist in “circular reactions.” No doubt these reactions are related to the external environment and no longer only to the body itself. Moreover, we have called them “secondary” to distinguish them from the “primary” reactions. No doubt either that the activity of the secondary schemata can start whenever the child wishes to prolong any interesting phenomenon and no longer only the result in connection with which the schemata in question were constituted. But, as we have stated, that is only a simple generalization of schemata without elaboration of the special relations between each of them and the new goal to be reached. In short, reactions of the third stage therefore constitute the simple prolongation of the primary circular reactions; they own only to their complexity the fact of drawing, after the event, a distinction between transitive and final states, between means and ends. On the other hand, the behavior patterns of the fourth stage involve such a distinction from the very outset. The criterion of their appearance is, in effect, the intercoordination of the secondary schemata. Now, in order that two schemata, until then detached, may be coordinated with one another in a single act, the subject must aim to attain an end which is not directly within reach and to put to work, with this intention, the schemata hitherto related to other situations. Thereafter the action no longer functions by simple repetition but by subsuming under the principle schema a more or less long series of transitional schemata. Hence there exists simultaneously the distinction between the end and the means, and the intentional coordination of the schemata. The intelligent act is thus constituted, which does not limit itself merely to reproducing the interesting results, but to arriving at them due to new combinations. (pp. 210-211)

Piaget (1963) gave the following examples of intentional coordination of schemata:

1. Obtaining items placed on the bassinet hood by pulling strings attached to the hood or in contact with the items themselves (pp. 213-216).
2. Withdrawing material objects that intervene between the intention and the result—e.g. displacing the hand of the experimenter or a cushion in order to obtain an object such as a matchbox or watch first presented to the child then concealed behind the intervening object (pp. 216-222).
3. Making use of intermediaries between the subject and the objective—e.g. using the hand of the experimenter or the child’s own feet to bring an object within reach (pp. 222-225).

From these examples we see the difference between (a) the primary circular reaction of stage two which “has no other end, in effect, than that of reproducing a result obtained earlier, or which has just been discovered by chance” (Piaget, 1963, p. 227); (b) the secondary circular reaction of stage three in which the “effect which is to be repeated is then posited in advance, as an end, and the child tries to rediscover the means which have just led him to it” which, “although intentional... is nevertheless the simple prolongation of an earlier effect” (p. 227); and (c) the coordination of secondary schemata and their application to new situations found in stage four:

In the present behavior patterns, the end is posited without having been attained beforehand, at least, not in the same situation. When the child tries to grasp his toys by pushing an obstacle away (Obs. 122-124), tries to act upon objects through the intermediary of someone’s else [sic] hand (Obs. 127-128), tries to shake a parrot from a distance (Obs. 129), these are projects which arise in the course of his action, in conformity, it is true, with his earlier circular reactions (the very nature of the end consequently does not differ from one behavior pattern to another), but in an actually new situation. (p. 227)

Stage five is marked by the appearance of a tertiary circular reaction in which the child “will not only submit to but even provoke new results instead of being satisfied merely to reproduce them once they have been revealed fortuitously” (Piaget, 1963, p. 266). This sensori-motor sub stage is one of experimentation and discovery:

These tertiary actions will lead the child to new complete acts of intelligence which we shall call “discovery of new means through active experimentation.” The acts of intelligence hitherto under study have only consisted in an application of familiar means (already acquired schemata) to new situations. But what will happen when the familiar means reveal themselves to be inadequate, in other words, when the intermediates between subject and object are not assimilable to the habitual schemata?...The subject will search on the spot for new means and will discover them precisely through tertiary reaction....The invention of new means through active experimentation...is to tertiary reaction what the “application of familiar means to new situations” is to secondary

reaction: a combination or coordination of schemata in comparison to simple schemata. (p. 267)

As the child plays out his experiments, he somewhat systematically varies his movements:

The tertiary reaction brings several innovations. At first, even in repeating his movements to seek and find an interesting result, the child varies and gradates them. So it is that, when throwing objects from a distance or rolling them (Obs. 144 and 145), tilting up a box or making it slide (Obs. 146), etc., he drops these objects from increasingly high altitudes, places his finger on a certain part of the box or on another part, etc...the child does not know what will happen and he tries to ferret out new phenomena. (Piaget, 1963, pp. 273-274)

Stepping back to a view of a higher level, sensorimotor intelligence behavior patterns can be divided into two groups: (a) those which are “in some way imposed by the external environment” (Piaget, 1963, p. 321), and (b) those which are “due to the subject’s spontaneous intention” (p. 321). Behavior patterns, or simple action-schemes, of the first group are manifest in stages one and two of the sensorimotor period. The second group can be further divided into three distinct types. In stage four we saw the first: “application of familiar means to new situations” (p. 322), with the procedures to make interesting sights last of stage three being a precursor. In stage five we saw the second: “discovery of new means through active experimentation” (p. 322). In stage six we see the third type: “invention of new means through mental combination” (p. 322).

Stage six marks the end of the sensorimotor period, and the early stages of the pre-operational period. In this stage, the behavior patterns of the previous stages do not disappear, but they begin to be “completed by behavior patterns of a new type: “invention through deduction or mental combination” (pp. 331-356). Piaget referred to this as systematic

intelligence, in which the behavior patterns are not only discovery, but also invention; not only sensorimotor groping, but also mental representation through signification:

The two essential questions raised by such behavior patterns in relation to the preceding ones are those of *invention* and *representation*. Henceforth there exists invention and no longer only discovery; there is, moreover, representation and no longer only sensorimotor groping. These two aspects of systematic intelligence are interdependent. To invent is to combine mental, that is to say, representative, schemata and, in order to become mental the sensorimotor schemata must be capable of intercombining in every way, that is to say, of being able to give rise to true inventions. (p. 341)

Piaget's examples of invention through representation include cases such as his son, Laurent, "all at once" discovering "the use of the stick" (p. 333); the experience of his daughter, Lucienne, learning to use a stick very quickly through invention and representation, compared with her sister, Jacqueline, who learned it much more slowly through prolonged efforts of sensorimotor groping (p. 336); and an example in which a watch chain which was to be put into a small hole only 16 x 34 mm. Again, Lucienne solved the problem quickly through what Piaget counted to be means of invention, as compared to her sister who learned it more slowly through a "long apprenticeship" of sensorimotor experimentation⁶⁴ (pp. 336- 337).

Thus, in moving from stages one through five into stage six, there is a "transition from directed gropings to invention, and from motor schema to representative schema" (p. 341). To establish continuity between these two apparent extremes, Piaget explained that although both are controlled by the same motor—i.e., the intellectual activity of assimilation and

⁶⁴ When confronted with the same problem a year later Jacqueline solves the problem through invention rather than experimentation and discovery.

accommodation (p. 341)—the primary difference between them is the speed at which this motor operates;

It must be understood...that the contrast between directed groping and actual *invention* is primarily due to a difference in speed. The structuring activity of assimilation only operates step by step in the course of experimental groping, so that it is not immediately visible, and one is tempted to attribute the discoveries which result from it solely to fortuitous contact with external facts. In invention, on the contrary, it is so rapid that the structurization seems sudden. The structuring assimilatory activity thus once again passes unnoticed at first glance and one is tempted to consider the "structures" as organizing themselves. Thereafter the contrast between the empiricism of simple groping and the intelligence of deductive invention seems to be complete. But if one thinks about the role of intellectual activity peculiar to combined assimilation and accommodation, one perceives that this activity is neither absent from empirical groping nor useless to the structure of representations. On the contrary, it constitutes the real motor of both, and the primary difference between the two situations stems from the speed at which the motor goes, a speed slowed down in the first case by the obstacles on the road and accelerated in the second case by the training acquired. (Piaget, 1963, pp. 341-342)

From this we are to understand that the apparent, but not actual, conflict in the transition from discovery by empiricist groping of the first five stages to deductive invention in stage six is simply the spontaneous recombination of mental schemata, without dependence on sensorimotor experience:

In the present case...in which the question raised is addressed to a mind sufficiently furnished with already constructed schemata so that the reorganization of these schemata operates spontaneously, the structuring activity no longer needs always to depend on the actual data of perception and, in the interpretation of these data, can make a complex system of simply evoked schemata converge. Invention is nothing other than this rapid reorganization and representation amounts to this evocation, both thus extending the mechanisms at work in the ensemble of the preceding behavior patterns. (Piaget, 1963, pp. 342-343)

Piaget summarized the characteristics of the sixth stage by saying,

Thus may be seen the unity of the behavior patterns of the sixth stage: Mental combinations of schemata with possibility of deduction surpassing actual

experimentation, invention, representative evocation by image symbols, so many characteristics marking the completion of sensorimotor intelligence and making it henceforth capable of entering the framework of language to be transformed, with the aid of the social group, into reflective intelligence. (p. 356)⁶⁵⁶⁶

⁶⁵ Here Piaget mentions image symbols and a preparation for a framework of language. In order to maintain some semblance of brevity, and to avoid confusion and complexity in my review of his ideas, I have omitted discussion of the development of signs, signals and language. Let me briefly address this here. From the beginning, during stages one through three, although signifiers are present they are, in those stages, undifferentiated:

Although representation does not yet exist, the baby forms and uses significations, since every sensori-motor assimilation (including perceptual assimilations) already implies the attribution of a signification, of a meaning. Significations and consequently also a duality between "signified" (the schemes themselves with their content; that is, the action) and "signifiers" are already present. However, these "signifiers" remain perceptual and are not yet differentiated from the "signified." This makes it impossible to talk about semiotic function at this level. An undifferentiated signifier is, in fact, as yet neither a "symbol" nor a "sign" (in the sense of verbal signs). It is by definition an "indicator" (including the "signals" occurring in conditioning, like the sound of the bell that announces food). An indicator is actually undifferentiated from its signified in that it constitutes an aspect of it (whiteness for milk), a part (the visible section for a semi-hidden object), a temporal antecedent (the door that opens for the arrival of Mama), a causal result (a stain), etc.

(Piaget & Inhelder, 1969, p. 52-53)

The first clear use of true, differentiated signs occurs during stage four (Piaget, 1963, p. 248):

We recall that to each of the preceding stages a particular type of signs and meanings corresponds. To the reflex stage corresponds a type of recognitions and of meanings immanent in the use of the reflex. The child recognizes whether he is sucking without an object, whether he is sucking a tegument or is really nursing. The primary circular reactions then engender a second type of signs, the "signals" acquired by insertion of a new perceptive element in the familiar schemata. Whether they are simple or derived from the coordination of heterogeneous schemata, the signals thus form part of the act which they set in motion in the manner of direct perception of the objective. So it is that a heard sound provokes the search for the corresponding image, etc. As we have seen, with the secondary reactions a third type of signs begins which are intermediate between the "signal" and the "sign," that is to say, form the transition between the sign which simply releases the action and that which permits independent prevision of the act. For instance, when a child hears a bed creak and by this sign recognizes the presence of his mother who will be able to feed him (Obs. 108) he limits himself to inserting a new perception in the complex schemata coordinated with sucking and in that respect the sign is still only a "signal" but he is on the way to attributing to his mother an activity independent of himself and, to this extent, the prevision under consideration presages the true "sign."

This decisive progress, which consists in bringing prevision to bear upon events independent of the action itself, is achieved during the fourth stage in correlation with the objectifying of the relations which characterize this stage in general. In other words, a fourth type of sign is now constituted which we shall call the actual "sign," which permits the child to foresee, not only an event connected with his action, but also any event conceived as being independent and connected with the activity of the object.

As previously noted, stage six marks the end of the sensorimotor period, and the early stages of the pre-operational and succeeding periods. The order of succession of the four periods of development and the sub stages of the sensorimotor is constant, and although "the average ages at which they occur may vary with the individual, according to his degree of intelligence or with the social milieu," (Piaget & Inhelder, 1969, p. 153) the general ages are as follows (pp. 93, 96, 130):

1. Sensorimotor period – birth to 2 or 3 years (with the average age of the six sub stages being: Stage 1 – birth to 1 months, Stage 2 – 1 to 4 months, Stage 3 – 4 to 8 months, Stage 4 – 8 to 12 months, Stage 5 – 12 to 18 months, and Stage 6 – 18 to 24 months)
2. Pre-operational period – 2 or 3 to 6 or 7 years
3. Concrete operational period – 6 or 7 to 11 or 12
4. Formal operational preadolescent period – 11 or 12 to 14 or 15

The pattern of development established in the six sub stages of the sensori-motor period—a process of assimilation and accommodation in equilibrium—continues through the

By the sixth stage, and continuing on, five behavioral patterns appear "which imply the representative evocation of an object or event not present and which consequently presuppose the formation or use of differentiated signifiers" (Piaget & Inhelder, 1969, p. 53):

- Deferred imitation – "imitation which starts after the disappearance of the model" (p. 53)
- Symbolic play – "the game of pretending, which is unknown at the sensori-motor level" (p. 53)
- Drawing or graphic image (p. 54)
- Mental image – "no trace of which is observed on the sensori-motor level" but "it appears as an internalized imitation," for example, "pointing to the sloping path [grandpa] took when he left" (p. 54)
- Verbal evocation of events that are not occurring in real time – "When the little girl says 'meow' after the cat has disappeared, verbal representation is added to imitation" (p. 54)

⁶⁶ Not also in this quote Piaget's attribution to the role of the "social group" in transforming previously acquired intelligence, through language, into what he calls "reflective intelligence."

remaining periods (pre-operational, concrete operational, and formal operational) with each progressive attainment building on the previous period. A description of each of the remaining periods will not be given since what is of primary interest to the present study—the process by which learning occurs—has already been quite thoroughly addressed.⁶⁷

Discovery Learning (Jerome Bruner – 1961). To the foundation of constructive learning theory established by Piaget, Jerome Bruner contributed important ideas regarding (a) modes of representation, (b) the importance of teaching and learning "optimal structure" (J. S. Bruner, 1966b, p. 41), (c) the spiral curriculum, and (d) learning through acts of discovery in order to rearrange and transform what is learned "in such a way that one is enabled to go beyond the evidence so reassembled to additional new insights" (J. S. Bruner, 1961, p. 22).

Just as Piaget viewed development as progressing from the physical sensorimotor experience of the child which results in learned action-schemes, to representative schema which facilitate mental operations, Bruner also distinguished between three modes of representation or systems of processing in both the physical (i.e., action) and mental (i.e., imagery and language) realms. In Bruner's (1964) view, growth necessitates and is facilitated by manageable representation of "recurrent features" of the "complex environments in which [we] live" (p. 1):

Two matters will concern us. The first has to do with the techniques or technologies that aid growing human beings to represent in a manageable way the recurrent features of the complex environments in which they live. It is fruitful, I think, to distinguish three systems of processing information by which human beings construct models of their world: through action, through imagery, and through language. A second concern is with integration, the means whereby acts are organized into higher-order ensembles, making

⁶⁷ The reader interested in learning more is referred to Brainerd (1978), which contains a thorough accounting of which of Piaget's publications concern which periods of development, an excellent summary of each period, and a review of relevant research.

possible the use of larger and larger units of information for the solution of particular problems. (J. S. Bruner, 1964, p. 1)

Bruner referred to these three systems of processing as *enactive*, *iconic*, and *symbolic*, and defined them as follows (J. S. Bruner, 1964):

1. Enactive representation – “By enactive representation I mean a mode of representing past events through appropriate motor response” (p. 2).
2. Iconic representation – “Iconic representation summarizes events by the selective organization of percepts and of images, by the spatial, temporal, and qualitative structures of the perceptual field and their transformed images” (p. 2).
3. Symbolic representation – “A symbolic system represents things by design features that include remoteness and arbitrariness. A word neither points directly to its referent here and now, nor does it resemble it as a picture” (p. 2).

As an example of the three modes, Bruner cited an experiment reported by Emerson in 1931 in which children were told to place a ring on a peg board, copying the position of a ring placed on an identical board by the experimenter. Children ranging from 3 to 12 were the subjects of the experiment. Their boards were placed in a variety of orientations relative to the experimenter’s board. The results of the experiment showed that older children performed better than younger children, but that the younger children could do about as well as the oldest as long as he did not have to change his body position to place his ring. The more the younger children had to turn, the more difficult the task. Bruner interpreted these results in terms of his three modes of representation, calling attention to the ability of the older children to use iconic or symbolic representation to mediate the loss of context experienced in reorienting one’s body:

The younger children could do about as well as the oldest so long as they did not have to change their own position vis-à-vis the experimenter's board. The more they had to turn, the more difficult the task. They were clearly depending upon their bodily orientation toward the experimenter's board to guide them. When this orientation is disturbed by having to turn, they lose the position on the board. Older children succeed even when they must turn, either by the use of imagery that is invariant across bodily displacements, or, later, by specifying column and row of the experimenter's ring and carrying the symbolized self-instruction back to their own board. It is a limited world, the world of enactive representation. (J. S. Bruner, 1964, p. 3)

Bruner's modes of representation provide an explanation of cognitive growth; that it proceeds in sequence from learned action patterns, to images that stand for events, and finally to a symbol system:

We have said that cognitive growth consists in part in the development of systems of representation as means for dealing with information. The growing child begins with a strong reliance on learned action patterns to represent the world around him. In time, there is added to this technology a means for simultaneizing regularities in experience into images that stand for events in the way that pictures do. And to this is finally added a technology of translating experience into a symbol system that can be operated upon by rules of transformation that greatly increase the possible range of problem solving. (J. S. Bruner, 1964, p. 11)

Although the young child begins only with the capacity for representation through action, then later imagery, then finally language, it is not Bruner's position that the first two forms of representation are not abandoned once language is available, for even "in ordinary adult learning a certain amount of motoric skill and practice seem to be a necessary precondition for the development of a simultaneous image to represent the sequence of acts involved" (J. S. Bruner, 1964, p. 3).

In *The Process of Education* (1960) Bruner published a set of views that grew out of a ten-day conference of thirty-five scientists, scholars, and educators, convened by the National Academy of Sciences through its Education Committee to discuss how education in science

might be improved (pp. vii – xvi). The book is written around four themes (introduced in pp. 11-16):

1. The role of structure in learning – “The teaching and learning of structure, rather than simply the mastery of facts and techniques, is at the center of the problem of transfer” (p. 12)
2. Readiness for learning – “Our schools may be wasting precious years by postponing the teaching of many important subjects on the ground that they are too difficult...the foundations of any subject may be taught to anybody at any age in some form” (p. 12)
3. The nature of intuition – “The shrewd guess, the fertile hypothesis, the courageous leap to a tentative conclusion—these are the most valuable coin of the thinker at work, whatever his line of work” (pp. 13-14)
4. The desire to learn and how it may be stimulated – “Ideally, interest in the material to be learned is the best stimulus to learning, rather than such external goals as grades or later competitive advantage” (p. 14)

The first three of Bruner’s themes are premised by his conviction that the intellectual activity of the child is no different in kind than the intellectual activity of a scientist working at the frontier of knowledge, but only in degree:

Intellectual activity anywhere is the same, whether at the frontier of knowledge or in a third-grade classroom. What a scientist does at his desk or in his laboratory, what a literary critic does in reading a poem, are of the same order as what anybody else does when he is engaged in like activities—if he is to achieve understanding. The difference is in degree, not in kind. The schoolboy learning physics *is* a physicist, and it is easier for him to learn physics behaving like a physicist than doing something else. (J. S. Bruner, 1960, p. 14)

Bruner believed that "teaching should be geared to the teaching of fundamental ideas in whatever subject is being taught"⁶⁸ (J. S. Bruner, 1960, p. 18). He referred to this as learning structure, the learning of which "should not only take us somewhere; it should allow us later to go further more easily" (p. 17). Structure provides the framework for a given subject. To learn the structure of a subject is to understand it "in a way that permits many other things to be related to it meaningfully," or "to learn how things are related" (p. 7). Bruner made four general claims in support of teaching fundamental structure as the primary and initial goal of a curriculum:

1. "Understanding fundamentals makes a subject more comprehensible" (p. 23).
2. "Unless detail is placed into a structured pattern, it is rapidly forgotten" (p. 24).
3. "An understanding of fundamental principles and ideas appears to be the main road to adequate 'transfer of training'" (p. 25).
4. By constantly reexamining material taught in elementary and secondary schools for its fundamental character, one is able to narrow the gap between "advanced" knowledge and "elementary" knowledge (p. 26).⁶⁹

Consistent with his basic premise that the intellectual activity of the child is no different in kind from the intellectual activity of a scientist, only different in degree (J. S. Bruner, 1960, p.

⁶⁸ Bruner described the challenges of teaching structure as: (a) "how to construct curricula that can be taught by ordinary teachers to ordinary students and that at the same time reflect clearly the basic or underlying principles of various fields of inquiry" (J. S. Bruner, 1960, p. 18), (b) how to enlist the aid of subject matter experts ("to decide that the elementary ideas of algebra depend upon the fundamentals of the commutative, distributive, and associative laws, one must be a mathematician in a position to appreciate and understand the fundamentals of mathematics" (p. 19)), and (c) how to develop "an attitude toward learning and inquiry, toward guessing and hunches, toward the possibility of solving problems on one's own" (p. 20) in a given field.

⁶⁹ The concern is the disconnect that can occur between what is learned in elementary school and what is learned in high school due, at least in part, to the changing nature of knowledge as developments in the field are made.

14), Bruner believed there is no reason to wait until the child is 'ready' (i.e. through cognitive maturation) before introducing certain topics which would otherwise not be accessible to him:

We begin with the hypothesis that any subject can be taught effectively in some intellectually honest form to any child at any stage of development. It is a bold hypothesis and an essential one in thinking about the nature of a curriculum. No evidence exists to contradict it; considerable evidence is being amassed that supports it. (J. S. Bruner, 1960, p. 33)

As an example he described "statistical manipulation and computation" as "only tools to be used *after* intuitive understanding has been established" (J. S. Bruner, 1960, p. 46). He also explained that intuitive understanding, as well as attitudes and approaches, is something that can be taught in the earlier grades:

It may well be that there are certain general attitudes or approaches toward science or literature that can be taught in the earlier grades that would have considerable relevance for later learning. The attitude that things are connected and not isolated is a case in point. One can indeed imagine kindergarten games designed to make children more actively alert to how things affect or are connected with each other—a kind of introduction to the idea of multiple determination of events in the physical and social world. (J. S. Bruner, 1960, p. 27)

The enabling characteristic of knowledge that lends utility to Bruner's notion of spiral curriculum is that it is, in fact, the basic and simple ideas that underlie all that is complex:

Though the proposition may seem startling at first, its intent is to underscore an essential point often overlooked in the planning of curricula. It is that the basic ideas that lie at the heart of all science and mathematics and the basic themes that give form to life and literature are as simple as they are powerful. (J. S. Bruner, 1960, pp. 12-13)

Having first the benefit of exposure to basic constructs and principles—exposure which permits the establishment of an intuitive understanding, grounded in experience commensurate with his view of the world and how he interprets ideas—the child's understanding can then be

enlarged through a “continual deepening” that ushers in effective utility of the knowledge and understanding previously acquired:

To be in command of these basic ideas, to use them effectively, requires a continual deepening of one’s understanding of them that comes from learning to use them in progressively more complex forms⁷⁰. It is only when such ideas are put in formalized terms as equations or elaborated verbal concepts that they are out of reach of the young child, if he has not first understood them intuitively and had a chance to try them out on his own. (J. S. Bruner, 1960, p. 13)

Of important note in the above quote is Bruner’s point regarding the accessibility of ideas to children. He elaborated this point by general hypothetical example, stating that the barrier to accessibility is not a result of the complexity of the ideas per se, but rather the formal language adults use to describe them:

Fourth-grade children can play absorbing games governed by the principles of topology and set theory, even discovering new “moves” or theorems. They can grasp the idea of tragedy and the basic human plights represented in myth. But they cannot put these ideas into formal language or manipulate them as grownups can. (J. S. Bruner, 1960, p. 13)

Because of this, he recommended that “the early teaching of science, mathematics, social studies, and literature should be designed to teach these subjects with scrupulous intellectual honesty, but with an emphasis upon the intuitive grasp of ideas and upon the use of these basic ideas” (J. S. Bruner, 1960, p. 13). From this departure, the spiral curriculum then “turns back on itself at higher levels” (p. 13) and the curriculum “as it develops [revisits] these basic ideas repeatedly, building upon them until the student has grasped the full formal apparatus that goes with them” (p. 13).

⁷⁰ cf. Reigeluth’s elaboration theory (C. M. Reigeluth, 1999).

One of the primary factors to consider in structuring the spiral curriculum is the child's way of "viewing the world and explaining it to himself" (J. S. Bruner, 1960, p. 33) which changes as the child develops:

Research on the intellectual development of the child highlights the fact that at each stage of development the child has a characteristic way of viewing the world and explaining it to himself. The task of teaching a subject to a child at any particular age is one of representing the structure of that subject in terms of the child's way of viewing things. (J. S. Bruner, 1960, p. 33)

It may be that nothing is intrinsically difficult. We just have to wait until the proper point of view and corresponding language for presenting it are revealed. (J. S. Bruner, 1960, p. 40)

In summary, an effective spiral curriculum (J.S. Bruner, 1960)

1. Begins with the basic and simple ideas that underlie that which is more complex (pp. 12-13).
2. Emphasizes the intuitive grasp of ideas and the use of those basic ideas in the early teaching of any subject (p. 46).
3. Revisits the basic ideas repeatedly (p. 13).
4. Enables continual deepening of understanding by facilitating the use of basic ideas in progressively more complex forms (p. 13).

Bruner is also known for his ideas on learning through discovery, which I have often heard spoken of in educational circles as if it is the complete essence of constructive learning theory. I have also observed that discovery learning has had considerable influence on today's

public education,⁷¹ particularly in math education. Bruner's definition of "discovery" was not restricted to "the act of finding out something that before was unknown to mankind, but rather [included] all forms of obtaining knowledge for oneself by the use of one's own mind" (J. S. Bruner, 1961, p. 22). He further stated that there are "powerful effects that come from permitting the student to put things together for himself, to be his own discoverer" (p. 22).

Bruner described discovery learning as taking place in the hypothetical rather than the expository mode. In the *expository* mode "decisions concerning the mode and pace and style of exposition are principally determined by the teacher as expositor; the student is listener" (J. S. Bruner, 1961, p. 23). In the *hypothetical* mode, on the other hand, "the teacher and student are in a more cooperative position" (p. 23) in which the student, at times, plays the principle role:

The student is not a bench-bound listener, but is taking a part in the formulation and at times may play the principle role in it. He will be aware of alternatives and may even have an "as if" attitude toward these and, as he receives information he may evaluate it as it comes. (J. S. Bruner, 1961, p. 23)

The technique of discovery is also a factor in its effectiveness. Bruner (1961, p. 24-25) noted two alternatives: *cumulative constructionism* and *episodic empiricism*. Using the latter, the child "string[s] out hypotheses non-cumulatively one after the other" (p. 25) thereby flooding themselves with "disorganized information" (p. 25) and "soon become[s] discouraged and confused" (p. 25). In contrast, the child who employs cumulative constructionism makes use of previously acquired information and uses it to determine subsequent inquiries. This child has "a

⁷¹ In fact, they are pervasive enough that it's probably fair to say they dominate the general approach to teaching math in K-6 grades across the country. At least in my own experience in traveling to various school districts to conduct training and provide consulting, this has certainly been the case.

certain cunning in his strategy of getting information” (p. 25) with the principle component of his strategy being “the recognition that the value of information is not simply in getting it but in being able to carry it” (p. 25), and a “knowledge of how to organize questions in cycles, how to summarize things to himself, and the like” (p. 25). Cumulative constructionism constrains the nature of subsequent questions of investigation, connects previously acquired knowledge with new knowledge, and continually organizing the incoming flow of information:

Episodic empiricism is illustrated by information gathering that is unbound by prior constraints, that lacks connectivity, and that is deficient in organizational persistence. The opposite extreme is illustrated by an approach that is characterized by constraint sensitivity, by connective maneuvers, and by organized persistence. (1961, p. 25)

Bruner hypothesized that an emphasis on discovery in learning would have the positive result of leading students to become more effective learners:

I would urge now in the spirit of an hypothesis that emphasis upon discovery in learning has precisely the effect upon the learner of leading him to be a constructionist, to organize what he is encountering in a manner not only designed to discover regularity and relatedness, but also to avoid the kind of information drift that fails to keep account of the uses to which information might have to be put. It is, if you will, a necessary condition for learning the variety of techniques of problem solving, of transforming information for better use, indeed for learning how to go about the task of learning. Practice in discovering for oneself teaches one to acquire information in a way that makes that information more readily viable in problem solving. (1961, p. 26)

He also expressed a belief that such a practice would result in a shift from extrinsic to intrinsic motivation and that what is learned will be more easily remembered:

To the degree that one is able to approach learning as a task of discovering something rather than "learning about" it, to that degree will there be a tendency for the child to carry out his learning activities with the autonomy of self-reward or, more properly by reward that is discovery itself. (1961, p. 26)

The very attitudes and activities that characterize “figuring out” or “discovering” things for oneself also seems to have the effect of making material more readily an accessible in memory. (1961, p. 32)

Although Bruner had intended to present discovery as a guided process—directed toward some specific goal and a pre-determined set of criteria regarding what is to be discovered—as it often happens, what he said about discovery was taken far beyond its intended bounds. By the mid-1960s discovery teaching had come to imply "providing a rich environment for learning with an accompanying freedom for learners to set their own learning agenda" (Driscoll, 2000, p. 233) which resulted in "a surge of popularity for open, unstructured classrooms" (p. 233). Bruner himself did not support this detachment of context or the unguided application of discovery:

I had, some years before, published a paper entitled "The Act of Discovery" (*Harvard Educational Review*, 1961), which had been interpreted as the basis for a "school of pedagogy" by a certain number of educators. As so frequently happens, the concept of discovery, originally formulated to highlight the importance of self-direction and intentionality, had become detached from its context and made into an end in itself. Discovery was being treated by some educators as if it were valuable in and of itself, no matter what it was a discovery of or in whose service. (J. S. Bruner, 1971, p. xv)

Bruner (1971) also stated that he was "not quite sure" anymore that he understood what discovery is, that you would not expect each organism to "rediscover the totality of its culture," and went so far as to refer to discovery as "the most inefficient technique possible for regaining what has been gathered [by the culture as a whole] over a long period of time" (pp. 68-69). In reference to language learning by the young child he said,⁷²

⁷² Driscoll (2000, p. 230) cited the second half of this statement as evidence that Bruner was reemphasizing "that discovery is not haphazard." I do not see it this way. In my own interpretation, Bruner is clearly stating that language learning is not facilitated by discovery, but by interaction with a model.

Thus, within the culture the earliest form of learning essential to the person becoming human is not so much discovery as it is having a model. The constant provision of a model, the constant response to the individual's response after response, back and forth between two people, constitute "invention" learning guided by an accessible model. (J. S. Bruner, 1971, p. 69)

As Bruner re-evaluated his thinking about discovery, he decided that one could not reasonably conclude that discovery is a principal means of educating children, but continued to recognize a necessary discovery-like component in human learning:

If you want to talk about invention, perhaps the most primitive form of uniquely human learning is the invention of certain patterns that probably come out of deep-groove characteristics of the human nervous system, with a lot of shaping taking place on the part of an adult. Consequently, wherever you look, you cannot really come away with a strong general consensus that discovery is a principal means of educating the young. Yet, the one thing that is apparent is that there seems to be a necessary component in human learning that is like discovery, namely, the opportunity to go about exploring a situation. (J. S. Bruner, 1971, p. 70)

He followed this up by redefining the important substrate of discovery learning which he had tried to articulate in *The Act of Discovery* (1961). In his new definition he articulated discovery teaching as a six part problem, the solution of which is aimed at "an approach to learning that allows the child not only to learn the material that is presented in a school setting, but to learn it in such a way that he can use the information in problem solving" (J. S. Bruner, 1971, p. 70). The six sub-problems of his new model are (J.S. Bruner, 1971)

1. Attitude

First is the attitude problem. How do you arrange learning in such a way that the child recognizes that when he has information he can go beyond it, that there is connectedness between the facts he has learned with other data and situations? He must have the attitude that he can use his head effectively to solve a problem, that when he has a little bit of information he can extrapolate information; and that he can interpolate when he has unconnected material. Basically, this is an attitudinal problem—something that will

counteract inertness in that he will recognize the material that he has learned as an occasion for going beyond it. (p. 71)

2. Compatibility

Second is the compatibility problem. How do you get the child to approach new material that he is learning in such a fashion that he fits it into his own system of associations, subdivisions, categories, and frames of reference, in order that he can make it his own and thus be able to use the information in a fashion compatible with what he already knows? (p. 71)

3. Activation

Third involves getting the child activated so that he can experience his own capacity to solve problems and have enough success so that he can feel rewarded for the exercise of thinking. (p. 71)

4. Practice

Fourth is giving the child practice in the skills related to the use of information and problem solving...The great problem here is how do you give the child practice in the utilization of these skills—because it turns out that however often you may set forth general ideas, unless the student has an opportunity to use them he is not going to be very effective in their use. (pp. 71-72)

5. The "self-loop" problem

Fifth is a special kind of a problem that I want to speak of as "the self-loop problem." The child, in learning in school settings, will frequently do kinds of things which he is not able to describe to himself. Psychologists see this all the time in new studies—children who are able to do many kinds of things, for example, to handle a balance mean quite adequately by putting rings on nails on both sides of a fulcrum and getting quite interesting balances, but are not able to say it to themselves and convert this fact into a compact notion which they could hold in mind. (pp. 71-72)

6. Capacity for handling information flow

The sixth problem involves the nature of our capacity for handling information flow manageably so that it can be used in problem solving. (p. 72)

In summary, as with virtually all of the other theories so far discussed, Bruner's ideas of discovery learning were (a) presented in a piecemeal fashion with limited context, (b) interpreted beyond their intended scope, (c) generalized into a practitioners' application, and (d) were later modified and subdued by their originator in favor of a new interpretation. However, as is also true of many of the other theories, the generalized educational practitioner's application of the original ideas is of considerable influence in both the classroom and the design of instruction.

The Human Perspective

In contrast with the predominately objective approaches to learning summarized in the previous three sections, some theorists have approached learning from a very human point of view. This view is based on the perspective that human beings act with intentionality and are guided by values. According to this view, learning is promoted by understanding the whole person (the learner as a thinking, feeling agent in his own learning), his motives (the reasons for which he may or may not engage with learning), and his goals (or intentions).

Motivation is a major component in human learning theory. However, it is not the only component. In a special issue of *The Elementary School Journal* devoted to the topic of motivation, Stipek (1984) described a history in which, up until the 1970s "reinforcement theory dominated the motivation literature" (p. 1), with the general belief being that "a child exerts effort on academic assignments to obtain a reward (e.g., a high grade) and to avoid punishment (e.g., a low grade)" (p. 1). She notes that by the 1980s, the prominent theoretical framework was "not so simple" (p. 1). For example, some children "who purposely do not try to attain a good grade...would be pleased to receive an 'A,' but they do not perceive an 'A' as a realistic goal" (p.

1). This illustrates two other important components of human learning: affect and agency. In this section eleven theories of human learning will be reviewed. They are (a) Maslow's hierarchy of human needs, (b) Fuller's biological motivation, (c) achievement motivation, (d) attribution theory, (e) self-worth theory, (f) self-efficacy, (g) self-determination theory of motivation, (h) self-regulation, (i) ARCS, (j) Rogers' freedom to learn, and (k) Bandura's agentic theory of the self.

Most of these theories have a much narrower explanatory scope than other theories of learning that have been reviewed. Some of them are intended only to address the motivational aspects of learning, some only the affective or agentic aspects, and others a variable combination of the three. Because of this, summaries of theories in this section will be somewhat shorter than in the behavioral, cognitive, constructive, and social theory sections.

Hierarchy of Human Needs (Maslow – 1943). What is now commonly referred to as Maslow's Hierarchy of needs, was presented by Maslow as "an attempt to formulate a positive theory of motivation" (Maslow, 1943b). This theory was presented in satisfaction of a set of propositions previously enumerated (Maslow, 1943a) and later extended in his presentation of *A Theory of Human Motivation* (Maslow, 1943b). In brief, these propositions are

1. Required the foundation of the "integrated wholeness of the organism" (p. 370)
2. Rejected any physiological drive (including hunger) as a centering point, since "any drive that is somatically based and localizable was shown to be atypical rather than typical in human motivation" (p. 370)
3. Called for a theory centered on "ultimate or basic goals rather than partial or superficial ones" (p. 370)
4. Acknowledged "various cultural paths to the same goal" (p. 370)

5. Recognized an act as typically having "*more* than one motivation" (p. 370)
6. Assumed all "organismic states" (p. 370) are both motivated and motivating
7. Assumed that "human needs arrange themselves in hierarchies of prepotency" (p. 370) and that "man is a perpetually wanting animal" (p. 370)
8. Rejected "lists of drives" (p. 370) as having any utility for theoretical or practical purposes
9. Required "classifications of motivations [to be] based upon goals rather than upon instigating drives or motivated behavior" (p. 371)
10. Required that the motivation theory be "human-centered rather than animal-centered" (p. 371)
11. Rejected field theory as a substitute for motivation theory
12. Required not only an accounting of the "integration of the organism [but] also the possibility of isolated, specific, partial or segmental reactions" (p. 371)
13. Specified that "motivation theory is not synonymous with behavior theory" (p. 371)

Maslow's theory was derived most directly from clinical experience, but was "in the functionalist tradition of James and Dewey...fused with the holism of Wertheimer (19), Goldstein (6), and Gestalt Psychology, and with the dynamicism of Freud (4) and Adler (1)" (Maslow, 1943b, p. 371). The theory outlined five sets of human goals, which were referred to as "basic needs" (pp. 372, 394). They are (a) physiological, (b) safety, (c) love, (d) esteem, and (e) self-actualization. Maslow also suggested two additional sources of motivation, which are (f) "the desire to achieve or maintain the various conditions upon which these basic satisfactions rest" (p. 394), and (g) "certain more intellectual desires" (p. 394).

The most common example of a *physiological* need is hunger. Maslow described "the man who is extremely and dangerously hungry, [as having] no other interests [but] but food. He dreams food, he remembers food, he thinks about food, he emotes only about food, he perceives only food and he wants only food" (1943b, p. 374) While acknowledging the reality of this drive, he denied its generality, stating that "emergency conditions are, almost by definition, rare in the normally functioning peaceful society" (p. 374):

Obviously a good way to obscure the 'higher' motivations, and to get a lopsided view of human capacities and human nature, is to make the organism extremely and chronically hungry or thirsty. Anyone who attempts to make an emergency picture into a typical one, and who will measure all of man's goals and desires by his behavior during extreme physiological deprivation is certainly being blind to many things. (Maslow, 1943b, p. 375)

Maslow felt that what is more interesting than this rare condition is "what happens when there *is* plenty of bread and when his belly is chronically filled" (1943b, p. 375). He described this more common condition as resulting in emergence of higher needs, the first of which is the need for *safety*. For infants, threats to safety may include sudden disturbance, being dropped, loud noises, flashing lights or other unusual sensory stimulation, rough handling, or inadequate support (p. 376). For the child, threats of safety include illness; disruption in routine or rhythm; injustice; unfairness; parental inconsistency; quarreling, physical assault, separation, divorce, or death within the family; and "parental outbursts of rage or threats of punishment directed to the child, calling him names, speaking to him harshly, shaking him, handling him roughly, or actual physical punishment" (pp. 377-378). Maslow describes most adults in our culture as being largely satisfied in their needs for safety. However, this need for safety is evident in "the very common preference for familiar rather than unfamiliar things, or for the known rather than the

unknown [and] the tendency to have some religion or world-philosophy that organizes the universe and the men in it" (p. 379).

The need for *love* is the need for affection relations with friends and family, and involves "both giving and receiving love" (Maslow, 1943b, p. 381). The need for *esteem* refers to a desire to have a stable and usually high evaluation of oneself, for self-respect, and for the esteem of others. A firmly based self-esteem is one which "is soundly based upon real capacity, achievement and respect from others" (p. 381). Maslow divided esteem into two sets: (a) "the desire for strength, for achievement, for adequacy, for confidence in the face of the world, and for independence and freedom" (p. 381); and (b) "the desire for reputation and prestige (defining it as respect or esteem from other people), recognition, attention, importance or appreciation" (p. 382). The need for *self-actualization* he defined as being realized when "the individual is doing what he is fitted for" (p. 382). The motivating nature of this drive is expressed in the statement, "what a man *can* be, he *must* be" (p. 382). Maslow explained that the specific form that the self-actualization need will take will vary significantly from one person to another. He said that "basically satisfied people" (p. 383) are satisfied in their physiological, safety, love, and esteem needs, and are then in a position to pursue creativity through self-actualization. He also said that basically satisfied people are the exception in our society, and as a result we do not know much about it (p. 383).

Maslow described the basic needs as being related to each other, "arranged in a hierarchy of prepotency" (1943b, p. 394) in which once a need is "fairly well satisfied, the next prepotent ('higher') need emerges, in turn to dominate the conscious life and to serve as the center of organization of behavior, since gratified needs are not active motivators" (p. 395). He admitted this hierarchy, however, to be "not nearly so rigid as we may have implied" (p. 386), citing

examples of people in whom self-esteem is more important than love; innately creative people who are driven to create more than anything else (possibly in spite of lack of basic satisfaction); people in whom aspiration has been abandoned, content to be satisfied if only they can get enough food; people who have "lost forever the desire and the ability to give and to receive affection" (p. 386); the undervaluation of a need that is typically satisfied or has been satisfied for a very long time; a person not exhibiting behavior in accord with his want for the more basic of two needs; and people who will "give up everything for the sake of a particular ideal, or value" (p. 387).

Biological Motivation (Fuller – 1962). Fuller (1962) presented a biological perspective on motivation that enumerated biological needs and their psychological consequences, integrative needs, and innate and acquired drives. Under biological needs he included oxygen, water, food, and the need for eliminating waste. One interesting thing the biological perspective offers in regards to the need for food is a departure from the traditional view of the hunger drive as an all-or-nothing sort of an affair:

There is not one need for food, but numerous requirements for specific substances. Nutritionalists have found that the essential nutrients for human beings (and needs are similar for other animals) are about a dozen amino acids (found in proteins), a carbohydrate (sugar or starch), certain forms of fat, a dozen more vitamins, and about the same number of inorganic salts. Quantitatively, the daily requirements for each type of nutrient vary from a millionth of an ounce up to a pound or so. (Fuller, 1962, p. 14)

Under integrative needs Fuller listed avoidance of trauma, sleep, the need for sex, the need for nurturing, and needs for exploration and manipulation. Of these needs, Fuller called out exploration and manipulation as being particularly important sources of motivation for man and primates:

Since [exploration] is a cerebral rather than an endocrine drive, one would expect it to be well developed in man according to the principle that man's central nervous system is more autonomous than that of the lower vertebrates. Furthermore, the reduction in the intensity of deprivation states associated with the metabolic drives results, in the case of civilized man, in relatively more influence of nonmetabolic drives and appetites. We conclude that exploratory drive could be an important source of human motivation.

Closely related to exploration is the manipulation of objects. Harlow and his colleagues have demonstrated that monkeys improve their performance in solving mechanical puzzles (opening hooks, unlocking hasps, etc.) when their learning is motivated by no reward other than the privilege of taking the device apart. Similar mechanical puzzles have a strong fascination for humans of all ages. (Fuller, 1962, p. 39)

Under innate and acquired drives he listed the emotions of fear, rage, and pleasure. Fuller explained his rather short list of innate and acquired drives by saying,

One can approach the subject of acquired drives with two distinct attitudes. Mankind obviously is impelled by many motives, often by several at a time. Men seek fame, power, love, social groups, money, canceled postage stamps, scientific principles. We might multiply the number of drives indefinitely to cover all types of activities. On the other hand, we might try to categorize these diverse behaviors under a few major drives. The extreme of the second attitude would be to consider even the most complex behavior as motivated directly by basic biological needs. In this paper we shall adopt an intermediate position: that there are a limited number of acquired drives which play an active part in human motivation. These are the conditions of the organism we call *emotions*. (Fuller, 1962, p. 45)

He further stated that the list of emotions selected to be included in his model were selected based on "the basis of the kind of behavior which will reduce their intensity" (Fuller, 1962, p. 46). Fear, "can be defined as the drive state which is reduced by avoiding a specific stimulus. Or, if avoidance is not possible, the fear drive produces a response of inactivation and concealment" (p. 47). Anger "is reduced by aggressive behavior directed toward objects or individuals" (p. 47). Pleasure is reduced "by approaching, contacting, and otherwise seeking stimulation through many sensory pathways" (p. 47). "Getting pleasure out of something produces a drive to manipulate, taste, explore, listen to, or look at the eliciting stimulus, and

when this is done the capacity of the stimulus to arouse pleasure is temporarily lost" (p. 61).

Fuller actually distinguished between two types of pleasure and referred to that just described as *pleasure 1*. In contrast, *pleasure 2*, he said, "involves a decreased excitability and...is a state of relationship which follows a heavy meal, the relief of sexual tension, or rest after vigorous activity" (p. 62).

Although "both rat and child learn very well when they are frightened" (p. 63), fear may not be a good source of motivation for learning since "what they learn is inappropriate to the situation as viewed by the teacher. The habits of avoidance established under these strong drives are not easily changed, and are often incompatible with multiplication or with form discrimination" (p. 63).

Fuller also described motivation in a social context. Although "we speak of such motivations as envy, jealousy, love, pride, respect, and patriotism"(Fuller, 1962, p. 64) Fuller attributed social behavior to both "acquired drives based upon the preemptive needs of the organism and expressive drives based upon innate reinforcing properties of stimulation" (p. 65). This is illustrated in his explanation for the human motivation to seek companionship:

Motivation to seek companionship may be based upon two main kinds of learning. First, a person may discover that his biological needs and his appetitive goals can be secured with less effort if he cooperates with other people. Secondly, he may be fearful, and find that fear is reduced by the presence of other people or of specific persons. (Fuller, 1962, p. 68)

Acknowledging that the motivations behind the everyday behavior of women and men are much more complex than those that can be studied in a laboratory setting, and in answer to the question by D. K. Adams, "What...are the tissue needs that supply the energy for our efforts toward assertion, aggression, mink coats, and status?" (a cited in Fuller, 1962, p. 98), Fuller

concluded that although there is a difference between rats and men—i.e., "that the humoral agents (hormones, blood constituents) are much less important as regulators of human behavior than they are in lower animals" (p. 100)—men cannot escape their subjection to those regulators entirely:

There is universal recognition of the importance of humoral and visceral factors in the metabolic processes of men, but they don't seem to go far enough in explaining the differences in motivation between men and rats. Rats and men both learn to go to food, but rats don't seek mink coats or write scientific treatises. Neither do men when they are confined in a concentration camp on a subminimal diet. The primary drives can still preempt the center of the motivational stage under extreme conditions. (Fuller, 1962, p. 100)

Achievement Motivation (Atkinson & McClelland – 1953). In contrast with theories of motivation based on biological and behavioral determinants are theories of motivation based on cognitive and social cognitive perspectives. Covington (1998) cited the following study, reported by Ferdinand Hoppe, as one of the precursors to the study of achievement motivation and “the key to the question of how, psychologically, humans define success and failure” (p. 27):

Professor Lewin's laboratory was crowded with the research paraphernalia of his time, including an odd conveyor-belt device. This contraption allowed a series of pegs to move on circular rollers at a uniform rate and speed, much like a row of ducks in a shooting gallery...

Hoppe (1930) invited an assortment of local tradespeople and university students to practice tossing rings on the moving pegs at various distances from the target. He found that some subjects felt satisfied after placing, say, eight rings, while others expressed extreme frustration at only twelve correct tosses. Additionally, Hoppe found that the performance level needed to arouse feelings of success changed over time for each individual. A score that was initially judged a success might well be considered unacceptable on a later practice trial. (p. 28)

Covington (1998) noted several factors of motivation derivable from Hoppe's findings (pp. 28 – 32):

1. *Levels of Aspiration*⁷³ – Judgments of success or failure depend less on actual levels of performance, and more on the relationship between the individual’s performances and aspirations. Feelings of success come when goals are achieved. Feelings of failure come when they are not.
2. *Self-Confidence* – “Self-confidence reflects the extent to which individuals believe themselves able enough mentally to win the prize, strong enough to turn back the foe, or possessing sufficient hand-eye coordination to toss enough rings correctly” (pp. 28-29)
3. *Expectancy* – “The term expectancy generally refers to perceived estimates of eventual success—how sure individuals are of doing well in the end, but not necessarily that they themselves are the cause of their success”⁷⁴ (p. 29)
4. *Realistic Challenges* – “The key to sustained involvement in learning requires that a realistic match be established between the individual’s present capabilities and the demands of the achievement task”⁷⁵ (p. 30)
5. *Self-Generated Goals* – Hoppe's subjects set their own achievement goals, and altered them as necessary. The result was that "their aspirations spiraled upward just ahead of current achievement levels, but not so far ahead that their temporary goals could not

⁷³ Covington (1998, p. 28) attributes use of the term *aspiration* for describing the individual’s personal goals to Diggory (1966).

⁷⁴ Covington notes here that “expectations” and “confidence” are not interchangeable concepts, inasmuch as confidence implies a belief in success due to one’s own ability.

⁷⁵ Covington cites an experiment by Charles Woodson, reported in 1975, in which varying degrees of match and mismatch were set up between student ability levels and the difficulty of a school test. Students who experienced the closest match (i.e., high ability, difficult test; low ability, easy test) learned the most. A mismatch interfered at all levels, with more able students becoming bored with easy standards, and less able students becoming frustrated when they failed to deliver against high standards.

be reached and surpassed through persistent effort and practice" (p. 32). In this manner, Hoppe's subjects were constantly performing at their current maximum.

6. *Control of One's Own Progress* – The feeling of control of one's own progress that came by way of setting one's own goals generated a positive dynamic that sustained involvement in the task. (p. 32)

These same principles from Hoppe's study can also be found in a theory of achievement motivation that is more well known, namely, Atkinson and McClelland's theory of achievement motivation, also known as *need achievement*, *need for achievement*, and *n Achievement*.⁷⁶ This theory comes from a broad program of research on achievement motivation that was initiated in the 1940s by McClelland and was first summarized in the 1953 publication by McClelland et al. of *The Achievement Motive* (J. W. Atkinson & Feather, 1966, p. vi). Achievement motivation is a theoretical model intended "to explain how the motive to achieve and the motive to avoid failure influence behavior in a situation where performance is evaluated against some standard of excellence" (J. W. Atkinson, 1957, p. 371). More specifically,

Achievement-oriented activity is activity undertaken by an individual with the expectation that his performance will be evaluated in terms of some standard of excellence. It is presumed that any situation which presents a challenge to achieve, by arousing an expectancy that action will lead to success, must also pose the threat of

⁷⁶ There seems to be some confusion in the motivation literature regarding who the theory should be attributed to. For example, based on the publications cited when introducing achievement motivation, Covington (1984, p. 6; 1998, pp. 13, 33) gives the impression that Atkinson (1957; 1981) is the initial author of the theory, later accompanied by McClelland (McClelland, 1965). However, Weiner's (1972, pp. 169-175) account of the historical evolution of the theory is that it was McClelland who, influenced by Henry Murray's theory of behavior based on *need*, led out in articulation of the theory, publishing some initial ideas in 1951, and then shortly after published *The Achievement Motive* (1953) with Atkinson, Clark, and Lowell. Being that McClelland is listed as the first author, and that Atkinson himself (J. W. Atkinson & Feather, 1966, p. vi) attributed achievement motivation to McClelland's research program, it seems that McClelland did, in fact, initiate the theory, but that the two worked closely together in its articulation and elaboration.

failure by arousing an expectancy that action may lead to failure. Thus achievement-oriented activity is always influenced by the resultant of a conflict between two opposed tendencies, the tendency to achieve success and the tendency to avoid failure. Normally, achievement-oriented activities are also influenced by other *extrinsic* motivational tendencies, which are attributable to other kinds of motive and incentive. The theory of achievement motivation focuses primarily upon the resolution of the conflict between the two opposed tendencies that are inherent in any achievement-oriented activity, but it also emphasizes the importance of extrinsic sources of motivation to undertake an activity, particularly when the resultant achievement-oriented tendency is negative. (J. W. Atkinson & Feather, 1966, p. 328)

Tendency to undertake an activity is defined as "the product of *motive*, *expectancy*, and *incentive*" (J. W. Atkinson & Feather, 1966, p. 328). There are two components to this tendency. The first is the tendency to achieve success (T_s). The second is the tendency to avoid failure (T_f). Tendency to achieve success is defined as the product of (a) the motive or need to achieve success (M_s), (b) the strength of expectancy (or subjective probability) that success will be the consequence of a particular activity (P_s), and (c) the incentive value of success at that particular activity (I_s):

$$T_s = M_s \times P_s \times I_s$$

Atkinson notes that this equation might be modified slightly by regrouping terms as follows:

$$T_s = P_s \times (M_s \times I_s)$$

This regrouping highlights the compound of M_s and I_s as "the subject value of success, the utility of success, or the valence of success at a particular activity to a particular person"⁷⁷ (J.

⁷⁷ Use here of the phrase *a particular person* provides an indication of the importance of accounting for individual differences in the theory of achievement motivation. Weiner (1972) stated that "[Atkinson's] concern with individual differences in the understanding of motivational processes cannot be overemphasized" (p. 194) and quoted the following statement made by Atkinson:

W. Atkinson & Feather, 1966, p. 329). An important special assumption about this function is that "the incentive value of success is assumed to be proportionate to the difficulty of the task (i.e., $I_s = 1 - P_s$)"⁷⁸ (p. 328). The equation for the tendency to achieve success, together with this special assumption, resulted in the following implications:

1. The tendency to achieve success should be strongest when a task is one of intermediate difficulty, but the difference in strength of tendency to achieve success that is attributable to a difference in the difficulty of the task (P_s) will be substantial only when M_s is relatively strong.
2. When the difficulty of a task is held constant, the tendency to achieve success is stronger when M_s is strong than when it is weak, but the difference in strength of tendency to achieve success that is attributable to a difference in strength of achievement motive (M_s) will be substantial only when the task is one of intermediate difficulty. (J. W. Atkinson & Feather, 1966, p. 329)

The tendency to avoid failure is defined as a parallel product of (a) the motive to avoid failure (M_{AF}), (b) the expectancy of failure (P_f), and (c) the incentive value of failure (I_f).

$$T_f = M_{AF} \times P_f \times I_f$$

Similar to the equation for tendency to achieve success, this equation for tendency to avoid failure is accompanied by a special assumption. In this case, that assumption is that "the

A most encouraging development in recent experimental analysis of motivation...is the use of tests to assess individual differences in the strength of theoretically-relevant motivational dispositions of humans. Here again, the broad implication of Lewinian ideas is apparent. The guiding hypothesis, $B = f(P,E)$, is now represented in a methodological development that may provide a means of bridging the gap between the study of individual differences in personality and the search for basic explanatory principles which has so far seriously handicapped both enterprises in psychology's relatively short history....

It is to be hoped that contemporary research on n[eed] achievement...and contemporary research on individual differences in anxiety, within the context of Drive X Habit theory, will point the way towards more fruitful systematic use of personality tests in future research on human motivation. (Atkinson, 1964, pp. 271, 272, as cited in Weiner, 1972p. 194)

⁷⁸ To clarify, although Atkinson used the term *proportionate*, the mathematical relationship described between I_s and P_s is one of *inverse* proportion, meaning as P_s grows larger, I_s grows smaller, and vice versa.

incentive value of failure is more negative the easier the task" (J. W. Atkinson & Feather, 1966, p. 331) (i.e., $I_s = -P_s$). The implications that followed are

1. The tendency to avoid failure should be strongest when a task is one of intermediate difficulty, but the difference in strength of tendency to avoid failure that is attributable to a difference in the difficulty of the task (P_f) will be substantial only when M_{AF} is relatively strong.
2. When the difficulty of a task is held constant, the tendency to avoid failure is stronger when M_{AF} is strong than when it is weak, but the difference in strength of tendency to avoid failure that is attributable to a difference in motive (M_{AF}) will be substantial only when the task is one of intermediate difficulty. (J. W. Atkinson & Feather, 1966, pp. 331-332)

Together, the tendency to achieve success and the tendency to avoid failure are combined to provide a measure of resultant-oriented tendency (T_A):

$$T_A = T_s + T_{-f}$$

"When the resultant achievement-oriented tendency is negative, there will be no active impulse to *undertake* a particular achievement-oriented activity (T_A) unless some positive extrinsic tendency to perform the activity (T_{ext}) overcomes the resistance of $T_s + T_{-f}$ " (J. W. Atkinson & Feather, 1966, p. 333). The modified equation, that includes a term to account for such extrinsic motivation is as follows:

$$T_A = T_s + T_{-f} + T_{ext}$$

In summary, achievement motivation, described as a tendency to engage in an achievement-oriented task, is "a joint multiplicative function of motive, expectancy (subjective probability), and incentive" (J. W. Atkinson, 1957, p. 371). It is a model that offers an explanation for the selection of one task over other alternatives which differ in difficulty, and an explanation for the level of performance exhibited in a given task once initiated. The two major implications of the theory are (a) that "performance level should be greatest when there is

greatest uncertainty about the outcome" (p. 371), and (b) that people with strong achievement motive "should prefer intermediate risk while persons in whom the motive to avoid failure is stronger should avoid intermediate risk, preferring instead either very easy and safe undertakings or extremely difficult and speculative undertakings" (p. 371).

Attribution Theory (Weiner – 1971). Attribution theory is "a theory about how people make causal explanations" (Kelley, 1973, p. 107). It's a theory of how people perceive and determine the causes of results. Although attribution theory "was not formulated as a theory of individual motivation....[it] can be employed in the study of self-perception and in the formulation of a theory of motivation"⁷⁹ (Weiner, 1972, p. 310) Applied to the individual learner, attribution theory is a theory of how the learner determines the causes of and is affected by their own successes and failures.

The basic assumption of attribution theory is that man is motivated to understand the causal structure of his environment, to know why an event has occurred, and to what source the event can be ascribed. Although there are multiple theories that fall under this label (Kelley & Michela, 1980, p. 458), the one which seems to have been most commonly adopted and appears to be most widely known in education is Weiner's attribution-based theory of motivation (as evidenced by coverage of attribution theory in texts such as: Bohlin et al., 2009, pp. 281-282;

⁷⁹ In support of this statement Weiner cites the following idea expressed by Heider (Heider, 1958, p. 79):

We shall be concerned with the actions of another person, in particular with the basic constituents of an action sequence which lead us to know that another person is trying to do something, intends to do something, has the ability to do something, etc. The concepts also apply to one's own actions, but our main emphasis will be on actions in interpersonal relations.

Eggen & Kauchak, 1999, pp. 412-413; O'Donnell et al., 2007, pp. 150-151; Ormrod, 2003, pp. 409-412; Sternberg & Williams, 2010, pp. 376-377; Woolfolk, 2010, pp. 388-390).

Weiner's theory was initially conceived in terms of the expectancy-value framework, supplemented with the motivation component of his mentor, John Atkinson (motivation \times expectancy \times value, 1957). However, concerned with restrictions of the predictions afforded by Atkinson's theory, and in the face of hypotheses not being confirmed by experimental studies due to the length of time required by experimental subjects to complete his evaluations (Weiner, 2010, p. 30), Weiner began looking for other predictors and "more economical experimental procedures" (p. 30). Around 1968 he "rediscovered attribution theory and Fritz Heider" (p. 30), and by 1971 had reconceptualized on a foundation which combined ideas from both Heider⁸⁰ and Rotter:

Heider and Rotter did not cite one another, although both were concerned with the perceived causes of success and failure and their locus or location. Rotter acknowledged one internal and one external cause, respectively, skill (ability) and luck (chance), whereas Heider intuited three causes (ability, effort, and task difficulty). I combined these two lists and proposed four main perceived causes of achievement outcomes—ability, effort, task difficulty, and luck (see Weiner et al., 1971). Two of these are internal to the person (ability and effort) and two are external (task difficulty and luck). It had taken me about 3 years to reach this very simple formulation! (Weiner, 2010, p. 30)

With this more solid conception he also created a graphical representation that provided a guide for his thinking and served as the foundation for subsequent theory building (Weiner, 2010, p. 31). His 2 \times 2 representation embodied (a) four determinants of behavioral outcomes (ability, effort, task difficulty, and luck), (b) their two causal dimensions (locus and stability),

⁸⁰ Both Kelley (1973, p. 107) and Weiner (1972, p. 313; 1985, p. 551) recognize Heider as the founder of attribution theory.

and (c) links of value to causal locus and of expectancy to causal stability. Weiner's graphical representation can be found in (2010, p. 32).

Weiner's model was, in part, an extension of Heider's (1958) model of effective forces, which stated that the action outcome, x , is "dependent upon a combination of effective personal force and effective environmental force" (Heider, 1958, p. 58). In other words, whether or not a person *can* do something depends on both his "personal power" (p. 99) and "environmental difficulty" (p. 99). With this model, predictions about future success are made based on past attributions:

The action manifestations, together with other "raw material" become the data that allow us, in a kind of factor analysis, to assess the role of the factors contributing to can. We assess when we attribute action outcome mainly to the person, mainly to the environment, or to a combination of both. Only then do we understand. Only then are we able to predict future action, for even when relatively momentary factors make an action possible, by circumscribing these factors, one acknowledges the existence of the more invariant and reliable personal and environmental conditions. (Heider, 1958, p. 99)

In Weiner's model, Heider's internal-external distinction was taken as the first of three dimensions to which an action result might be attributed. Weiner initially called this dimension *locus of control* after the use of Rotter (1954, 1966, as cited in Weiner, 1974), but later changed it to *locus of causality* (1985, p. 552). Locus of causality refers to the cause of the result of an action as being located either within the person, or outside in the environment. To this first dimension, Weiner, Frieze, Kukla, Reed, Rest, and Rosenbaum (1971, as cited in Weiner, 1974, p. 107) then added a second dimension of *stability*, to account for internal causal factors such as effort and mood, which are perceived of as being more variable than others, "changing from moment to moment or period to period" (Weiner, 1985, p. 551). Weiner (1979, as cited in Weiner, 1985) later added a third dimension, *controllability*, to account for factors that are under

volition or optional control of the individual.⁸¹ These three dimensions (internal versus external, stable versus unstable, and controllable versus uncontrollable), together with the possibility of success or failure of an action, result in sixteen possible attributions. For example, if a student received a good grade on a test, the student might conclude that the grade was a result of his innate intelligence. This attribution would be classified as a successful outcome due to an uncontrollable, internal, and stable factor of intelligence, reinforcing the student's self-estimation that he is smart. Contrariwise, if the student received a bad grade on a test and concluded that the grade was a result of his innate intelligence, this would again attribute the failed outcome to an uncontrollable, internal, and stable factor of intelligence. However, in this case, it would reinforce a self-belief that the he is dumb.

Weiner's theory was further revised until it reached its final conception, a graphical representation of which can be found in Weiner (2010, p. 34). Weiner illustrated the temporal sequence of the model with two examples:

Assume a student fails an important exam. The initial experience following failure is unhappiness. Then there is a search for causality. Presume this person failed in the past even though she studies hard, whereas others succeeded on this exam. This pattern of information gives rise to the belief that the current failure is due to lack of aptitude. Aptitude is an internal, stable, uncontrollable cause, so there is a lowering of self-esteem, low expectancy of future success, hopelessness and helplessness, and shame and humiliation. Low expectancy (hopelessness) accompanied by these negative affects promotes the decision to, for example, drop out of school.

Now imagine that another student fails the same exam. This person also initially experiences unhappiness. But she has been successful in the past and the night before the test she was partying rather than studying. Her current failure therefore is ascribed to insufficient effort. This internal, unstable, and controllable cause lowers personal regard

⁸¹ Weiner (1985, p. 554) also noted two other possible dimensions for the model, *intentionality* and *globality*, but did not add them to the model because of a philosophical problem in the case of the former, and lack of evidence in the case of the latter.

but also gives rise to the maintenance of expectancy, hope, guilt, and regret, all of which are positive motivators. Hence, motivation increases and she tries harder in the future. As noted earlier, prior failure or nonreinforcement can have positive or negative future motivational consequences. (Weiner, 2010, p. 33)

As demonstrated from Weiner's examples, the resulting affective responses lead to a sense of self-worth and self-efficacy. Independent theories for both of these concepts will be discussed next.

Self-Worth Theory (Covington – 1976). The self-worth theory of achievement motivation (Covington & Beery, 1976; Covington, 1984) assumes that *the highest human priority is the search for self-acceptance* and that "one's worth often comes to depend on the ability to achieve competitively" (Covington, 1998, p. 78):

In our society there is a pervasive tendency to equate accomplishment with human value—put simply, individuals are thought to be only as worthy as their achievements. Because of this, it is understandable that students often confuse ability with worth....In essence, then, self-worth theory holds that, psychologically speaking, school achievement is best understood in terms of maintaining a positive self-image of one's ability, particularly when risking competitive failure. (Covington, 1998, p. 78).

From Covington's explanation of the interplay between human value and accomplishment we gain the perspective that two factors, *achievement* and *ability*, dominate as the ultimate value in the minds of many school children, and that this perspective likely carries into adulthood. The self-worth model emphasizes feelings of worthlessness that arise from "the disclosure of incompetency" (Covington, 1984, p. 8). The four main elements of this model are (a) ability, (b) effort, (c) performance, and (d) self worth, arranged in a causal structure as shown in Covington (1984, p. 8). In this model *ability* represents one's self-perception of ability. His model is a directed graph in which ability, performance and effort are linked to self-worth and ability and effort are also linked to performance.

The basic assumption of the self-worth model is that multiple factors influence one's sense of self worth. Its fundamental premise is that "one's sense of worth depends heavily on one's accomplishments" (Covington, 1984, p. 8). This is represented in the model by the performance → self worth link. This implies that unless a person is, or can become, successful at some valued activity, he or she "will be cut off from a major source of self-esteem" (p. 8). However, the fact that performance isn't the only path to self-worth implies that self-worth might also be derived from one's perception of their own ability (brilliance) or through the efforts of hard work (diligence). As Covington put it in general terms, "human beings tend to embrace success no matter how it occurs" (p. 8), but there are exceptions. People will sometimes reject credit for their successes if they feel they cannot repeat them. Also, success resulting from remedial assistance is not always valued in the same way that successes based solely on one's own efforts are. Covington, however, expressed a view that despite such exceptions, "humans do typically discount factors that might qualify or discredit their successes and cast their failures in the best possible light (Baumeister & Jones 1978; Covington & Omelich 1979c; Sigal & Gould 1977)" (p. 8).

The model also shows the direct and indirect influences of self perceptions of ability and the expenditure of effort on one's sense of worth. "Mere perception of high ability can sometimes come to imply worthiness, even in the absence of solid accomplishments" (Covington, 1984, p. 9), however, "it is within [the instrumental linkage of ability → performance → worth] that the value of ability ultimately resides, since typically an individual's sense of worth cannot long rest solely on a reputation for intelligence" (p. 9). Thus, what really counts is achievement and "ability is valued as its chief causal agent" (p. 9).

Effort is also a direct sense of self worth, since a strong effort is sometimes rewarded, and it is generally recognized that hard work is a necessary component of successful performance. However, Covington (1984) described effort as "a double-edged sword" (p. 10). On the one hand, effort in school is necessary to "avoid teacher punishment and personal feelings of guilt" (p. 10). On the other hand, trying hard "puts the student at risk" (p. 10) because "a combination of high effort and failure also leads to suspicions of low ability....[which] triggers humiliation and shame" (p. 10).

Covington (1984) described two self-serving strategies to avoid failure: excuses and the assurance of success. Excuses include, for example, the setting of unrealistically high goals and procrastination—both of which allow the student to "fail with honor" (p. 12). Other examples of excuses in the school classroom include (from Covington, 1998): not studying (p. 16); responding vaguely (p. 84), not trying (p. 85); avoiding work that is not absolutely required (p. 85); doing as little as possible (p. 85); remaining silent (p. 85); outright refusal (p. 85); false effort (p. 85); giving the outward appearances of understanding, while not really understanding (p. 85); a pensive, quizzical look to give the impression that one is too busy thinking to be interrupted (p. 85); asking questions whose answers are already known (p. 85); copying from a neighbors' paper, and perhaps adding a unique touch (p. 85), and the public admission of some minor personal weakness or handicap to avoid disclosing intellectual inadequacy, also known as, "the academic wooden leg" (p. 89).

Strategies for the assurance of success include setting standards for success at such a modest level that the likelihood of failing is very low, and avoiding failure by succeeding (Covington, 1984, p. 12). The latter strategy is often favored by bright students who succeed through a combination of intelligence and hard work. However, because it is used as a defense

strategy to avoid failure, they "often remain doubtful of their abilities despite an enviable record of accomplishments" (p. 12). This type of person is referred to by Covington as an "overstriver" (p. 12). Another success-guaranteeing strategy listed by Covington (1998) is academic cheating (p. 92).

Temporary relief by these failure avoiding strategies is "illusory, since their repeated use will finally destroy the will to learn" (Covington, 1984, p. 12). Better alternatives, Covington suggests, are "the use of noncompetitive learning structures whenever possible [e.g., cooperative learning, individual goal setting, and contract learning]" (p. 16) and "to encourage *additional* sources of worth beyond the mere possession of ability" (p. 17). He (1998) also suggests that "we must be weary of blaming the failure of students to learn simply on a *lack* of motivation" (p. 16):

The absence of behavior—docility, passivity, and listlessness—is surely just as motivated as is a lively abundance of behavior. According to the self-worth analysis, the reluctant learner who may refuse to study is already motivated, driven by circumstances to protect his or her self-esteem. (Covington, 1998, p. 16)

Self-Efficacy (Bandura – 1977). The theory of self-efficacy, as presented by Bandura (1977a), was outlined as a theoretical framework "in which the concept of *self-efficacy* is assigned a central role, for analyzing changes achieved in fearful and avoidant behavior" (p. 193). The theory was based on the principle assumption that "psychological procedures, whatever their form, serve as a means of creating and strengthening expectations of personal efficacy" (p. 193). The theory distinguishes between expectations of efficacy and response-outcome expectancies. An *outcome* expectancy is "a person's estimate that a given behavior will lead to certain outcomes" (p. 193). An *efficacy* expectation is "the conviction that one can successfully execute the behavior required to produce the outcomes" (p. 193). Although a person

may expect a certain activity to lead to a particular outcome, they may lack the motivation to perform the action, doubting their ability to do so:

Outcome and efficacy expectations are differentiated, because individuals can believe that a particular course of action will produce certain outcomes, but if they entertain serious doubts about whether they can perform the necessary activities such information does not influence their behavior. (Bandura, 1977a, p. 193)

Self-efficacy typically comes into play when there is an actual or perceived threat to one's personal safety, or one's ability to deal with potentially aversive events (Bandura, 1983).

Increasing a person's self-efficacy increases their ability to deal with a potentially aversive situation. For example, experimental studies on the treatment of adult snake phobics have demonstrated that raising levels of self-efficacy is an effective technique to help them cope with threatening situations. Perceived self-efficacy mediates anxiety arousal (Bandura & Adams, 1977, p. 287). Similar findings were also reported in later studies (for example, Bandura, Adams, Hardy, & Howells, 1980; Bandura, Reese, & Adams, 1982).

Bandura (1994a) defined self-efficacy as "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives" (p. 2). People with "high assurance in their capabilities" (p. 2):

5. Approach difficult tasks as challenges to be mastered
6. Set challenging goals and maintain strong commitment to them
7. Heighten or sustain their efforts in the face of failures or setbacks
8. Attribute failure to insufficient effort or deficient knowledge and skills which are acquirable

9. Approach threatening situations with assurance that they can exercise control over them

In contrast, people "who doubt their capabilities" (p. 2):

10. Shy away from tasks they view as personal threats
11. Have low aspirations and weak commitment to goals they choose to pursue
12. Dwell on personal deficiencies, obstacles they will encounter, and all kinds of adverse outcomes, rather than concentrating on how to perform successfully
13. Slacken their efforts and give up quickly in the face of difficulties
14. Are slow to recover their sense of efficacy following failure or setbacks
15. Fall easy victim to stress and depression

Bandura (1977a, pp. 191, 195-200; 1994a, pp. 2-3) described four main sources of influence by which a person's self-efficacy is developed and maintained: (a) performance accomplishments or mastery experiences; (b) vicarious experiences; (c) verbal or social persuasion; and (d) physiological, or somatic and emotional, states. Mastery experiences, or personal performance accomplishments, are the most effective way to create a strong sense of efficacy. "Successes build a robust belief in one's personal efficacy. Failures undermined it, especially if failures occur before a sense of efficacy is firmly established" (Bandura, 1994a, p. 2). Vicarious experiences through observance of social models also influence one's perception of self-efficacy. The most important factor that determines the strength of influence of an observed success or failure on one's own self-efficacy is the degree of similarity between the observer and the model:

Seeing people similar to oneself succeed by sustained effort raises observers' beliefs that they too possess the capabilities master comparable activities to succeed. By the same

token, observing others' fail despite high effort lowers observers' judgments of their own efficacy and undermines their efforts. The impact of modeling on perceived self-efficacy is strongly influenced by perceived similarity to the models. The greater the assumed similarity the more persuasive are the models' successes and failures. If people see the models as very different from themselves their perceived self-efficacy is not much influenced by the models' behavior and the results its produces. (Bandura, 1994a, p. 3)

Verbal or social persuasion also affects one's perception of self-efficacy. It is "a way of strengthening people's beliefs that they have what it takes to succeed" (Bandura, 1994a, p. 3).

Verbal or social persuasion can provide a temporary boost in perceived ability. When it is effective in mobilizing a person to action, and their actions lead to success, the enhanced self-efficacy may become more permanent. "People who are persuaded verbally that they possess the capabilities to master given activities are likely to mobilize greater effort and sustain it than if they harbor self-doubts and dwell on personal deficiencies when problems arise" (p. 3). This increases their chances of success. Unfortunately, "it is more difficult to instill high beliefs of personal efficacy by social persuasion alone than to undermine it [since] unrealistic boosts in efficacy are quickly disconfirmed by disappointing results of one's efforts" (p. 3).

People also rely on their somatic or emotional states when judging their capabilities. Stress and tension are interpreted as "signs of vulnerability to poor performance" (Bandura, 1994a, p. 3). Fatigue, aches and pains, and mood also effect perception of ability. Bandura notes, however, that it is not the intensity of the emotional or physical reaction that is important, but rather, how it is perceived and interpreted. People with a high sense of self-efficacy may perceive affective arousal as "an energizing facilitator of performance, whereas those who are beset by self-doubts regard their arousal as a debilitator" (p. 3).

Since "most human motivation is cognitively generated" (Bandura, 1994a, p. 4), self-beliefs of efficacy are an important factor in human motivation. Beliefs of self-efficacy work in

coordination with component skill and incentive to act. Inasmuch as a person has both the component skills needed to succeed, and the incentive to engage, self-efficacy plays an important role in determining what activities a person will choose to engage in, how much effort they will expend, and how long that effort will be sustained when things get tough:

Expectation alone will not produce desired performance if the component capabilities are lacking. Moreover, there are many things that people can do with certainty of success that they do not perform because they have no incentives to do so. Given appropriate skills and adequate incentives, however, efficacy expectations are a major determinant of people's choice of activities, how much effort they will expend, and of how long they will sustain effort in dealing with stressful situations. (Bandura, 1977a, p. 194)

Self-Determination Theory of Motivation (Deci & Ryan – 1985). For many years Edward L. Deci and Richard M. Ryan have been engaged in a program of research on human motivation that has led to and been organized by self-determination theory. In a recent article, McCally (McCally, 2010, p. 19) pointed to the publication of *Intrinsic Motivation and Self-Determination in Human Behavior* (Deci & Ryan, 1985) as marking the formal emergence of self-determination theory. Although many of the ideas were published in earlier sources—including *Intrinsic Motivation* (1975) and *The Psychology of Self-Determination* (1980)—the 1985 publication of *Intrinsic Motivation and Self-Determination in Human Behavior* is also listed as the first reference on Deci and Ryan's own website (SDT.2008, "References"), along with two more recent journal articles (Deci & Ryan, 2000; Ryan & Deci, 2000). These three sources, together with the website, were selected as primary sources in the present search for principles of learning found in self-determination theory (SDT).

SDT is a meta-theory that attempts to account for two views of causality regarding human behavior: (a) the view that humans act with agency and intrinsic motivation, and (b) the

view that their actions can be determined or influenced by external factors. SDT provides a framework to integrate observed cases of both phenomena:

The primary agenda of self-determination theory (SDT; Deci & Ryan, 1985b; Ryan & Deci, 2000b) has been to provide an account of the seemingly discrepant viewpoints characterized, on the one hand, by the humanistic, psychoanalytic, and developmental theories that employ an organismic metatheory and, on the other hand, by the behavioral, cognitive, and post-modern theories that do not. In other words, recognizing that there is compelling evidence in favor of human tendencies toward active engagement and development and that there is, as well, manifold indication of fragmentation and conditioned responses, SDT provides a framework that integrates the phenomena illuminated by these discrepant viewpoints. (Ryan & Deci, 2002, p. 5)

The fundamental postulate of SDT is the organismic dialect—a dialectic in which the human organism both *acts* on internal and external forces, and *is vulnerable* to those forces. Deci and Ryan (1985) explained it this way:

An organismic theory begins with the assumption of an active organism; it assumes that human beings act on their internal and external environments to be effective and to satisfy the full range of their needs. In the process, behavior is influenced by internal structures that are being continually elaborated and refined to reflect ongoing experiences. The life force or energy for the activity and for the development of the internal structure is what we refer to as *intrinsic motivation*....

Deci (1980) pointed out, however, that although the human organism is innately active and is inclined toward the development of an internal, unified structure of self, it is also vulnerable to being passive and to developing fractionated structures. These vulnerabilities are the means through which the organism becomes conditioned and through which its psychological functioning becomes rigid. (p. 8)

Although people are generally curious, self-motivated, agentic, and inspired; and striving to learn, to extend themselves, to master new skills, and to apply their talents; it is also true that "the human spirit can be diminished or crushed and that individuals sometimes reject growth and responsibility" (Ryan & Deci, 2000, p. 68). SDT considers the natural tendencies toward growth as requiring "nutriments or supports from the social environment to function effectively" (Deci

& Ryan, 2000, p. 262). SDT declares this requirement to be the satisfaction of three innate psychological needs: (a) autonomy, (b) competence, and (c) relatedness.

The details of the SDT framework are set in five mini theories (*SDT.2008*), the first three of which were presented in 1985 (Deci & Ryan, 1985, pp. 43, 87, 113, 149), with the others added later:

1. *Cognitive evaluation theory (CET)* "addresses the effects of social contexts on intrinsic motivation, or how factors such as rewards, interpersonal controls, and ego-involvements impact intrinsic motivation and interest" (*SDT.2008*, "Cognitive Evaluation Theory").
2. *Organismic integration theory (OIT)* "addresses the topic of extrinsic motivation in its various forms....[including] external regulation, introjection, identification, and integration" (*SDT.2008*, "Organismic Integration Theory").
3. *Causality orientations theory (COT)* describes three types of causality orientations: the autonomy orientation, the control orientation, and the amotivated orientation (*SDT.2008*, "Causal Orientations Theory").
4. *Basic psychological needs theory (BPNT)* "argues that psychological well-being and optimal functioning is predicated on autonomy, competence, and relatedness [therefore], contexts that support versus thwart these needs should invariantly impact wellness" (*SDT.2008*, "Basic Psychological Needs Theory").
5. *Goal contents theory (GCT)* "grows out of the distinctions between intrinsic and extrinsic goals and their impact on motivation and wellness" (*SDT.2008*, "Cognitive Evaluation Theory").

SDT is not concerned with what causes intrinsic motivation, but rather what elicits and sustains it (Ryan & Deci, 2000, p. 70). Cognitive evaluation theory explains social contextual effects on intrinsic motivation in terms of the three basic psychological needs. The first is *autonomy*. "Feelings of competence will not enhance intrinsic motivation unless accompanied by a sense of autonomy" (p. 70). Deci and Ryan (Deci & Ryan, 2000) cited conditions of threat, evaluation, and deadlines as leading to "the undermining of intrinsic motivation, presumably because they also prompted a shift toward a more external perceived locus of causality" (p. 234). In contrast, they cited conditions of choice and acknowledging a person's inner experience as prompting a perception of an internal locus of causality and, in turn, enhanced intrinsic motivation and augmentation of a person's confidence in his performance (p. 234).

Deci and Ryan also cited studies demonstrating the importance of the second basic psychological need, *competence*. Specifically, they cited experiments in which it was shown that positive feedback enhanced intrinsic motivation, and that negative feedback decreased intrinsic motivation:

Events such as positive feedback that signify effectance provide satisfaction of the need for competence, thus enhancing intrinsic motivation, whereas events such as negative feedback that convey ineffectance tend to thwart the need for competence and thus undermine intrinsic motivation. (Deci & Ryan, 2000, p. 234)

The third basic psychological need, *relatedness*, is defined by Ryan and Deci (2000) as "the need to feel belongingness and connectedness with others" (p. 73). Although relatedness plays a more distal role than the first two needs (autonomy and competence), it is still a factor in maintaining intrinsic motivation (Deci & Ryan, 2000, p. 235). In support of this claim, Deci and Ryan cite a study in which it was found that "when children worked on an interesting activity in

the presence of an adult experimenter who ignored their attempts to interact, the children displayed a very low level of intrinsic motivation (Anderson, Manoogian, & Reznick, 1976)" (p. 235). They also noted, however, that "people often engage in intrinsically motivating behaviors (e.g., playing solitaire, hiking) in isolation" (p. 235). They interpreted this to mean that relatedness may not be an important proximal factor, but instead provides a backdrop sense of security to intrinsically motivated activity:

Relational supports may not be necessary as proximal factors in maintaining intrinsic motivation. Instead, a secure relational base appears to provide a needed backdrop—a distal support—for intrinsic motivation, a sense of security that makes the expression of this innate growth tendency more likely and more robust. (Deci & Ryan, 2000, p. 235)

The second theory of SDT, organismic integration theory, proposes an active, natural process of internalization by which "individuals assimilate and reconstitute formerly external regulations so the individuals can be self-determined while enacting them" (Deci & Ryan, 2000, p. 236). In other words, it is the means through which *external* motivation becomes *internal* motivation, to one degree or another:

The real question concerning nonintrinsically motivated practices is how individuals acquire the motivation to carry them out and how this motivation affects ongoing persistence, behavioral quality, and well-being. Whenever a person (be it a parent, teacher, boss, coach, or therapist) attempts to foster certain behaviors in others, the others' motivation for the behavior can range from amotivation or unwillingness, to passive compliance, to active personal commitment. According to SDT, these different motivations reflect differing degrees to which the value and regulation of the requested behavior have been internalized and integrated. Internalization refers to people's "taking in" a value or regulation, and integration refers to the further transformation of that regulation into their own so that, subsequently, it will emanate from their sense of self. (Ryan & Deci, 2000, p. 71)

This continuum of unwillingness, passive compliance, and active personal commitment, is represented visually in a chart that can be found in Ryan and Deci (2000, p. 72). At the far left,

the chart depicts a state of amotivation and non-regulation of behavior. This is a state of "lacking the intent to act" (p. 72) in which either no action takes place or people act without intent, just going through the motions. At the far right is a state of completely self-determined behavior, intrinsically motivated and intrinsically regulated. The source of behavior of this type is completely internal, and is regulated by interest, enjoyment, or inherent satisfaction.

What is particularly interesting in this model of motivation is the middle ground of external motivation, internalized in varying degrees. "Unlike some perspectives that view extrinsically motivated behavior as invariantly non-autonomous, SDT proposes that extrinsic motivation can vary greatly in its relative autonomy" (Ryan & Deci, 2000, p. 71). Organismic integration theory therefore proposes that extrinsic motivation may be (a) completely internalized (integrated), (b) mostly internalized (identified), (c) mostly external but partly internalized (introjected), or (d) remain completely external. Some amount of autonomy is present at each level. Extrinsically motivated behaviors that are *externally* regulated are least autonomous, with behavior being performed only "to satisfy an external demand or reward contingency" (p. 71). This is the type of external regulation used in operant conditioning. Moving to the right are externally motivated behaviors that are *introjected*.

Introjection involves taking in a regulation but not fully accepting it as one's own. It is a relatively controlled form of regulation in which behaviors are performed to avoid guilt or anxiety or to attain ego enhancements such as pride. Put differently, introjection represents regulation by contingent self-esteem (Deci and Ryan, 1995, cited in Ryan & Deci, 2000, p. 72)

The next type of extrinsically motivated behavior is regulated through identification.

Identified regulation is regulation of behavior in which there is conscious acknowledgement of the value of a goal or regulation. Whatever action is taken is made for a reason that is accepted as

being personally important, but the regulation itself has not been fully integrated. Hence, this type of regulation is mostly, but not completely, internal. In comparison, the extrinsically motivated behavior with the greatest degree of autonomy occurs when "regulations are fully assimilated to the self, which means they have been evaluated and brought into congruence with one's other values and needs" (p. 73). This is *integrated* regulation. These four types of extrinsic motivation, together with amotivation and intrinsic motivation, make up the framework of organismic integration theory, and provide a visual model for SDT.

Causality orientations theory, the third mini theory of SDT, describes three orientations of causality: (a) autonomy oriented, (b) control oriented, and (c) impersonally oriented. These orientations represent general tendencies, respectively, toward (a) intrinsic motivation and well-integrated extrinsic motivation, (b) external and introjected regulation, and (c) amotivation and lack of intentional action (Deci & Ryan, 2000, p. 241). According to causality orientations theory, a person's orientation is predictive of their regulatory styles.

As has already been mentioned, basic psychological needs theory asserts that the elicitation and maintenance of internal motivation is dependent on the satisfaction of three psychological needs: autonomy, competence, and relatedness. Satisfaction of these three needs is directly linked to a person's well-being (Deci & Ryan, 2000, p. 243). BPNT predicts three accommodations when these needs are not satisfied. First is the development of *need substitutes* or *compensatory motives*. Such compensations do not satisfy the basic needs, but provide "some collateral satisfaction" (p. 249). For example, "if people's need for relatedness is thwarted when they are young, they might compensate by attempting to gain approval or sense of worth by pursuing image-oriented goals, such as accumulating money or material possessions" (p. 249). Second is the development of *nonoptimal regulatory styles and motivational orientations*.

"Social environments that block satisfaction of the need for autonomy promote controlled motivation" (pp. 250-251). Similarly, "environments that also block satisfaction of the needs for competence and relatedness tend to promote amotivation" (p. 251). BPNT assumes that both controlled and amotivational orientations have "negative effects on performance and well-being" and that they are the cause by which "basic needs are further thwarted and negative consequences are compound" (p. 251). The third type of accommodation made when basic needs are not met is the development of "rigid behavior patterns that are as adaptive as possible under the hostile circumstances and that help protect people from the inner hurts resulting from the thwarted needs" (p. 251). The unfortunate side affect of patterns of this type is that they "have the maladaptive features of tending to keep people from dealing with their inner experiences and of tending to persist into new situations which they are not needed and have negative consequences" (p. 251).

The last of the five mini theories of SDT deals with the effects of the contents of goals people pursue and their reasons for pursuing them. In specific, it assumes the distinction made by Kasser and Ryan (1993, 1996, as cited in Deci & Ryan, 2000, p. 244) between *intrinsic aspirations* and *extrinsic aspirations*. Intrinsic aspirations are "goals such as affiliation, personal growth, and community contributions, which are closely associated with basic need satisfaction" (p. 244). Extrinsic aspirations are goals such as "attaining wealth, fame, and image, which are more related to obtaining contingent approval or external signs of worth, and thus are, on average, expected to be less likely to yield direct need satisfaction and may even distract from it" (p. 244).

Self-Regulation (Zimmerman & Schunk – 1989). The concept of self-regulation did not originate with Schunk or Zimmerman, but their three volume series (Schunk & Zimmerman,

1994; Schunk & Zimmerman, 1998; Zimmerman & Schunk, 1989) provided a forum for the exchange and elaboration of ideas regarding self-regulatory activities in learning, and promoted the application of these ideas in practical use. The first volume in the series, *Self-Regulated Learning and Academic Achievement: Theory, Research, and Practice* (Zimmerman & Schunk, 1989), presented self-regulated learning according to several different theoretical views, including: operant theory (p. 27), a phenomenological view (p. 51), social cognitive theory (p. 83), a volitional analysis (p. 111), a Vygotskian view (p. 143), and a constructive approach (p. 169). The second, *Self-Regulation of Learning and Performance: Issues and Educational Applications* (Schunk & Zimmerman, 1994), presented a conceptual framework for studying self-regulation. The third, *Self-Regulated Learning: From Teaching to Self-Regulated Practice* (Schunk & Zimmerman, 1998), provided "suggestions for teaching self-regulatory skills that are firmly derived from principles of self-regulation...[and discussed] detailed applications of self-regulation principles in classrooms and other learning settings" (p. ix). These three volumes facilitated, at least in part, the transition of self-regulation from its study as a set of subfunctions or component mechanisms of cognition to an emergent theory of learning, building predominately on the foundation established by Bandura in social cognitive learning (Bandura, 1986), in particular, Bandura's review of self-regulatory mechanisms (pp. 335-389).⁸²

Inasmuch as there is not one theory or model of self-regulated learning (Puustinen & Pulkkinen, 2001; Zimmerman & Schunk, 1989, p. 1), I have chosen to identify here the common conceptions among them, as described by Zimmerman in the first chapter of each of the three

⁸² In the first of the three volume series mentioned, Schunk (1989) reviewed self-regulated learning in social cognitive theory and continued to refer to Bandura in subsequent publications (Schunk, 1990, p. 72; Schunk, 1994, p. 76)

volumes. First is the shared belief that "students' perceptions of themselves as learners and their use of various processes to regulate their learning are critical factors in analysis of academic achievement" (Zimmerman & Schunk, 1989, p. 1). Second are the assumptions that students can (a) "personally improve their ability to learn through selective use of metacognitive and motivational strategies" (p. 4), (b) "proactively select, structure, and even create advantageous learning environments" (p. 4), and (c) "play a significant role in choosing the form and amount of instruction they need" (p. 4). Third, is the definition of self-regulated learners as being "metacognitively, motivationally, and behaviorally active participants in their own learning process" (Zimmerman, 1986, as cited in Zimmerman & Schunk, 1989, p. 4).

Zimmerman's conceptual analysis of the dimensions of academic self-regulation (Schunk & Zimmerman, 1994, p. 8) includes four task conditions, four attributes of self-regulating learners, and four self-regulatory processes. The first task condition is that students must be able to *choose to participate*. "Schools or research procedures that externally compel students to participate prevent them from self-regulating their motivation" (p. 8). The second task condition is that students must be able to *choose their method of learning*. This includes choosing both learning strategy and use of time (p. 9). The third task condition is that students must be able to *choose their performance outcomes*. This condition implies that self-regulation involves self-monitoring. The fourth task condition is that students must be able to *choose or control their physical and social environment*.

Zimmerman's conceptual framework also included four attributes of self-regulating learners. First, they are *intrinsically or self-motivated*. Second, they utilize *planned or automatic methods of learning* that enable them to function "at an automated level" (Schunk & Zimmerman, 1994, p. 12). Third, they are *self-aware of performance outcomes*. And fourth, they

are *environmentally and socially sensitive and resourceful*, "significantly more likely to organize or restructure their place of study than regular learners" (p. 13).

Finally, Zimmerman's conceptual framework included four self-regulatory processes. The first is the self-motivation derived from *setting academic goals, a sense of self-efficacy, and values* (p. 13). Second is the *use of metacognitive strategies* (p. 13). Third are the processes of *self-monitoring and self-recording*. Fourth is the *structuring of one's environment and the self-selection of exemplary models to observe* (p. 15).

One additional concept presented by Zimmerman in the third volume (Schunk & Zimmerman, 1998, pp. 2-10) is his model of self-regulated learning cycle phases (p. 3):

Most self-regulation theorists view learning as a multidimensional process involving personal (cognitive and emotional), behavioral, and contextual components (Zimmerman, 1986, 1989). For an academic skill to be mastered, learners must behaviorally apply cognitive strategies to a task within a contextually relevant setting. This usually requires repeated attempts to learn because mastering involves coordinating, personal, behavioral, and environmental components, each of which is separately dynamic as well as jointly interactive. (p. 2).

Zimmerman further described self-regulation theorists view of learning as "an open-ended process that requires cyclical activity on the part of the learner that occurs in three major phases: forethought, performance or volitional control, and self-reflection" (Schunk & Zimmerman, 1998, p. 2). The forethought phase accounts for "five types of forethought processes and beliefs [that] have been studied in research on academic self-regulation" (Schunk & Zimmerman, 1998, p. 2). They are: goal setting, strategic planning, self-efficacy beliefs, goal orientation, and intrinsic interest. The performance or volitional control phase accounts for three processes that have been studied in research on academic self-regulation, namely: attention focusing, self-instruction and imagery, and self-monitoring. The self-reflection phases accounts

for four types of self reflection. They are: self-evaluation, attributions, self-reactions, and adaptivity.

Based on my own review of various models of self-regulated learning (McCombs & Marzano, 1990), Zimmerman's common conceptions of self-regulated learning, conceptual framework for academic self learning, and self-regulated learning cycles model is a fair abstraction of the common ground they share. However, as should be expected, looking at only the abstracted model one is deprived of the more rich detail in the individual models. To the reader interested in detail that could not reasonably covered in this brief summary, I recommend reviewing the models presented in Zimmerman and Schunk's three volume series, plus the model presented in McCombs and Marzano (1990, pp. 54-63) and Schunk's (2005) summary of Pintrich's model.

ARCS Theory of Motivation (Keller – 1979). Keller (1979; 1983) elaborated a macro theory of motivation and instructional design that included "a model of motivation, performance, and instructional influence" (Keller, 1979, p. 29) and "a systematic approach to designing motivating instruction" (p. 32). His model presented a synthesis of motivational influences from behavioral contingency design and management (p. 27); cognitive accounting of individual abilities, skills and knowledge (p. 27); and the expectancy-value theory of motivation typically applied in the context of social learning theory (p. 28). Kelley viewed this contribution as adding the *heart* to general understanding of the nature of the learner.⁸³

⁸³ Kelley (1979, p. 27) here refers to Plato's three-part nature of the soul and equates the understanding of the learner that comes through behavioral theory to the *stomach*, the understanding that comes through cognitive theory to the *head*, and his own contribution as providing the *heart*.

Keller's model of motivation, as conceived in 1979, was organized in terms of person inputs, outputs, and environmental inputs. A graphical representation of this model can be found in Keller (1979, p. 29). According to the model, motives and expectancy, as well as "any systematic effort to influence motivation" (p. 28) determine level of effort expended. Effort, together with the application of individual abilities, skills, and knowledge, plus any effort to design or manage the learning experience, determine performance. Performance, along with any design of contingencies, determines consequences. Dotted lines in the model represent feedback that is available to the learner at each step in the process. The diagram also represents feedback from consequences as being subject to cognitive evaluation.

"Building on this conceptual foundation, the ARCS Model was created by generating a large list of motivational strategy statements, and sorting them to see whether the four categories of the model provided a conceptually valid typology" (Keller, 1987, p. 3). In the process, some of the components of the model were renamed "to strengthen the central feature of each and to generate a useful acronym" (p. 3). The acronym of the revised model stands for (a) attention, (b) relevance, (c) confidence, and (d) satisfaction.

Attention is assumed to be both an element of motivation and a pre-requisite for learning. For learning to occur attention must be obtained, sustained, and directed to relevant stimuli.

Attention is further defined by three subcategories:

1. *Perceptual arousal* – "Almost any sudden or unexpected change in the environment will activate a person's perceptual level of curiosity....a change in voice level, light intensity, temperature, or a surprising piece of information" (Keller, 2010, p. 47). This is the first step in the attention process but it does not last long because people adapt fairly quickly.

2. *Inquiry arousal* – "A deeper level of curiosity may be activated by creating a problem situation which can be resolved only by knowledge-seeking behavior" (p. 47)
3. *Variability* – "To sustain attention it is beneficial to incorporate variability" (p. 48).
This helps to prevent learners from adapting and tuning out.

Relevance emphasizes the importance of learners understanding why they should expend effort on a given task. The three subcategories of relevance are

4. *Goal orientation* – "Generally speaking, people will be more motivated to learn if they perceive that the new knowledge or skill will help them achieve a goal in the present or future" (Keller, 2010, p. 49).
5. *Motive matching* – "Understanding the students' personal motive structures can lead to the development of compatible learning environments" (p. 49). People with a high need for achievement typically enjoy setting goals for themselves. They also like to control the means by which goals are obtained, and are often uncomfortable in group work, because of a dependence on others in planning and achieving results. People with a high need for affiliation, on the other hand, enjoy being with others in noncompetitive situations. Some people are motivated by a combination of the two factors.
6. *Familiarity* – People "tend to be most interested in content that has some connections to their prior experiences and interests" (p. 50). "Instructional material that confirms the learner's preexisting beliefs and interests will be seen as relevant" (p. 50).

Confidence highlights the importance of students feeling confident in their ability to succeed. Keller's three subcomponents of confidence are

1. *Learning requirements* – "Letting the learners know what is expected of them is one of the simplest ways to help instill confidence" (Keller, 2010, p. 51). Note that this assumes students already possess prerequisite abilities for the task.
2. *Success opportunities* – "After creating an expectation for success, it is important for the learners to actually succeed at challenging tasks that are meaningful" (p. 51). For learners at a new task, the level of challenge should be fairly low and frequent feedback should be given "that helps them succeed or confirms their success" (p. 51).
3. *Personal control* – "Confidence is often associated with perceptions of personal control over being able to succeed at a task" (p. 51). Corrective feedback that helps students see the causes of their mistakes and take action to correct them improves confidence.

Satisfaction emphasizes the contribution of feeling satisfied after a learning experience in order for motivation to continue. This is the final step in the motivational process. The three subcomponents of satisfaction are

1. *Natural consequences* – It can be very satisfying for a student to be able to successfully perform a challenging task that he or she could not do before (Keller, 2010, p. 53) and the use of newly acquired skills is, in and of itself, rewarding. Another type of natural consequence is genuine praise that "focuses on specific aspects of performance that are praiseworthy" (p. 53).

2. *Positive consequences* – "Incentives in the form of awards, monetary bonuses, trophies, and special privileges are satisfying outcomes...provided they are used appropriately according to the established principles of using reinforcements" (p. 53). Extrinsic rewards are useful when students are not intrinsically motivated, when the task is inherently monotonous, or in highly competitive situations. Intrinsic and extrinsic methods should be used in combination, maintaining the learner's a sense of control, but also recognizing their efforts and accomplishments.
3. *Equity* – "Sometimes a person will feel very good about the outcomes of an achievement until he or she finds out what someone else received" (p. 54). Equity is perceived when outcomes are consistently commensurate with accomplishments.

Freedom to Learn (Rogers – 1969). Rogers is recognized as one of the founders of human psychology, having developed the client centered approach to counseling and psychotherapy which has been widely used (Rogers, 1983, p. iii).⁸⁴ In comparison with the foregoing theories of human motivation and agency, his theory of human learning, which will be summarized in this section, is broader in scope, and addresses not just the means by which a person is motivated, but the learner as a whole person.

Rogers presented his theory of learning in *Freedom to Learn* (1969), which he wrote while a resident fellow at the *Center for Studies of the Person* in La Jolla, CA. His goal was not

⁸⁴ The Carl Rogers that authored *Freedom to Learn* for the 80's (1983), is the son of the Carl Rogers whose theory is being summarized.

to write about learning in terms of the “lifeless, sterile, futile, quickly forgotten stuff which is crammed into the mind of the poor helpless individual tied into his seat by the iron clad bonds of conformity” (p. 3), but rather the type of learning characterized by “the insatiable curiosity which drives the adolescent boy to absorb everything he can see or hear or read about gasoline engines in order to improve the efficiency and speed of his ‘hot-rod’” (p. 3). The student of this type of learning, he said, is “the student who says, ‘I am discovering, drawing in from the outside, and making that which is drawn in a real part of me’” (p. 3).

To further characterize the two types of learning already mentioned, Rogers described them as defining opposite ends of a continuum of meaning, feeling, and relevance. One end of the continuum he represented by the following poignant observation:

At one end of the scale is the kind of task psychologists sometimes set for their subjects—the learning of nonsense syllables. To memorize such items as *baz*, *ent*, *nep*, *arl*, *lud* and the like, is a difficult task. Because there is no meaning involved, these syllables are not easy to learn and are likely to be forgotten quickly.

We frequently fail to recognize that much of the material presented to students in the classroom has, for the student, the same perplexing, meaningless quality that the list of nonsense syllables has for us. This is especially true for the underprivileged child whose background provides no context for the material with which he is confronted. But nearly every student finds that large portions of his curriculum are for him, meaningless. Thus education becomes the futile attempt to learn material which has no personal meaning.

Such learning involves the mind only. It is learning which takes place from the neck up. It does not involve feelings or personal meanings; it has no relevance for the whole person. (Rogers, 1969, pp. 3-4)

In contrast, he described the other end of the continuum in terms of significant, meaningful experiences, which are not easily forgotten:

When the toddler touches the warm radiator he learns for himself the meaning of the word, “hot”; he has learned a future caution in regard to all similar radiators; and he has taken in these learnings in a significant, involved way which will *not* be soon forgotten. Likewise the child who has memorized “two plus two equal four” may one day in his play with blocks or marbles suddenly realize, “Two and two *do* make four!” He has

discovered something significant for himself, in a way which involves both his thoughts and feelings. Or the child who has laboriously acquired "reading skills" is caught up one day in a printed story, whether a comic book or an adventure tale, and realizes that words can have a magic power which lifts him out of himself into another world. He has now "really" learned to read. (Rogers, 1969, p. 4)

Rogers (1969) listed five defining elements of significant or experiential learning:

1. *It has a quality of personal involvement* – Significant learning has a quality of personal involvement in which "the whole person in both his feeling and cognitive aspects [is] in the learning event" (p. 5).
2. *It is self-initiated* – "Even when the impetus or stimulus comes from the outside, the sense of discovery, of reaching out, of grasping and comprehending, comes from within" (p. 5).
3. *It is pervasive* – Significant learning "makes a difference in the behavior, the attitudes, perhaps even the personality of the learner" (p. 5).
4. *It is evaluated by the learner* – The learner knows "whether it is meeting his need, whether it leads toward what he *wants* to know, whether it illuminates the dark area of ignorance he is experiencing" (p. 5).
5. *Its essence is meaning* – "When such learning takes place, the element of meaning to the learner is built into the whole experience" (p. 5).

As an example of significant learning—the kind that illustrates his theory of freedom to learn—Rogers cited the informal notes kept by Barbara J. Shiel, a teacher, who out of despair and frustration decided to try a drastic experiment in promoting experiential learning in her sixth grade class. In the experiment Mrs. Shiel introduced the concept of *work contracts*. These were

ditto sheets that contained a list of all of the subjects the class was to study, along with a list of suggestions for study under each, and a space for students to write their plans in each area:

As soon as the contract was made, the child began to study or work on his plan. He could work as long as he needed or wanted to work on a task or project. Because I was not free to discard the state-devised curriculum time schedule, I explained the weekly time-subject blocks to the children—this was to be a consideration in their planning. We also discussed sequential learning, especially in math, mastering a skill before proceeding to the next level of learning. They discovered the text provided an introduction to a skill, demonstrated the skill, and provided exercises to master it and tests to check achievement. When they felt they were ready to go on, they were free to do so. They set their own pace, began at their own level, and went as far as they were able or self-motivated to go. (Rogers, 1969, pp. 17-18)

Since evaluation was self-initiated and respected by the teacher, there was no need for cheating to achieve success. We discovered that “failure” is only a word, that there is a difference between “failure” and making a mistake, and that mistakes are a part of the learning process. (Rogers, 1969, p. 18)

One cannot measure the difference in attitude, the increased interest, the growing pride in self-improvement, but one is aware that they exist. (Rogers, 1969, p. 19)

The experience of Mrs. Shiel's experiment is illustrative of ten principles of learning that Rogers (1969, pp. 157-164) abstracted from his own experience:

1. *Human beings have a natural potentiality for learning.* "They are curious about their world, until and unless this curiosity is blunted by their experience in our educational system" (p. 157).
2. *Significant learning takes place when the subject matter is perceived by the student as having relevance for his own purposes.* "A somewhat more formal way of stating this is that a person learns significantly only those things which he perceives as being involved in the maintenance of or the enhancement of his own self" (p. 158).

3. *Learning which involves a change in self organization—in the perception of oneself—is threatening and tends to be resisted.*

Why has there been so much furor, sometimes even lawsuits, concerning the adolescent boy who comes to school with long hair? Surely the length of his hair makes little objective difference. The reason seems to be that if I, as a teacher or administrator, accept the value which he places on non-conformity then it threatens the value which I have placed on conforming to social demands. If I permit this contradiction to exist I may find myself changing, because I will be forced to a reappraisal of some of my values. (p. 159)

4. *Those learnings which are threatening to the self are more easily perceived and assimilated when external threats are at a minimum.*

The boy who is retarded in his reading already feels threatened and inadequate because of this deficiency. When he is forced to attempt to read aloud in front of the group, when he is ridiculed for his efforts, when his grades are a vivid reflection of his failure, it is no surprise that he may go through several years of school with no perceptible increase in his reading ability. On the other hand, a supportive, understanding environment and a lack of grades, or an encouragement of self evaluation, remove the external threats and permit him to make progress because he is no longer paralyzed by fear.⁸⁵ (pp. 159-160)

5. *When threat to the self is low, experience can be perceived in differentiated fashion and learning can proceed.*

When [the learner] is in an environment in which he is assured of personal security and when he becomes convinced that there is no threat to his ego, he is once more free to...move forward in the process of learning. (p. 161)

6. *Much significant learning is acquired through doing.* "Placing the student in direct experiential confrontation with practical problems, social problems, ethical and

⁸⁵ Here Rogers makes reference to Teaching Machines: "This is also one of the great advantages of the teaching machine, when properly used. Here the poor reader can begin at his own level of achievement and practically every minute step he makes is marked by reward and a feeling of success." (p. 160)

philosophical problems, personal issues, and research problems, is one of the most effective modes of promoting learning" (p. 162).

7. *Learning is facilitated when the student participates responsibly in the learning process. "When he chooses his own directions, helps to discover his own learning resources, formulates his own problems, decides his own course of action, lives with the consequences of these choices, then significant learning is maximized" (p. 162).*
8. *Self-initiated learning which involves the whole person of the learner—feelings as well as intellect—is the most lasting and pervasive.*

We have discovered this in psychotherapy, where it is the totally involved learning of oneself by oneself which is most effective. This is not the learning which takes place "only from the neck up." It is a "gut level" type of learning which is profound and pervasive. It can also occur in the tentative discovery of a new self-generated idea or in the learning of a difficult skill, or in the act of artistic creation—a painting, a poem, a sculpture. It is the whole person who "let's himself go" in these creative learnings. An important element in these situations is that the learner *knows* it is his own learning and thus can hold to it or relinquish it in the face of a more profound learning without having to turn to some authority for corroboration of his judgment. (pp. 162-163)

9. *Independence, creativity, and self-reliance are all facilitated when self-criticism and self-evaluation are basic and evaluation by others is of secondary importance.*

If a child is to grow up to be independent and self reliant he must be given opportunities at an early age not only to make his own judgments and his own mistakes but to evaluate the consequences of these judgments and choices. (p. 163).

10. *The most socially useful learning in the modern world is the learning of the process of learning, a continuing openness to experience and incorporation into oneself of the process of change.*

If our present culture survives it will be because we have been able to develop individuals for whom *change* is the central fact of life and who have been able to live comfortably with this central fact. It means that they will not be concerned, as so many are today, that their past learning is inadequate to enable them to cope with current situations. They will instead have the comfortable expectation that it will be continuously necessary to incorporate new and challenging learnings about ever-changing situations. (pp. 163-164)

Rogers' theory of learning also included ten principles that define the role of the teacher as a facilitator of learning. Rogers (1983) summarized this role by stating that "the primary task of the teacher is to *permit* [italics added] the student to learn, to feed his or her own curiosity" (p. 18). Rogers' ten principles of facilitation are complementary to his ten principles of learning. Together they form a human learning theory that emphasizes learner agency, connection, and affect. These ten principles are as follows (summarized from Rogers, 1969, pp. 164-166):

1. *The facilitator has much to do with setting the initial mood or climate of the group or class experience. "If his own basic philosophy is one of trust in the group and in the individuals who compose the group, then this point of view will be communicated in many subtle ways" (p. 164).*
2. *The facilitator helps to elicit and clarify the purposes of the individuals in the class as well as the more general purposes of the group.*
3. *He relies upon the desire of each student to implement those purposes which have meaning for him, as the motivational force behind significant learning.*
4. *He endeavors to organize and make easily available the widest possible range of resources for learning.*
5. *He regards himself as a flexible resource to be utilized by the group.*

6. *In responding to expressions in the classroom group, he accepts both the intellectual content and the emotionalized attitudes, endeavoring to give each aspect the approximate degree of emphasis which it has for the individual or group.*
7. *As the acceptant classroom climate becomes established, the facilitator is able increasingly to become a participant learner, a member of the group, expressing his views as those of one individual only.*
8. *He takes the initiative in sharing himself with the group—his feelings as well as his thoughts—in ways which do not demand nor impose but represent simply a personal sharing which students may take or leave.*
9. *Throughout the classroom experience, he remains alert to the expressions indicative of deep or strong feelings.* "He endeavors to understand these from the person's point of view and to communicate his empathic understanding...he helps to bring them into the open for constructive understanding and use by the group" (pp. 165-166).
10. *In his functioning as a facilitator of learning, the leader endeavors to recognize and accept his own limitations.* "He realizes that he can only grant freedom to his students to the extent that he is comfortable in giving such freedom" (p. 166).

An Agentic Theory of the Self (Bandura – 1997). Although the subject of human agency was raised briefly under the topic of self-efficacy in *Social Foundations of Thought and Action: A Social Cognitive Learning Theory* (Bandura, 1986, p. 393) it was not until later that Bandura began to articulate his theory of agency (1997; 1999b; 2001; 2006b; 2008b; 2008c; 2009a). Following his lead of elevating human agency into a subsuming relationship with self-efficacy (see, for example, Bandura, 1999b, pp. 28-32; 2009a, p. 9), and affording it a more prominent elaboration of learner control in the social cognitive theory framework (Bandura,

2005, pp. 16-22, 26-28; 2008b, pp. 170-171, 178-180), I have chosen to review it separately in the present review.

Bandura has discussed the topic of agency several times in recent years from perspectives such as an *agentic perspective of social cognitive theory* (1999b; 2001), the *exercise of human agency* (2000), the *psychology of human agency* (2006b), an *agentic perspective on positive psychology* (2008a), the *reconstruction of free will from an agentic perspective* (2008b), and an *agentic theory of the self* (2008c). Based on my own reading and comparison of each, I find there is significant overlap in these accounts, and though there is an obvious course of iteration in play from his earlier treatments to the more recent, the differences are relatively minor, primarily being additions, rather than modifications or deletions. Hence, because of both its clarity and recency, I have selected as my primary source for review in this section a summary which Bandura published in the *Encyclopedia for the Life Course and Human Development* (2009a).

Bandura (2009a) defined human agency as "the human capability to exert influence over one's functioning and the course of events by one's actions" (p. 8). "Through cognitive self-guidance, humans can visualize futures that act on the present; construct, evaluate, and modify alternative courses of action to gain valued outcomes; and override environmental influences" (p. 8). "To be an agent is to influence intentionally one's functioning and life circumstances" (Bandura, 2008c, p. 16).

Four core properties of human agency were described in Bandura (2006b, pp. 164-165) They are (a) intentionality, (b) forethought, (c) self-reactiveness, and (d) self-reflection. *Intentionality* deals with the forming of intentions that "include action plans and strategies for realizing them" (Bandura, 2009a, p. 8). *Forethought* involves "the temporal extension of agency" (p. 8) by setting goals and anticipating future events:

[Forethought] includes more than future-directed plans. People set goals for themselves and foresee likely outcomes of prospective actions to guide and motivate their efforts anticipatorily. When projected over a long-term course on matters of value, a forethoughtful perspective provides direction, coherence, and meaning to one's life. (Bandura, 2009a, p. 8)

Self-reactiveness broadens the role of the agent to be more than just “planners and fore thinkers” (Bandura, 2009a, p. 8) and includes processes of self-management and self-motivation, as well as emotional states that can undermine self-regulation:

The translation of plans into successful courses of action requires the self-management of thought processes; motivation to stick with chosen courses in the face of difficulties, setbacks, and uncertainties; and emotional states that can undermine self-regulatory efforts. (Bandura, 2009a, p. 8)

Lastly, *self-reflection* refers to the self-examining nature of human agents. "Through self-awareness, they reflect on their personal efficacy, the soundness of their thoughts and actions, the meaning of their pursuits, and...[if needed] change existing life course patterns" (Bandura, 2009a, p. 8).

Human agency is exercised through three different modes: personal, proxy, and collective (Bandura, 1997). *Personal* agency is exercised individually, and is the process by which an individual affects what he or she can control directly. In some cases, however, direct influence is not possible. The exercise of agency through *proxy* is the indirect influence a person can exert on circumstances beyond their immediate control, by acting through others:

In many spheres of functioning, people do not have direct control over conditions that affect their lives. In such cases, they exercise proxy agency. They do so by influencing others who have the resources, knowledge, and means to act on their behalf to secure the outcomes they desire. For example, children work through parents to get what they want, marital partners through spouses, employees through labor unions, and the general public through their elected officials. (Bandura, 2009a, p. 8)

Agency can also be exercised in groups. “People do not live their lives in individual autonomy. Indeed, many of the outcomes they seek are achievable only through interdependent efforts” (Bandura, 2000, p. 75). *Collective* agency is an interdependence of human functioning that is enacted when people who share common beliefs act as a group to produce effects by collective action. “A group’s attainments are the product not only of shared knowledge and skills of its different members, but also of the interactive, coordinative, and synergistic dynamics of their transactions” (pp. 75-76).

Beliefs of personal and collective efficacy are the most central and pervasive mechanisms of human agency. “Unless people believe they can produce desired effects and forestall undesired ones by their actions, they have little incentive to act or to persevere in the face of difficulties” (Bandura, 2009a, p. 9). Regardless of whatever other factors might also serve as guides and motivators, they are all dependent on a person's core belief that he or she has power to affect changes by their actions.

The Social Perspective

A social learning theory is a theory of learning in a social context. The most fundamental assumption of such a theory is that the individual person learns not in isolation but as a member of a larger group. A second assumption is that some, or all, of the members of the group participate in the learning of each individual or of the group as a whole.

Before reviewing the theories that were selected for inclusion in the present study some confusion of terms needs to be addressed. First, *situated learning* and *situated cognition*, two terms which refer both to the role of context in learning and the situated nature of meaning, are often used interchangeably. For example, in a special issue of *Educational Technology* dedicated to a review of situated learning McLellan (1993, p. 5) referred to an article by Brown, Collins,

and Duguid (1989) as the publication responsible for introducing the concept of *situated learning*. Just one year later, in a follow up issue (McLellan, 1994, p. 7), she referred to the very same article as introducing *situated cognition*. Though it seems that *situated cognition* might be the preferred term for cognitive scientists in both the social and clinical sciences of human psychology and the computer science of artificial intelligence, and that *situated learning* is the preferred term for those in the social science of education, these two terms are generally used as synonyms. I suggest reviewing Clancy (1997) for additional background on *situated cognition* (p. 1), the philosophical foundations from whence it sprang (pp. 3, 22), its introduction into cognitive science (p. 23), and the "ism" of *contextualism* (pp. 63-66) by which it is sometimes subsumed, or to which it is sometimes related.

Second, while *situated learning* is used as a general term to describe theories of learning that emphasize learning 'in situ', it was also used as the title of Lave and Wenger's (1991) publication in which they introduced the idea of legitimate peripheral participation in communities of practice. Although the full title of the book is *Situated Learning: Legitimate Peripheral Participation*, the spine of the book carries only the first portion of the title, *Situated Learning*. As a result this term is sometimes used to refer specifically to Lave and Wenger's theory while, at other times, to refer to theories of *situated learning* in general.

Third, the term *apprenticeship* is used in some of the theories that are summarized in this section. In some cases its use is quite literal, referring to actual apprentices learning a trade in a real world environment of *situated practice*—for example, the case studies of Yucatec midwives, Vai and Gola tailors, naval quartermasters, meat cutters, and nondrinking alcoholics in Lave and Wenger (1991). In other cases, such as that of cognitive apprenticeship (J. S. Brown et al., 1989; A. Collins et al., 1987; A. Collins, Brown, & Holum, 1991), it is used more in a metaphorical

sense, where the situation does not embody true apprenticeship in the form of learning a craft or trade, but borrows from this real world model to establish a method of teaching and learning in the classroom that builds on the same principles.

Six theories which take the perspective of individuals learning as part of a larger social group were selected for review in the present study: (a) Vygotsky's theory of internalization and the zone of proximal development; (b) Bandura's social cognitive learning theory, beginning from his initial behavioral studies of observational and vicarious learning; (c) Lave and Wenger's situated learning, or legitimate peripheral participation in communities of practice; (d) Wilson and Ryder's dynamic and distributed learning communities; (e) Engestrom's expansive learning and third generation activity theory; and (f) Brown, Collins, and Duguid's theory of cognitive apprenticeship.⁸⁶ Each will be summarized briefly. Inline citations as well as the reference list at the end of this report provide pointers to the original sources that should be consulted for a more in depth review.

Sociocultural Development (Lev Semyonovich Vygotsky – 1934/1978). "The first major presentation of Vygotsky's thinking in English was the 1962 publication of *Thought and Language*, translated by Euginia Hanfmann and Gertrude Vakar, and introduced by Jerome Bruner" (Glick, 2004, p. 349). Sixteen years later, in 1978, it was followed by publication of *Mind in Society*, which, although it carries Vygotsky's name as author, was "carefully composed

⁸⁶ Although the introduction of cognitive apprenticeship is generally credited to Brown, Collins, and Duguid (1989)—see, for example, McLellan (1993; 1994)—Collins is listed as the primary author on the 1987 technical report (A. Collins, Brown, & Newman, 1987) that preceded the 1989 article, and which presented a much more detailed account of cognitive apprenticeship than the relatively vague coverage it received in 1989. Because of this, the order of authorship for the 1989 publication may not be an accurate reflection of relative individual contribution to the theory of cognitive learning as a whole, but more a reflection of contribution to the article itself.

from many separate writings...edited by Cole, Scribner, John-Steiner, and Souberman " (p. 349). Glick notes that while the 1962 publication of *Language and Thought* had little lasting impact at the time of its publication, *Mind and Society* was a "hallmark event in Vygotsky studies" (p. 349):

Something obviously happened between 1962 and 1978, something that effected an interest in and a fascination with Vygotsky's ideas, or at least what were taken to be Vygotsky's ideas. In 1962, the publication of *Thought and Language* seemed a one-time event. In 1978 *Mind in Society* spawned a generation of scholarship. (Glick, 2004, p. 349)

The limited impact of *Thought and Language* can be explained by the timing of its publication. Arriving at the beginning of a period of rediscovery of "structure," along with Piaget being a recent find, it apparently "did not hit the dead center of psychologists' interests" (p. 350). By 1978, however, "Piaget was under attack from a number of directions" (p. 351) and it was in this new context that *Mind and Society* was published, coming "at a point of disenchantment with the Piagetian treatment of structure and hence seemed to be an answer to the problems encountered over a two-decade period involvement with Piaget " (p. 351). Since that time, Vygotsky's writings have grown in popularity and have been used to prop up modern conceptualization of developmental theory, social learning theory, and constructivism. But, as is common to all exegetic studies, certain variations exist in the interpretation and application of his ideas. And these variations are not always compatible with each other.⁸⁷

⁸⁷ One of the biggest challenges in reviewing Vygotsky's ideas is "the ready availability in the West of writings on him by those who have not studied him closely" (Langford, 2005, p. 149). Because of this I have chosen to focus my review on Vygotsky's own writings rather than rely on secondary interpretive sources.

Glick (2004) described the Vygotsky as received by the field of developmental psychology via *Mind in Society* in 1978 as "a subtly different Vygotsky from the one introduced in 1962" (pp. 351-352). He argued that "some of the topics now taken as central to a Vygotskian view are topics that underwent a slight alteration between *Thought and Language* and *Mind in Society*" (p. 352)—the primary difference being a question of whether Vygotsky's central concepts represent "laws of acquisition" of advanced behaviors, or an attempt at "differential diagnosis of differing developmental levels" (p. 352). Ratner (2004) expressed concerns regarding certain neo-Vygotskian beliefs based on misunderstandings of the concept of sociogenesis. He argued that the concept of "co-constructionism" is, in fact, diametrically opposed to Vygotsky's "emphasis on the social formation of psychology" (pp. 408, 409).

Langford (2005) characterized Vygotsky's influence on education in the West as ambiguous both because some of his ideas have been misunderstood, and because Vygotsky "espoused three very different views of education in his career" (p. 123). In the first period, running roughly from 1918-1921 (pp. 138-140) Vygotsky "adopted the reflexological view of education, in which it is assumed that learning is in accordance with the laws of conditioned reflexes" (p. 147). By 1928 he had migrated his position to one of social progressivism (pp. 124-129), then between 1932-1934 he returned to a view of traditional education with the curriculum of what is to be learned shifting from topics dictated by the child's interest to topics provided by a pre-established curriculum. In this third period, the "learner learning" (p. 147), at least for students over the age of 7, was replaced by the "teacher teaching" (p. 147).

Based on my own review of a selection of Vygotsky's translated works, in comparison with a survey of ideas commonly attributed to Vygotsky in educational psychology textbooks (for example, O'Donnell et al., 2007; Sternberg & Williams, 2010; Woolfolk, 2010), I find it

easy to agree with Glick's assertion that "it is likely that what anyone takes to be the core Vygotskian ideas are precisely those ideas that address a contemporary theoretical need, and which do not reflect the full scope of Vygotsky's thinking in its own terms" (Glick, 2004, p. 349).⁸⁸

Despite the rather complicated historical context; and the problems inherent to language translation, manuscript abridgement, and exegesis of historical text; what has emerged from Vygotsky's writings and the various interpretations thereof is the popular acceptance of three core ideas which are of great influence in the modern practice of learning and teaching. They are (a) tools and speech, (b) internalization and mediation, and (c) the zone of proximal development.⁸⁹

Sympathetic to psychologists who promoted the rejection of the then popular botanical model of learning from whence sprang the notion of a "kindergarten," Vygotsky pitched his ideas in terms of the new psychology of the time, which had "ascended the ladder of science by adopting zoological models as the basis for a new general approach to understanding the development of children" (Vygotsky, 1978, p. 20). What he suggested, however, was a refining correction to the zoological view of higher intellection processes; he believed the higher mental

⁸⁸ I find this to be a consistent trend in the popular application of all theories reviewed. The theories as outlined in Educational Psychology textbooks, the understanding of those theories by educators, and the form of the theories adopted in practice are not the pure, original theories at all, but rather, what I have come to refer to as *practitioner's theories*—a rehash of theories which have been, at least in many cases, decontextualized and reconceived. I use the term *practitioner's theories* to emphasize that they have evolved and taken form through well-intentioned attempts to apply the original theory in practical situations, but have been extended, in most cases, beyond the legitimate or defensible boundaries of the theory as established by the originating theorist—the ideas of the theory being selected based on convenience to a contemporary theoretical or practical need, reinterpreted to fit the circumstances at hand.

⁸⁹ These three ideas were identified based on coverage of Vygotsky's ideas in college textbooks such as Driscoll (2000, pp. 239-255), O'Donnell, Reeve, and Smith (2007), Sternberg and Williams (2010), Wertsch (1985), and Woolfolk (2010). They are the ideas which are most frequently reviewed in these texts, and the ideas which have been taken as the basis for further research and application in modern educational.

process of man to be more than simply a continuation of "corresponding processes in animals" (p. 20).

His argument began by stating that the most important aspect of practical intelligence in children is "the child's use of tools" (Vygotsky, 1978, p. 20) and cited Kohler's experiments with apes as exemplary in exploring this type of practical intelligence (p. 20). He continued his argument by declaring an important difference between man and ape, namely, that man can not only *use* but also *make* tools (Luria, 1994, p. 46).⁹⁰ Furthermore, not only does man make tools, but the tools he uses and makes impact his own internal psychological development. As Luria stated:

The tools used by man not only radically change his conditions of existence, they even react on him in that they effect a change in him and in his psychic condition. In the complicated inter-relations with his surroundings his organization is being differentiated and refined; his hand and his brain assume definite shapes, a series of complicated methods of conduct are being evolved, with the aid of which man adapts himself more perfectly to the surrounding world. (Luria, 1994, p. 46)

Vygotsky cited K. Buhler's research which "sought to establish similarities between child and ape" (p. 20) as establishing the important discovery that "the beginnings of practical intelligence in the child (he termed it 'technical thinking'), as well as the actions of the chimpanzee, are independent of speech" (p. 21). However, he was in disagreement with Buhler's conclusion that "'in the case of man, even in later life, technical thinking, or thinking in terms of tools, is far less closely bound up with language and concepts than other forms of thinking'" (p.

⁹⁰ Alexander Luria was Vygotsky's associate and partner, and the two worked closely together. Luria's quote used here to support Vygotsky's position is consistent with Vygotsky's personal belief, as evidenced by his own writings and a collaborative piece with Luria, *Tools and Symbols in Child Development* (Vygotsky & Luria, 1994). Luria's quote was selected for use here because of its powerful articulation.

21). He found Buhler's assumption that "the relationship between practical intelligence and speech that characterizes the ten-month-old child remains intact throughout her lifetime" (pp. 20-21) to run contrary to his own findings, and cited this type of reasoning as a shortcoming of the phylogenetic comparison method toward an understanding of human learning. Vygotsky believed that "although practical intelligence and sign use can operate independently of each other in young children, the *dialectical unity* [italics added] of these systems in the human adult is the very essence of complex human behavior" (p. 24). His own analysis accorded to symbolic activity a "specific *organizing* function that penetrates the process of tool use and produces fundamentally new forms of behavior" (p. 24). He credited the source of man's unique advantage to the *synthesis* of both tool use (i.e., practical activity) and speech:

The most significant moment in the course of intellectual development, which gives birth to the purely human forms of practical and abstract intelligence, occurs when speech and practical activity, two previously completely independent lines of development, converge. Although children's use of tools during their preverbal period is comparable to that of apes, as soon as speech and the use of signs are incorporated into any action, the action becomes transformed and organized along entirely new lines. The specifically human use of tools is thus realized, going beyond more limited use of tools possible among the higher animals. (Vygotsky, 1978, p. 24)

He further noted that "observations of children in an experimental situation similar to that of Kohler's apes show that the children not only *act* in attempting to achieve a goal but also *speak*" (p. 25). He related an example from the observational record of his collaborator, R. E. Levina, which detailed both the actions and verbalization of a four-and-a-half-year-old girl who was asked to get candy from a cupboard, with a stool and a stick as possible tools:

Levina posed practical problems for four- and five-year-old children such as obtaining a piece of candy from a cupboard. The candy was placed out of reach so the child could not obtain it directly. As the child got more and more involved in trying to obtain the candy, "egocentric" speech began to manifest itself as part of her active striving. At first this

speech consisted of a description and analysis of the situation, but it gradually took on a "planful" character, reflecting possible paths to solution of the problem. Finally, it was included as part of the solution.

For example, a four-and-a-half-year-old girl was asked to get candy from a cupboard with a stool and a stick as possible tools. Levina's description reads as follows: (Stands on a stool, quietly looking, feeling along a shelf with stick.) "On the stool." (Glances at experimenter. Puts stick in other hand.) "Is that really the candy?" (Hesitates.) "I can get it from that other stool, stand and get it." (Gets second stool.) "No, that doesn't get it. I could use the stick." (Takes stick, knocks at the candy.) "It will move now." (Knocks candy.) "It moved, I couldn't get it with the stool, but the, but the stick worked." (Vygotksy, 1978, p. 25)

Vygotksy summarized the role of speech in development and intelligence by saying,

The specifically human capacity for language enables children to provide for auxiliary tools in the solution of difficult tasks, to overcome impulsive action, to plan a solution to a problem prior to its execution, and to master their own behavior. Signs and words serve children first and foremost as a means of social contact with other people. The cognitive and communicative functions of language then become the basis of a new and superior form of activity in children, distinguishing them from animals. (Vygotksy, 1978, p. 29)

The example of the young girl verbalizing her experience and thoughts while trying to obtain the candy is a case of egocentric speech, a concept borrowed from Piaget (Vygotksy, 1978, p. 24). Vygotksy hypothesized this form of audible talking to oneself as "the transitional form between external and internal speech" (p. 27). "Inner speech is speech for oneself; external speech is for others" (Vygotksy, 1962, p. 131). He considered inner speech to be the opposite of external speech. External speech, he said, is "the turning of thought into words, its materialization of objectification. With inner speech, the process is reversed: Speech turns into inward thought" (p. 131).

Inner speech is the essential processes which facilitates internalization and mediation, the second of Vygotksy's ideas which has been adopted into the educational psychology mainstream of topics. By *internalization* Vygotksy meant "the internal reconstruction of an external

operation" (Vygotsky, 1978, p. 56). He illustrated this concept with a now frequently cited example of a young child learning to point as a means of communication. It begins as nothing more than an unsuccessful attempt to grasp something beyond his reach. However, when the mother comes to the child's aid and hands him the object "the situation changes fundamentally" and "pointing becomes a gesture for others" (p. 56). Vygotsky described internalization as consisting of a *series of transformations*:

(a) *An operation that initially represents an external activity is reconstructed and begins to occur internally.* Of particular importance to the development of higher mental processes is the transformation of sign-using activity, the history and characteristics of which are illustrated by the development of practical intelligence, voluntary attention, and memory.

(b) *An interpersonal process is transformed into an intrapersonal one.* Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first *between* people (*interpsychological*), and then *inside* the child (*intrapsychological*). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relations between human individuals.

(c) The transformation of an interpersonal process into an intrapersonal one is the result of a long series of developmental events. The process being transformed continues to exist and to change as an external form of activity for a long time before definitively turning inward. For many functions, the stage of external signs lasts forever, that is, it is their final stage of development. Other functions develop further and gradually become inner functions. However, they take on the character of inner processes only as a result of a prolonged development. Their transfer inward is linked with changes in the laws governing their activity; they are incorporated into a new system with its own laws. (Vygotsky, 1978, p. 57)

Another example of internalization, perhaps easier to grasp than the previous one given of learning to point, is a case in which Vygotsky and Luria were conducting experiments to investigate the psychogenesis of cultural forms of behavior. They found that "the cultural development of the child passes...through four main stages or phases which follow consecutively one after another" (Vygotsky, 1994b, p. 64). In their first example, they describe

this four stage process of internalization occurring during the course of a memorization experiment. I draw from both Vygotsky's and Luria's separate accounts. From Luria's we have the premise, the intuitive description, and context:

The cultural-historic development of psychology goes along the path of complication of cultural methods and habits; the history of culture starts with a primitive outward technique and ends with a complicated psychological technique. It inevitably develops in man the functional utilization of his own conduct.... We can demonstrate this, for example, in our experiments with memory, in the course of which a child learns how to use the most important internal mechanism - *the structural connection*.

A child who can hardly memorize five or six words of the series read out to him is asked to commit them to memory with the aid of pictures laid out on the table (e.g. lotto). Not one of the pictures actually reproduces the word in question, and the task can be performed only if the child connects in one structure the word in question with one of the pictures.

It is an obviously impossible task for a child of five or six or a backward child during his first years at school to establish a connection between the word 'village' and the picture of a house, between the word 'tail' and the picture of a dog, and, what is most important, to appreciate truly that connection and use it so as to memorize the material offered to him; on the other hand, a well developed child will perform that task without great difficulties. We had occasion to observe how a child in establishing and utilizing such connections could, by looking at the cards, reproduce 25- 30 and more words after one reading, while his natural memory could fix five or six at the most. Moreover, the connecting links were established with extraordinary subtlety. Thus, in order to remember the word 'spade' the child chose a picture of chickens picking up grains 'because they picked it just as the spade digs the earth'; for the word 'theatre' the child chose the picture of a crab on the seashore 'because the crab looks at the pebbles in the sea, and they are just as pretty as a theatre', etc. (Luria, 1994, p. 53)

Now, from Vygotsky's account, the analysis and explanation of the four stages involved in the process of internalization for this type of task:

The first stage could be described as the stage of primitive behaviour or primitive psychology. The experiment reveals this in that the younger child tries to remember the data supplied to him by a primitive or natural means in accordance with the degree to which he is interested in them. The amount remembered is determined by the degree of his attention, by the amount of his individual memory and by the measure of his interest in the matter.

Usually only the difficulties which the child meets on this path bring him to the second stage. In our experiments it usually took place in the following way. Either the

child himself, after more or less protracted search and trials, discovers some mnemotechnical method, or we lend him our assistance in case he is unable to master the task with the resources of his natural memory. For example, we place pictures in front of the child and choose words to be memorized in such a way that they should be in some way naturally connected with those pictures. When the child who has heard the words looks at the picture, he easily reproduces a whole series of words, since such pictures, irrespective of the child's consciousness, will remind him of the words which he has just heard.

The child usually grasps very quickly the method which we suggest to him, but does not usually know by what means the pictures help him to remember the words. He usually reacts in the following manner: when a new series of words is given to him, he will again—but now on his own initiative—place the pictures in front of him, and look at them every time a word is given to him. But since this time there is no direct connection between words and pictures, and the child does not know how to use the pictures as a means of memorizing a given word, he looks at the picture and reproduces not the word he was given, but another suggested by the picture....This stage is conventionally called the stage of 'naive psychology....'

This second stage is usually transitory in its importance. In the course of the experiment the child usually passes on very quickly to the third stage of the external cultural method....Now he replaces the processes of memorizing by a rather complicated external activity. When he is given a word, he chooses out of a number of pictures in front of him the one which is most closely associated with the word given. At first he tries to use the natural association which exists between the picture and word, but soon afterwards passes on to the creation and formation of new associations.

However, in the experiment even this third stage lasts a comparatively short time and is replaced by the fourth stage, which originates in the third. The external activity of the child *remembering by means of a sign passes on into internal activity. The external means, so to speak, becomes ingrown or internal* [Italics added].

The simplest way to observe this is the study of a situation in which a child must remember given words by using pictures placed in definite order [cf. method of loci for mnemonic techniques of memory]. After a few times the child usually learns the pictures themselves. He has no further need to recur to them. He already associates words given with the titles of pictures, the order of which he already knows. Such 'complete ingrowing' is based on the fact that inner stimuli are substituted for the external ones. The mnemotechnical map which lies before the child becomes his internal scheme. (Vygotsky, 1994b, pp. 64-66)

Vygotsky's third idea is by far the most prominent and influential of the three. It is the concept of the zone of proximal development. "The zone of proximal development...is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult

guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). Having reviewed and rejected three different theoretical positions—i.e., (a) "processes of child development are independent of learning" (p. 79), (b) "learning *is* development" (p. 80), and (c) a third position which "attempts to overcome the extremes of the other two by simply combining them" (p. 81)—the concept of the zone of proximal development is Vygotsky's own explanation for the relationship between learning and development. According to this view, learning leads out ahead of development, and it is critically dependent upon social interaction:

We propose that an essential feature of learning is that it creates the zone of proximal development; that is, learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers. Once these processes are internalized, they become part of the child's independent developmental achievement. (Vygotsky, 1978, p. 90)

This idea has obvious implications for instruction, which Vygotsky explained as follows:

In the child's development...imitation and instruction play a major role. They bring out the specifically human qualities of the mind and lead the child to new developmental levels. In learning to speak, as in learning school subjects, imitation is indispensable. What the child can do in cooperation today he can do alone tomorrow. Therefore the only good kind of instruction is that which marches ahead of development and leads it; it must be aimed not so much at the ripe as at the ripening functions. It remains necessary to determine the lowest threshold at which instruction in, say, arithmetic may begin since a certain minimal ripeness of functions is required. But we must consider the upper threshold as well; instruction must be oriented toward the future, not the past.

For a time, our schools favored the "complex" system of instruction, which was believed to be adapted to the child's ways of thinking. In offering the child problems he was able to handle without help, this method failed to utilize the zone of proximal development and to lead the child to what he could not yet do. Instruction was oriented to the child's weakness rather than his strength, thus encouraging him to remain at the preschool stage of development. (Vygotsky, 1962, p. 104)

The concept of the zone of proximal development has led to much research and is the source of several hot topics in modern educational psychology, such as scaffolding (O'Donnell et

al., 2007, p. 50; Sternberg & Williams, 2010, p. 53; Woolfolk, 2010, p. 50), mediated experience (Sternberg & Williams, 2010, p. 53), guided participation (O'Donnell et al., 2007, pp. 49-51, 327-334), instructional conversation⁹¹ (pp. 51-52), socially shared cognition (p. 52), intersubjectivity (p. 52), transfer of responsibility (p. 52), peer learning (pp. 54, 387, 397, 399), and the role of adults and peers in learning (Woolfolk, 2010, p. 50). These topics are currently in the center ring of both theory and practice. Regardless of whether or not the contemporary view of Vygotsky's ideas is accurate, it is certainly making an impact.

Social Cognitive Learning Theory (Albert Bandura – 1977). Bandura described his theory of social learning as being developed in a context in which "the prevailing analysis of learning focused almost entirely on learning through the effects of one's actions [with] the explanatory mechanisms [cast] in terms of peripheral association of environmental stimuli to responses" (Bandura, 2006a, p. 55). He viewed this type of behavioristic theorizing as "discordant with the obvious social reality that much of what we learn is through the power of social modeling" (Bandura, 2005, p. 10; Bandura, 2006a, p. 55)—noting the absurdity of a culture in which language, customs, practices, occupational competencies, educational practices, religious practices, etc., would be "gradually shaped in each member by rewarding or punishing consequences of their trial-and-error performances" (Bandura, 2005, p. 10; Bandura, 2006a, p. 55). Instead, he posited that in reality the "tedious and potentially hazard process" (p. 11) of trial-and-error learning, which could prove fatal in some cases,⁹² are "shortcut by social modeling" (p.

⁹¹ A didactic method in which the IRE (initiate, respond, evaluate) discourse model was replaced with the PQS (probe, question, scaffold) discourse model.

⁹² Bandura (1965, p. 2) gives the following examples:

11). Although previous research had been conducted and published in this area, Bandura described his program of research as the first to position social modeling in a context apart from the behaviorist paradigm:

The foremost proponents of behaviorism, Watson (1908) and Thorndike (1898), dismissed the existence of observational learning because, in their view, learning required performance of responses. The notion of learning by observation was too divergent to be given serious consideration. This was a durable legacy. Despite the centrality and pervasiveness of social modeling in everyday life, there was no research to speak of on modeling processes until the publication of *Social Learning and Imitation* by Miller and Dollard in 1941. They recognized modeling phenomena but construed them as a special case of discrimination learning. A model provides a social cue, the observer performs a matching response, and its reinforcement strengthens the tendency to behave imitatively.

I found this conception wanting on the determinants, mechanisms, and scope of observational learning. We launched a program of research on observational learning as it typically occurs in the absence of reinforced performance. We tested the determinants of observational learning and the mechanisms through which it works.

In a chapter entitled "Vicarious Processes: A Case of No-Trial Learning" (Bandura 1965), I presented the findings of our studies showing that observational learning requires neither response enactment nor reinforcement. (Bandura, 2005)

Bandura's program of research on observational learning stemmed from his roots in psychotherapy. After receiving his PhD from the University of Iowa in 1952 his first decade of publishing focused on topics including: "'Primary' and 'Secondary' Suggestibility" (1953); "The Rorschach White Space Response and 'Oppositional Behavior'" (1954a); "The Rorschach White Space Response and Perceptual Reversal" (1954b); "Psychotherapists' Anxiety Level, Self-

In laboratory investigations experimenters arrange comparatively benign environments in which errors will not produce fatal consequences for the organism. By contrast, naturalistic environs are loaded with potentially lethal consequences that unmercifully befall those who happen to perform hazardous errors. For this reason, it would be exceedingly injudicious to rely primarily upon trial-and-error and successive approximations methods in teaching children to swim, adolescents to drive automobiles, or adults to master complex occupational and social tasks. If rodents and pigeons toiling in Skinner boxes and various mazes could likewise get electrocuted, dismembered, or extensively bruised for errors that inevitably occur during early phases of learning, it is a reasonably safe prediction that few of these venturesome subjects would ever survive the shaping process.

Insight, and Psychotherapeutic Competence" (1956); "Review of Case Studies in Childhood Emotional Disabilities (Vol. 2) by G. Gardner" (Bandura, 1957); "Child-Rearing Patterns Associated With Adolescent Aggressive Disorders" (Bandura, 1958a); "Dependency Conflicts in Aggressive Delinquents" (Bandura, 1958b); "Adolescent Aggression" (Bandura, 1959); and "Psychotherapists' Approach-Avoidance Reactions to Patients' Expression of Hostility" (Bandura, Lipsher, & Miller, 1960).

His transition toward a study of observational and social learning began with the publication of "Psychotherapy as a Learning Process" (Bandura, 1961). At the time this article was published a view of psychotherapy *as a learning process* was not new, or particularly unique. In fact, Bandura opened by stating that "it is *customary* [italics added] to conceptualize psychotherapy as a learning process" (p. 143). He went on to say, however, that few therapists who espouse this view "accept the full implications of this position" (p. 143). In the article he reviewed various principles of contemporary learning theory that might fruitfully be applied to psychotherapy, including counterconditioning, extinction, discrimination learning, reward, punishment, and social imitation. More importantly, however, he framed the central question that he himself would later answer with what is now known as social cognitive theory: "Can human behavior be modified through psychological means and if so, what are the learning mechanisms that mediate behavior change?" (p. 143).

In early research leading up to the definition of social cognitive theory, Bandura provided empirical evidence that children do, in fact, imitate adult models (Bandura & Huston, 1961). Building on his earlier studies of aggression in adults and children, he conducted a series of experiments in which he demonstrated the transmission of aggression from adults to children through delayed imitation of aggressive adult models (Bandura & Ross, 1961). These

experiments are now quite famously known as the "Bobo doll" experiments. In similar experiments he showed that imitation of adult behavior could just as effectively be mediated by film, and that there were no significant differences in the effective transmission of aggression via film model as compared to transmission via live model (Bandura, Ross, & Ross, 1963). In other words, violent acts could be taught simply by carrying them out in front of the child, and whether they were presented by a live model or by film made no difference. These findings were unsettling to an already apprehensive public and contributed to growing concern regarding the effects of televised violence on children (Bandura, 2006a, p. 57). They also drew significant opposition to Bandura's work from the broadcast industry—to the point of airing a dramatized "blistering cross-examination concerning [his] modeling studies" (p. 58) in which the character playing his role did not fare well.

In another study, Bandura and McDonald (1963) found that even the moral judgments of children "are readily modifiable, particularly through the utilization of adult modeling cues" (p. 280). Three conditions were compared for effectiveness: (a) model plus reinforcement, (b) model without reinforcement, and (c) reinforcement with no model. These three groups were described as follows:

One group of children observed adult models who expressed moral judgments counter to the group's orientation and the children were positively reinforced for adopting the models' evaluative responses. A second group observed the models but the children received no reinforcement for matching the models' behavior. The third group had no exposure to the models but each child was reinforced whenever he expressed moral judgments that ran counter to his dominant evaluative tendencies. Thus the experimental design permitted the test of the relative efficacy of social reinforcement, the behavior of models, and these two factors combined in shaping children's moral judgments. (pp. 275-276)

From the results of this study Bandura and McDonald concluded that "the provision of models alone...was as effective in altering children's moral judgments as was the experimental condition with social reinforcement" (p. 279). They also noted that operant conditioning procedures appeared to be "particularly inefficient when there are strong dominant response tendencies and the desired alternative responses are only weakly developed or absent" (p. 281). This they attributed to the relatively infrequent display of the desired responses resulting in "little opportunity to influence them through reinforcement" (p. 281).

In another study Bandura and Mischel (1965) tested "the relative efficacy of live and symbolic models for modifying delay-of-reward behavior [in which] groups of children with marked preferences for either immediate but less valued rewards, or more valuable delay reinforcers, were assigned randomly to one of three experimental conditions" (p. 698, abstract). Children in the first group "observed live models who exhibited delay behavior that was counter to the children's pattern" (p. 698, abstract). Children in the second group were "presented essentially the same modeling cues except in symbolic verbal form" (p. 698, abstract) via written recording of "the model's choices and accompanying philosophy-of-life commentaries" (p. 701). Children in the third group "had no exposure to any models" (p. 698, abstract). Results of the study provided support for the "influential role of modeling variables in the social transmission of self-controlling responses" (p. 703):

Children who had shown a predominantly delayed-reward pattern displayed an increased preference for immediate and less valued rewards as a function of models favoring immediate gratification; conversely, subjects who had exhibited a marked disposition toward immediate rewards displayed an enduring increased willingness to wait for more highly valued delayed reinforcers following exposure to models displaying high-delay behavior. (Bandura & Mischel, 1965, p. 703)

In a milestone culmination of his early research, Bandura (1965) argued for a repositioning of the study of vicarious and observational learning outside of the traditional operant conditioning paradigm, in which responses must be performed and reinforced in order for learning to occur:

Research and theoretical interpretations of learning processes have focused almost exclusively on a single mode of response acquisition which is exemplified by the operant or instrumental conditioning paradigm. In this procedure the organism is impelled, in one way or another, to perform responses under specific stimulus conditions and, through differential reinforcement of spontaneously emitted variations in behavior, new response patterns are developed or existing repertoires are brought under new discriminative stimulus control. It is generally assumed that the principles governing the latter mode of response acquisition account also for social learning phenomena occurring under naturalistic conditions. (Bandura, 1965, pp. 1-2)

Bandura argued that one of the biggest problems with the prevailing paradigm was that "apart from other questions of efficiency...and survival, it is doubtful if many classes of responses would ever be acquired if social training proceeded solely by the method of approximations through differential reinforcement of emitted responses" (Bandura, 1965, p. 2). He further argued that vicarious learning is a means of short-circuiting this method, and humorously employed a play on terminology to underscore the fallacy of differential reinforcement as a suitable means for acquiring certain types of skills in hazardous situations:⁹³

It is evident from informal observation that vicarious-learning experiences and response-guidance procedures involving both symbolic and live models are utilized extensively in social learning to short-circuit the acquisition process, and to prevent one-trial extinction of the organism in potentially hazardous situations. (Bandura, 1965, p. 2)

⁹³ For example, "teaching children to swim, adolescents to drive automobiles, or adults to master complex occupational and social tasks" (Bandura, 1965, p. 2)

In another clever terminology play, as if to one up Guthrie, Bandura entitled his monograph *Vicarious Learning: A Case of No-Trial Learning*. By "no-trial" he meant to emphasize that learning could occur without the need for even one single reinforced response:

For the purposes of the present discussion, a vicarious learning event is defined as one in which new responses are acquired or the characteristics of existing response repertoires are modified as a function of observing the behavior of others and its reinforcing consequences, without the modeled responses being overtly performed by the viewer during the exposure period. In demonstrating vicarious learning phenomena, it is therefore necessary to employ a nonresponse acquisition procedure in which a subject simply observes a model's behavior, but otherwise performs no overt responses, nor is administered any reinforcing stimuli during the period of acquisition. Any learning that occurs under these limiting conditions is purely on an observational or covert basis. This mode of response acquisition is accordingly designated as no-trial learning, since the observer does not engage in any *over responding trials* although, as will be shown later, he may require multiple *observational trials* in order to reproduce the stimuli accurately.⁹⁴ (Bandura, 1965, p. 3)

It is important to note that in promoting this change Bandura did not advocate the wholesale abandonment of principles of learning in the behaviorist tradition altogether. For example, although he argued that learning can take place through observation without the observer performing any responses to be reinforced, he was not throwing out the principle of reinforcement. What he was doing was presenting a supplementary view of reinforcement based on evidence from a number of empirical studies which suggested that reinforcement, both of the classical conditioning and the operant conditioning varieties, may occur vicariously. Thus,

⁹⁴ The phrase "reproduce the stimuli accurately" refers to a process of mediation through which "in the course of observation, transitory sensory and perceptual phenomena are converted to retrievable images of the modeled sequences of behavior" (Bandura, 1965, p. 10), or through which "in addition to the acquisition of imaginal responses, once verbal labels have become attached to objective stimuli, the observer acquires, during the period of exposure, verbal equivalents of the model's behavior" (Bandura, 1965, p. 11).

reinforcement could be provided not only by rewarding or punishing the learner directly, but by rewarding or punishing someone else in their presence, with whom they could identify.

In addition to the argument made in favor of broadening the general view of learning to account for "significant vicarious phenomenon...evident in the delayed reproduction of modeling behavior originally learned by observers under a nonresponse acquisition procedure" (Bandura, 1965, p. 47) Bandura's publication of *Vicarious Learning: A Case of No-Trial Learning* was important for two other reasons. First, it emphasized "the function of representational processes in observational learning" (p. 47) under which "imaginal and verbal representations of modeling stimuli constitute the enduring learning products of observational experiences" (p. 47). Second, it concluded with a challenge that set a new standard for the variables of learning theory:

The study of social transmission of response patterns is necessitated by the fact that the behavioral repertoires which constitute an enduring part of a culture are to a large extent transmitted on the basis of repeated observation of behavior displayed by social models rather than by memory drums. While the learning process is essentially the same, the characteristics of the social transmitters and other interpersonal variables can greatly affect the rate, level, and types of responses that will be acquired observationally. Moreover, the efficacy of parameters established on the basis of learning in one-person situations may differ in dyadic and group situations (Bandura *et al.*, 1963b). A comprehensive theory of behavior must therefore be based on experimentation involving both social and learning variables. (Bandura, 1965, p. 48)

Twelve years after declaring the need for any comprehensive theory of behavior to include an accounting of both *learning* and *social* variables Bandura answered his own challenge

with the publication of *Social Learning Theory* (Bandura, 1977b).⁹⁵ Building on his earlier research, Bandura's theory of social learning⁹⁶ assumes that behavior originates not only from response consequences of direct experience (p. 17), but also through the observation of other people. In fact, the central claim of the theory is that *most* human behavior is learned in this way:

Learning would be exceedingly laborious, not to mention hazardous, if people had to rely solely on the effects of their own actions to inform them what to do. Fortunately, most human behavior is learned observationally through modeling: from observing others one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action. (Bandura, 1977b, p. 22)

According to social learning theory, observational learning is comprised of four component processes: (a) attentional, (b) retention, (c) motor reproduction, and (d) motivational:

1. Attention – "People cannot learn much by observation unless they attend to, and perceive accurately, the significant features of the modeled behavior." (Bandura, 1977b, p. 24)
2. Retention – "People cannot be much influenced by observation of modeled behavior if they do not remember it." (Bandura, 1977b, p. 25)
3. Motor reproduction – "The third component of modeling involves converting symbolic representations into appropriate actions...by organizing one's responses spatially and temporally in accordance with the modeled patterns." (Bandura, 1977b, p. 27)

⁹⁵ Although some of the material in this publication was actually printed six years earlier in a monograph entitled *Social Learning Theory* (Bandura, 1971), the 1977 publication is cited in Bandura's biographical sketch (Pajares) as the book that "dramatically altered the direction psychology was to take in the 1980s" (para. 18). Since Bandura links to this biographical sketch from his own professional website (Bandura), it seems reasonable to accept it as an accurate representation of events and attribution of importance to the 1977 publication.

⁹⁶ Bandura was not the first, or the only, theorist to use the term social learning theory. Phares (2001) credits Dollard and Miller as being among the first to use the term *social learning* and Rotter as presenting the first comprehensive social learning theory (p. 1564). Note also that distinguishing his theory from other theories with similar names was one of Bandura's reasons for later changing the name of his own theory to Social Cognitive Theory (Bandura, 2006a, p. 65).

4. Motivational process – "People do not enact everything they learn. They are more likely to adopt modeled behavior if it results in outcomes they value than if it has unrewarding or punishing effects...those behaviors that seem to be effective for others are favored over behaviors that are seen to have negative consequences." (Bandura, 1977b, p. 28)

Social learning theory acknowledges the acquisition of antecedent determiners of behavior. Antecedent determiners are expectancies of "what leads to what" (Bandura, 1977b, p. 58). They can be learned not only through direct experience, but also through symbolic generalization, such as the casting of stereotypes (pp. 63-64), and of course, through vicarious experience (pp. 65-67).

Social learning theory also acknowledges the acquisition of consequent determinants of behavior, or, learning from the result of one's actions, (p. 96). Consequent determinants are often learned through direct experience, but can also be learned through vicarious reinforcement (p. 117)—that is, through observation of the reinforcement that others receive in answer to their behavior. In fact, it has been shown that "by attending to the pattern of successes and failures of others, observers generally learn faster than do the performers themselves [especially if] the tasks depend more heavily on *conceptual* [italics added] than on *manual* [italics added] skills" (p. 122).

Like reinforcement in direct experiential learning, reinforcement in observational learning has the same informative, incentive, and strengthening functions (Bandura, 1977b, p. 17) that it does in learning through direct experience. However, in observational learning it is assumed that reinforcement has an antecedent influence rather than a consequent one. It is facilitative rather than necessary, and is only "one of several factors that can influence what is observed and what goes unnoticed" (p. 37):

It follows from social learning theory that observational learning can be achieved more effectively by informing observers in advance about the benefits of adopting modeled behavior than by waiting until they happen to imitate a model and then rewarding them for it. (Bandura, 1977b, p. 37)

Breaking further from the behaviorist tradition, in *Social Learning Theory* Bandura (1977b) introduced an element of cognitive control into the learning process in the forms of (a) "cognitively based motivation" (p. 160), (b) "cognitive representation of contingencies" (p. 165), (c) "[mental] representational guidance of behavior" (p. 170), (d) "problem solving in thought rather than action" (p. 171), (e) "means of distinguishing accurate from inaccurate thinking" (p. 180), and (f) the regulation of "influential cognitions" (p. 187).

Bandura also introduced the concept of triadic reciprocal determinism.⁹⁷ Although this was the last idea discussed in *Social Learning Theory*, it became the first idea presented in most subsequent explanations of the theory. Triadic reciprocal determinism was explained as "a continuous reciprocal interaction between personal, behavioral, and environmental determinants" (Bandura, 1977b, p. 194). Where the behaviorist view was one in which the environment determined behavior, social learning theory included the additional notions that (a) behavior also determines the environment to which a person is subjected to, and (b) that cognitive regulation influences both behavior and how environmental stimuli are perceived.

The same ideas presented in 1977 were again published in 1986 under the name of *social cognitive theory* (Bandura, 1986). This name change helped to distinguish Bandura's theory from other similarly named theories with which it was often confused, and to clarify its use in

⁹⁷ Later referred to as triadic reciprocal *causation* (see, for example, Bandura, 1994b; 1996).

explaining not only “how people acquire cognitive, social, emotional, and behavior competencies but also how they motivate and regulate their behavior and create social systems that organize and structure their lives” (Bandura, 2006a, p. 65). Bandura explained the purpose behind his use of the terms *social* and *cognitive* by saying,

In the more fitting appellation as *social cognitive theory*, the *social* portion of the title acknowledges the social origins of much human thought and action; the *cognitive* portion recognizes the influential contribution of cognitive processes to human motivation, affect, and action. (Bandura, 2006a, p. 65)

Along with the name change, many of the transitional links to behavioral learning theory that were leveraged in the initial presentation were dropped—presumably because they were no longer needed in order for the core ideas to be accepted. By 1986 observational and vicarious learning was well known, and well supported by both empirical and anecdotal evidence. The ideas of the theory were further organized and presented a decade later in an entry for the *International Encyclopedia of Education* (Bandura, 1996). In summary, they are as follows:

1. *Model of Causation*. Human adaptation is explained in terms of “triadic reciprocal causation” (p. 5513) with continuous interaction between environmental, behavior, and personal (cognitive, biological, and other) factors. “People are both producers and products of their environment” (p. 5513). “People are neither driven by inner forces nor shaped and controlled by their environment....[but are] contributors to their own development and psychosocial functioning within a network of reciprocally interacting influences” (p. 5513).
2. *Symbolizing Capability*. “Social cognitive theory assigns a central role to cognitive, vicarious, self-regulatory, and self-reflective processes in human development and

functioning" (p. 5513). The remarkable capacity for symbolization enables people to "process and transform transient experiences into cognitive models that server as guides for reasoning and action"(p. 5513). Understanding is gained, and knowledge is expanded by "operating symbolically on the information derived from personal and vicarious experiences" (pp. 5513-5514). This "remarkable flexibility of symbolization enables people to create ideas that transcend their experiences" (p. 5514).

3. *Vicarious Capability*. "A culture could never transmit its language, mores, social practices, and adaptive competencies if they had to be shaped laboriously in each new member by response consequences" (p. 5514). "The abbreviation of the acquisition process through modeling is vital for survival as well as for human development because natural endowment provides few inborn skills, and errors can be hazardous" (p. 5514). "Humans have evolved an advanced capacity for observational learning...[and] virtually all behavioral, cognitive, and affective learning resulting from direct experience can occur vicariously by observing people's behavior and its consequences for them" (p. 5514). The four subfunctions that govern observational learning are (a) attentional processes, (b) cognitive representational and memory processes, (c) the behavioral production process, and (d) motivational processes (p. 5514). "Modeling is not a process of behavioral mimicry. Rather, modeling influences convey rules for generative and innovative behavior...[in which] higher-level learning is achieved through abstract modeling in which observers extract the rules governing the modeled judgments and action" (p. 5514). "Modeling influences can strengthen or weaken restraints over behavior patterns that have been previously learned...by the information it conveys about the probable rewarding or punishing

consequences of modeled courses of action" (p. 5515). "People are easily aroused by the emotional expressions of others....[and] learn to fear the things that frighten others, to dislike what repulsed them, and to like what gratifies them" (p. 5515). "In sum, modeling influences serve diverse functions as tutors, inhibitors, disinhibitors, social prompters, emotion arousers, and shapers of values and conceptions of reality" (p. 5515).

4. *Forethought Capability*. "Most human behavior, being purposive, is regulated by forethought" (p. 5515). "Future events cannot be causes of current motivation and action because they have no actual existence. However, by being represented cognitively in the present, foreseeable future events are converted into current motivators and regulators of behavior" (p. 5515).
5. *Self-regulatory Capability*. "People are not simply knowers and performers. They are also self-reactors with a capacity for self-direction" (p. 5515). "Human self-regulation relies on discrepancy production, as well as discrepancy reduction. People motivate and guide their actions by setting themselves challenging goals and then mobilizing their skills and effort to reach them" (p. 5516). "Because internalized controls can be selectively activated and disengaged, marked changes in moral conduct can be achieved without altering people's personality structures, moral principles or self-evaluative systems" (p. 5516).
6. *Self-reflective Capability*. "Effective cognitive functioning requires ways of distinguishing between accurate and faulty thinking....Four different modes of thought verification can be distinguished: *enactive*, *vicarious*, *persuasive*, and *logical* forms" (p. 5516). "Enactive verification relies on the adequacy of the fit between

thought and the results of one's actions" (p. 5516). "In the vicarious mode...observing other people's behavior and its effects serves as a way of checking the correctness of one's own thinking about what leads to what" (p. 5516). "The persuasory mode of thought verification relies on comparing one's thoughts to the judgments of other [sic]" (p. 5516). "In the course of development, people acquire rules of inference....that [enable] them to detect certain errors in thought by logical verification" (p. 5516). "People's beliefs in their efficacy influence how they think, feel, act and motivate themselves" (p. 5517). These beliefs come from: "a) performance mastery experiences; (b) vicarious experiences for judging capabilities in comparison with performances of others; (c) verbal persuasion and related types of social influences;.... and (d) physiological states and reactions" (p. 5517).

7. *Characteristics of Human Nature*. "Human nature is characterized by a vast potentiality that can be developed by direct and vicarious experience into a variety of forms within biological limits" (p. 5517).

Based on a comparative analysis of several presentations of social cognitive theory (Bandura, 1977b; Bandura, 1989; Bandura, 1994b; Bandura, 1996; Bandura, 1999a; Bandura, 2009b) it appears that unlike some of the other theories reviewed in the present study, Bandura's theory of social learning has been refined over time, but not substantially revised or reworked since its initial articulation. While originally cast with a behavioral orientation (Bandura, 1977b), it took on a more cognitive feel in the 1980s and early-to-mid 1990s (Bandura, 1989; Bandura, 1994b; Bandura, 1996). In more recent years it has undergone another shift toward an agentic perspective of social cognitive theory (Bandura, 2001; Bandura, 2008b; Bandura, 2008c) and toward a psychology of human agency (Bandura, 2006b). Throughout these changes, however,

the core ideas and basic assumptions of the theory as originally presented remain intact.

Bandura's further expansion of the theory into the realms of self efficacy and agency will not be reviewed here, as they have already been addressed in our summary of human learning theories in a previous section.

Expansive Learning and Activity Theory (Engestrom – 1987). Another social learning model which has been expounded in a rather profound, dialectical, and somewhat philosophical way, is Yrjö Engeström's expansive learning theory (Engestrom, 1987). Viewing psychology to be "at the limits of cognitivism" (ch. 2, p. 1) Engestrom took upon himself the challenge to construct a "coherent theoretical [instrument] for grasping and bringing about processes where 'circumstances are changed by men and the educator himself is educated'"(ch 2., p. 8). Although the following summary of his theory is rather brief a more detailed reading can be found in *Learning by Expanding* (Engestrom, 1987), the publication in which the theory was first introduced, or in one of Engestrom's more recent articles (such as, Engestrom, 2000a; 2001; 2009; 2010).

It should be noted that Engestrom's target was not merely a theory of learning but something much more comprehensive, i.e., "a viable root model of human activity" (Engestrom, 1987, ch. 2, p. 8). To guide him toward this objective, he set for himself some rather stringent initial criteria: (a) "activity must be pictured in its simplest, genetically original structural form, as the smallest unit that still preserves the essential unity and quality behind any complex activity" (ch. 2, p. 8); (b) "activity must be analyzable in its dynamics and transformations [and] in its evolution and historical change...no static or eternal models" (ch. 2, p. 8); (c) "activity must be analyzable as a contextual or ecological phenomenon [concentrating] on systemic relations between the individual and the outside world" (ch. 2, p. 8); and (d) "activity must be analyzable

as culturally mediated phenomenon [sic]...no dyadic organism-environment models will suffice [he insisted upon a triadic structure of human activity]" (ch. 2, p. 8).

To find his theoretical starting point, Engestrom identified three previous lines of research that met his initial requirements (Engestrom, 1987, ch. 2, p. 9):

1. Theorizing on signs – consisting of research beginning with the triadic relationship of object, mental interpretant, and sign by C.S. Pierce, one of the founders of semiotics, down through Karl Popper, who posited a conception of three worlds (physical, mental states, and contents of thought)
2. The genesis of intersubjectivity – the continuity studies of infant communication and language development, founded by G. H. Mead
3. The cultural-historical school of psychology – consisting of ideas that began with Vygotsky and reach maturity with Leont'ev

The first line of research, theorizing on signs, he rejected as a model because it "narrows human activity down to individual intellectual understanding [and provides] little cues for grasping how material culture is created in joint activity" (Engestrom, 1987, ch. 2, p. 15). The second—though it includes the social, interactive, symbol-mediated construction of reality—he also rejected, because its construction "is still conceived of as construction-for-the-mind, not as practical material construction" (ch. 2, p. 22). The third, he accepted as a starting point, because it "gives birth to the concept of activity based on material production, mediated by technical and psychological tools as well as other human beings" (ch. 2, p. 32). On this premise he erected what he referred to as the third generation of cultural-historical activity theory, starting with Vygotsky's "famous triangular model in which the conditioned direct connection between stimulus (S) and response (R) was transcended by 'a complex mediated act'...commonly

expressed as the triad of a subject, object, and mediating artifact" (Engestrom, 2001, p. 134).

This common expression of Vygotsky's model is referred to by Engestrom as the *first generation* of activity theory (Engestrom, 1999, pp. 1-3; 2001, p. 134).

Engestrom considered the insertion of mediating cultural artifacts into human action to be revolutionary, providing a way to bind the individual to his culture and society to the individual:

The insertion of cultural artifacts into human actions was revolutionary in that the basic unit of analysis now overcame the split between the Cartesian individual and the untouchable societal structure. The individual could no longer be understood without his or her cultural means; and the society could no longer be understood without the agency of individuals who use and produce artifacts. This meant that objects ceased to be just raw material for the formation of logical operations in the subject as they were for Piaget. Objects became the cultural entities and the object-orientedness of action became the key to understanding human psyche....The concept of activity took the paradigm a huge step forward in that it turned the focus on complex interrelations between the individual subject and his or her community. (Engestrom, 2001, p. 134)

For Engestrom there was still one important limitation of Vygotsky's model; it focused on the individual. Engstrom overcame this by drawing on Leont'ev's famous example of the primeval collective hunt which "showed how *historically evolving division of labor* has brought about the crucial differentiation between an individual action and a collective activity" (Engestrom, 1999, "Three Generations of Activity Theory", para. 3). Beginning with a "general mode of biological adaptation as the animal form of activity may be depicted" (Engestrom, 1987, ch. 2, p. 33), Engestrom applied Leont'ev's ideas to complete a "derivation...[by] genetic analysis" (ch. 2, p. 33) and demonstrate evolutionary "ruptures" in the three sides of the biological adaptation triangle. *Individual survival* is ruptured by the emerging use of tools. *Social life* is

ruptured by collective traditions, rituals, and rules. And *collective survival* is ruptured by division of labor.⁹⁸

Through further derivations in line with Leont'ev's differentiation of the individual action and the collective activity, he took "what used to be *separate ruptures* or emerging mediators" (Engestrom, 1987, ch. 2, p. 35) and converted them to "*unified determining factors*" (ch. 2, p. 35), thus completing a graphical representation of what he referred to as the *second generation* of activity theory (1999, pp. 1-3; 2001, p. 134). This model accounted not only for individual actions, but for collective activity of a community.

Note that in the second generation model what used to be biological *adaptive activity* has been transformed into *consumption* and placed in subordinate relation to three dominant aspects of human activity: (a) *production*, (b) *distribution*, and (c) *exchange* (Engestrom, 1987, ch. 2, p. 36). Marx (Marx, 1973, p. 89 as cited in Engestrom, 1987) explained the relationship between these three dominant aspects of human activity and the individual aspect of consumption as follows:

Production creates the objects which correspond to the given needs; distribution divides them up according to social laws; exchange further parcels out the already divided shares in accord with individual needs; and finally, in consumption, the product steps outside this social movement and becomes a direct object and servant of individual need, and satisfies it in being consumed. Thus production appears to be the point of departure, consumption as the conclusion, distribution and exchange as the middle (...). (ch. 2, p. 36)

⁹⁸ Engestrom (1987) described anthropoid apes as "the prime example of the rupture by tools" and dolphins with their extraordinary capacity to organize individuals to function as a collective whole as a possible prime example of ruptures in "'doing together' and 'being together'" (ch. 2, p. 34).

Two examples of how this model might be instantiated in the representation and analysis of a specific activity are given in Engestrom (2000a, p. 962). The first example, represents the *subject*—in this case a physician—engaged in the activity of reviewing patient records prior to meeting with the patient. The *object* of this activity is the patient records. The expected *outcome* is an understanding of the patient's history and the purpose of the visit. Notice that the interaction between the subject (the physician) and the object (the patient records) is mediated by the physician's medical knowledge, a *tool* which he leverages to interpret the records and formulate an understanding of the patient's general health condition. Continuing the scenario, the second example represents the activity of examining and diagnosing the patient, in which the patient becomes the *object* and his preliminary assessment the intended *outcome*.

Building on the second generation triangular model of human activity, Engestrom described "the minimal model for the third generation of activity theory" (Engestrom, 2001, p. 136) as requiring at least two interacting activity systems. An example of this model can be found in Engestrom (2010, p. 6). This example depicts the activity of a home healthcare care worker engaged in completing a list of routine tasks while visiting the client's home, and this in relation to the client's activity of "maintaining a meaningful and dignified life at home while struggling with threats such as loneliness, loss of physical mobility and the ability to act independently, and memory problems commonly known as dementia" (p. 6). This model of two activity systems in relation to one another is the minimal model for third generation activity theory.

Engestrom (2001) summarized the following five principles of his revised activity theory as follows:

1. Prime unit of analysis: "A collective, artifact-mediated and object-oriented activity system, seen in its network relations to other activity systems, is taken as the prime unit of analysis" (p. 136).
2. Multi-voicedness: "An activity system is always a community of multiple points of view, traditions and interests" (p. 136).
3. Historicity: "Activity systems take shape and get transformed over lengthy periods of time. Their problems and potentials can only be understood against their own history" (p. 136).
4. Contradictions: Contradictions play a central role as "sources of change and development...[They] are historically accumulating structural tensions within and between activity systems" (p. 137).
5. Possibility of expansive transformations: "An expansive transformation is accomplished when the object and motive of the activity are reconceptualized to embrace a radically wider horizon of possibilities than in the previous mode of activity" (p. 137).

Expansive learning theory is different from all other theories previously reviewed in three significant ways. First, it is concerned with the learning of new forms of activity as they are created, rather than the mastery of putative stable, well-defined, existing knowledge and skill:

Standard theories of learning are focused on processes where a subject (traditionally an individual, more recently possibly an organization) acquires some identifiable knowledge or skills in such a way that a corresponding, relatively lasting change in the behavior of the subject may be observed. It is a self-evident presupposition that the knowledge or skill to be acquired is itself stable and reasonably well defined. There is a competent 'teacher' who knows what is to be learned.

The problem is that much of the most intriguing kinds of learning in work organizations violates this presupposition. People and organizations are all the time learning something that is not stable, not even defined or understood ahead of time. In important transformations of our personal lives and organizational practices, we must learn new forms of activity which are not yet there. They are literally learned as they are being created. There is no competent teacher. Standard learning theories have little to offer if one wants to understand these processes. (Engestrom, 2001, pp. 137-138)

Engestrom voiced a rather strong view against a notion of learning "limited to processes of acquisition of skills, knowledge and behaviors, already mastered and codified by educational

institutions" (Engestrom, 2000b, p. 526), arguing that such a perspective makes learning irrelevant to the discovery and implementation of novel solutions:

If our notion of learning is limited to processes of acquisition of skills, knowledge, and behaviors already mastered and codified by educational institutions and other accepted representatives of cultural heritage, then finding and implementing future-oriented novel solutions to pressing societal problems has little to do with learning.

I have proposed that a historically new form of learning, namely *expansive learning* of cultural patterns of activity that are not yet there, is emerging and needs to be understood (Engestrom, 1987). (p. 526)

He further argued that the traditional view of learning is a perpetuated relic of the enlightenment era, and called for a shift of focus toward emergent learning processes *from below* as a necessary alternative in order for education to maintain relevance:

Give people facts, open their minds, and eventually they will realize what the world should become....I would call this an *enlightenment view of learning*. Learning is a fairly simple matter of acquiring, accepting, and putting together deeper, more valid facts about the world. Of course, this tacitly presupposes that there are teachers around who already know the facts and the needed course of development. Inner contradictions, self-movement, and agency from below are all but excluded. It is a paternalistic conception of learning that assumes a fixed, Olympian point of view high above, where the truth is plain to see. (Engestrom, 2000b, p. 530)

If education is to remain relevant, educators need to study carefully these changes and build on their internal contradictions and emergent learning processes from below, rather than continue preaching the right answers from above. (Engestrom, 2000b, pp. 533-534)

Second, expansive learning theory is concerned with collective transformation, rather than individual learning. Although changes in the collective are initiated by individuals within the community, the transformation itself is a change in the collective system:

The object of expansive learning activity is the entire activity system in which the learners are engaged. Expansive learning activity produces culturally new patterns of activity. Expansive learning at work produces new forms of work activity. (Engestrom, 2001, p. 139)

Although change originates with individual participants in the collective, the effective change takes place in collective activity system as a whole:

Human collective activity systems move through relatively long cycles of qualitative transformations. As the inner contradictions of an activity system are aggravated, some individual participants begin to question and deviate from its established norms. In some cases, this escalates into collaborative envisioning and a deliberate collective change effort from below. (Engestrom, 2000b, p. 526)

In fact, in his original presentation of expansion learning theory, Engestrom actually reformulated Vygotsky's conception of zone of proximal development (Engestrom, 1987, ch. 3, p. 27) in terms of collective activities. Although he indicated it to be provisional at the time, he is still using the same reformulated definition:

Vygotsky's concept of *zone of proximal development* is another important root of the theory of expansive learning. Vygotsky (1978, p. 86) defined the zone as "*the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.*" In *Learning by Expanding*, Vygotsky's individually oriented concept was redefined to deal with learning and development at the level of collective activities:

"It is the distance between the present everyday actions of the individuals and the historically new form of the societal activity that can be collectively generated as a solution to the double bind potentially embedded in the everyday actions."
(Engestrom, 1987, p. 174)

In effect, the zone of proximal development was redefined as the space for expansive transition from actions to activity (Engestrom, 2000). (Engestrom, 2010, p. 4)

Third, expansive learning theory focuses on horizontal development rather than vertical. Although it acknowledges a vertical dimension, it emphasizes a focus on the horizontal dimension:

We habitually tend to depict learning and development as vertical processes, aimed at elevating humans upward, to higher levels of competence. Rather than merely denounce this view as an outdated relic of enlightenment, I suggest that we focus on constructing a complementary perspective, namely that of horizontal or sideways learning and development. Both dimensions are involved in expansion. (Engestrom, 2000b, p. 533)

The impetus for change in expansive learning theory is attributed to inner contradictions from within an activity or between two activities:

Contradictions are not just inevitable features of activity. They are "the principle of its self-movement and (...) the form in which the development is cast" (Ilyenkov 1977, 330). This means that new qualitative stages and forms of activity emerge as solutions to the contradictions of the preceding stage of form. This in turn takes place in the form of 'invisible breakthroughs'. (Engestrom, 1987, ch. 2, p. 45)

Engestrom developed the concept of the contradiction leveraging Bateson's description of inner contradictions, which were referred to as the *double bind* (Engestrom, 1987, ch. 3, p. 4).

He, of course, reformulated Bateson's individual dilemma in terms of a social one:

The type of development we are concerned with here—expansive generation of new activity structures—requires above all an *instinctive or conscious mastery of double binds*. Double bind may now be reformulated as a *social, societally essential dilemma which cannot be resolved through separate individual actions alone—but in which joint co-operative actions can push a historically new form of activity into emergence*. (Engestrom, 1987, ch. 3, p. 20).

Engestrom described four levels of contradictions which may appear in the human activity system (Engestrom, 1987, ch. 2, pp. 43-45):

Level 1: Primary inner contradiction (double nature) *within* each constituent component of the central activity.

Level 2: Secondary contradictions *between* the constituents of the central activity.

Level 3: Tertiary contradiction *between* the objective/motive of the dominant form of the central activity and the object/motive of a culturally more advanced form of the central activity.

Level 4: Quaternary contradictions *between* the central activity *and* its neighbor activities. (ch. 2, p. 44)

In concert with his redefined zone of proximal development, Engestrom identified the collective generation of solutions to the double bind potentiality (i.e., learning) as occurring in long cycles of qualitative transformations, driving by inner contradictions of the activity system, which causes individual participants to question established norms:

Human collective activity systems move through relatively long cycles of qualitative transformations. As the inner contradictions of an activity system are aggravated, some individual participants begin to question and deviate from its established norms. In some cases, this escalates into collaborative envisioning and a deliberate collective change effort from below. (Engestrom, 2000b, p. 526)

As described in Engestrom (2001, p. 152), the seven steps in the cycle are (a) primary contradiction, (b) secondary contradiction, (c) modeling the new situation, (d) new model, (e) implementing the new model, (f) quaternary contradictions and realignment with neighbors, and (g) consolidating the new practice. Later, Engstrom (2010, p. 8) presented the same seven steps with simpler names that highlighted the major activities at each step. They revised labels are (a) questioning, (b) analysis, (c) modeling the new solution, (d) examining and testing the new model, (e) implementing the new model, (f) reflecting on the process, and (g) consolidating and generalizing the new practice. Repeated iterations of these seven steps form an "expansive cycle or spiral" (p. 7), and facilitate the ascension of the activity patterns from the abstract to the concrete. This ascension is characterized by the following description:

This is a method of grasping the essence of an object by tracing and reproducing theoretically the logic of its development, of its historical formation through the emergence and resolution of its inner contradictions. A new theoretical idea or concept is initially produced in the form of an abstract, simple explanatory relationship, a 'germ

cell'. This initial abstraction is step-by-step enriched and transformed into a concrete system of multiple, constantly developing manifestations. In learning activity, the initial simple idea is transformed into a complex object, into a new form of practice. (Engestrom, 2010, p. 5)

Through process of the cycle, the object and motive of the activity are reconceptualized to allow for greater possibility and flexibility than the previous pattern of activity:

An expansive transformation is accomplished when the object and motive of the activity are reconceptualized to embrace a radically wider horizon of possibilities than in the previous mode of the activity. A full cycle of expansive transformation may be understood as a collective journey through the *zone of proximal development* of the activity. (Engestrom, 2000b, p. 526; Engestrom, 2001, p. 137)

The steps of the cyclical model, of course, are a heuristic device comprised of an ideal sequence that Engestrom explains is likely never followed exactly:

The process of expansive learning should be understood as construction and resolution of successively evolving contradictions....The cycle of expansive learning is not a universal formula of phases or stages. In fact, one probably never finds a concrete collective learning process which would cleanly follow the ideal-typical model. The model is a heuristic conceptual device derived from the logic of ascending from the abstract to the concrete. (Engestrom, 2010, p. 7)

Cognitive Apprenticeship (Brown, Collins, and Duguid – 1989) . Introduction of the cognitive apprenticeship model is credited by McLellan (1993, p. 7; 1994, p. 5) to Brown, Collins, and Duguid (1989). However, a much more detailed exposition is found in both Collins, Brown and Newman (1987) and Collins, Brown, and Holum (1991). Of these two, I recommend the latter, and have selected it as the primary text on which the following summary is based.

The cognitive apprenticeship model is erected on an adaptation of the traditional and historic model of learning and teaching through apprenticeship. It sets forth "a general

framework for the design of learning environments"(A. Collins et al., 1991, p. 1). Collins, Brown, and Holum (1991) set the context for the model as follows:

In ancient times, teaching and learning were accomplished through apprenticeship: We taught our children how to speak, grow crops, craft cabinets, or tailor clothes by showing them how and by helping them do it. Apprenticeship was the vehicle for transmitting the knowledge required for expert practice in fields from painting and sculpting to medicine and law. It was the natural way to learn. In modern times, apprenticeship has largely been replaced by formal schooling, except in children's learning of language, in some aspects of graduate education, and in on-the-job training. We propose an alternative model of instruction that is accessible within the framework of the typical American classroom. It is a model of instruction that goes back to apprenticeship but incorporates elements of schooling. We call this model "cognitive apprenticeship" Collins, Brown, and Newman, 1989). (p. 1)

While recognizing many differences between schooling and apprenticeship methods, Collins et al. focused on one in particular, namely, that "in apprenticeship, learners can see the processes of work" (A. Collins et al., 1991):

In apprenticeship, learners can see the processes of work: They watch a parent sow, plant, and harvest crops and help as they are able; they assist a tradesman as he crafts a cabinet; they piece together garments under the supervision of a more experienced tailor. Apprenticeship involves learning a physical, tangible activity. But in schooling, the "practice" of problem solving, reading comprehension, and writing is not at all obvious—it is not necessarily observable to the student. In apprenticeship, the processes of the activity are visible. In schooling, the processes of thinking are often invisible to both the students and the teacher. Cognitive apprenticeship is a model of instruction that works to make thinking visible. (p. 1)

Translating the model of traditional apprenticeship to cognitive apprenticeship involves making the teacher's thinking visible to students and the students' thinking visible to the teacher (A. Collins et al., 1991, p. 3). It also involves situating abstract tasks into authentic contexts—which helps motivate students to work and to learn the subcomponents of the task by demonstrating the value of the finished product. By varying the diversity of situations in which

tasks are performed students learn to recognize the common aspects between them, which facilitates generalization and transfer of knowledge.

Collins et al. made it clear that they were not asserting an argument in favor of cognitive apprenticeship as the only way to learn. They recognized that students with good active listening and active reading skills, "who test their understanding and pursue the issues that are raised in their minds, learn things that apprenticeship can never teach" (A. Collins et al., 1991, p. 3). However, they noted that it could be a useful tool for mediating the learning experience of a passive listener or reader, and that it is "a useful instructional paradigm when a teacher needs to teach a fairly complex task to students" (p. 17).

The cognitive apprenticeship framework for designing learning environments consists of four dimensions: *content*, *method*, *sequence*, and *sociology*. Each of these will be described in brief.

The first dimension, *content*, consists of both *domain knowledge* and *three types of strategies*. Domain knowledge refers to "the concepts, facts, and procedures explicitly identified with a particular subject matter" (A. Collins et al., 1991, p. 13). This type of knowledge is commonly taught in schools, and is what textbooks and class lectures are typically focused on. The first of the three strategies in the content dimension, *heuristic strategies*, are "generally effective techniques and approaches for accomplishing tasks that might be regarded as 'tricks of the trade'; they don't always work, but when they do, they are quite helpful" (p. 13). These strategies are usually acquired by experts through the practice of solving problems. The second type of strategy, *control strategies*, are strategies used to "control the processes of carrying out a task" (p. 13). Control strategies have monitoring, diagnostic, and remedial components, and guide the ongoing decision process of how to proceed with a task, taking into account one's

current state relative to the end goal. *Learning strategies*, the third type, are "strategies for learning any of the other kinds of content described above" (p. 13). These are general strategies that experts have developed for exploring new domains or for "extending or reconfiguring knowledge in solving problems or carrying out complex tasks" (p. 13).

The second dimension of the framework, *method*, consists of six teaching methods: modeling, coaching, scaffolding, articulation, reflection, and exploration (A. Collins et al., 1991, pp. 13-14). The first three methods—modeling, coaching, and scaffolding—make up the core of cognitive apprenticeship. The next two—articulation and reflection—are "designed to help students both to focus their observations of expert problem solving and to gain conscious access to (and control of) their own problem-solving strategies" (p. 13). The final method—exploration—is used to encourage the learner's independence in both executing expert problem-solving processes and in defining the problems to be solved. Collins et al. (1991) defined these methods as follows:

Modeling [italics added] involves an expert's performing a task so that the students can observe and build a conceptual model of the processes that are required to accomplish it. In cognitive domains, this requires the externalization of usually internal processes and activities—specifically, the heuristics and control processes by which experts apply their basic conceptual and procedural knowledge. (p. 13)

Coaching [italics added] consists of observing students while they carry out a task and offering hints, scaffolding, feedback, modeling, reminders, and new tasks aimed at bringing their performance closer to expert performance....The content of the coaching interaction is immediately related to specific events or problems that arise as the student attempts to accomplish the target task. (p. 14)

Scaffolding [italics added] refers to the supports the teacher provides to help the student carry out the task. These supports can take either the forms of suggestions or help....When scaffolding is provided by the teacher, it involves the teacher in executing parts of the task that the student cannot yet manage. A requisite to such scaffolding is accurate diagnosis of the student's current skill level or difficulty and the availability of an intermediate step at the appropriate level of difficulty in carrying out the target

activity. Fading involves the gradual removal of supports until the students are on their own. (p. 14)

Articulation [italics added] involves any method of getting students to articulate their knowledge, reasoning, or problem-solving processes. (p. 14)

Reflection [italics added] involves enabling students to compare their own problem-solving processes with those of an expert, another student, and ultimately an internal cognitive model of expertise. Reflection is enhanced by the use of various techniques for reproducing or "replaying" the performance of both expert and novice for comparison [e.g., video or audio recording]....usually some form of "abstracted replay," in which the criterial features of expert and student performance are highlighted, is desirable. (p. 14)

Exploration [italics added] involves pushing students into a mode of problem solving on their own. Forcing them to do exploration is critical, if they are to learn how to frame questions or problems that are interesting and that they can solve. Exploration is the natural culmination of the fading of supports. It involves not only fading in problem solving but fading in problem setting as well. But students do not know *a priori* how to explore a domain productively. So exploration strategies need to be taught as part of the learning strategies more generally. Exploration as a method of teaching involves setting general goals for students and then encouraging them to focus on particular subgoals of interest to them, or even to revise the general goals as they come upon something more interesting to pursue. (p. 14)

The third dimension of the framework, *sequencing*, suggests three principles that must be balanced when sequencing learning activities for students: (a) global before local skills, (b) increasing complexity, and (c) increasing diversity (A. Collins et al., 1991, p. 15). To illustrate the first principle, Collins et al. cite an example from Lave of apprentices learning to sew a garment from precut pieces before learning to cut out the pieces themselves. This enables them to have a "clear conceptual model of the overall activity...[and] make sense of the portion that [they] are carrying out" (p. 15). The conceptual model will also provide the learner with a guide to monitor his own progress, performance and self-correction. The second principle "refers to the construction of a sequence of tasks such that more and more of the skills and concepts necessary for expert performance are required" (p. 15). The third principle "refers to the construction of a

sequence of tasks in which a wider and wider variety of strategies or skills are required" (p. 15). Collins et al. note that although repeated practice of a new strategy or skill is important, it also "becomes increasingly important that tasks requiring a diversity of skills and strategies be introduced so that the student learns to distinguish the conditions under which they do (and do not) apply" (p. 16). A further advantage to the introduction of an increasing diversity of strategies is that the students' strategies "acquire a richer net of contextual associations and thus are more readily available for use with unfamiliar or novel problems" (p. 16).

The fourth dimension, *sociology*, deals with "critical characteristics affecting the sociology of learning"(A. Collins et al., 1991, p. 16). They are (a) situated learning, (b) community of practice, (c) intrinsic motivation, and (d) exploiting cooperation. First, by situating tasks so that students carry them out in "an environment that reflects the multiple uses to which their knowledge will be put in the future" (p. 16) four things happen:

1. Students develop an understanding of the purposes and uses of the knowledge they are learning
2. Students learn by "actively using knowledge rather than passively receiving it" (p. 16)
3. Students learn the conditions in which their knowledge can be used
4. By learning in multiple contexts students are able to abstract knowledge and acquire it in "dual form, both tied to the contexts of its uses and independent of any particular context" (p. 16)

Second, in communities of practice a learning environment is created "in which participants actively communicate about and engage in the skills involved in expertise...[which] leads to a sense of ownership, characterized by personal investment and mutual dependence"(A. Collins et al., 1991, p. 16). Third, both situated learning and the establishment of communities of

practice provide for intrinsic motivation for learning. In these settings students perform tasks for reasons other than "getting a good grade or pleasing the teacher" (p. 16). Fourth, exploiting cooperation "refers to having students work together in a way that fosters cooperative problem solving" (p. 16) which can also be a powerful motivator.

Communities of Practice (Lave & Wenger – 1991). Bandura's theory of social cognitive learning is focused primarily on observational and vicarious learning, or the type of learning that occurs by observing the behavior and consequences of others. A different type of social learning is found in Lave and Wenger's (1991) theory of situated learning through legitimate peripheral participation in communities of practice. This theory builds on Lave's (1988) previous study of cognition in practice in which she set out to reexamine "the role of cognitive theory in explaining the effect of education on everyday activity" beginning with a study of how Vai and Gola tailors in Liberia learn and use math (p. xiii). From the results of this study, Lave proposed a socio-cultural view of learning in which cognition is a dialect between learners and the setting in which they are situated, and that problems and solutions are generated from disjunctions, conflicts, and contradictions that naturally occur as people are involved in various real-world activities. Lave's study of learning in the apprenticeship of Vai and Gola tailors was later included as one of five case studies to exemplify situated learning (Lave & Wenger, 1991, pp. 59-87). Lave and Wenger described situated learning as "more encompassing in intent than conventional notions of 'learning *in situ*' or 'learning by doing' for which it was used as a rough equivalent" (p. 31). They explained their view of situated learning as "an integral part of generative social practice in the lived-in world" (p. 35):

There is a significant contrast between a theory of learning in which practice (in a narrow, replicative sense) is subsumed within processes of learning and one in which

learning is taken to be an integral aspect of practice (in a historical, generative sense). In our view, learning is not merely situated in practice—as if it were some independently reifiable process that just happened to be located somewhere; learning is an integral part of generative social practice in the lived-in world. (Lave & Wenger, 1991, pp. 34-35)

They applied this view using the concept of legitimate peripheral participation:

It seems all too natural to decompose it into a set of three contrasting pairs: legitimate versus illegitimate, peripheral versus central, participation versus nonparticipation. But we intend for the concept to be taken as a whole... Thus, in the terms proposed here there may very well be no such thing as an "illegitimate peripheral participant." The form that the legitimacy of participation takes is a defining characteristic of ways of belong, and is therefore not only a crucial condition for learning, but a constitutive element of its content. Similarly, with regard to "peripherality" there may well be no such simple thing as "central participation" in a community of practice. Peripherality suggests that there are multiple, varied, more- or less-engaged and –inclusive ways of being located in the fields of participation defined by a community. Peripheral participation is about being located in the social world. (Lave & Wenger, 1991, p. 35)

The concept of legitimate peripheral participation was not intended as an educational form, a pedagogical strategy, or a teaching technique, but rather, as "an analytical viewpoint on learning, a way of understanding learning" (Lave & Wenger, 1991, p. 40). The focus is not on pedagogy, but on the structure of social practice in which learning occurs:

In considering learning as part of social practice, we have focused our attention on the structure of social practice rather than privileging the structure of pedagogy as the source of learning. Learning understood as legitimate peripheral participation is not necessarily or directly dependent on pedagogical goals or official agenda, even in situations in which these goals appear to be a central factor (e.g., classroom instruction, tutoring). (Lave & Wenger, 1991, pp. 113-114)

In contrast with "conventional explanations [that] view learning as a process by which a learner internalizes knowledge" (Lave & Wenger, 1991, p. 47), Lave and Wenger explained learning as "increasing participation in communities of practice" (p. 49) which involves "the whole person acting in the world" (p. 49). Learning implies "not only a relation to specific

activities, but a relation to social communities—it implies becoming a full participant, a member, a kind of person" (p. 53):

In this view, learning only partly—and often incidentally—implies becoming able to be involved in new activities, to perform new tasks and functions, to master new understandings. Activities, tasks, functions, and understandings do not exist in isolation; they are part of broader systems of relations in which they have meaning. These systems of relations arise out of and are reproduced and developed within social communities, which are in part systems of relations among persons. The person is defined by as well as defines these relations. Learning thus implies becoming a different person with respect to the possibilities enabled by these systems of relations. (Lave & Wenger, 1991, p. 53)

Legitimate peripheral participation takes place in communities of practice, with newcomers acting first in the periphery and moving "toward full participation" (Lave & Wenger, 1991, p. 91). Lave and Wenger defined a community of practice in general terms as "a set of relations among persons, activity, and world, over time and in relation with other tangential and overlapping communities of practice" (p. 98) but left it "largely as an intuitive notion, [which] requires a more rigorous treatment" (p. 42). This was later provided by Wenger (1998; 2006):

Communities of practice are formed by people who engage in a process of collective learning in a shared domain of human endeavor: a tribe learning to survive, a band of artists seeking new forms of expression, a group of engineers working on similar problems, a clique of pupils defining their identity in the school, a network of surgeons exploring novel techniques, a gathering of first-time managers helping each other cope. In a nutshell: Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly. (Wenger, 2006, para. 2)

Wenger listed three crucial characteristics that differentiate a community in general from a community of practice:

1. The domain: A shared domain of interest, with membership implying commitment to the domain and "a shared competence that distinguishes members from other people" (section "What are communities of practice?")
2. The community: A community in which members "interact and learn together" (section "What are communities of practice?")
3. The practice: A group of practitioners in which members "develop a shared repertoire of resources: experiences, stories, tools, ways of addressing recurring problems" (section "What are communities of practice?")

Lave and Wenger (1991) summarized their perspective on learning through legitimate peripheral participation as coming closer to an understanding of the significance of learning in the human experience:

There has crept into our analysis, as we have moved away from conventional notions of learning, an expanded scale of time and a more encompassing view of what constitutes learning activity. Legitimate peripheral participation has led us to emphasize the sustained character of developmental cycles of communities of practice, the gradual process of fashioning relations of identity as a full practitioner, and the enduring strains inherent in the continuity-displacement contradiction. This longer and broader conception of what it means to learn, implied by the concept of legitimate peripheral participation, comes closer to embracing the rich significance of learning in human experience. (p. 121)

Dynamic, Distr., and Bounded Communities (Wilson & Ryder – 1996). Another type of learning community, the dynamic learning community,⁹⁹ was described by Wilson and Ryder (1996; 1998). Similar in some ways to the communities of practice already described by Lave and Wenger, dynamic learning communities are conceived of as "decentralized learning groups"

⁹⁹ In 1996 Wilson and Ryder use the term "dynamic," but switch to "distributed" in their 1998 web publication of essentially the same paper with some minor changes.

(B. Wilson & Ryder, 1996, p. 801) that "will tend to pop up between the cracks of established learning programs" (B. Wilson & Ryder, 1998, p. 2). Unlike communities of practice, distributed learning communities are formed with "a consensual goal to support each other in learning" (p. 2) rather than some other shared social context. Distributed learning communities are characterized by the following attributes (B. Wilson & Ryder, 1996, pp. 801-802):

1. Distributed control
2. Commitment to the generation and sharing of new knowledge
3. Flexible and negotiated learning activities
4. Autonomous community members
5. High levels of dialogue, interaction, and collaboration
6. A shared goal, problem, or project that brings a common focus and incentive to work together

More recently, Wilson and Ryder (2004) articulated another type of learning community that they referred to as the bounded community. Unlike the self-forming dynamic learning community, the bounded community is a community formed by a teacher or an instructor within a course-based learning environment. In a bounded learning community, "participants find themselves in a situation where" (p. 2)

1. Participation is required in order to obtain a desired end
 2. They do not choose their classmates or instructor
 3. They must commit to a fixed length of time
 4. They must make an explicit effort to connect with others (by coming to school or connecting online)
- (p. 2)

Wilson and Ryder gave three reasons to support the formation of such communities:

1. Learning communities provide a social context for the material
2. Students feel more connected within a community

3. Learning communities can serve as a bridge between school and work environment
(p. 3)

While the concepts of dynamic, distributed, and bounded learning communities do not appear to be as well known as other ideas on social learning reviewed herein, I have chosen to include them for two reasons. First of all, they represent a fairly common practice I am seeing in American schools, both in K-12 and at the college level. Secondly, they share many similarities with Lave and Wenger's theory of communities of practice. In fact, Wilson, Ludwig-Hardman, Thornam, and Dunlap described bounded communities as type of community of practice in which

1. The major enterprise is intentional learning, completing required activities, and performing well on course assessments
2. The group membership is based on course enrollment and team assignment
3. Resources are shared and interactions conducted under the guidance of an instructor
(B. G. Wilson et al., 2004, p. 4)

Chapter Summary

In this chapter 35 theories of learning, from the behavioral, cognitive, constructive, human, and social perspectives were summarized. The behavioral perspective was represented in this review by (a) Aristotle's laws of associationism, (b) Thorndike's connectionism, (c) Pavlov's classical conditioning, (d) Watson's behaviorism, (e) Skinner's operant conditioning, (f) Hull's mathematico-deductive theory, (g) Guthrie's contiguous conditioning, and (h) Estes' stimulus sampling theory. The cognitive perspective was represented by (a) Aristotle's laws of association, (b) Ebbinghaus' theory of memory and forgetting, (c) Tolman's purposive behaviorism, (d) Kohler's insight learning, (e) Atkinson and Shiffrin's cognitive information processing model, (f) Ausubel's subsumption theory, (g) and various flavors of schema theory.

The constructive perspective was represented by (a) a summary of the application of constructivist ideas in the classroom, (b) Piaget's theory of intellectual development, and (c) Bruner's discovery learning. The human perspective was represented by theories of agency and motivation, including (a) Maslow's hierarchy of human needs, (b) Fuller's review of biological motivation, (c) Atkinson and McClelland's achievement motivation, (d) Weiner's attribution theory, (e) Covington's self-worth theory, (f) Bandura's theory of self-efficacy, (g) Deci and Ryan's self-determination theory of motivation, (h) self-regulation theory as summarized by Zimmerman and Schunk, (i) Keller's ARCS theory of motivation, (j) Roger's freedom to learn, and (k) Bandura's agentic theory of the self. Social learning theory was represented by (a) Vygotsky's sociocultural development; (b) Bandura's social cognitive learning theory; (c) Engestrom's expansive learning theory and third generation activity theory; (d) cognitive apprenticeship; (e) Lave and Wenger's communities of practice; and (f) Wilson and Ryder's theory of dynamic, distributed, and bounded communities. The next chapter presents the themes identified.

Chapter 4: Results

Overview

The purpose of the present study has been to review theories of learning in the behavioral, cognitive, constructive, human, and social traditions to identify principles of learning local to those theories which might represent specific instances of more universal principles fundamentally requisite to the facilitation of learning in general. The basic premise underlying this goal is that throughout human history, and most prolifically in the last 125 years or so, many different views of learning have been elaborated. Though to one degree or another each view is different from the others, it has been assumed that each presents a valid view of learning—valid in the sense that each is based on a sincere conviction regarding the nature of learning and how it is facilitated.

Many of the ideas reviewed have resulted from, or been supported by, direct empirical evidence. Others have been suggested based on observational or practical experience of the theorist. The ideas come from different points in time, are described from a variety of perspectives, and emphasize different aspects and types of learning; yet there are a number of common themes shared among them regarding the means by which learning occurs. It is hypothesized that such themes represent universal and fundamental principles of learning. These principles are the objective of the present study. They have been sought through careful review and analysis of both theoretical and empirical literature by methods of textual research (Clingan, 2008) and constant comparative analysis (Glaser & Strauss, 1967), as has been described in chapter two. Ten such principles have been identified:

1. *Repetition – Learning is facilitated by repeated experience.* This principle subsumes local principles of learning such as Thorndike's law of exercise, multiple reinforced

- trials of behavioral learning, maintenance and elaborative rehearsal in cognitive learning theory, series of failed attempts followed by insight and success in Kohler's experiments with apes, learning of a concept through successive encounters with examples and non-examples in Ausubel's subsumption theory, Bruner's spiral curriculum, and Engestrom's cycles of learning.
2. *Time – Learning takes time.* The amount of time required for learning is primarily a function of the total number repetitions required and their necessary distribution due to mental or physical fatigue. Time is not an active factor in learning, but its passing allows for active learning processes to take place.
 3. *Step Size – Smaller increments of attainment are more easily and more quickly achieved than larger ones.* Step size is defined not by the amount or complexity of content or the intricacy and difficulty of the act to be learned, but rather by the amount of effort necessary to learn it. Although *amount* and *complexity* are often positively correlated with *effort*, it is the latter by which step size is defined. Effort can only be determined by simultaneously taking into account both the nature of the task and the capacity of the individual.
 4. *Sequence – Prior learning may facilitate or hinder ensuing attainment.* This principle subsumes local principles of learning such as Thorndike's associative shifting, Pavlov's higher-order conditioning, Skinner's shaping and vanishing, proactive and retroactive interference, the role of automaticity in facilitating new learning, the availability of anchoring items in the process of subsumption, tuning and restructuring of schema, endogenous constructivism, Piaget's cognitive substructures

formed through sensori-motor action that serve as the foundation of intelligence for all later learning, and the development of self-worth and self-efficacy.

5. *Contrast* – *That which is to be learned must be differentiated from and related to that which has already been learned, or from that which is similar, but critically different.*

Local principles of learning subsumed by the universal principle of contrast include things such as: stimulus identifiability; discrimination learning; pattern recognition; clustering; subordinate, superordinate, and combinatorial subsumption; the need for examples and non-examples as well as varied context; specialization and generalization; the challenging of student hypotheses in constructive learning; and sequences of increasing diversity in cognitive apprenticeship.

6. *Significance* – *That which is to be learned must be significant in some way to the learner.* Significance is found in imagery, attention, the expenditure of effort, intensity, familiarity, emotion, mental vigor and receptivity, elaboration, depth of processing, relation to prior experience, anchoring ideas, schema activation, active participation, and novelty.

7. *Feedback* – *Feedback is the means by which learning is directed toward a specific target of attainment.* This principle includes the direct, planned, instructional feedback which the term commonly refers to, but is used here in a much larger sense, encompassing also local principles of learning such as reward and punishment, results of trial and error learning, performance outcomes, the incongruence of schemata with functional demand, contradictions to hypotheses, observed outcomes of vicarious experiences, and self-evaluation or critique.

8. *Context – Learning is facilitated by a context of practice that is the same as, or accurately represents, the context of performance.* Context is defined by the features of a situation including the total surroundings and properties of objects. Varied practice promotes generalization and independence of association or performance from only one specific context.
9. *Engagement – Learning is engaging when the learner is capable of doing so, and when motivation outweighs inhibition.* This principle subsumes local principles of learning such as Thorndike's concepts of set or attitude and original tendencies, biological drives, Skinner's concept of reinforcement, Hull's reaction potential, Este's anticipation of reward, general states of emotional and health, the need for achievement and affiliation, the need for safety, curiosity, the need for exploration and manipulation, novelty, expectancy and confidence, and a person's desire for prediction and control.
10. *Agency – Learners are not passive recipients of learning, but active agents with the ability to choose how they will apply their attention and effort, and to choose what learning activities they will engage in. Others may exercise their agency to promote or inhibit the agency of the learner, and may play a role in facilitating or impeding successful learning.* This principle covers both the agency of the learner as well as the agency of others who may affect, in some way, that person's learning. Although behavioral learning theory generally rejected the idea of will, examples are cited that demonstrate the active agency of the experimenter and the resulting influence of his actions on the learner.

The remainder of this section will present a brief summary of each of the principles identified and show how they are derived from, and connected to, the preceding research. Because of the volume of literature reviewed and the data collected, this presentation will contain only a few illustrative quotes and references to the most exemplary citations relevant to each theme. A more comprehensive list of citations, including several direct quotes which best represent the ties between the themes (principles) identified and the literature reviewed is available by request.

Themes Identified

Repetition. This is perhaps the most intuitive principle of learning, traceable to ancient Egyptian and Chinese education, with records dating back to approximately 4,400 and 3,000 B.C., respectively (Aspinwall, 1912, pp. 1, 3). In ancient Greece, Aristotle commented on the role of repetition in learning by saying "it is frequent repetition that produces a natural tendency" (Ross & Aristotle, 1906, p. 113) and "the more frequently two things are experienced together, the more likely it will be that the experience or recall of one will stimulate the recall of the other" (p. 35).

Through repeated pairing of a conditioned stimulus (or stimulus which is to be conditioned) and an unconditioned stimulus (i.e., a stimulus which naturally produces a reflex response) Pavlov was able to condition the reflex to be triggered by the conditioned stimulus (Pavlov et al., 1928, p. 23). Thorndike plotted learning curves showing that cats repeatedly placed in puzzle boxes were able to escape in less time and with fewer unproductive movements on subsequent trials (Thorndike, 1898). Watson extended the work of Pavlov and Thorndike to

the experimental study of man (Watson, 1930, p. v) and called out repetition as one of two factors¹⁰⁰ which establish a habit (Watson, 1914, p. 271). In the course of repeated trials, Skinner was able to employ contingencies of reinforcement (Skinner, 1938) to sustain or produce a desired behavior. Through shaping¹⁰¹ he was able to teach new behaviors that do not naturally occur (Peterson, 2004; Skinner, 1961e; Skinner, 1961f), and through vanishing¹⁰² (Skinner, 1986, p. 107) he enabled the performance of behavior without the need for detailed cues to prompt its occurrence. Skinner also discovered that "a significant change in behavior is often obvious as the result of a single reinforcement" (1961g, p. 146):

My rats learned to press the lever in one trial, and no learning could be faster than that. (I noted, with a touch of regret, that because the change was so quick I could not record a learning curve. But "it should not be difficult," I said, "with some suitable change in conditions, to retard the process.") (Skinner, 1979, p. 89)

One explanation for why his rats learned to press the lever in one trial is that what they were actually learning was not *how* to press a lever, but rather the *conditional relationship* between pressing the lever and receiving food. Having already learned to use their paws for similar movements and in the employ of obtaining the objective of food, the incremental attainment required to learn the relation of the bar to the dispensing of food would be quite small. Skinner interpreted the one-trial learning result in basically the same way when he highlighted the dependency on prior learning of later reflexes in the chain before the final act of 'pressing the lever and obtaining food' could be learned in a single trial:

¹⁰⁰ The other being recency.

¹⁰¹ Shaping is the teaching of a goal behavior by reinforcement of successive approximations to that behavior.

¹⁰² Vanishing is the gradual fading of cues which prompt a desired behavior so that the behavior will eventually continue or occur without necessity of the prompt.

I may point out that the result depends upon the preliminary development of the later reflexes in the chain. It could not be obtained consistently when the total act of 'pressing the lever and obtaining food' is regarded as a unit and treated experimentally as such. If reinforcing power is not first given to the sound of the magazine through the establishment of a discrimination, a certain interval of time will elapse between response [pressing the food lever] and the stimulation from the food, and the effectiveness of the reinforcement will be severely reduced. In rare cases instantaneous conditioning may be observed, but the consistent result obtained in the present case will necessarily be lacking. (Skinner, 1938, pp. 71-72)

This explanation—which explains the need for repetition, at least in part, as a function of the size of attainment¹⁰³ to be made—is similar to Guthrie's reconciliation between his theory of one trial learning and the obvious need for practice and repetition in most real-world learning tasks. Although his central premise was that “a stimulus pattern gains its full associative strength on the occasion of its first pairing with a response” (Guthrie, 1942, p. 30) he clearly and directly stated the importance of repetition in learning any skill:

In the psychology of learning we often confuse the effects of repetition on a single association of stimulus and response with the effects of practice on the development of skill, which is something quite different. In learning any skill, what must be acquired is not an association or any series of associations, but many thousands of associations that will connect specific movements with specific situations. One lesson or trial is all that is necessary to learn to depress the brake pedal on a car. Learning to drive the car requires a varied experience which will cause the pedal to be depressed in many situations and left severely alone in many others.” (Guthrie, 1942, p. 36)

Repetition was also at the core of Hull's theory, showing up as variable N in his equation for habit strength. Habit strength referred to the strength of the association between a stimulus and a response. According to this equation, as the number of pairings between the two increases,

¹⁰³ This relationship between *repetition* and *step size* is an example of the interrelations that appear to exist between the various principles of learning which have been identified in the present study. More will be said on this type of interrelation in chapter 5.

habit strength increases. The mathematical formula that describes this relationship is as follows, where N represents the number of pairings between stimulus and response:

$${}_sH_R = 1 - 10^{-0.0305 N}$$

This equation for habit strength was embedded as a key component of reaction potential, which was expressed as a function of both Habit Strength (${}_sH_R$) and Drive (D):¹⁰⁴

$$\text{Reaction Potential} = {}_sE_R = {}_sH_R \times D$$

Repetition was critically important to Este's stimulus sampling theory. In fact, the entire theory was founded on the assumption that through multiple trials in which (a) the successive sampling of active stimulus elements, and (b) the relative proportion of those elements conditioned to a desired response class R are carefully controlled, one can guarantee a response of type R , thereby associating all remaining elements in the stimulus sample which were not previously conditioned to R to become so (W. K. Estes, 1950).

The repeated stimulus-response pairing and multiple reinforced trials of behavioral learning theory is paralleled in cognitive learning theory by notions of repeated presentation, rehearsal, and review. Ebbinghaus (1913) reported that frequent repetitions were necessary to both (a) get to the point where content could be reproduced from memory, and (b) prevent forgetting of the content once it had been learned:

Under ordinary circumstances, indeed, frequent repetitions are indispensable in order to make possible the reproduction of a given content. Vocabularies, discourses, and poems

¹⁰⁴ Hull (1952) later added Incentive Motivation (K) and Stimulus-intensity Dynamism (V) to the equation:

$$\text{Reaction Potential} = {}_sE_R = {}_sH_R \times D \times V \times K$$

of any length cannot be learned by a single repetition even with the greatest concentration of attention on the part of an individual of very great ability. By a sufficient number of repetitions their final mastery is ensured, and by additional later reproductions gain in assurance and ease is secured. (p. 4)

Left to itself every mental content gradually loses its capacity for being revived, or at least suffers loss in this regard under the influence of time. Facts crammed at examination time soon vanish, if they were not sufficiently grounded by other study and later subjected to a sufficient review. But even a thing so early and deeply founded as one's mother tongue is noticeably impaired if not used for several years. (p. 4)

Although Ebbinghaus worked according to carefully planned schedules of review in order to ascertain certain characteristics of acquisition and forgetting, in general learning, repetition need not be intentional. For example, incidental repetition was evident in Tolman's studies of latent learning in which rats were allowed to freely explore during a "long series of preliminary training" in order to build up a cognitive map of the maze without reward of food (Tolman, 1938, p. 22; 1948, p. 194). Kohler's accounts of chimpanzees engaged in learning through insight were characterized by a series of failed attempts, followed by a period of reflection, followed by sudden success (Kohler, 1951). The chimpanzees were not acting with intention to repeat a process, but a desire to obtain the goal objective banana. Repeated attempts naturally arose as they were unable to acquire their target on the first attempt and without the employment of some intermediary means which was to be discovered through insight.

Repetition, in the form of short term retention of information through maintenance rehearsal and long term encoding through elaborative rehearsal (Sternberg & Williams, 2010, p. 274), provided the keys to knowledge acquisition in the general model of cognitive information processing, based on the memory stores and memory processes proposed by Atkinson and Shiffrin (1968).

Ausubel's theory of meaningful learning relied heavily and explicitly on repetition in several ways:

1. Perpetuation of dissociability: Without repetition "specific items of meaningful experience...tend gradually to undergo obliterative subsumption" (Ausubel, 1962, p. 218).
2. Discriminability: "Discriminability of new materials could be enhanced by repetition" (Ausubel, 1962, p. 219).
3. Clarity and stability: "The most immediate effect of practice is to increase the stability and clarity, and hence the dissociability strength, of the emergent new meanings in cognitive structure" (Ausubel et al., 1978, p. 311).
4. Transferability: Transfer can be facilitated through varied repetition by "providing opportunity for learning principles in as wide a variety of situations as possible, by explicitly emphasizing the similarity between training and criterial tasks and by presenting the latter tasks continuously or in close succession" (Ausubel et al., 1978, p. 200).
5. Criterial attributes: Criterial attributes of a concept are acquired by "(1) [exposure to a] heterogeneity of instances after consolidation in a more homogeneous setting; (2) appropriate blending and sequencing of positive and negative instances; and (3) the relevance of the presented or available information to the concept in question" (Ausubel et al., 1978, p. 87).
6. Consolidation: Consolidation of previously learned material "is achieved through confirmation, correction, clarification, differential practice, and review in the

course of repeated exposure, with feedback, to learning material” (Ausubel et al., 1978, p. 197).

Ausubel also suggested that explicit instruction might replace or diminish the need for repetition¹⁰⁵ by the instructor “pointing out similarities and differences between [examples] and their presumed subsumers in cognitive structure” (Ausubel, 1962, p. 219). Additionally, he talked about a special type of repetition, in which multiple instances are presented simultaneously.¹⁰⁶ In such a case, the pattern of repetition is revealed not in multiple occurrences in *time*, but in the simultaneous comparison of variants of *form*:¹⁰⁷

When an entire array of instances is simultaneously available to the learner rather than being presented successively, concept acquisition is significantly facilitated....This effect presumably reflects the avoidance of memory loss and the possibility of closer grouping during the process of abstracting the criterial attributes of a concept. (Ausubel et al., 1978, p. 114)

Repetition in schema theory is found in the elements that are "common to a large number of things or situations" (Anderson et al., 1978, p. 434). Schemata represent multiple instances of things that may be grouped based on a recurrent pattern of common features, functions, or characteristics. They are created, developed, tuned, and restructured through repeated experience (Rumelhart & Norman, 1976):

Learning through tuning...involves actual changes to the very categories we use for interpreting new information. Thus tuning involves more than merely an addition to our

¹⁰⁵ A relation between the principle of *repetition* and the role of a *teacher*

¹⁰⁶ A relation between the principles of *repetition* and *time*

¹⁰⁷ Repetition often occurs in two dimensions (time and variation of form), Ausubel draws attention to the insightful possibility that repetition of form, while holding time constant, might provide a more efficient way of learning concepts through varied examples presented all at once.

data base. Upon having developed a set of categories of interpretation (as you will see below, we call these schemata) these categories presumably undergo continual tuning or minor modification to bring them more in congruence with the functional demands placed on these categories... a young child learns that not all animals are 'doggies.' Slowly his 'doggie' schema becomes modified into congruence with the actual demands on his interpretation system. (Rumelhart & Norman, 1976, p. 4)

The role of repetition in constructive learning theory is in the similarities found when relating new experience to previous experience. "Deep understanding occurs when the presence of new information prompts the emergence or enhancement of cognitive structures that enable us to rethink our prior ideas" (Brooks & Brooks, 1993, p. 15). According to Piaget, development is the result of repeated patterns of exercise of the reflex (Piaget & Inhelder, 1969, p. 8), the circular reaction (Piaget, 1963, p. 66), the reuse of known schemes of assimilation employed in novel situations (Piaget & Inhelder, 1969, p. 10), the "gradual accommodation to external reality" through repeated use (Piaget, 1963, p. 29), and—in short—the "the tendency toward repetition of behavior patterns and toward the utilization of external objects in the framework of such repetition" (p. 42).

According to Bruner, it is only through "the exercise of problem solving and the effort of discovery that one learns the working heuristics of discovery"(J. S. Bruner, 1961, p. 31). "The more one has practice, the more likely is one to generalize what one has learned into a style of problem solving or inquiry that serves for any kind of task...or almost any kind of task" (p. 31). Bruner also believed that it was by "translating redundancy [in the environment] into a manipulable model" that the child is able "to go beyond the information before him" (J. S. Bruner, 1964, p. 13). The importance of repetition to Bruner's concept of learning was particularly clear in his description of the spiral curriculum which, he said, "as it develops

[revisits] basic ideas repeatedly, building upon them until the student has grasped the full formal apparatus that goes with them" (J. S. Bruner, 1960, p. 13).

Bruner's concept of the spiral curriculum builds on Vygotsky's ideas. According to Vygotsky, "through repeated experiences...children learn covertly (mentally) to plan their activities" (Vygotsky, 1978, p. 29). Such repeated experience he said, "proceeds here not in a circle but in a spiral, passing through the same point at each new revolution while advancing to a higher level" (p. 56). Through repetition the need for sign-mediated association "becomes no longer necessary" (Vygotsky, 1994b, p. 66) and the process of internalization takes place (this process of internalization is exemplified in the experiments with pictures described in Luria, 1994, pp. 53-55; and Vygotsky, 1994b, pp. 64-66).

Although Bandura (1965) referred to his "nonresponse acquisition procedure" (p. 3) as "no-trial learning" (p. 3) since "a subject simply observes a model's behavior but otherwise performs no overt instrumental responses, nor is administered any stimuli during the period of acquisition" (p. 3) he also noted that "as will be shown later, [the observer] may require multiple *observational trials* in order to reproduce the modeled stimuli accurately" (p. 3). Bandura also stated that "the behavior repertoires which constitute an enduring part of a culture are to a large extent transmitted on the basis of repeated observation of behavior by social models" (Bandura, 1965, p. 48) and that "the people with whom one regularly associates, either through preference or imposition, delimit the types of behavior that will be repeatedly observed and hence learned most thoroughly" (Bandura, 1977b, p. 24). In addition to repeated exposure to observational models, repetition also plays a role in the self-corrective adjustment process of refining newly acquired behaviors:

In most everyday learning, people usually achieve a close approximation of the new behavior by modeling, and they refine it through self-corrective adjustments on the basis of informative feedback from performance and from focused demonstrations of segments that have been only partially learned. (Bandura, 1977b, p. 28)

Heider (1958) spoke of the perception of patterns defined "spatially or temporally" (p. 58). He noted that it seems to be "approximately true that the smaller the part of the pattern taken into account, the more ambiguous it is" (p. 58), thus implying that increased exposure to the pattern brings greater clarity, and in the case of attribution theory, promotes more accurate attribution to appropriate causal factors. Self-efficacy and self-worth are likewise built up through progressively independent and varied circumstances that give induction a chance to operate and "strengthen and generalize expectations of personal efficacy" (Bandura, 1977a, p. 202). Zimmerman (1998, pp. 2-3) described learning in terms of self-regulated learning cycle phases consisting of three repeating stages: forethought, performance, and self-reflection.

In situated learning research Lave (1988) found that participants in her studies often made multiple attempts before solving problems. In the process they checked their partial or interim solutions to see if they were consistent with reality and if they were likely to reach a satisfactory answer using their chosen method. Repetition in activity theory is in the form of cycles of expansive learning (Engestrom, 2001, p. 152; Engestrom, 2009, p. 70; Engestrom, 2010, pp. 7-8). And in cognitive apprenticeship repetition coupled with a sequence of increasingly complex tasks is an important characteristic of practice (A. Collins et al., 1991, pp. 15-16). Table 2 summarizes the local principles from the theories reviewed that are subsumed by the universal principle of *repetition*.

Table 2

Principles of Learning Subsumed by the Universal Principle of Repetition

Theory Group	Local principles
Behavioral	<p><i>Aristotle:</i> Frequent repetition produces a natural tendency Law of frequency Exercise strengthens the memory of an image</p> <p><i>Thorndike:</i> Law of exercise Repetition alone does not produce learning</p> <p><i>Pavlov:</i> Association through repeated pairing of CS and UCS</p> <p><i>Watson:</i> Frequency (repetition) is one of two principles that produce learning</p> <p><i>Skinner:</i> Multiple trials for initial conditioning to approach food tray Significant change in behavior after a single reinforcement One-trial learning requires preliminary development of later reflexes in the chain Periodic reconditioning Shaping: reinforcement of successive approximations to the goal behavior Vanishing: gradual fading out of prompts</p> <p><i>Hull:</i> Habit strength as a function of number of S-R pairings</p> <p><i>Guthrie:</i> One trial learning (acquisition of movements) Obvious need for repeated practice (learning of acts or skills)</p> <p><i>Estes:</i> Successive sampling of stimulus elements across repeated trials</p>
Cognitive	<p><i>Ebbinghaus:</i> Frequent repetitions necessary to produce content from memory Surplus repetition is not wasted Insufficient repetition for reproduction is still useful Frequent repetitions necessary to prevent forgetting Clarity and longevity of new material increases in memory with repetition Number of repetitions needed to memorize a series increases with length Increased repetition in one study period produces a savings in later relearning Greater repetition to learn a longer series results in longer lists being more easily relearned</p> <p><i>Tolman:</i> Repetition through repeated, non-goal-directed experience Repetition through mental review and comparison</p>

Kohler:

Series of repeated failed attempts, followed by reflection, followed by success

Cognitive Information Processing:

Concept learning through multiple, systematically varied examples

Maintenance rehearsal: short term retention of information

Elaborative rehearsal: long term encoding

Rehearsal increases the length of stay in STS and gives coding and other storage processes time to operate

Almost any kind of operation on information is a form of rehearsal

Only a limited number of items can be rehearsed at any given time

Flashbulb memories: repeated mental rehearsal of shocking experiences

Automaticity and possible entrenchment through repeated experience

Mindless drilling does not lead to improvement

Effective practice or drill must be mindful and deliberate

Revisiting material with variation of time, context, purpose, and perspective

Incidental learning as a result of repeated, periodic presentation

Organization through repeated exposure

Ausubel:

Overlearning (excessive repetition) makes even rote learned materials less vulnerable to forgetting

Repetition is critical to the "perpetuation of dissociability" of subsumable or correlative concepts

Explicit instruction can reduce or possibly eliminate the need for repetition

Clarity and stability are influenced by repetition

Criterial or defining attributes of a concept are acquired by successive encounters

Multi-contextual learning facilitates abstraction of commonality and strengthens transferability

Sequential stages in concept acquisition

Simultaneous availability of multiple instances in array

Progressive differentiation

Integrative reconciliation in response to additional experience

Controlled sequencing of stimuli that provide successive contrast

Consolidation of previously learned material through differential practice, review, and repeated exposure

Transferability through application to a large number of different, specific contexts

Practice and drill and the significance of repetition in meaningful learning

Spaced review over long periods of time is required for retention of more complex ideas

Value of both early and delayed review

Benefits of repetition through practice

Incidental practice often is not effective, due to haphazard frequency and distribution of trials

Relation between repetition and feedback

Fidelity of practice to the actual task to be learned

Appropriate balance of repetition for consolidation versus diversification

Schema Theory:

Schema represent multiple instances of things that may be grouped based on a recurrent pattern of common features, functions, or characteristics

Schema are created, developed, tuned, and restructured through repeated experience

Typical and default values for schema variables are learned through encountering

multiple instances
Increased precision of schema through experience

Constructive

General:

Revisiting what has previously been learned to relate new information to it

Piaget:

Action schemes are the structure of actions generalized by repetition

Consolidation: A reflex becomes stronger and more precise by exercising it

First habits are formed through patterns of exercise

Circular reactions

Schemes of assimilation are repeated and elaborated as the child develops

Adaptation comes through repeated use and accommodation

Only practice leads to normal functioning

Coordination of reflexes occurs through repeated contact with the environment

Repetition of the reflex leads to a generalizing assimilation of objects to activity

There is a natural or fundamental tendency toward repetition of behavior

Bruner:

Spiral curriculum

Representing redundancy in the environment

Cumulative constructionism: use of previously acquired information in guiding further discovery

Learning the heuristics of discovery through practice

Human

Attribution Theory:

Perception of patterns defined spatially and temporally

Self-Efficacy:

Repetition in progressively independent and varied circumstances to build self-efficacy

Beliefs of self-worth and self-efficacy are built through repeated experiences of success

Self-Regulation Theory:

Self-regulated learning cycle phases (forethought, performance, self-reflection)

Social

Vygotsky:

Children learn mental planning through repeated experiences

Internalization occurs through repeated encounter

Development proceeds in a spiral, passing through the same point at each new revolution

The need for sign mediation subsides with repetition

Bandura:

Multiple observational trials may be required to reproduce modeled stimuli accurately

Behavior repertoires of culture are transmitted on the basis of repeated observation

Behavior that is repeatedly observed is learned most thoroughly

New behavior is refined through self-corrective adjustments (in repeated practice)

Situated learning:
Multiple attempts made in solving problems

Activity theory:
Cycles of expansive learning

Cognitive apprenticeship:
Importance of repeated practice of a new skill in increasingly complex tasks

Time . Although no claim was discovered during the course of the present study to indicate that the passing of time actually causes learning, the theories reviewed unanimously assume it to be a general pre-condition in order for learning to take place. This foundational role of time in learning was well stated by McGeoch (1932, p. 359):

Time, in and of itself, does nothing. It contributes, rather, a logical framework in terms of which we can describe the sequence of observed events. Certain spans of it are necessary in order to give other and effective factors a chance to operate, and time, thus, figures largely in scientific description, but not as a factor in causal laws nor as itself active in any way.

The role of time in Thorndike's theory is inferred, for example, by his law of exercise (Thorndike, 1914a, p. 70), the concept of multiple or varied response (p. 132), and the process of associative shifting (p. 136). Pavlov noted the presence of time in his experiments of conditioning when he said, "there are great differences in the time required for the establishing of a conditioned reflex" (Pavlov et al., 1928, p. 89). Watson's principles of frequency and recency (Watson, 1914, p. 262) are both variables of time. He also spoke of the diminishing returns of practice and the need for spacing trials out across multiple days: "Within certain limits, which have not been determined yet, it is far more economical, so far as the number of trials is concerned, to give a few rather than a large number of trials per day" (Watson, 1914, p. 230).

Skinner's schedules of reinforcement are inseparable from the passing of time inasmuch as they are defined by the administration of reinforcement according to periodic or random delivery (Ferster & Skinner, 1957; Skinner, 1958), as are his methods of operant conditioning—namely shaping (Skinner, 1953, p. 91; Skinner, 1961e, p. 413), vanishing (1986, p. 107), and chaining (Skinner, 1953, p. 224).

Time-relevant aspects of Hull's theory include (a) habit strength, which is built up over time as the number of pairings between stimulus and response increases; (b) reactive inhibition, which is caused by fatigue and has been used to explain why higher levels of performance are reached in distributed practice (i.e., when practice trials are spaced far apart) than in massed practice (i.e., when practice trials are closer together); (c) the "oscillation effect," which states that factors tending to inhibit a learned response change from moment to moment; and (d) extinction,¹⁰⁸ with the value of momentary effective reaction potential at the end of training determining how many non-reinforced responses will need to be made before extinction occurs.

It has already been explained that while Guthrie believed that "a stimulus pattern gains its full associative strength on the occasion of its first pairing with a response" (Guthrie, 1942, p. 30), he also acknowledged that "in learning any skill, what must be acquired is not an association or any series of associations, but many thousands of associations that will connect specific movements with specific situations" (Guthrie, 1942, p. 36). Obviously, this type of learning requires time. Another aspect of time prevalent in Guthrie's theory is the notion that the most

¹⁰⁸ Extinction is a part of all behaviorist learning theories but has been mentioned here specifically to capture Hull's view that the greater the momentary reaction potential at the end of training, the greater the resistance to extinction, and hence, the longer duration of time for which the learned association persists.

recent movement that was successful will be that which is associated with a given stimulus (Guthrie, 1940, p. 145).

The stimulus condition in Estes' model was regarded as "a finite population of relatively small, independent, environmental events, of which only a sample is effective at any given time" (W. K. Estes, 1950, p. 96). In this view of learning multiple trials are necessary for each of the stimulus elements to become conditioned to the response because of fluctuations in momentary effective stimuli, which result from either changes in the environment (e.g., extraneous noises, temperature fluctuations, and stray odors), or changes in the subject (e.g., changes in focus of attention, posture, or sensory transmission system) (Bower & Hilgard, 1981, pp. 215-216).

The element of time in learning was addressed more directly, and was even the primary focus of study in many cases, in cognitive learning theory research. Ebbinghaus, for example, examined the effect of multiple periods of study on retention of what has been learned, concluding that his memorized series of nonsense syllables "are gradually forgotten" (Ebbinghaus, 1913, p. 81), but that "the series which have been learned twice fade away much more slowly than those which have been learned but once" (p. 81) and "if the relearning is performed a second, a third or a greater number of times, the series are more deeply engraved and fade out less easily and finally, as one would anticipate, they become possessions of the soul" (p. 81). He also studied the savings in relearning (i.e., the reduced amount of time needed to relearn that which was previously learned), and the time savings in learning achieved by distributing practice over multiple sessions:

"For the relearning of a 12-syllable series at a definite time, accordingly, 38 repetitions, distributed in a certain way over the three preceding days, had just as favorable an effect as 68 repetitions made on the day just previous. Even if one makes very great concessions to the uncertainty of numbers based on so few researches, the difference is large enough

to be significant. It makes the assumption probable that with any considerable number of repetitions a suitable distribution of them over a space of time is decidedly more advantageous than the massing of them at a single time.” (Ebbinghaus, 1913, p. 89)

The hypothesized building of cognitive maps for the rats in Tolman’s latent learning experiments occurred over the course of a “long series of preliminary training” in which the rats were permitted to explore the maze without the reward of food (Tolman, 1938, p. 22; 1948, p. 194). Kohler’s apes learned the use of sticks and boxes over periods ranging from several minutes to several weeks. Tschego, for example, learned to use sticks to pull food within reach of the bars of her cage after trying other methods for more than half an hour, finally resorting to the sticks only after a period of rest and under duress of the smaller monkeys outside the cage threatening to steal the food (Kohler, 1951, pp. 31-32). Koko learned to use the box to reach high objects only after several weeks (pp. 39-45).

The significance of time in cognitive information processing theory is manifest in the limited retention period of sensory and short term memory stores—the former capable of holding relatively small amounts of information only for “brief moments of time” (Sternberg & Williams, 2010, p. 272) and the latter “capable of holding relatively limited amounts of information for a matter of seconds and, in some cases, up to two minutes” (p. 272). In contrast, long-term memory store is believed to have “very large—possibly unlimited—capacity [and] is capable of storing information for very long periods of time, possibly indefinitely” (p. 272). Information will disappear unless something is done to ensure its survival. Typically this is rehearsal. Rehearsal not only serves the purpose of keeping information active, but such a state of activity gives strength to the memory trace in long-term storage and enables encoding to occur:

"Rehearsal serves the purpose of increasing the strength built up in a long-term store, both by increasing the length of stay in STS (during which time a trace is built up in LTS) and by giving coding and other storage processes time to operate" (R. C. Atkinson & Shiffrin, 1968, p. 35).

Ausubel had much to say on the role of time in learning. He believed (a) that rote-learned items had less of a retention span than meaningfully learned items because they lacked an anchoring point (Ausubel, 1962, p. 216); (b) that the "major organizational principle" (p. 216) of learning is one of progressive differentiation, which occurs through "a process of subsumption" (p. 216); and (c) that this process of subsumption has both an "orienting, relational, and cataloguing [stage] to anchor the new material to an established ideational system" (p. 216), and a later "obliterative stage of subsumption [in which] the specific items become progressively less dissociable as entities in their own right" (p. 217) because "it is more economical and less burdensome to retain a single inclusive concept than to remember a large number of more specific items" (p. 217). He spoke of spaced review over long periods of time and intervals between practice sessions, concluding that "evidence supports the conclusion that distributed practice is more effective than massed practice for both learning and retention" (Ausubel et al., 1978, p. 326). He also described the relative advantages of both early and delayed review, noting the principle advantage of early review to be "its superior consolidating, 'feedback,' and 'sensitizing' effects in relation to more highly available material" (Ausubel et al., 1978, p. 321) and the principle advantage of delayed review to be "the superior relearning of partially forgotten material, both on motivational and cognitive grounds" (p. 321), and concluded that "the two varieties are presumably complementary rather than redundant or mutually exclusive, and can thus be profitably combined" (p. 321).

According to schema theorists Rumelhart and Norman, learning happens through “the gradual accretion of information, through the fine tuning of conceptualizations we already possess or through the restructuring of existing knowledge” (1976, p. 3). They described “real” learning as taking place “over periods of years, not hours” (p. 5). Similarly, in constructive learning theory we find the view that learning is an ongoing process and that “our perceptions are constantly engaged in a grand dance that shapes our understandings” (Brooks & Brooks, 1993, p. 4). In the constructive view of learning students must be “given time and stimulation to seek relevance and the opportunity to reveal their own points of view [as well as] opportunities to ponder the question, form their own responses, and accept the risk of sharing their thoughts with others” (pp. 37-38). They must be allowed time to “construct relationships and create metaphors” (p. 115).

The connection between Piaget’s stages of development (Piaget, 1963; Piaget & Inhelder, 1969) and the passing of time is obvious. So too, is the connection between time and Bruner’s notions of spiral curriculum and learning through “cumulative constructionism” in discovery (J. S. Bruner, 1961, p. 25). In both cases, time is a necessary factor that provides a span of opportunity for the process of learning to take place.

Vygotsky spoke of development as "a series of inner changes" (Vygotsky, 1994b, p. 64). He also said that external functions "take on the character of inner processes only as a result of a prolonged development" (Vygotsky, 1978, p. 57) and that "the transformation of an interpersonal process into an intrapersonal one is the result of a long series of developmental events" (p. 57). Such descriptions of development as a prolonged series, along with his sliding window of the zone of proximal development (pp. 84-91) strongly suggest that learning takes time.

Bandura described observational learning as a more efficient means of learning than reinforcement learning. He said, "Reinforcement provides an effective means of regulating behaviors that have already been learned, but it is a relatively inefficient way of creating them" (Bandura, 1977b, p. 22). However, Bandura notes that even in the acquisition of behavior through modeling an investment of time is required to refine the new behavior once an initial "close approximation" (p. 28) has been achieved.

Situated learning describes the process of "fashioning relations of identity as a full practitioner" (Lave & Wenger, 1991, p. 121) as a gradual one. In the example of the apprenticeship of Yucatan midwives Lave reported that "as time goes on, the apprentice takes over more and more of the work load, starting with the routine and tedious parts, and ending with what is in Yucatan the culturally most significant, the birth of the placenta" (p. 69). Again, the presence of time in learning, is obvious in the gradual increase in scope of the tasks the apprentice is able to take on.

Three aspects of time are mentioned in activity theory: (a) historicity, (b) learning over long, discontinuous periods of time, and (c) large-scale cycles of learning involve several smaller cycles which may transpire in just a few days or even hours:

Activity systems take shape and get transformed over lengthy periods of time. Their problems and potentials can only be understood against their own history. (Engestrom, 2001, p. 136)

Learning in co-configuration settings is typically distributed over long, discontinuous periods of time. (Engestrom, 2004, p. 15)

Large-scale cycles involve numerous smaller cycles of learning actions. Such a smaller cycle may take place within a few days or even hours of intensive collaborative analysis and problem solving. Careful investigation may reveal a rich texture of learning actions within such temporally short efforts. (Engestrom, 2010, p. 11)

Cognitive apprenticeship does not directly address the role of time in learning, but its necessity is evident in the processes of modeling, coaching, scaffolding and fading, articulation, reflection, and exploration described by Collins et al. (1991). Table 3 summarizes the local principles from the theories reviewed that are subsumed by the universal principle of *time*.

Table 3

Principles of Learning Subsumed by the Universal Principle of Time

Theory Group	Local principles
Behavioral	<p><i>Aristotle:</i> Developing "intellectual goodness" takes time Gradation of attainment over time</p> <p><i>Thorndike:</i> Frequency and duration of performing a given activity Time for attempting multiple or varied responses Associative shifting through multiple trials</p> <p><i>Pavlov:</i> Strength of connection preserved through repetition "time and again" Variations in time required to establish a conditioned reflex Stimulating power of a certain food can be eliminated over a long period of time by presenting it without letting the animal eat it</p> <p><i>Watson:</i> Frequency and recency are both variables of time First few trials require a large amount of excess time Habits are formed usually very gradually Fewer trials per day is more economical than many</p> <p><i>Skinner:</i> Schedules of reinforcement Shaping Vanishing Chaining Learning takes time because of fatigue and the need for rest</p> <p><i>Hull:</i> Habit strength is built up over time through repeated pairing of stimulus and response Higher levels of performance are reached in distributed practice than in massed practice Factors tending to inhibit a learned response change from moment to moment Momentary effective reaction potential at the end of training determines how many</p>

non-reinforced responses will need to be made before extinction occurs

Guthrie:

A stimulus pattern gains its full associative strength on the occasion of its first pairing with a response

Learning any skill requires learning many thousands of associations

Learning a skill requires varied experience

Recency principle

Estes:

Conditioning by stimulus sample occurs over time through exposure to multiple samples of the stimulus element population

Cognitive

Ebbinghaus:

Memorized series of nonsense syllables are gradually forgotten

That which has been learned twice fades away more slowly

Increased relearning eventually produces knowledge that is not forgotten

Advantage of distributed over massed repetition

The forgetting curve

Tolman:

Time is required for latent learning and the building up of cognitive maps

Kohler:

Koko took several weeks to learn to use the box

Tschoego learned to pull fruit to her cage with a stick in just over half an hour

Cognitive Information Processing:

The sensory register holds is capable of holding relatively small amounts of information for brief moments of time

Short-term memory is capable of holding relatively limited amounts of information for a matter of seconds and, in some cases, up to two minutes

Long-term memory has possibly unlimited capacity and is capable of storing information for very long periods of time, possibly indefinitely

Information will disappear rapidly from short-term memory unless you take action to ensure its survival

Total-time hypothesis

Maintenance rehearsal holds information in memory for short periods of time

Elaborative rehearsal encodes information for long-term storage

Distributed learning is better than massed learning

Teaching strategy: allow time for rehearsal

Teaching strategy: schedule frequent practices of new information

Decay theory

Revisiting the same material at different times

Rehearsal increases the length of stay in STS and gives coding and other processes time to operate

Ausubel:

Retention span

Progressive differentiation

Stages of subsumption

Interference causing forgetting

Concept formation occurs in time through successive stages of hypothesis generation

and testing and generalization
Simultaneous availability of multiple instances
Reminiscence
Sequentially organized learning with consolidation or mastery
Spaced review over long periods of time
Intervals between practice sessions
Advantages of both early and delayed review

Schema Theory:

Decrease in accessibility of text elements remotely connected to the dominant schema as time passes
The learning of complex topics takes months, or even years
Time is required both for accumulation of information, and organization of that information
Role of contiguity in the creation of new schemata
Restructuring often takes place only after considerable time and effort

Constructive

General:

Learning is an ongoing process
Students need time to construct relationships and create metaphors

Piaget:

Stages of development demonstrate learning over time
First habits are formed through exercise or conditioning
Circular reaction

Bruner:

Spiral curriculum
Cumulative constructionism, or the use of previously acquired information in guiding further discovery
Learning the heuristics of discovery through practice

Human

n/a

Social

Vygotsky:

Sliding window of ZPD
Long series of developmental events
Prolongation
Development is a series of inner changes

Bandura:

Efficiency in learning (less time required through observational learning than through trial and error)
Repeated practice with feedback

Situated learning:

Developing relations of identity is a gradual process
Learning occurs over time

Activity theory:

Historicity: activity systems take shape and get transformed over lengthening periods of time

Learning occurs over long, discontinuous periods of time
Smaller cycles of learning may occur in a few days or hours

Cognitive apprenticeship:

Time as a necessary condition for learning through apprenticeship is not explicitly discussed but is self evident.

Step Size. In simple cases of stimulus-response conditioning—in which a single response is to be conditioned to a single stimulus—the step size of learning, or increment of graduation in attainment, is defined by (a) the number of differentiable stimulus elements present during each trial; (b) the variation in stimulus elements from one trial to the next; and (c) the prominence or significance of the stimulus to which a response is intended to be conditioned, relative to the other stimulus elements that are also present. The effect of step size on time required for learning, in cases of simple conditioning, is most obvious during conditioning for discrimination or generalization, in which too great a variation in stimulus attributes from one trial to the next fail to evoke the desired response. For more complex learning in which multiple associations or bonds are formed—e.g., (a) Thorndike's example of improvement in addition of one place numbers, (b) his example of improvement in typewriting by sight method (Thorndike, 1914a, p. 228), or (c) Guthrie's explanation of the learning of acts, which he said are made up of many individual movements (Guthrie, 1942, p. 36)—step size takes on greater dimensionality in accounting not only for variation in elements of the stimulus condition but also the number of bonds or associations to be formed and the ease of formation of each bond (Thorndike, 1914a, p. 229). In simple conditioning a single stimulus is conditioned to a single response. In complex conditioning, multiple stimulus-response pairs (i.e., bonds or associations) are conditioned, and step size is determined both by variation in the elements of each stimulus condition as well as the total number of stimulus-response pairs to be conditioned.

Variation in the stimulus condition may be intentional, but may also be unavoidable. In his fourth postulate Hull assumed a fixed incremental increase of habit strength as a summative result of each pairing of the stimulus and response (Hull, 1943, p. 178) even though he recognized that the conditioned stimulus is "nearly always a very complicated compound" which is "almost never repeated exactly" (Hull, 1942, p. 73). Skinner found that by reinforcing small increments of, or even only approximations to, the goal behavior he was able to condition complex behaviors that did not naturally occur in the organisms repertoire—i.e., teaching a pigeon to kick a ball (Skinner, 1961f, p. 132). In Este's sampling theory, the step size of learning was defined by the number of stimulus elements in each trial that were not yet conditioned to the desired response. Too large of a step size would result in elements previously conditioned to the desired response to become conditioned to an alternative response, thereby undoing previous learning. "On each occurrence of a response, R_I , all new elements (*i.e.*, elements not already conditioned to R_I) in the momentary effective sample of stimulus elements, s , become conditioned to R_I " and "the conditioning of a stimulus event to one R automatically involves the breaking of any pre-existing conditional relationships with other R 's. (W. K. Estes, 1950, p. 97).

Step size, as a principle of learning, is inferable from behavioral learning theory through the relationship between variations in the time required for simple conditioning to occur combined with noted cross-trial variations in the stimulus condition. In this context, step size is primarily the *number of critical elements introduced or varied* from one trial to the next. In discrimination learning or conditioning for generalization step size is the *size of deviation in the stimulus condition* from what has previously been conditioned. For more complex conditioning, as in shaping or chaining, step size is the *increment of approximation towards the goal behavior* (shaping) or the *length of a sequence of behaviors* that will be joined (chaining).

Even stronger evidence suggesting the reality of this principle comes from cognitive learning theory, in which it was addressed directly. Ebbinghaus, for example, investigated the “rapidity of learning series of syllables as a function of their length” (Ebbinghaus, 1913, pp. 46-51), and concluded that “in the cases examined, the number of repetitions necessary for the memorization of series in which the number of syllables progressively increased, itself increases with extraordinary rapidity with the increase in number of the syllables” (Ebbinghaus, 1913, p. 48). From this account we add *amount of new content to be learned* to our understanding of step size. Atkinson and Shiffrin (1968) explained the general phenomenon reported by Ebbinghaus in terms of (a) a process of transferring information from short term memory into long term memory, and (b) the concept of a limited rehearsal buffer. They stated that, “throughout the period that information resides in the short-term store, transfer takes” (p. 27), however, the amount of information that can be held in short term store is limited and decays rapidly. By means of a limited capacity rehearsal buffer (p. 36) information is kept active in short term memory through maintenance rehearsal and encoded into long term memory through elaborative rehearsal. Encoding processes are assumed to suffer if an attempt is made to hold too much information in the rehearsal buffer:

Presumably a buffer is set up and used in an attempt to maximize performance in certain situations. In setting up a maximal-sized buffer, however, the subject is devoting all his effort to rehearsal and not engaging in other processes such as coding and hypothesis testing. In situations, therefore, where coding, long-term search, hypothesis testing, and other mechanisms appreciably improve performance, it is likely that a trade-off will occur in which the buffer size will be reduced and rehearsal may even become somewhat random while coding and other strategies increase. (R. C. Atkinson & Shiffrin, 1968, p. 37)

Another cognitive theory perspective on step size was described by Ausubel et al. (1978) in terms of the *complexity of the task*, noting that "some tasks are so complex that they cannot be learned directly;" that "the learner must first be trained on a simplified version of the task and then transfer this training to an attempt at mastering the task itself" (p. 200). He recommended that "the content and step size of subsequent practice trials [should] be differentially adjusted in terms of the individual learner's success or failure and type of error on preceding learning tasks or test items" (p. 339).

One final perspective from cognitive learning theory is different from the foregoing views in the following way. Each has suggested a need to restrict the increment of change to a manageable size. While this is also true of schema theory as far as learning through accretion and tuning go, it has contrastingly been suggested that there is a need for a critical amount of information to be amassed before the third type of learning, restructuring of one's schema, will take place (Rumelhart & Norman, 1976, p. 4). Thus, on the one hand smaller increments of learning are more easily and more quickly achieved than larger ones, but, at least in some cases, the impetus for change must be sizable enough so as to cause its occurrence.

Similar to the requirement of a minimal critical mass for change in schema restructuring is the view in constructivist learning theory that curriculum should be structured around primary concepts in a holistic way, rather than separated into parts as is typically the case in traditional education (Brooks & Brooks, 1993). This suggests a measure of step size in terms of *concept independence*, where the optimal step size is one in which the information presented is complete enough to stand as a meaningful whole that presents a framework to which detail can be added.

Because Piaget saw development as a very smooth and "continuous progression from spontaneous movements and reflexes to acquired habits and from the latter to intelligence"

(Piaget & Inhelder, 1969, p. 5) one can suppose that he might have considered the step size of learning to be quite small. Bruner spoke more clearly on this aspect of learning and described a measure of step size in terms of *the number of component operations that make up a complete act*. He took the position (J. S. Bruner, 1964, p. 2) that “there are very few single or simple adult acts that cannot be performed by a young child,” that “any more highly skilled activity can be decomposed into simpler components, each of which can be carried out by a less skilled operator,” and that “what higher skills require is that the component operations be combined.” Through integration “acts are organized into higher-order ensembles, making possible the use of larger and larger units of information for the solution of particular problems” (J. S. Bruner, 1964, p. 1).

Vygotsky describes step size in terms of incremental attainment through repeated exposure in a spiral pattern (Vygotsky, 1978, p. 56) and the constantly changing zone of proximal development (p. 86) which is created as learning marches out ahead “in advance of development” (p. 86). Bandura clearly demonstrated the principle of step size as he used response induction aids to assist clinical patients overcome their fear of snakes (Bandura, Jeffery, & Wright, 1974)—modifying the step size as needed so as not to go too fast, and introducing induction aids such as gloves before direct skin contact. Bandura also explained that the amount of observational learning that will take place depends on the availability of component skills:

The amount of observational learning that will be exhibited behaviorally partly depends on the availability of component skills. Learners who possess the constituent elements can easily integrate them to produce the new patterns; but if some of these response components are lacking, behavioral reproduction will be faulty. When deficits exist, then the basic subskills required for complex performances must first be developed by modeling and practice. (Bandura, 1977b, pp. 27-28)

From this we see that the size of the step being taken depends on the component skills that are already available. A learner possessing all of the component skills for a larger act need only integrate and coordinate them, while a learner lacking the component skills must also acquire them. Thus, the latter represents a case of larger step size than the first. Bandura also described a process of attenuated scaffolding to produce lasting changes in self-efficacy:

Results of recent studies support the thesis that generalized, lasting changes in self-efficacy and behavior can best be achieved by participant methods using powerful induction procedures initially to develop capabilities, then removing external aids to verify personal efficacy, then finally using self-directed mastery to strengthen and generalize expectations of personal efficacy (Bandura et al., 1975). (Bandura, 1977a, p. 202)

In situated learning step size is controlled through the gradual increase in responsibility (Lave & Wenger, 1991, p. 69). In activity theory, as has already been mentioned, large-scale cycles of learning involve numerous smaller cycles of learning actions (Engestrom, 2010, p. 11). In cognitive apprenticeship, the step size of learning is managed through scaffolding and fading:

Scaffolding refers to the supports the teacher provides to help the student carry out the task. These supports can take either the forms of suggestions or help....When scaffolding is provided by the teacher, it involves the teacher in executing parts of the task that the student cannot yet manage. A requisite to such scaffolding is accurate diagnosis of the student's current skill level or difficulty and the availability of an intermediate step at the appropriate level of difficulty in carrying out the target activity. Fading involves the gradual removal of supports until the students are on their own. (A. Collins et al., 1991, p. 14)

Step size is also managed in cognitive apprenticeship by controlling the amount of complexity in the tasks the learner is required to perform:

Increasing complexity refers to the construction of a sequence of tasks such that more and more of the skills and concepts necessary for expert performance are required (VanLehn and Brown, 1980; Burton, Brown, and Fisher, 1984; White, 1984). For example, in the

tailoring apprenticeship described by Lave, apprentices first learn to construct drawers, which have straight lines, few pieces, and no special features, such as waistbands or pockets. They then learn to construct blouses, which require curved lines, patch pockets, and the integration of a complex subpiece, the collar. There are two mechanisms for helping students manage increasing complexity. The first mechanism is to sequence tasks in order to control task complexity. The second key mechanism is the use of scaffolding, which enables students to handle at the outset, with the support of the teacher or other helper, the complex set of activities needed to accomplish any interesting task. (A. Collins et al., 1991, p. 15)

Table 4 summarizes the local principles from the theories reviewed that are subsumed by the universal principle of *step size*.

Table 4

Principles of Learning Subsumed by the Universal Principle of Step size

Theory Group	Local principles
Behavioral	<p><i>Aristotle:</i> Graduated attainment</p> <p><i>Thorndike:</i> Gradually all non-successful impulses will be stamped out Formation of each association may be represented with a time curve Associative shifting The extreme of ease: when a single experience stamps the association in completely Improvement is the addition or subtraction of bonds Changes in rate of improvement result from the number of bonds and the ease of formation</p> <p><i>Pavlov:</i> Each reinforced pairing of CS and UCS is a step up in strength of association Learning steps as progressive differentiation of similar stimuli</p> <p><i>Watson:</i> Gradually, and usually very gradually, the number of right responses exceeds the number of wrong responses until finally all the responses are right and the habit is formed</p> <p><i>Skinner:</i> Shaping Vanishing Chaining Developing competence in any field must be divided into a very large number of very small steps</p>

Hull:
Fractional anticipatory goal reaction
Step-size as a function of generalization and stimulus condition equivalence

Guthrie:
One trial learning as the smallest step of progression
Learning of skills requires the acquisition of many movements

Estes:
Number of new elements conditioned on each sampled trial
Number of new elements must be significantly less than the number of elements already conditioned to the response

Cognitive

Ebbinghaus:
Number of syllables that can be correctly recited after only one reading (usually seven)
Number of repetitions necessary for the memorization of a series increases with extraordinary rapidity with the increase in number of the syllables

Tolman:
No specific correlating local principles identified

Kohler:
No specific correlating local principles identified

Cognitive Information Processing:
Limited capacity of attention
Limited capacity of short-term memory
Rehearsal buffer of limited size

Ausubel:
Some tasks are so complex that they cannot be learned directly
Conditions of practice should gradually begin to approximate the desired (unprompted) end-point of the learning product
Step size of practice trials should be adjusted to learner's success or failure on preceding learning
Progressive differentiation

Schema Theory:
Tuning: minor modification to bring established categories into congruence with the functional demands placed on them
Restructuring: results from unwieldiness and ill-formedness of some critical mass of information that has been

Constructive

General:
Too small of a step size decontextualizes new information

Piaget:
Development is a continuous and smooth process

Bruner:
Acts organized into ensembles
Larger and larger units of information

Simple components of complex operations
Growth in spurts

Human *Self-Efficacy:*
Graduated building up of self-efficacy through progressively attenuated scaffolding

Social *Vygotsky:*
Incremental attainment through repeated exposure
Zone of proximal development
Good learning is in advance of development

Bandura:
Progressive response induction aids
The number of subskills which must be combined, or learned to perform a more complex skill

Situated learning:
Gradual increase in responsibility

Activity theory:
Large-scale cycles involve numerous smaller cycles of learning actions

Cognitive apprenticeship:
Managing step size through scaffolding and fading
Increasing complexity

Sequence. Based on the amount of evidence collected during the present study, it seems that this might possibly be the most frequently addressed principle of learning among the theories reviewed. Aristotle declared that “in all arts and crafts we require a preliminary education and habituation to enable us to exercise them” (Aristotle & Burnet, 1913, p. 106). He also explained the association of connected ideas as starting with the central most idea, or “middle member” of the series¹⁰⁹ (Ross & Aristotle, 1906, p. 113). Thus, having established the central most idea, other subsequent ideas may be grouped around it.

¹⁰⁹ Based on the interpretation given by Ross (Ross & Aristotle, 1906, p. 273).

Thorndike discussed the concept of sequence under the topics of (a) partial activity or prepotency of elements, i.e., based on prior learning some elements of a stimulus situation will have greater influence in determining a response than others (Thorndike, 1914a, p. 134); (b) assimilation, i.e., due to the assimilation of analogous elements between two stimuli, an animal will respond to a novel stimulus in the way it has previously responded to a similar stimulus (p. 135); (c) associative shifting, or the shifting of a previously learned response to a new stimulus cue (Thorndike, 1898, pp. 14, 28; Thorndike, 1914a, p. 136); and (d) in report of his tests of the influence of prior experience on the shape of learning curves (Thorndike, 1898, pp. 17, 28).

In Pavlov's conditioning the mechanism of association relied on the prior existence of nerve innervations that could be conditioned. The dogs, presumably, would never have acquired the salivating reaction to the sight of meat powder had they not first smelled or tasted it (Pavlov et al., 1928, p. 22). The prior experience of smelling and tasting created a situation in which the dogs anticipated consumption simply by seeing the meat powder, and then subsequently simply by other coincident stimulus elements, such as the assistant wearing a lab coat, or the sounding of a bell. Pavlov also demonstrated higher order conditioning, or the conditioning of a stimulus to produce a response with which it has never been paired (p. 105). Higher order conditioning is carried out by presenting a stimulus to be conditioned in conjunction with a stimulus that has already been conditioned to the response.

Watson described individual acquisitions of elementary habits as building blocks of learning (Watson, 1914, pp. 48-49; Watson, 1919, p. 269). He also talked about the integration of previously acquired separate movements to form new unitary wholes (Watson, 1919, p. 272). Skinner took advantage of previously learned simple behaviors to create chains of more complex behavior (Skinner, 1953, p. 224). By reinforcing progressive approximations to an end goal

behavior which does not naturally occur in the organisms repertoire of behavior he was able to shape behavior, with each subsequent attainment building on what had previously been learned shaping (Skinner, 1953, p. 91; Skinner, 1961e, p. 413; Skinner, 1961f, p. 132). And his rats which learned to press the food bar in one trial were certainly not lifting and pressing their paws or dashing to grab the resultant food pellet for the first time, but were simply integrating the two previously learned behaviors to play out the required sequence that provided the reward of food (Skinner, 1979, p. 89). Hull (as cited in Hergenhahn, 1982, p. 132) believed that learning was only necessary when the organisms existing hierarchy of innate or previously learned responses fails to satisfy a need. His notion of fractional antedating goal response (1934, p. 43) was his explanation for maze learning, and comparable to Skinner's chaining. By demonstration of a convergent habit-family hierarchy chain, Hull demonstrated that habits can generalize, or function with little or no delay, in "new situations having nothing whatever as objective stimuli in common with the conditions under which the habit was originally formed" (p. 35).

Like Watson,¹¹⁰ Guthrie believed that it is natural to make use of prior learning in present and future situations—so natural in fact that a subject's response to a given situation could be predicted based on "that one of his practiced movements that was last in evidence when on some former occasion he solved his problem in circumstances like those now prevailing" (Guthrie, 1940, p. 145). He also agreed with Thorndike's concept of pre-potent elements, i.e., that "in a new situation the animal will respond in terms of familiar parts of the situation" (p. 142). Guthrie described the process of learning any skill as requiring "not an association or any series of

¹¹⁰ Cf. Watson's principle of recency (Watson, 1914, p. 262).

associations, but many thousands of associations that will connect specific movements with specific situations” (Guthrie, 1942, p. 36).

Another way in which the principle of sequence shows up in Guthrie’s theory is in his description of forgetting. He believed that forgetting “is not a passive fading of stimulus-response associations contingent upon the lapse of time, but requires active unlearning, which consists in learning to do something else under the circumstances” (Guthrie, 1942, p. 29). Under this view, new learning may be negatively influenced by previous learning in that it may require not only the acquisition of new associations, but the breaking of those which have been previously established.¹¹¹

Ebbinghaus explicitly studied the effects of prior learning on later learning and observed both positive and negative effects (Ebbinghaus, 1913, p. 104). Having first learned a list of syllables he created a derivative list composed of the same syllables, in the same order, but left some of them out (e.g., every other, every third, every fifth, every seventh, etc.). He found that the time required for learning the derivative list, created by skipping items, took less time to learn. This is a case of the positive effects of sequence. What was previously learned made new learning easier and more efficient. In contrast, when his derivative list was created by permutation—changing the order of the syllables—it took longer to learn the new list than it would have taken, on average, to learn a new list of the same length where no previous familiarity existed. This is an example of the negative effects of sequence, in which his previous learning interfered with the new list he was trying to learn.

¹¹¹ Note the similarity between Guthrie’s position and the common present day belief that it is better to learn to do something right the first time, than to have to unlearn a bad habit later. Guthrie (1938, p. 60) suggested three methods for breaking old habits: the threshold method, the fatigue method, and the incompatible response method.

Other examples from cognitive theory come from Tolman's latent learning and Kohler's experiments with apes. Although Tolman's rats could not have known at the time they were exploring the maze that their knowledge would later be useful in obtaining food more directly, they were able to transfer latent knowledge of the maze to that very task when it was needed (Tolman, 1948, p. 195). Kohler found that "the possibility of utilizing old methods generally inhibits the development of new ones" (Kohler, 1951, p. 39) and that it was necessary to remove all possibility of using the old method in order that the apes would learn a new approach. He also observed that once Koko had learned to use the box in a certain situation, he quickly generalized it as the means of obtaining food in all cases (Kohler, 1951, p. 45).

One of the most obvious examples of sequence in cognitive learning theory is evident in the process of pattern recognition, which Leahey and Harris (1997) define as the process by which we "recognize environmental stimuli as exemplars of concepts already in memory" (p. 113). Clearly, a pattern can only be recognized if it has already been learned. Once present and available in the mind, it can be used to facilitate recognition and interpretation of new material or experience.

The positive and negative effects of prior learning on new learning are currently studied in cognitive learning theory under the topic of transfer. Sternberg and Williams (2010) defined transfer as "carrying over knowledge from one problem or situation to a new problem" (p. 334). In their review they drew a contrast between positive and negative transfer, low-road and high-road transfer, and forward-reaching and backward-reaching transfer. Positive transfer occurs "when the solution of an earlier-encountered problem facilitates the solution of a later-encountered problem" (p. 334). Negative transfer occurs "when the solution of an earlier-encountered problem impedes the solution of a later-encountered problem" (p. 334). Low-road

transfer is “spontaneous and automatic” and occurs “when a highly practiced skill is carried over from one situation to another, with little or no reflective thinking” (p. 335). High-road transfer occurs “when you consciously apply abstract knowledge you have learned in one situation to another situation” (p. 335). Note that in this type of transfer one must first abstract the general principles from one situation so they can be applied in another. Forward-reaching transfer occurs when “you intend the transfer to occur at the time you are learning” (p. 336). In backward-reaching transfer “you realize the applicability of what you learned in the past only after it becomes relevant” (p. 336).

Another aspect of sequence often discussed in cognitive information processing theory is the benefit on present learning that comes from having previously learned knowledge or skill to a point where it happens without any direct attention control. This is usually referred to as automaticity and has the primary benefit of enabling certain procedures to be executed with “hardly any effort or even conscious awareness” of what is being done (Wenke and Frensch, 2003, as cited in Sternberg & Williams, 2010, p. 333). Once component tasks have been learned to a point of automaticity more complex tasks may be learned or performed by adding additional component tasks that could not have been included previously because the limits of attention had been reached.

Ausubel et al. (1978) clarified the importance of sequence in learning by saying, "If we had to reduce all of educational psychology to just one principle, we would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (p. 163). Because this theme was so central to his ideas of learning, extensive references to this concept were directly made in Ausubel's writing. At the core are his forms of meaningful learning: (a) subordinate learning, (b) superordinate learning, (c)

combinatorial learning, and (d) assimilation learning (Ausubel et al., 1978, p. 68). Each of these describes a particular type of integration of new material with existing cognitive structure. Also relevant to the principle of sequence in learning are the ideas of: progressive differentiation (Ausubel et al., 1978, pp. 67-68, 124, 189-190); prior consolidation (Ausubel et al., 1978, p. 345); the stability of anchoring ideas (Ausubel et al., 1978, p. 165); the sequential organization of subject matter (Ausubel et al., 1978, p. 196); the use of advance organizers to provide to introduce appropriate subsumers "prior to the actual presentation of the learning task" (Ausubel, 1962, p. 219; Ausubel et al., 1978, pp. 164-165); the transition from learning through "direct empirical and nonverbal contact with data" as children to learning through higher order abstractions as adults (Ausubel, 1962, p. 213; Ausubel et al., 1978, p. 140); concept acquisition through exposure to "a heterogeneity of instances after consolidation in a more homogenous setting" (Ausubel et al., 1978, p. 87); representational learning (Ausubel et al., 1978, p. 127); rote learning (Ausubel, 1962, pp. 216, 217, 223); and the dependence of transfer on both overlearning (Ausubel et al., 1978, p. 197) and the "relevance, meaningfulness, clarity, stability, integrativeness, and explanatory power of the originally learned subsumers" (Ausubel et al., 1978, p. 198).

Sequence is also at the core of schema theory, both in the influence that previously acquired schema have on the learning of new materials—with "the schemata a person already possesses are a principal determiner of what will be learned" (Anderson et al., 1978, p. 439)—and in the ongoing process of developing schemata through accretion, tuning, and restructuring (1976).

In constructivist learning theory it is believed that "each of us makes sense of our world by synthesizing new experiences into what we have previously come to understand" (Brooks &

Brooks, 1993, p. 4). One particular paradigm of constructivism, endogenous constructivism, is even more sharply focused on the importance of prior knowledge in constructing new knowledge and "emphasizes internal construction of holistic knowledge structures, or the construction of new knowledge from old" (Harris & Graham, 1994, p. 234).

Much has already been said regarding Piaget's theory of development and the dependence of one stage on what has been acquired during previous stages. During the first eighteen months of life "the child constructs all the cognitive substructures that will serve as a point of departure for his later perceptive and intellectual development, as well as a certain number of elementary affective reactions that will partly determine his subsequent affectivity" (Piaget & Inhelder, 1969, p. 3). Sensori-motor schemes are revealed through three broad successive forms—rhythm structures, regulations, and reversibility (Piaget & Inhelder, 1969, pp. 19-20)—and the universe becomes "increasingly structured by the sensori-motor intelligence according to a spatio-temporal organization and by the formation of permanent objects" (Piaget & Inhelder, 1969, pp. 18-19). Sensori-motor knowledge is then later reconstructed at the perceptual level (Piaget, 1963, forward) with the appearance of the semiotic function (Piaget & Inhelder, 1969, p. 51). Piaget's mechanism of development is one of assimilation and accommodation—integrating new knowledge to conform with existing schemes on the one hand, and modifying those schemes to adjust to new elements on the other (Piaget & Inhelder, 1969, pp. 5-7).

In *The Act of Discovery* (1961) Bruner wrote, "Discovery, like surprise, favors the well prepared mind" (p. 22). The premise of his spiral curriculum is that "any subject can be taught effectively in some intellectually honest form to any child at any stage of development" (J. S. Bruner, 1960, p. 33), and that the ideas introduced can then be revisited repeatedly, "building upon them until the student has grasped the full formal apparatus that goes with them" (p. 13).

The ideas introduced earlier in the curriculum facilitate more effective and more efficient learning later on, particularly when what is introduced earlier is structure—i.e., "the fundamental ideas in whatever subject is being taught" (J. S. Bruner, 1960, p. 18). Bruner wrote that, "an understanding of fundamental principles and ideas appears to be the main road to adequate transfer of training" (J. S. Bruner, 1960, p. 25). He also described how more complex acts can be realized by orchestrating smaller component acts previously learned into an integrated sequence (J. S. Bruner, 1964, p. 2). He described how transfer could be specific or non-specific (J. S. Bruner, 1960, p. 17) and cited the acquisition of language as one of the great facilitators of subsequent learning since "once the child has succeeded in internalizing language as a cognitive instrument, it becomes possible for him to represent and systematically transform the regularities of experience with far greater flexibility and power than before." (J. S. Bruner, 1964, p. 4) and provides "a progressive release from immediacy" (J. S. Bruner, 1964, p. 14).

Vygotsky marked language as a means by which practical tasks are solved (Vygotsky, 1978, p. 26) and by which thought is organized (p. 89). However, he said, only after a certain level of internal development is reached does it become possible to master "cultural methods" (Vygotsky, 1994b, p. 8). In regards to the zone of proximal development (Vygotsky, 1978, p. 86), what makes one child able to do more with assistance than another is that which he has obtained through prior experience which can now be brought to bear in solving a problem with assistance. As an example, Vygotsky described arithmetic operations as extending the zone of proximal development and providing a basis for highly complex thinking:

The major consequence of analyzing the educational process in this manner is to show that the initial mastery of, for example, the four arithmetic operations provides the basis for the subsequent development of a variety of highly complex internal processes in children's thinking. (Vygotsky, 1978, p. 90)

In social cognitive theory, Bandura described sequence in terms of the availability of component skills pre-requisite to a more complex performance (Bandura, 1977b, pp. 27-28). Learners who possess the component skills can easily integrate them to produce new patterns. Thus, what is learned through observational learning depends on prior development (p. 29). It is also true that self-efficacy is built on previous successes (Bandura, 1977a, p. 202), and that "first learning has certain advantages over later learning, since there is less interference from contradictory habits" (Fuller, 1962, p. 67).

In situated learning the newcomer's task is one that requires less time, effort and responsibility than the task of a full participant (Lave & Wenger, 1991, p. 110). But, as time goes on, and prior experience accumulates, the apprentice takes on more and more of the workload (p. 69). More advanced tasks become possible by leveraging learned skills and experience.

Sequence is implied in activity theory under the principle of historicity. It can be assumed that models proposed as solutions to inner contradictions (Engeström, 2010, p. 7) are constructed based on the leverage of prior experience. Thus, any given solution is possible, in part, only because of previously accumulated knowledge and experience.

Collins et al. (1991) caution that in establishing learning sequences for students, care should be taken to do so in a way that "preserve[s] meaningfulness of what they are doing" (p. 15). They recommend that tasks should be structured with global skills being taught before local skills to provide a conceptual model of the overall task that then provides context for any subcomponent of that task they are asked to perform. They also recommend the sequencing of tasks in order of increasing complexity, meaning at each stage, "more and more of the skills and concepts necessary for expert performance are required" (p. 15).

Table 5 summarizes the local principles from the theories reviewed that are subsumed by the universal principle of *sequence*.

Table 5

Principles of Learning Subsumed by the Universal Principle of Sequence

Theory Group	Local principles
Behavioral	<p><i>Aristotle:</i> The linking of ideas similar, contrary, or contiguous Central concept is key to accessing related ideas</p> <p><i>Thorndike:</i> Associative shifting Assimilation Partial activity or prepotency of elements Influence of prior experience Associative polarity Response availability Order of bond formation and effect of the formation of one bond upon the condition of other bonds</p> <p><i>Pavlov:</i> Prior experience sets the stage for association Higher-order conditioning</p> <p><i>Watson:</i> Individual acquisitions as building blocks of behavior The integration of separate movements to form new unitary activities Positive effects of prior learning on new learning Positive effects depend on similarity between the old habit and the new habit to be learned Movements displayed in a novel situation will be those gained from a past habit organization</p> <p><i>Skinner:</i> One trial learning Establishing a discriminative response to the sound of the food magazine prior to introducing the lever response The law of chaining Shaping</p> <p><i>Hull:</i> New learning occurs only when existing responses do not reduce need The fractional anticipatory goal reaction Convergent habit-family hierarchy mediate transfer of reaction from one situation to a second which may be totally different</p>

Guthrie:

Recency principle

New situation response based on familiar parts of the situation

Learning a skill requires learning many associations

Forgetting requires active unlearning

Estes:

In each trial, the probability of a certain response is modeled as the relative portion of active stimulus elements in the stimulus condition that are already conditioned to that response

Response subclass hierarchy

Cognitive

Ebbinghaus:

Savings in number of repetitions when learning a derivative list created by skipping members

Increased number of repetitions required when learning a list created by permutation of previous list

Slight savings when learning a known list in reverse:

Tolman:

Previous knowledge acquired through latent learning applied when needed to accomplish a goal-oriented task

Kohler:

Preference to using existing knowledge and skills

Generalized use of the box

Cognitive Information Processing:

Interference and serial-position curve

Retroactive interference

Proactive interference

Automaticity

Stages of L1 language acquisition: a building sequence of development

Pattern recognition: recognizing environmental stimuli as exemplars of concepts already in memory

Ausubel:

The most important single factor influencing learning is what the learner already knows

Availability in learner's cognitive structure of specifically relevant anchoring ideas

Extent to which anchoring ideas are discriminable from both similar and different concepts in the learning material

Stability and clarity of anchoring ideas

Acquisition of new information is highly dependent on the relevant ideas already in cognitive structure

Progressive differentiation

Importance of prior consolidation of more particular habit exemplars

Stability of anchoring ideas

Sequential organization of subject matter

Advance organizers

After junior high school age, we require less empirical and nonverbal contact with data on which verbal constructs are based

With increasing age concepts are learned through assimilation more than formation

Concept acquisition sequencing
 Representation learning: representing known concepts with culturally designated signs or symbols
 Forms of meaningful learning: subordinate, superordinate, combinatorial, and assimilation
 Acquiring information results in a modification of both the newly acquired information and the specifically relevant aspect of cognitive structure to which the new information is linked
 Adequately established subsumers
 Rote learning
 Positive transfer attributable to carry over of general elements of strategy, orientation, and adaptation
 Prior learnings are not transferable until overlearned
 Gradual acquisition of a coding principle to facilitate solution of a given class of problems
 Prior learning helps to circumvent limitations of memory and process of storing information

Schema Theory:

The schemata a person already possesses are a principal determiner of what will be learned from a text
 More significant than the structure that is in some sense contained in a text is the structure the reader imposes on the text
 Acquisition of schema: accretion, tuning, and restructuring

Constructive

General:

Endogenous constructivism: the construction of new knowledge from old
 Synthesizing new experiences into what we have previously come to understand
 Structuring curriculum around primary concepts
 A repertoire of previously learned thinking and reasoning strategies enables achievement of complex goals
 Generalization and transfer

Piaget:

During first 18 months cognitive substructures are developed that will be foundation of intelligence for all later learning
 Through sensori-motor activity the broad categories of action are constructed (object, space, time, causality)
 Sensori-motor knowledge is reconstructed at the perceptual level
 Assimilation: reality data are treated or modified in such a way as to become incorporated into the structure of the subject
 Accommodation: adjusting to the environment
 The semiotic function appears at end of sensori-motor period
 Search for causality of previously experienced phenomena
 Consistent succession of stages
 Intellectual development is connected to, and builds on, organic biological growth
 Consistent succession of stages
 Intellectual development is connected to, and builds on, organic biological growth

Bruner:

Spiral curriculum
 Cumulative constructionism, or the use of previously acquired information in guiding further discovery

Integration of smaller units into larger units
Language makes possible the representation and transformation of regularities of experience with greater flexibility and power
Importance of learning structure of a subject
Specific and non-specific transfer
Continual deepening through progressively more complex forms

Human

Biological Motivation:

First learning has advantage over later learning due to less interference from contradictory habits

Self-Efficacy:

Self-efficacy built on previous success

Social

Vygotsky:

Language and the use of tools provide the rudiments of solving practice tasks

Transfer through similar elements

Zone of Proximal Development – what makes one child able to do more with assistance than another is that which he has obtained through prior experience which can now be brought to bear in solving a problem with assistance

Progressive utility of language

Learning creates the ZPD

Example of arithmetic operations providing basis for highly complex thinking

Internal development a pre-requisite to master cultural methods

Rich psychological experience

Bandura:

Availability of component skills pre-requisite to complex performance

Attention, retention, motor, and motivational subfunctions pre-requisite

Situated learning:

Learning progresses from learning simple to more complex tasks

Activity theory:

Implied: new models proposed in the third step of the cycle of expansive learning are generated based on previous experience

Cognitive apprenticeship:

Sequence without sacrificing significance

Global before local provides conceptual model of target skill or process

Increasing complexity

Contrast. Two of Aristotle's three laws of learning—the law of similarity and the law of contrast (Hergenhahn, 1982, p. 35; Ross & Aristotle, 1906, pp. 4, 39, 111, 260)—have to do with the importance of relating what is already known with what is being learned. He also observed

that ideas which “have orderly arrangement” are easily recalled, and that “things wanting in exactitude are with difficulty remembered” (Ross & Aristotle, 1906, p. 111).

Contrast shows up in Thorndike’s writing under the topics of assimilation, attention, prepotency of elements, belongingness, and stimulus identifiability:

1. Assimilation – “To any situations, which have no special original or acquired response of their own, the response made will be that which by original or acquired nature is connected with some situation which they resemble.”
(Thorndike, 1914, p. 135)
2. Attention – “Unless two differing boxes are attended to, there will be no difference in the reactions to them.” (Thorndike, 1898, p. 101)
3. Prepotency of elements – Certain features of a situation may be prepotent in determining a response than others and an animal is able to attend to critical elements and ignore less important ones. From Thorndike (1914):

“Similarly, a cat that has learned to get out of a dozen boxes—in each case by pulling some loop, turning some bar, depressing a platform, or the like—will, in a new box, be, as we say, ‘more attentive to’ small objects on the sides of the box than it was before. The connections made may then be, not absolutely with the gross situation as a total, but predominantly with some element or elements of it.” (p. 134)

4. Belongingness – “A connection between two units or ideas is more readily established if the subject perceives the two as belonging or going together” (as summarized by Bower & Hilgard, 1981, p. 35).
5. Stimulus identifiability – “A situation is easy to connect to a response to the extent that the situation is identifiable, distinctive, and distinguishable from others in a learning series” (Bower & Hilgard, 1981, p. 36).

Pavlov et al. explored the dog's ability to recognize "elements of a stimulus" (Pavlov et al., 1928, p. 90); the initial generalization of a response to similar stimuli (p. 171); stimulus differentiation through conditioned inhibition (pp. 207-208); and the limits of discrimination, which, when exceeded, resulted in neurosis ((p. 342).

Following Pavlov's lead, the principle of contrast in behavioral learning theory in general is considered under study of the processes of discrimination and generalization. Watson—who felt that "recency and repetition, combined with the process of substitution...will finally result in the establishment of the habit" (Watson, 1914, p. 271)—noted that "the substituted stimulus can be made [so specific that no] other stimulus of its class will then call out the reflex." (Watson & Kimble, 2002, p. xii). He also spoke of the principle of contrast when he described adjustment to new situations. He observed that when placed in a situation to which it is not yet adjusted, having no applicable habits to fall back on, the infant will display its repertoire of instinctive and reflexive movements which will become refined, connected and associated to meet the demands of the new situation. He also observed that an adult placed in a novel situation will first try movements from his past habit organization. These larger groups of movements, not suitable for the task in current form, will then be "combined into a new whole" (Watson, 1919, p. 308). From this we see two characteristics of learning relevant to the principle of contrast: (a) the primacy of turning to prior habits or behaviors to meet the demands of new situations, and (b) the emergence of new habits or behaviors when existing habits fall short of what is required.

Skinner distinguished discrimination of a stimulus (Skinner, 1938, p. 167) from differentiation between "forms of a response" (p. 308). In the first case, the subject learns to respond (e.g., to press a lever in order to obtain a food pellet) when a light is on, but not when the light is off. This is a matter of discriminating between two different states of a single element

in the total stimulus condition: light on and light off. In the latter case—differentiation between forms of response—certain response are reinforced while others are not, in the presence of the same stimulus condition. It is by this method that the shaping of behavior occurs. Skinner's distinction further expands our understanding of the principle of contrast by showing that it plays a role both the situational cues to behavior as well as systematic variations in response.

Hull's account of stimulus generalization described it's occurrence as necessary since "the conditioned stimulus (which, as we have seen, is nearly always a very complicated compound) is almost never repeated exactly even when it is conventionally said to be so" (Hull, 1942, p. 73). He noted that experiments have shown, however, that exact replication is not necessary for a response to occur:

Thus all stimuli on any given stimulus continuum, such as that of pitch, of sound intensity, etc., which are not too remote from the point of the continuum originally conditioned, will evoke a reaction, but if a stimulus is too remote, the excitatory potential may fall below the reaction threshold and no reaction whatever will occur. (p. 73)

When there is minimal difference from one stimulus condition to another, the learned response for the first stimulus condition will suffice for the second. If the difference is large, a new response will have to be learned. Hull described two types of discrimination learning: simple and compound. Simple discrimination learning can occur when "the presentations of the stimuli to be discriminated are separated by appreciable intervals of time" (Hull, 1942, p. 85). For finer discriminations of stimulus compounds "successive presentations usually separated by only fractions of a second or so are required" (p. 85). If the presentation interval is too large, the contrast between the two will not be perceived.

Guthrie spoke of the need for “varied experience” to learn a skill such as driving, “which will cause the pedal to be depressed in many situations and left severely alone in many others” (Guthrie, 1942, p. 36) and agreed with Pavlov (cf. elements of a stimulus) and Thorndike (cf. prepotency of elements) that “in a new situation the animal will respond in terms of familiar parts of the situation” (Guthrie, 1940, p. 142). The principle of contrast was also leveraged in his explanation of forgetting—which he said was not due to the passing of time “but requires active unlearning, which consists in learning to do something else under the circumstances” (Guthrie, 1942, p. 29, cf. Skinner's differentiation of response)—and for his third method of unlearning habit, the method of incompatible response:

The third method, the incompatible response method, establishes a condition in which the stimuli for the undesirable response are presented in conjunction with other stimuli that produce a response which is incompatible with the undesired response. To break a habit, not only must one avoid the cues which elicit the undesirable behavior, but they must become associated with other behavior.(Guthrie, 1938, p. 60)

For Estes, contrast is evident in his statistical model of the probability of a response, R , which is a function of the similarity of the current stimulus sample to other stimulus samples, in terms of the number of elements in the stimulus conditioned to R :

If a set of x elements from an S are conditioned to (*i.e.*, have the conditional relation to) some R -class, R_j at a given time, the probability that the next response to occur will be an instance of R_j is x/S .(W. K. Estes, 1950, p. 97)

In cognitive learning theory Ebbinghaus documented a savings in learning derivative lists of syllables which he created by periodic omission of syllables (*i.e.*, leaving out every 2nd, 3rd, 7th, etc...) from the original list (Ebbinghaus, 1913, p. 104), but increased difficulty in learning derivative lists created by reversing the original lists (pp. 112-113), presumably because prior

knowledge in the first case facilitated learning whereas in the second it interfered with learning the new order. Tolman described contrast in learning as a process of “‘discovering’ or ‘refining’ what all the respective alternative responses lead to” and selecting and performing the response that leads to the “more ‘demanded-for’ consequences” in a given situation, but “if there be no such difference in demands there will be no such selection and performance of the one response, even though there has been learning (Tolman, 1932, p. 364). Kohler's apes learned that previously learned behavior was ineffective in certain situations and developed new behaviors in order to obtain the food objective (Kohler, 1951, pp. 31-32, 39).

A great deal of attention has been given to the principle of contrast in cognitive information processing theory. According to this theory in order for information to be processed into long term memory it “must be meaningful and make connections with related knowledge already in long term memory” (Driscoll, 2000, p. 79) through a process of elaborative rehearsal (Sternberg & Williams, 2010, p. 274):

A coding process is a select alteration and/or addition to the information in the short-term store as the result of a search of the long-term store. This change may take a number of different forms, often using strong preexisting associations already in long-term store. (R. C. Atkinson & Shiffrin, 1968, p. 39)

Simply attending to information is not enough. It must be analyzed and familiar patterns identified to provide a basis for further processing (Driscoll, 2000, p. 84). Three models proposed for pattern recognition are (a) template matching, which assumes that “mental copies of environmental stimuli, or templates, are stored in memory” (p. 84) and that pattern recognition is a matter of matching incoming information with templates; (b) the prototype model, which assumes that “what is stored in memory is not an exact copy of a stimulus, but rather an

abstracted, general prototype” (p. 85); and (c) feature analysis, which presumes that only specific, distinctive features are stored in memory and that incoming information is analyzed for the presence of these features (p. 85). Another view is that what is stored in memory are highly typical instances of a concept, or exemplars (Sternberg & Williams, 2010, p. 316). Sternberg and Williams noted that, “When teaching new concepts expert teachers start with highly typical exemplars. Then they move on to ones that are less typical. At the same time, they help students see the more and less typical features” (p. 316). Similarly, Tennyson and Cocchiarella (1986, as cited in Driscoll, 2000) proposed a model for teaching concepts that begins with first presenting a prototypic concept example followed by a variety of examples that differ from the prototype in systematic ways to help learners “abstract the meaningful dimensions of the concept and determine which features are critical and invariant and which are nonessential and variable across examples” (p. 85). Tennyson and Park (1980, p. 59) (1980, p. 59, cited in Sternberg & Williams, 2010, p. 316) suggested three rules to help clarify the boundaries of a concept through the presentation of contrasting examples: (a) present examples in order from easiest to most difficult, (b) select examples that are different from one another, and (c) compare and contrast examples and nonexamples. Through this process students come to recognize both defining features of a concept—i.e., features that are both necessary and sufficient to define a concept (Katz, 1972; Katz & Fodor, 1963; Medin, Proffitt, & Schwartz, 2000 (Katz, 1972 Katz & Fodor, 1963 Medin, Proffitt, & Schwartz, 2000, as cited in Sternberg & Williams, 2010, p. 314)—and characteristic feature of a concept, which are properties that are typical of something represented in a concept, but not always associated with it (e.g., the ability to fly in birds) (Sternberg & Williams, 2010, p. 314).

Richard Spiro and his colleagues (cited in Woolfolk, 1998, p. 348) suggested that "revisiting the same material, at different times, in rearranged contexts, for different purposes, and from different conceptual perspectives is essential for attaining the goals of advanced knowledge acquisition." Similarly, King (1994, p. 30) found that questions which prompted "comparing and contrasting, inferring cause and effect, noting strengths and weaknesses, evaluating ideas, explaining, and justifying" were especially effective.

According to Ausubel et al. (1978, p. 58) "cognitive structure itself tends to be hierarchically organized with respect to level of abstraction, generality, and inclusiveness of ideas." His theory of meaningful learning describes various ways in which new information is related to, and contrasted with, existing cognitive structure through subordination, superordination, combination, and assimilation learning (Ausubel et al., 1978, p. 68). "As new material enters the cognitive field, it interacts with and is appropriately subsumed under a relevant and more inclusive conceptual system" (Ausubel, 1962, p. 217). Ausubel described the availability of appropriate subsumers as one of three principle variables influencing meaningful verbal learning, the other two being (a) discriminability, and (b) the clarity and stability of subsumers (pp. 219-220):

The most important cognitive structure variables...are (1) the availability in the learner's cognitive structure of specifically relevant anchoring ideas at an optimal level of inclusiveness, generality, and abstraction; (2) the extent to which such ideas are discriminable from both similar and different (but potentially confusable) concepts and principles in the learning material; and (3) the stability and clarity of the anchoring ideas. (Ausubel et al., 1978, p. 164)

Ausubel (1962) identified the "major organizational principle" of cognitive structure as one of "progressive differentiation of trace systems of a given sphere of knowledge from regions

of greater to lesser inclusiveness, each linked to the next higher step in the hierarchy through a process of subsumption" (p. 216). The interaction between new material to be learned and existing cognitive structure is "an assimilation of old and new meanings to form a more highly differentiated cognitive structure" (Ausubel et al., 1978, pp. 67-68). "As new information is subsumed under a given concept or proposition, new information is learned and the subsuming concept or proposition is modified" (Ausubel et al., 1978, p. 124).

In the first stage of subsumption new information is anchored¹¹² to the existing ideational system through "orienting, relational, and cataloguing operations" (Ausubel, 1962, p. 217). For a period of time "the recently catalogued sub-concepts and informational data can be dissociated from their subsuming concepts and are reproducible as the individually identifiable entities" (Ausubel, 1962, p. 217). This initial dissociability is the result of a "clear, stable and suitably organized" cognitive structure (Ausubel et al., 1978, p. 164). However, over time this dissociability fades:

Barring repetition or some other special reason [e.g., primacy, uniqueness, enhanced discriminability, or the availability of a specially relevant and stable subsumer] for the perpetuation of dissociability, specific items of meaningful experience that are supportive

¹¹² Herein lies the primary difference between meaningful and rote learning:

Meaningfully and rotely learned materials are learned and retained in qualitatively different ways because meaningful learning tasks are, by definition, relatable and anchorable to relevant and more inclusive concepts in cognitive structure....Rotely learned materials, on the other hand, are isolated from cognitive structure and are primarily influenced by the interfering effects of similar rote materials. (Ausubel, 1962, p. 223)

of or correlative to an established conceptual entity tend gradually to undergo obliterative subsumption. (Ausubel, 1962, p. 218)

Ausubel (1962) referred to this second stage as one of obliteration subsumption and memorial reduction:

Although the stability of meaningful material is initially enhanced by anchorage to relevant conceptual foci in the learner's cognitive structure, such material is gradually subjected to the erosive influence of the conceptualizing trend in cognitive organization. Because it is more economical and less burdensome to retain a single inclusive concept than to remember a large number of more specific items, the import of the latter tends to be incorporated by the generalized meaning of the former. When this second or obliterative stage of subsumption begins, the specific items become progressively less dissociable as entities in their own right until they are no longer available and are said to be forgotten.... Memorial reduction is "the reduction to the least common denominator capable of representing cumulative prior experience." (p.217)

For rote learning, forgetting is due to "exposure to materials similar to but not identical with the learning task, shortly before (proactive inhibition) or after (retroactive inhibition) the learning session" (Ausubel, 1962, p. 220). In contrast, the forgetting of meaningfully learned information and material is "regarded as a continuation of the same interactional process established at the moment of learning" (p. 222). This loss is not due to the inherent similarity between new and old ideas, but rather to insufficient discriminability between the two. Thus, "small, barely discriminable differences among instances...increase the difficulty of concept attainment" (Ausubel et al., 1978, p. 113). Although similarity can help facilitate initial anchorage to existing ideas, unless the differences are "clearly and explicitly perceptible" (Ausubel, 1962, p. 222) new information may be interpreted as identical to existing information (Ausubel et al., 1978, p. 182) and no new learning will occur. Effective concept acquisition depends on "(1) heterogeneity of instances after consolidation in a more homogeneous setting; (2) appropriate blending and sequencing of positive and negative instances; and (3) the relevance

of the presented or available information to the concept in question” (Ausubel et al., 1978, p. 87).

The critical role of contrast in concept acquisition is evident in the summary by Ausubel et al. of the sequential stages in concept acquisition:

Sequential stages in concept acquisition: 1. Discriminative analysis of different stimulus patterns; 2. The formulation of hypotheses regarding abstracted common elements; 3. Subsequent testing of these hypotheses in specific situations; 4. Selective designation from among them of one general category or set of common attributes under which all of the variants can be successfully subsumed; 5. Relation of this set of attributes to relevant anchoring ideas in cognitive structure; 6. Differentiation of the new concept from related, previously learned concepts; 7. Generalization of the criterial attributes of the new concept to all members of the class; 8. Representation of the new categorical content by a language symbol that is congruent with conventional usage. (Ausubel et al., 1978, p. 99)

Ausubel et al. (1978) noted that “the defining attributes of a concept are learned most readily when the concept is encountered in a large number of different contexts” (p. 113), and that, in general, “positive instances lead more effectively than negative instances to concept acquisition” (p. 113).

Irrelevant information complicates the task of learning by making it harder to identify critical attributes of a concept (Ausubel et al., 1978, p. 114) and lack of discriminability between new and old information likely accounts for negative transfer, in the form of proactive interference, in school learning (p. 182). Comparative organizers can increase discriminability and facilitate learning and retention and the presentation of sequences of stimuli to provide successive contrasts between relevant and irrelevant criterial attributes can aid in concept formation (p. 183).

When learners encounter an apparent contradiction between new information and existing ideas they may choose to ignore the new information, try to retain it on a rote basis, or reconcile and integrate the two sets of ideas in relation to a more inclusive subsumer:

Sometimes in meaningful learning and retention, new learning material may be adequately discriminable from existing ideas in cognitive structure but may be in real or seeming contradiction to these ideas. When this happens, the learner may peremptorily dismiss the new propositions as invalid, may try to set them apart from previously learned knowledge (retain them on a rote basis), or, hopefully, may try to reconcile and integrate the two sets of ideas in relation to a more inclusive subsumer. (Ausubel et al., 1978, p. 184)

This type of reconciliation is comparable to the schema theory notion of achieving congruence of ideas through tuning:

Learning through tuning is a substantially more significant kind of learning. This involves actual changes to the very categories we use for interpreting new information. Thus tuning involves more than merely an addition to our data base. Upon having developed a set of categories of interpretation (as you will see below, we call these schemata) these categories presumably undergo continual tuning or minor modification to bring them more in congruence with the functional demands placed on these categories. (Rumelhart & Norman, 1976, p. 4)

Major changes, or restructuring, generally occur with considerable time and effort after a “critical mass of information” has been accumulated (Rumelhart & Norman, 1976, p. 4). The need for change is largely based on the degree of discrepancy between new and old information, but there must be recognition of the discrepancy in order for change to occur:

The more discrepant the arriving information from that described by the available schemata, the greater the necessity for change. If the information is only mildly discrepant, tuning of the schemata may be sufficient. If the material is more discrepant, schema creation is probably required. (Rumelhart & Norman, 1976, p. 21)

In order for restructuring to occur, there must be recognition of the discrepancy. But when mismatched by the available schemata the learner may so misinterpret (misunderstand) the material, that the discrepancies might not even be noted. The need for restructuring might only be noted with mild discrepancies, when the misfit is glaring. (pp. 21-22)

Brooks and Brooks (1993) describe this as a process of “synthesizing new experiences into what we have previously come to understand” (p. 4). “Deep understanding occurs when the presence of new information prompts the emergence or enhancement of cognitive structures that enable us to rethink our prior ideas” (p. 15). Accordingly, they recommend that teachers “engage students in experiences that might engender contradictions to their initial hypotheses and then encourage discussion” (p. 112). In the earliest stage of Piaget’s theory of development there is no need for reconciling the old with the new since all things are new to the newborn infant.¹¹³ However, even in the first attainments of knowledge, contrast is manifest in the process of cognitive assimilation, by which the child comes to “distinguishing the nipple from other objects” (Piaget & Inhelder, 1969, p. 7). It is also manifest in the differentiation of regulated rhythmic movements (pp. 19-20) through selected self-reinforcing circular reactions that finally result in established sensori-motor schemes. These differentiated schemes (p. 11) then become the means of intentional interaction with one’s surroundings and the foundation of future intellectual thought (pp. 3, 13).

¹¹³ The only a priori or innate knowledge that Piaget is willing to consider is a biologically inherited functional nucleus that drives intellectual organization:

If there truly in fact exists a functional nucleus of the intellectual organization which comes from the biological organization in its most general aspect, it is apparent that this invariant will orient the whole of the successive structures which the mind will then work out in its contact with reality. It will thus play the role that philosophers assigned to the a priori; that is to say, it will impose on the structures certain necessary and irreducible conditions. Only the mistake has sometimes been made of regarding the a priori as consisting in structures existing ready-made from the beginning of development, whereas if the functional invariant of thought is at work in the most primitive stages, it is only little by little that it impresses itself on consciousness due to the elaboration of structures which are increasingly adapted to the function itself. This a priori only appears in the form of essential structures at the end of the evolution of concepts and not at their beginning. Although it is hereditary, this a priori is thus the very opposite of what were formerly called “innate ideas.” (Piaget, 1963, pp. 2-3)

Rhythmic movements develop into action schemes through accommodation, which takes place when established sensori-motor schemes are insufficient to meet the demands of the situation. Through continued accommodation, sensori-motor schemes become further differentiated and elaborated, with new means being coordinated by combination of those which have already been established. Eventually new schemes are created not only through sensori-motor groping, or by combination of existing schemes (p. 11), but through semiotic representation (p. 51) and intellectual manipulation. Differentiation at each stage bears evidence of the principle of contrast—e.g., certain means being selected for specific cases of action (Piaget, 1963, p. 4) but not for others, and invented for cases in which no existing scheme will suffice. "It is by adapting to things that thought organizes itself and it is by organizing itself that it structures things"(p. 8).

As a framework of sensori-motor schemes becomes established, new experiences are able to be assimilated in terms of existing schemata or accommodated by intellectual adaptation:

Intelligence is assimilation to the extent that it incorporates all the given data of experience within its framework. Whether it is a question of thought which, due to judgment, brings the new into the known and thus reduces the universe to its own terms or whether it is a question of sensorimotor intelligence which also structures things perceived by bringing them into its schemata, in every case intellectual adaptation involves an element of assimilation, that is to say, of structuring through incorporation of external reality into forms due to the subject's activity. (Piaget, 1963, p. 6)

Whenever possible "reality data are treated or modified in such a way as to become incorporated into the structure of the subject" (Piaget & Inhelder, 1969, p. 5). In many cases however, this assimilation actually results in significant changes to the existing structure, and is therefore an accommodation by the organism to the environment (pp. 6-7). Both assimilation and accommodation are examples of the principle of contrast in action—relating what is known to

what is new and adapting as necessary when what is new cannot be accounted for or understood in terms of what is already known.

Bruner (1964) described the acquisition of "ways of representing recurrent regularities in their environment" as children grow and their transcendence of the momentary by "developing ways of linking past to present to future—representation and integration" (p. 13). He specifically noted the importance of detail in the representation of structured patterns. When detail is lacking the pattern is "rapidly forgotten" (J. S. Bruner, 1960, p. 24).

Those who are most effective in learning employ a method of inquiry that Bruner referred to as constructionism. This compared to the less efficient method of episodic empiricism. The method of constructionism is characterized by linking new knowledge with existing knowledge and letting the constraints of what has been learned drive the discovery of new learning. Episodic empiricism, on the other hand, is "unbound by prior constraints," "lacks connectivity," and "is deficient in organizational persistence" (J. S. Bruner, 1961, p. 25).

Bruner's description of the act of learning highlights the centrality of the principle of contrast by describing new information as often running counter to what a person has previously known. This discrepancy gives cause for refactoring or refinement. Furthermore, by perceiving the contrast between situations or tasks a person is able to extrapolate or interpolate or convert information into a new form, manipulating existing knowledge to fit new tasks.

Learning a subject seems to involve three almost simultaneous tasks. First there is acquisition of new information—often information that runs counter to or is a replacement for what the person has previously known implicitly or explicitly. At the very least it is a refinement of previous knowledge. A second aspect of learning may be called transformation—the process of manipulating knowledge to make it fit new tasks. We learn to "unmask" or analyze information, to order it in a way that permits extrapolation or interpolation or conversion into another form. Transformation comprises the ways we deal with information in order to go beyond it. (J. S. Bruner, 1960, p. 48)

Vygotsky's organizing function of symbolic activity (1978, p. 24) is only possible when symbols are clearly differentiated from one another. As external operations, functions and processes are internalized they must be "incorporated into a new system with its own laws" (p. 57).

In observational learning if an observed behavior is interpreted to be the same as a known behavior, nothing new will be learned. This is because in order to represent a behavior in memory in symbolic form, it must be distinct (Bandura, 1977b, p. 25). Similarly, the spatial and temporal organization for a new behavior must be established in contrast to other, similar, forms of motion (p. 27). Otherwise, the new behavior will simply be subsumed by the existing, similar behavior.

Contrast in activity theory is the impetus for all learning, and is described by Engestrom as contradictions (1987, ch. 3, p. 27), disturbances (2000a, p. 964), and "conflictual *questioning* of the existing standard practice" (2000a, p. 968). Learning occurs when the existing patterns do not meet a need, or when elements of the activity system are found to be in contradiction with one another. In resolution of the contradiction a new pattern emerges, that is in contrast to the former pattern, critically different and suitable to meet a need that could not be met by the old pattern.

This type of reformation was also argued for in cognitive apprenticeship theory by Brown and Duguid (1994), who said that "learning...does not consist in getting rid of pure ignorance, but in reforming knowledge that is already there" (p. 9). Another aspect of contrast involves learning the contexts in which "the skill is or is not applicable" (A. Collins et al., 1991, p. 3). This can be learned when the teacher varies the diversity of situations and articulates the common aspects between them. Collins et al. (1991) suggest that this be accomplished through a

technique of increasing diversity, that is, "the construction of a sequence of tasks in which a wider and wider variety of strategies or skills are required...[so] that the student learns to distinguish the conditions under which they do (and do not) apply" (pp. 15-16). Table 6 summarizes the local principles from the theories reviewed that are subsumed by the universal principle of *contrast*.

Table 6

Principles of Learning Subsumed by the Universal Principle of Contrast

Theory Group	Local principles
Behavioral	<p><i>Aristotle:</i> Law of similarity Law of contrast Organization of ideas</p> <p><i>Thorndike:</i> Assimilation Attention: unless two differing boxes are attended to, there will be no difference in the reactions to them Partial activity or prepotency of elements Belongingness Stimulus identifiability</p> <p><i>Pavlov:</i> The elements of a stimulus Differentiation of stimulations The limits of discrimination</p> <p><i>Watson:</i> Discrimination: the substituted stimulus can be made [so specific that no] other stimulus of its class will then call out the reflex Adjustment</p> <p><i>Skinner:</i> Discrimination and differentiation</p> <p><i>Hull:</i> Relation of time and discrimination Simple discrimination learning Patterning of conditioned stimulus compounds Compound discrimination learning Generalization and stimulus equivalence</p>

Guthrie:

Generalization: requires varied experience
Forgetting: learning to do something else in the circumstances
Incompatible response method for breaking a habit

Estes:

Similarity and discrimination of stimulus sample

Cognitive

Ebbinghaus:

Savings in learning derivative lists by omission of syllables: positive effect of previous associations
Increased number of repetitions required when learning a list created by permutation of previous list: interference of previous associations
It is more difficult to remember things that lack clarity

Tolman:

Learning what each response path leads to

Kohler:

When previous behavior was ineffective, new behaviors were developed

Cognitive Information Processing:

New knowledge must be related to old
Analysis and pattern identification
Pattern recognition
Template matching
Prototype model
Exemplars
Feature analysis
Critical and invariant features
Elaborative rehearsal: associating new knowledge with old
Defining features
Characteristic features
Use of examples to clarify the boundaries of a concept
Revisit the same material in different contexts and for different purposes
Coding and organization using pre-existing associations already in long-term store
Clustering related items into categories or patterns
Guided questioning: comparing and contrasting
Familiarity facilitates verification of statements

Ausubel:

Hierarchical organization of cognitive structure
Forms of meaningful learning: subordinate, superordinate, combinatorial, assimilation
Subsumability
Subsumers
Discriminability
Stability and clarity of subsumers
Progressive differentiation
Anchoring
Rotely learned materials subject to interference of similar material
Dissociability
Obliterative stage of subsumption and memorial reduction

Forgetting due to contrast
 Insufficient discriminability
 Similarity
 Assimilation
 Concept formation and assimilation
 Varied context
 Positive and negative instances
 Irrelevant Information
 Integrative reconciliation
 Negative transfer
 Comparative organizers
 Successive contrast
 Apparent or actual contradiction
 Early review: promotes consolidation and relation of new material to existing to
 acquire more subtle potential meanings
 Transferability: balance between overlearning of intratask instances and exposure to
 intertask diversity on the other

Schema Theory:

Matching new information to schemata
 Organization of structures and accumulation of facts
 Congruence through tuning and restructuring
 Improving the accuracy
 Generalizing the applicability
 Specializing the applicability
 Determining default values
 Adjustment of variable constraints
 Degree of discrepancy
 Encoding: constants substituted for variables
 Analogies, metaphors, and models

Constructive

General:

Synthesizing new experiences into what we have previously come to understand
 Interpret to conform versus generate new rules
 Deep understanding through contrast
 Teaching method: challenge original hypotheses
 Linking new information to existing knowledge

Piaget:

Establishing the base substructure for future operations of thought
 Adaptation to the universe
 Assimilation
 Accommodation
 Differentiation
 Contrast through contact with the environment

Bruner:

Importance of detail
 Linking past to present to future – representation and integration
 Episodic empiricism vs. constructionism - learning is effective when past
 information is connected and related to new information
 The act of learning: information that is counter to or is a replacement for what a
 person has previously known

Human	n/a
Social	<p><i>Vygotsky:</i> Organization through symbolic activity Internalization</p> <p><i>Bandura:</i> Attention: perceptual sets determine features extracted from observations Retention: representation in memory in symbolic form must be distinct Motor Reproduction: spatial and temporal organization must be distinct</p> <p><i>Situated learning:</i> No specific correlating local principles identified</p> <p><i>Activity theory:</i> Disturbances and contradictions Questioning of standard practice</p> <p><i>Cognitive apprenticeship:</i> Understanding what needs to be learned in terms of what is already known Generalization and transferability through varied context Sequence of increasing diversity Learning different conditions of knowledge application Abstraction of knowledge through multiple contexts</p>

Significance. Aristotle believed that "memory, even the memory of concepts, cannot exist apart from imagery" (Ross & Aristotle, 1906, p. 103). Certainly no conscious mental image can be formed in the absence of attention and in some cases may require an appreciable level of effort. Aristotle described a stimulus as imprinting a sense-affection like a "seal-ring acts in stamping" (Ross & Aristotle, 1906, p. 105), but noted also that impressions are difficult to make on those who are in a "rapid state of transition" or those who are in a "worn-out condition " (p. 105). He compared the former to the fruitless effort of stamping a seal on running water and the latter to stamping it on an old building, the hardness of which prevents the sense-affection from leaving any impression. The first condition suggests that there must be established a relatively stable foundation of prior experience in order that new experiences might be related to it, and

that as the number of 'moving parts' or the amount of new information increases in any given learning situation, the relative significance for any individual portion of the total decreases. The second condition, that of a hardened old building, suggest that when the established foundation is too firmly set, the learner may not be willing to accommodate new information; it will simply bounce off and fall away unclaimed.

Aristotle also called attention to the relationship between significance and the need for repetition:

It so happens that some people receive a greater benefit from a single experience than others in whom the sequence has frequently taken place, and hence, in some instances, after seeing things once, we remember them better than others who have seen them frequently. (Ross & Aristotle, 1906, p. 111)

In my own observation, those who benefit to a greater degree than others from a single experience typically do so simply because they are more attentive to the details of the experience, more actively engaged in relating the new to the old, and have a more complete and diverse base of prior experience to which the new might be connected.

Thorndike (1898) described significance in terms of attention and effort. Attention, he said, "emphasizes and facilitates the process which it accompanies" (p. 101). The amount of attention given to an act determines the "celerity with which an association may be formed" (pp. 17, 27). "The kinds of acts which insure attention are those where the movement which works the mechanism is one which the cat makes definitely to get out" (p. 27). Thus, learning experiences which require a deliberate and definite act by the learner are more likely to claim the learner's attention and provide a significant learning experience.

Thorndike also found that his subjects must expend effort, acting according to their own impetus, in order to learn. In his experiments, no animal was able to learn an act by being put through it:¹¹⁴

An animal cannot learn an act by being put through it. For instance, a cat who fails to push down a thumb-piece and push out the door cannot be taught by having one take its paw and press the thumb-piece down with it. (Thorndike, 1898, p. 46)

Significance is found in Pavlov's conditioning (Pavlov et al., 1928) first of all in the connection between the CS and the UCS. A CS per se holds no significance for the subject relative to the UCR. Because of this, the CS cannot be conditioned to the UCR without being paired with the UCS. This pairing brings significance to the CS inasmuch as it becomes tied to a stimulus that inherently calls out the unconditioned response.

Pavlov also wrote of the relationship between the intensity of the stimulus and the time required to establish a conditioned reflex:

Although there are great differences in the time required for the establishing of a conditioned reflex, some relations have been seen to exist. From our experiments it is evident that the intensity of the stimulus is of essential importance. (Pavlov et al., 1928, p. 89)

He found that the amount of time necessary to condition a stimulus was related to "the intensity of a stimulus and its effect" (p. 91). For example, when stones were placed in the mouth of the dog they were easily ejected and nothing remained in the mouth. However, "if you throw

¹¹⁴ See also Watson (Watson, 1914, pp. 282-296)

some sand in the dog's mouth (the same stones but pulverised) , there is an abundant flow of saliva" (p. 48).

Watson (1914) spoke of intensity in terms of both stimulus threshold (p. 37) and of the effort required on the part of the subject in order to establish a habit:

The first and most obvious need in behavior is to provide some form of stimulation which will make the animal move in some way. Unless the animal will work steadily we are powerless to force habits upon him. (p. 57)

In operant conditioning, the significance of a learning experience is seen primarily in the effect of reinforcement. The delivery of a food pellet to a hungry pigeon is physiologically significant to the pigeon, and as long as the pigeon is able to connect the contingent behavior to the delivery of the pellet it will learn to repeat that behavior in order to receive food.

Reinforcement relies on the significance of hunger satiation which drives the animal to perform as required, using behaviors that would not normally be observed in the animal's natural state, in order to obtain food. For example,

Once we have arranged the particular type of consequence called a reinforcement, our techniques permit us to shape up the behavior of an organism almost at will. It has become a routine exercise to demonstrate this in classes in elementary psychology by conditioning such an organism as a pigeon. Simply by presenting food to a hungry pigeon at the right time, it is possible to shape up three or four well-defined responses in a single demonstration period—such responses as turning around, pacing the floor in the pattern of a figure-8, standing still in a corner of the demonstration apparatus, stretching the neck, or stamping the foot. Extremely complex performances may be reached through successive stages in the shaping process, the contingencies of reinforcement being changed progressively in the direction of the required behavior. The results are often quite dramatic. In such a demonstration one can *see* learning take place. (Skinner, 1961g, p. 146)

Other examples of significance through intensity are (a) Hull's stimulus-intensity dynamism (Hull, 1952), which states that the greater the intensity of the stimulus, the greater the

probability that a learned response will be elicited; (b) his notion of drive reduction (Hull, 1943, p. 178); and Guthrie's stimulus threshold approach to breaking a habit (Guthrie, 1938, p. 60), which relied on presentation of the stimulus at an intensity sufficiently low so as to not call out the response—thereby removing significance from the situation.

Significance in Estes' stimulus sampling model is in the form of attention. Only a certain portion of the total number of stimulus elements will be effective, or experienced by the subject, on any given trial (W. K. Estes, 1950, p. 96; Hergenhahn, 1982, p. 223). It is only those stimulus elements which are attended to that have meaning and become connected to the response which is made. No connection is made between the response and stimulus elements which the subject does not take notice of.

In cognitive learning theory, significance is less frequently attributed to intensity of sensation and more frequently discussed in terms of the allocation of attention, the connection of new information with existing cognitive structures, and self-directed effort. For example, Ebbinghaus reported that attention, or "mental vigor and receptivity," are less in the later hours of the day and that "the series learned in the morning and then relearned at a later hour, aside from other influences, require more work for relearning than they would if the relearning were done at a time of mental vigor equal to that of the original learning (Ebbinghaus, 1913, p. 66). He described a great dependence of retention and reproduction on the intensity of attention and interest at the time of learning:

Very great is the dependence of retention and reproduction upon the intensity of the attention and interest which were attached to the mental states the first time they were present. The burnt child shuns the fire, and the dog which has been beaten runs from the whip, after a single vivid experience. People in whom we are interested we may see daily and yet not be able to recall the color of their hair or of their eyes. (pp. 3-4)

He also found significance through connection with existing knowledge when he discovered a great savings in the number of repetitions required to learn sense material versus non-sense syllables—the former taking one tenth the amount of time than the later. This savings he attributed to factors which provided significance to what was being learned, namely, "the combined ties of meaning, rhythm, rhyme, and a common language" (pp. 50-51).

Significance in Tolman's view of learning was attributed to both attention and intensity. Attention was manifest in the form of a "persistence until character" (Tolman, 1925a, p. 37) of behavior, meaning, the goal-directed behavior persisted until the goal was reached (p. 38). Intensity was manifest as a "strong appetite" which provided the catalyst for a rat that had become familiar with a maze through latent learning to enact its cognitive map and return directly to the goal box once food had been introduced at that location (Tolman, 1938, p. 161). Similarly, Kohler's apes, which learned to use round about means and tools to obtain an objective, were only able to do so when they were actively attending to the effort of trying to do so, or, in a few cases, when they attended to and then imitated the actions of one of their successful peers (Kohler, 1951). This attention behavior learning was also significant in respect to the apes' desire to obtain the banana. They did not learn to use ropes, sticks, and boxes simply for the sake of performing the actions which were ultimately learned per se. Rather, they learned what was required in order to secure for themselves that which they desired.

Under the cognitive information processing model significance has been described as attention, intensity, connectedness between new and existing knowledge, and effort. Ericsson (1996a and 1996b, as cited in Sternberg & Williams, 2010, p. 336) described the importance of attention in learning by saying,

Mindless drilling practice leads to little improvement. For practice or drill of any kind to be effective, it should be mindful, or deliberate. Individuals should be attentive to what they are doing. They should watch for and correct errors and work toward improvement.

Atkinson and Shiffrin (1968) viewed attention as limited in capacity and noted that "only that information selected by the subject, often a small proportion of the initial ensemble, is maintained" (p. 35). Furthermore, they believed that attention is under the control of the individual and that in processing incoming information "the first decision the subject must make concerns which sensory register to attend to" (pp. 31-32). Attention has been conceptualized as a "filter" which selects from among different information input "channels" (Broadbent, 1958); a "tuner" which selectively attenuates, or raises the thresholds for accepting signals from non-relevant or non-interesting sources (Treisman, 1960); and as "mechanisms that control the significance of stimuli" through the allocation of limited resources or capacity (Kahneman, 1973, p. 2). As Kahneman stated, attention controls the significance of stimuli. That which is attended to is significant. That which is not attended to is lost.

Another view of significance in cognitive information processing theory has to do with intensity of emotion. Flashbulb memories, a term coined by Brown and Kulik (1977), are memories of an event that is so emotionally powerful that the recollection is highly vivid and richly detailed. Although some research shows that the details of these events are often recalled in accurately (Romeu, 2006 Schacter, 1996 and Talarico & Rubin, 2007, as cited in, Sternberg & Williams, 2010, p. 294) the fact remains that the occurrence of the event itself and, in many cases, many fine and accurate details, are impressed on the mind with great resistance to forgetting.

Another aspect of significance that is more frequently addressed in cognitive information processing theory is that of connections between incoming information and information that is already stored in long-term memory. Hoffding (1891) pointed out that before any association of ideas can be made there must first be recognition, or "in other words that the sensation shall have a point of attachment in consciousness" (p. 153). Mediation is a strategy that "involves tying difficult-to-remember information to something more meaningful" (Bruning et al., 2004, p. 67). Similarly, another strategy using mnemonics involves "attaching new information to well-known information—in possibly a very artificial way" (p. 69).

Learning, according to cognitive information processing theory, requires effort, for example, the effort to encode. "For rehearsal to succeed you need to do more than just mindlessly repeat words. You must make an active effort to encode and store the information" (Sternberg & Williams, 2010, p. 317). Atkinson and Shiffrin (1968) found that effort applied to various coding operations "will increase the strength of the stored information" (R. C. Atkinson & Shiffrin, 1968, p. 39). Elaborative rehearsal "involves taking the information to be learned and trying to associate it with other things you know" (Sternberg & Williams, 2010, p. 274).

In the levels-of-processing model of cognition, "memory does not comprise three or any specific number of separate stores, instead, storage varies along a continuous dimension in terms of depth of encoding (theoretically there are an infinite number of levels of processing)" and "the deeper the level at which an item is processed, the higher the probability that the item will be retrieved" (Sternberg & Williams, 2010, p. 286). Deep processing—i.e., the kind of processing that brings significance to the information being learned—happens when, for example, students are asked to underline a set of vocab words in an essay versus asked to explain the essay in their own words (Bruning et al., 2004, p. 77); when students "reason with concepts rather than simply

memorize concepts" (Sternberg & Williams, 2010, p. 317); when students make overt responses (R. C. Atkinson & Shiffrin, 1968, p. 27); and through organization, elaboration, and cognitive activity (Eggen & Kauchak, 1999, p. 258).

Ausubel primarily recognized connectedness and effort as bringing significance to learning, though he also acknowledge the role of intensity. Connectedness, however, is the core behind his ideas on meaningful learning and is how he explained the difference between meaningful and rote material—i.e., in terms of whether or not the material being learned could be related to existing cognitive structure:

Meaningfully learned materials have been related to existing concepts in cognitive structure in ways making possible the understanding of various kinds of significant (e.g., derivative, descriptive, supportive) relationships... Rote learned materials, on the other hand, are discrete and isolated entities which have not been related to established concepts in the learner's cognitive structure. (Ausubel, 1962, pp. 215-216)

The key to meaningful learning, according to Ausubel et al. (1978), is the prior establishment of adequate subsuming ideas in cognitive structure:

Once subsuming ideas are themselves adequately established in cognitive structure: 1) They have maximally specific and direct relevance for subsequent learning tasks. 2) They possess enough explanatory power to render otherwise arbitrary factual detail potentially meaningful. 3) They possess sufficient inherent stability to provide the firmest type of anchorage for newly learned detailed meanings. 4) They organize related new facts around a common theme, thereby integrating the component elements of new knowledge, both with each other and with existing knowledge. (p. 58)

Such connections with prior knowledge are most effectively made when learners expend effort by adopting a "set to relate the material to cognitive structure" (Ausubel, 1962, p. 213) and "reformulate new propositions in their own words" (Ausubel et al., 1978, pp. 123-124). Ausubel

et al. (1978) found that greater effort and attention are given after longer retention intervals, when learners perceive a greater need, since more forgetting has occurred:

After a longer retention interval, when more material is forgotten, the learner is more highly motivated to profit from the opportunity for review. He or she is less likely to regard this opportunity as unnecessary and superfluous, and is therefore more disposed to take good advantage of it in terms of effort and attention. (p. 319)

Although connectedness and effort are the foundation of significance in Ausubel's theory of meaningful learning he also acknowledged intensity as a factor in some cases—especially in the learning of rote materials—specifically noting intensity in the forms of "unusual vividness" (Ausubel, 1962, p. 216), "primacy," "uniqueness," and "enhanced discriminability" (p. 218).

Connectedness is also the central idea underlying schema theory. New information is interpreted and understood as relevant schemata are activated and new information is fit into the existing schema (Anderson et al., 1978, p. 434; Pichert & Anderson, 1977, p. 314; Rumelhart & Norman, 1976, p. 13) by binding or encoding it in terms of the variables of the activated schema (Rumelhart & Norman, 1976, p. 10). In this way schema impose structure on the new information (Pichert & Anderson, 1977, p. 309).

Schemata also function as a filter inasmuch as new information that fits the schema will be prioritized over information that does not (Anderson et al., 1978, p. 439). Later recall of learned information is facilitated by schemata, which are used in production as a retrieval plan "to provide implicit cues for important elements" (Pichert & Anderson, 1977, p. 309). Thus, schemata provide significance both for incoming information to be learned and coherence to communication later produced and ideas recalled by the learner. For example Bower, Black and

Turner (Bower et al., 1979, abstract) found that "a scrambled text that presented some script actions out of order tended to be recalled in canonical order."

Another aspect of significance in the view of schema-based learning theory is that the structuring of new schema is dependent upon the prior accretion of information. In other words, a given schema is only meaningful in its connection to—and power to anticipate, explain, or describe—a set of relevant experiences. In this way, "accretion of information would appear to be a necessary pre-requisite for restructuring; there must be a backlog of experiences and memories on which to base the new structures" (Rumelhart & Norman, 1976, p. 5).

Connectedness, effort and attention are also important aspects of learning in constructive learning theory. King (1994p. 340) found that questions which prompted “comparing and contrasting, inferring cause and effect, noting strengths and weaknesses, evaluating ideas, explaining, and justifying” were especially effective in promoting learning. Brooks and Brooks (1993) recommend encouraging student attention and effort by “asking thoughtful, open-ended questions and encouraging students to ask questions of each other” (p. 110) and seeking elaboration of student's initial responses (p. 111).

Piaget (1969) described awareness of connections inherent in external stimuli (significance) as only possible when they can be assimilated by means of existing structures:

The organizing activity of the subject must be considered just as important as the connections inherent in the external stimuli, for the subject becomes aware of these connections only to the degree that he can assimilate them by means of his existing structures....that is to say, the input, the stimulus, is filtered through a structure that consists of the action-schemes (or at a higher level, the operations of thought), which in turn are modified and enriched when the subject's behavioral repertoire is accommodated to the demands of reality. The filtering or modification of the input is called assimilation; the modification of internal schemes to fit reality is called accommodation. (pp. 5-6)

Bruner described significance as "representing the structure of [a] subject in terms of the child's way of viewing things" (J. S. Bruner, 1960, p. 33) so that it makes sense to the child. He also noted that "understanding the fundamentals makes a subject more comprehensible" (p. 23). Here again, we see a theme of significance through connecting previous learning with new learning, for a subject is only comprehensible when there is a prior understanding of fundamentals.

In human learning theory, Fuller (1962, p. 24) explained that some sensations are more significant than others, for example, the relief of hunger following a meal is more gradual than the cessation of pain through escape. Stimuli also lose novelty with repetition, and excessive novelty may give cause for activation without organizing a direct response (p. 92). Rogers (1969, pp. 3-4) explained significant learning as learning that involves feeling, personal meaning, and relevance. He said that much significant learning is acquired through doing, and maximized through active participation. "When [the learner] chooses his own directions, helps to discover his own learning resources, formulates his own problems, decides his own course of action, lives with the consequences of these choices, then significant learning is maximized"(p. 162).

Vygotsky said that learning has significance when "an external activity is reconstructed and begins to occur internally" (Vygotsky, 1978, p. 57). "The internalization of cultural forms of behavior involves the reconstruction of psychological activity on the basis of sign operations" (p. 57). When another person responds to one's actions—for example, when a mother responds to a baby's reaching for a toy beyond its grasp—the action becomes significant and the baby internalizes the symbolic gesture of pointing and a culturally mediated sign:

We call the internal reconstruction of an external operation *internalization*. A good example of this process may be found in the development of pointing. Initially, this

gesture is nothing more than an unsuccessful attempt to grasp something, a movement aimed at a certain object which designates forthcoming activity. The child attempts to grasp an object placed beyond his reach; his hands, stretched toward that object, remain poised in the air. His fingers make grasping movements. At this initial stage pointing is represented by the child's movement, which seems to be pointing to an object—that and nothing more.

When the mother comes to the child's aid and realizes his movement indicates something, the situation changes fundamentally. Pointing becomes a gesture for others. The child's unsuccessful attempt engenders a reaction not from the object he seeks but *from another person*. Consequently, the primary meaning of that unsuccessful grasping movement is established by others. Only later, when the child can link his unsuccessful grasping movement to the object situation as a whole, does he begin to understand this movement as pointing. At this juncture there occurs a change in that movement's function: from an object-oriented movement it becomes a movement aimed at another person, a means of establishing relations. *The grasping movement changes to the act of pointing*. As a result of this change, the movement itself is then physically simplified, and what results is the form of pointing that we may call a true gesture. It becomes a true gesture only after it objectively manifests all the functions of pointing for others and is understood by others as such a gesture. Its meaning and functions are created at first by an objective situation and then by people who surround the child. (p. 56)

Significance is found in attention, accurate perception of significant features, and expenditure of effort (Bandura, 1977b, p. 24). It is found in the commitment of time, intensified effort, increased responsibility, and sense of identity (Lave & Wenger, 1991, p. 111). It is found in resolution of actual contradiction in real-world situations (Engestrom, 2001, pp. 135, 137, 140, 142-145; Engestrom, 2010, pp. 3-4, 5, 7, 9, 11, 17-20); the learning of knowledge in context (J. S. Brown & Duguid, 1991, p. 47); active participation (J. S. Brown et al., 1989, p. 38); narratives and stories (p. 40); the learner's articulation of their "knowledge, reasoning, or problem-solving processes" (A. Collins et al., 1991, p. 14); and a sense of ownership, personal investment, and mutual dependency (p. 16). Table 7 summarizes the local principles from the theories reviewed that are subsumed by the universal principle of *significance*.

Table 7

Principles of Learning Subsumed by the Universal Principle of Significance

Theory Group	Local principles
Behavioral	<p><i>Aristotle:</i> Imagery Receptivity Relationship between significance and need for repetition</p> <p><i>Thorndike:</i> Amount of attention determines speed of learning Attention insured in acts where a definite movement is required Attention emphasizes and facilitates the process which it accompanies Effort: an animal cannot learn an act by being put through it</p> <p><i>Pavlov:</i> Size of conditioned reflex dependent on intensity of stimulus Relationship between intensity of stimulus and time to establish a conditioned reflex Effort: ejecting stones v. ejecting sand from mouth Association: CS gains meaning through pairing with UCS</p> <p><i>Watson:</i> Intensity of stimulus must be sufficient to elicit a response The animal must work steadily</p> <p><i>Skinner:</i> Intensity through hunger satiation The law of threshold Attention: work in area free from distractions Magnitude of response</p> <p><i>Hull:</i> Stimulus-intensity dynamism Drive reduction</p> <p><i>Guthrie:</i> Stimulus threshold intensity Dynamogenesis Significance through isolation of association (preventing an association from being unlearned) Emotional reinforcement Intention to learn Significance by doing</p> <p><i>Estes:</i> Attention: effective stimulus elements</p>
Cognitive	<p><i>Ebbinghaus:</i> Mental vigor and receptivity Meaning, rhythm, rhyme, and a common language</p>

Intensity of attention and interest

Tolman:

Attention as 'persistence until'
'Working over' and 'elaboration'
Strong appetite

Kohler:

Actively attending to the effort of trying
Desire to obtain food

Cognitive Information Processing:

Active effort to encode
Elaboration
Deep processing
Reasoning
Overt response
Organization, elaboration, and cognitive activity
Mindless drilling vs. attentive learning
Getting attention
Limited attention
Learner choice
Attention as a filter
Attention as a tuner
Attention as allocation of capacity
Point of attachment in consciousness
Strength – significance is created through rehearsal
Connecting new information to something meaningful
Leveraging preexisting associations to encode new information
Intensity: emotionally powerful

Ausubel:

Meaningful v. rote
Meaning through subsumability
Adequately established subsuming ideas in cognitive structure
Central unifying ideas
Anchoring ideas
Anchorage, dissociability, and oblitative subsumption
Discriminability
Set (attitude) to relate new material to cognitive structure
Effort and attention result from learner's perception of need
Reformulate new propositions in own words
Intensity: unusual vividness
Intensity: primacy, uniqueness, enhanced discriminability

Schema Theory:

Connected: new information fit into existing schema
Schema activation
Structure imposed by schema on new information
Schema as filter for what will be learned
Schema as retrieval plan
Significance of text elements depends on schema
New structures are based on a backlog of experience and memories
Variable binding

Schema selection
Understanding based on level of specificity of the activated schema

Constructive

General:

Effort encouraged through guided questioning
Learning requires extended learner effort
Student participation through inquiry methods
Cross domain (physical, intellection, emotional, and social) experience
Intentional process of constructing meaning from information and experience
Significance due to language, cultural, and social background
Meaningful learning
Possibility of application

Piaget:

Awareness of connections only by means of existing cognitive structures
Assimilation

Bruner:

Representing the structure of a subject in terms of the child's view
Understanding fundamentals
Importance of detail
Discovery facilitated through prior experience and knowledge
Accessibility in memory
Exercise of problem solving and effort of discovery

Human

Biological Motivation:

Relative significance of relief from hunger versus pain
Decrease in novelty with repetition
Excessive novelty may activate without organizing a direct response

Freedom to Learn:

Feeling
Personal meaning
Relevance
Much significant learning is acquired through doing
Learning is facilitated when the student participates responsibly in the learning process
Significant learning is maximized through participation

Social

Vygotsky:

Symbolic representation
Response of others to one's own actions
Internalization
Attention and interest (in primitive stage), then relation to inner framework (fourth stage)

Bandura:

Attention, accurate perception, and significant features
Expenditure of effort

Situated learning:

Commitment of time, intensified effort, more and broader responsibilities, and sense

of identity

Activity theory:

Resolution of actual contradictions in real-world situations

Cognitive apprenticeship:

Knowledge in context

Active participation

Narratives and stories

Articulating

A sense of ownership, personal investment and mutual dependency

Feedback. All intentional or directed learning is aimed at the attainment of some target. Feedback is the means by which the learner, or any other agent directing the learning process, ascertains whether or not progress is being made toward the end goal, and whether or not the goal has been reached.

Aristotle recognized the importance of feedback—in particular, the role of external feedback from a teacher—in making a difference between learning to do something well and learning to do something poorly:

The material form from which and the means by which any form of goodness is produced and those by which it is destroyed are the same.... for it is by playing the lyre that both good and bad lyre-players are produced, and it is the same with builders and the rest. It is by building well that they will become good builders and by building badly that they will become bad builders. If it were otherwise, we should have no need of anyone to teach us; all would become good or bad as the case might be. (Aristotle & Burnet, 1913, p. 45)

Feedback was central to Thorndike's theory of learning, cast in terms of his law of effect. He believed, based on his own experimental evidence, that repetition in the absence of feedback does nothing to improve performance. In an experiment in which subjects were blindfolded and repeatedly asked to draw a four-inch line with one quick movement Thorndike discovered that doing so 3,000 times "caused no learning" because the lines drawn in the eleventh or twelfth

sittings were “not demonstrably better than or different from those drawn in the first or second” (Thorndike, 1931, p. 10). He also explored the relative effectiveness of positive and negative feedback through a variety of experiments and concluded that satisfiers (reward) and annoyers (punishment) are not equal in their power to strengthen or weaken a connection. In one such experiment students learned Spanish vocabulary by selecting for each Spanish word one of five possible English meanings followed by the rewarding feedback of being told “Right” or the punishing feedback of being told “Wrong.” From the results of this experiment Thorndike concluded that punishment does not diminish response as originally stated in the law of effect. In his own words,

Indeed the announcement of “Wrong” in our experiments does not weaken the connection at all, so far as we can see. Rather there is more gain in strength from the occurrence of the response than there is weakening by the attachment of “Wrong” to it. Whereas two occurrences of a right response followed by “Right” strengthen the connection much more than one does, two occurrences of a wrong response followed by “Wrong” weaken that connection less than one does. (Thorndike, 1931, p. 45)

He also observed a “spreading of effect,” meaning that “a satisfying after-effect” not only strengthens “the connection which it follows directly and to which it belongs” (p. 174), but also strengthens “by a smaller amount the connections preceding and following that, and by a still smaller amount the preceding and succeeding connections two steps removed” (p. 174).

In the reflex-type conditioning of Pavlov feedback is simply the administration of the unconditioned stimulus, or the lack thereof. “If for a long time, such as days or weeks continuously, a certain kind of food is shown to the animal without it being given to him to eat, it loses its power of stimulating from a distance” (Pavlov et al., 1928, p. 85).

Watson described feedback in two forms: (a) punishment and (b) satisfaction of a need (Watson, 1914, pp. 204-206). He also compared the process of adjustment¹¹⁵ in man to the satisfaction a hungry animal experiences when food is introduced into the stomach, noting that man “becomes adjusted only when he reacts in such a way as to bring about the disappearance of the particular organic stimulus which is acting at the moment” (Watson, 1919, p. 271). This removal of the drive stimulus provides feedback to the man that the actions which led to his current state were successful in removing the stimulus and sets the expectation of future success in similar situations.

The work for which B. F. Skinner is most well known in relation to behavioral psychology is his method of operant conditioning, which relies completely on reinforcement, which may be administered according to various schedules. For a detailed description of each schedule type see Ferster and Skinner (1957). With no intention to trivialize his program of research or method of operating conditioning, I believe it is fair to say Skinner’s method is simply one of directing learning or behavior by providing feedback to the organism, or rather controlling consequences to the organism’s emitted behavior. In his own words, “Behavior is shaped and maintained by its consequences” (Skinner, 1989, p. 14). Using this method, by controlling the type, amount, timing, and schedule of reinforcement, the experimenter directly controls the feedback received by the subject, and thereby indirectly controls its behavior:

“The Law of Effect has been taken seriously; we have made sure that effects *do* occur and that they occur under conditions which are optimal for producing the changes called learning. Once we have arranged the particular type of consequence called a

¹¹⁵ Meaning a change in behavior.

reinforcement, our techniques permit us to shape up the behavior of an organism almost at will." (Skinner, 1961g, pp. 145-146)

One of the most important factors in providing effective reinforcement is that it must be given "almost simultaneously with the desired behavior" (Skinner, 1961e, p. 413). Hull (1942) called out reinforcement as the source for the "increment of a habit" (p. 72) and agreed on the importance of the concomitant timing of reinforcement and behavior:

In higher organisms, through some process of learning not yet wholly clear, the power of reinforcement is extended to any stimulus situation which has been consistently and rather closely associated in time with the reduction in a primary need, or even with any *other* stimulus so associated. Stimuli (or the objects yielding these stimuli) which have thus become reinforcing states of affairs are said to be *secondary reinforcing agents*, and reinforcements so mediated are called *secondary reinforcements*. (pp. 67-68)

Timing of feedback was also mentioned in the challenge Guthrie noted, particularly with children, of connecting present punishment with prior behavior. He felt this connection was so problematic that instead of providing feedback in the form of post performance punishment, he recommended the arrangement of circumstances to as to ensure performances of the desired action:

"The child that is punished at eight in the evening because he did not return home at seven will learn as a result of the punishment; but what he will learn will be problematical. Unless he is as rational as the average adult and can establish a chain of associations through complicated speech cues while he is brooding over his punishment, one thing he will not learn is to return in the future at seven. *He learns what he does*. To achieve a habit of returning at seven it is necessary with the average child to forget the first unfortunate outcome, which is now past and has had its bad effect on habit, and to lay plans to insure that the next evening he will be reminded in time and perform the action as it is desired." (Guthrie, 1942, p. 26)

Guthrie's formal position on feedback appears to have been that it does not play a role in learning, and his primary thrust was an attempt to reduce "established facts of learning" (Guthrie,

1930, p. 412) to the simple principle of association of contiguity. Feedback did not seem to play a role in his formal theory. However, though somewhat inconsistent with his formal position, Guthrie did on occasion mention feedback—e.g., in terms of (a) drive removal, (b) instructor guidance (or interruption), and (c) the learner's own recognition of failure:

The successful act or series of acts is learned because it is always the last association with the drive and... **this association remains because the drive has been removed** [italics added] by the consummatory response. (Guthrie, 1939, p. 481)

A first lucky drive to the green, a first arrow on the target, or the first strike at bowling does not make a man a golfer, an archer or a bowler. The fortunate outcome was an accident. But it is out of accidents that skills are made. The next try is likely to be from a different stance and to have less fortunate results. The very fact that it is a second try rather than the first means that the action has a different beginning. In order to master the sport, the beginner must be exposed to the variety of situations that are encountered in the course of play. His awkward and erroneous movements must be somehow eliminated. *His instructor's words or his own recognition of failure may lead to changes of attack with the result that new movements are attached to the situation* [italics added]. The problem of teaching skills is largely the problem of *breaking up wrong action and encouraging practice* [italics added] in which there is eventually a chance of successful movement. The track coach or the orchestra leader *may correct many obviously wrong methods by interrupting the activities and suggesting new behavior to replace the wrong methods* [italics added]. His *method is to interrupt in order to discourage wrong movements and to leave undisturbed the right movements* [italics added] when they finally appear. *They will remain unless something happens to cause other behavior to be established in their place.*" (Guthrie, 1942, p. 36)

Estes described reinforcement as having both "informational and motivation components" (W. K. Estes, 1967, p. 3; W. K. Estes, 1982b, p. 46). The motivational component identifies the reinforcer as either pleasurable or painful. The informational component provides information about whether the response was correct or incorrect. Leahey and Harris (1997, pp. 57-58) apply this perspective to explain the results of Tolman's experiment of learning a punchboard maze—results which contradict the prediction suggested by the law of effect, namely, that punishment would discourage behavior while reward would encourage it.

The experiment contained four groups: bell-right, bell-wrong, bell-right-shock, and bell-wrong-shock. Both “bell-right” groups did better than the “bell-wrong” groups and the “bell-right-shock” group learned in spite of receiving shocks with their rate of learning not significantly different from the ‘bell-right” group (Tolman, Hall, & Bretnall, 1932). Leahey and Harris interpret these results to mean that the informational component of the shock for the bell-right-shock group was of greater influence than the physical discomfort of the shock.

Estes (1967) also cites studies suggesting that individuals do not necessarily have to be aware of the connection between their responses and reinforcing operations in order for reinforcement to be effective:

Suitably programmed rewards controlled the occurrence of verbal behaviors in a manner predictable from analogous studies of operant behavior in animals, and, in particular, that effects of rewards were independent of the subjects' awareness of relationships or contingencies between their responses and reinforcing operations. (p. 1)

In cognitive learning theory we find the study of memory by Ebbinghaus marked by three forms of feedback: (a) the possibility of reproduction , (b) the ease of recall, and (c) the ease of relearning. The successful learning of a given content is evident first by the possibility of unaided reproduction (Ebbinghaus, 1913, p. 4). Another indicator of progress toward the end goal of completely unaided reproduction of a series is the ease with which it can be "read" from an "inscription" on the "mental substratum"(pp. 52-53): the greater the learning, the deeper the engraving. The third feedback indicator is the savings in relearning the list, that is, the reduced amount of time required to the first unaided and complete production of the list, as compared with the time required for the previous learning (p. 61). In contrast with the reward and punishment type feedback of behavioral learning theory we find a form of feedback in which

learning progress is directed not by the imposition of reinforcement by an external agent but by some internal motivation to reach a goal and self-evident progress of performance toward the goal.

Tolman's research adds to this perspective the possibility of retaining the feedback of learned consequences and using it in subsequent settings to make behavior choices. In addition to the punchboard maze experiments previously mentioned, Tolman provided two additional insights on feedback in learning, one theoretical and one experimental. The first is found in his criticism of what he referred to as "the trial and error doctrine" (Tolman, 1932, p. 364). "Correct stimulus-response connections," he said, "do not get 'stamped in,' and incorrect ones do not get 'stamped out.'" Instead, he believed that the response selected in a given situation was determined by the previously learned consequences of each available alternative.

The second insight comes from the cleverly designed "Searching for the Stimulus" experiments (Tolman, 1948). In these experiments rats who received a shock after attempting to eat out of a food cup set in front of a striped visual pattern were observed to "look around *after* the shock to see what it was that had hit them" (p. 201). It was found that these rats would avoid going near the cup, or even try to hide the cup and striped pattern with sawdust, even months after only one shocking encounter. When the conditions of the experiment were modified so that the lights would briefly go out coincidental to the shock—during which time the pattern and food cup dropped out of sight—a large percentage of the rats that were put back into the cage only 24 hours later showed no avoidance of the striped pattern. Thus, while it may be true that individuals do not necessarily have to have conscious awareness of the connection between their responses and reinforcing operations for the reinforcing operations to be effective, Tolman's

experiment suggest that the connection must be made, at least at some level, in order for learning to occur:

Mindless drilling practice leads to little improvement. For practice or drill of any kind to be effective, it should be mindful, or deliberate. Individuals should be attentive to what they are doing. They should watch for and correct errors and work toward improvement (Ericsson, 1996a, 1996b). (Sternberg & Williams, 2010, p. 336)

Ausubel et al. (1978, p. 310) described feedback as knowledge of results rather than reinforcement of correct responses. He described the process by which concepts are formed as a process of ongoing hypothesis generation and testing (p. 56) and stated that the consolidation of ideas—a necessary step in order to establish a framework of subsuming ideas—is achieved "through confirmation, correction, clarification, differential practice, and review in the course of repeated exposure, with feedback, to learning material" (p. 197). He also introduced an additional type of feedback which is the "internal logic of meaningfully learned material" that "allows for more self-provided feedback that do inherently arbitrary associations" (p. 310).

Ausubel et al. (1978) cited Thorndike to support a position that learning cannot take place in the absence of feedback:

Thorndike's research on frequency (1931, 1932) is often cited as proof that the effect of frequency is negligible on learning. However, "it merely demonstrates that certain atypical kinds of learning cannot take place in the absence of explicit intention or feedback, no matter how frequently the learning task is repeated. (p. 316)

Ausubel (1962) also noted that feedback from an instructor can assist learners in identifying similarities and differences between new materials and "their presumed subsumers in cognitive structure" (p. 219).

Two types of self-recognized feedback are suggested by schema theory (Rumelhart & Norman, 1976, p. 17). They are (a) limited utility of accumulated information, and (b) incongruence with functional demand. In the first type, a critical mass of information has accumulated in the mind, but the initial organization of the various individual pieces of information is recognized as no longer sufficient for effective utilization of the body as a whole. As it grows it becomes unwieldy and "gives rise to the need for restructuring" (p. 4).

The second type has to do with recognition that an existing schema does not meet functional demands due to (a) insufficient accuracy, (b) overly narrow constraints, (c) overly broad constraints, or (d) unspecified default values. In the first case, *insufficient accuracy*, it is recognized that the variable terms of the schema need to be improved in order to "specify the concepts that fit the variables with more accuracy" (p. 17). In the second, *overly narrow constraints*, it is discovered that the range of a given variable in a schema needs to be generalized to "extend its range of applicability" (p. 17) to include other relevant cases that the schema should account for. In the third, *overly broad constraints*, the range of a given variable needs to be constrained by "adding to the constraints of the variable or, in the extreme, by effectively replacing the variable with a constant term" (p. 17). In the fourth, *unspecified defaults*, it is found that default values for the variables of the schema, which provide for making intelligence guesses when making inferences or to guide further processing, have not yet been specified. In all cases, discrepancy must be recognized by the learner in order for restructuring to occur (pp. 21-22).

In applied constructive learning theory, feedback results from the interaction of new and existing knowledge, in particular, as "new information prompts the emergence or enhancement of cognitive structures that enable us to rethink our prior ideas" (Brooks & Brooks, 1993, p. 15)

or when students are engaged in "experiences that might engender contradictions to their initial hypotheses" (p. 112). This idea comes from Piaget, who believed that the functioning of reflexes, specifically, and accommodation, in general, is driven by interaction with the environment. "Certain instincts are lost or certain reflexes cease to function normally, due to the lack of a suitable environment" (Piaget, 1963, p. 30). It is through feedback, received first through the senses, and later through "the new structure of thought"(Piaget & Inhelder, 1969, p. 131), that the infant develops its sensorimotor action schemes and subsequent cognitive substructures. It is the constant sensory feedback and consequences of action that facilitate development of "the broad categories of action which are the schemes of the permanent object, space, time, and causality" (p. 13).

Bruner described feedback as evaluation, and named it as one of three aspects of learning. "A third aspect of learning is evaluation: checking whether the way we have manipulated information is adequate to the task. Is the generalization fitting, have we extrapolated it appropriately, are we operating properly" (J. S. Bruner, 1960, p. 48)? In his model of discovery the student "is not a bench-bound listener, but is taking a part in the formulation"(J. S. Bruner, 1961, p. 23) and is constantly evaluating incoming information and reconciling it with his system of beliefs and understanding. This incoming information provides feedback as to whether or not his understanding accurately reflects the world around him.

Feedback in human learning theories consistently follows three themes: (a) the effects of outcomes, (b) the role of self-evaluation, and (c) secondary feedback through cognitive interpretation and attribution. From the outcomes of one's actions expectancies are derived and used to predict future outcomes (for example, J. W. Atkinson & Feather, 1966; Heider, 1958, p. 99; Keller, 2010, pp. 6-7). It is also the outcomes of action, in particular *accomplishments*, that

determine one's sense of worth and self-efficacy (Covington, 1984, pp. 8-9). Accomplishments are of greatest influence on self-worth and self-efficacy when they are attributed to be results of one's own effort and ability, rather than external or uncontrollable factors (Deci & Ryan, 1985, p. 61). For example, success resulting from remedial assistance is not usually valued as highly as success attributed to one's independent effort and ability (Covington, 1984, p. 8). Successes typically increase beliefs of self-worth and self-efficacy. Failures diminish them. Whether or not the outcome of action is considered a success or failure depends in part on one's prior expectations, or level of aspirations. Ferdinand Hoppe (as cited in Covington, 1998, p. 28) found that judgments of success or failure depend less on actual levels of performance, and more on the relationship between the individual's performances and aspirations. Feelings of success come when goals are achieved. Feelings of failure come when they are not.

Human learning theories often recognize all sources of feedback as being subject to cognitive interpretation and a process of causal attribution (Heider, 1958, p. 99; Weiner, 2010, p. 33). The result of this cognition form a secondary source of feedback. Feedback also comes through vicarious experiences in which one perceives the subject of observation as similar to oneself, and assumes that outcomes of the subject's actions will be similar to outcomes for one's own actions. It may also come in the form of verbal and social persuasion or physiological, somatic, or emotional responses to a given situation (Bandura, 1977a, pp. 191 (abstract), and 195-200; Bandura, 1994a, pp. 2-3).

Feedback affects intrinsic motivation when (a) it is positive rather than negative (Deci & Ryan, 1985, pp. 60-61), (b) the locus of causality is perceived to be internal (p. 61) and (c) it is informational rather than controlling (p. 92). In most human theories—especially those centered on models of agency, self-regulation, or self-determination—feedback from others is of

secondary importance in comparison to feedback from one's own self-awareness, self-monitoring, self-recording, and self-evaluation (Rogers, 1969, p. 163).

In social learning theory, two sources of feedback are typical. The first is found in the consequences of one's actions. For example, Vygotsky (1994b, p. 64) described four stages of the child's cultural development. In the first "the younger child tries to remember the data supplied to him by a primitive or natural means" (p. 64). In the second stage the child begins to use a mnemotechnical method—e.g., using picture cards available to him. The transition from the first to the second stage is usually made only after the child discovers—through the result and consequences of his actions—that he is unable to remember the information on his own. In another example, from situated learning, Lave (1988) found that participants in her studies often made multiple attempts before solving problems. In the process they checked their partial or interim solutions to see if they were consistent with reality and if they were likely to reach a satisfactory answer using their chosen method. One of the advantages of situated learning is the "immediate ground for self-evaluation" (Lave & Wenger, 1991, p. 111) that it provides. "The scarcity of tests, praise, or blame typical of apprenticeship follows from the apprentice's legitimacy as a participant" (p. 111). Another example of feedback through consequences, from expansive learning theory, are the contradictions manifested in accepted practice that cause members of the group to question, criticize, or reject some aspects of the existing practice (Engestrom, 2010, p. 7). In solving problems in cognitive apprenticeship "the adequacy of the solution they reach becomes apparent in relation to the role it must play in allowing activity to continue" (J. S. Brown et al., 1989, p. 36).

The second type of feedback typically mentioned in social learning theory is input from others, for example, in the learning of complex skills:

A common problem in learning complex skills, such as golf or swimming, is that performers cannot fully observe their responses, and must therefore rely upon vague kinesthetic cues or verbal reports of onlookers." (Bandura, 1977b, p. 28)

In cognitive apprenticeship, this type of feedback comes through coaching:

Coaching consists of observing students while they carry out a task and offering hints, scaffolding, feedback, modeling, reminders, and new tasks aimed at bringing their performance closer to expert performance....The content of the coaching interaction is immediately related to specific events or problems that arise as the student attempts to accomplish the target task. (A. Collins et al., 1991, p. 14)

Table 8 summarizes the local principles from the theories reviewed that are subsumed by the universal principle of *feedback*.

Table 8

Principles of Learning Subsumed by the Universal Principle of Feedback

Theory Group	Local principles
Behavioral	<p><i>Aristotle:</i> Guidance from teachers necessary to produce good builders</p> <p><i>Thorndike:</i> Law of effect Reward versus punishment Spread of effect</p> <p><i>Pavlov:</i> Presence or absence of UCS in conjunction with UCS</p> <p><i>Watson:</i> Response of a care giver Satisfaction of a need Feedback as reinforcement usually in the form of punishment or food</p> <p><i>Skinner:</i> Feedback as reinforcement Positive reinforcement Negative reinforcement Primary reinforcers Secondary reinforcers Schedules of reinforcement</p>

Timing of reinforcement

Hull:

Reinforcement

Law of effect

Guthrie:

No feedback, simply arrangement to ensure stimulus and response association

Drive removal

Instructor's words

Recognition of failure (in learning skills)

Estes:

Two dimensions of feedback: affective and cognitive

Linking responses to a particular stimulus population

Cognitive

Ebbinghaus:

Evidence of progress: ability to reproduce a list from memory

Evidence of progress: ease of recall

Evidence of progress: ease of relearning

Tolman:

Searching for the stimulus experiments

Affective versus cognitive dimensions of feedback

Consequences

Kohler:

Failure or success of attempts

Cognitive Information Processing:

Errors as a source of feedback

An accurate sense of both your current state and how far you have to go

Lack of feedback hinders performance

Feedback enables self correction

Ausubel:

Explicitly pointing out similarities and differences

Hypothesis generation and testing

Confirmation, correction, and clarification

Knowledge of results

Self-provided feedback via internal logic of meaningfully learned material

Learning cannot take place in the absence of feedback

Prompting replaced by confirmation as learning progresses

Schema Theory:

Incongruence with functional demand

Limited utility of accumulated information

Insufficient accuracy

Overly narrow constraints

Overly broad constraints

Unspecified default values

Recognition of discrepancy

Feedback through analysis

Constructive

General:

Contradictions to hypotheses
Guided practice
Standards assessment

Piaget:

Feedback through interaction with the environment

Bruner:

Evaluating: checking whether the way we have manipulated information is adequate to the task

Human

Achievement Motivation:

Expectancies for success and failure are formed from results of past successes or failures

Attribution Theory:

Action manifestations used to predict future action
Outcome
Outcome-dependent affect
Causal antecedents
Causal ascriptions
Causal dimensions

Self-Worth Theory:

Outcomes of performance
One's sense of worth depends heavily on one's accomplishments
Human beings tend to embrace success no matter how it occurs
Successes resulting from remedial assistance are not always valued as highly as successes resulting from one's own efforts
People will sometimes reject credit for their successes if they feel they cannot repeat them
Perceptions of ability (even in the absence of solid accomplishments)

Self-Efficacy:

Performance accomplishments or mastery experiences
Vicarious experiences
Verbal or social persuasion
Physiological, or somatic and emotional, states
The cognitive interpretation of physiological states based on beliefs of self-efficacy

Self-Determination Theory of Motivation:

Positive feedback enhances intrinsic motivation
Negative feedback and perceived incompetence decrease intrinsic motivation, unless the locus of causality is not perceived to be internal
Informative versus controlling feedback
Controlling feedback leads to less intrinsic motivation

Self-Regulation:

Self-awareness of performance outcomes
Effort feedback
Self-recording

Self-monitoring
Self-evaluation
Attributions

ARCS:
Effort-expectancy feedback loop
Performance-expectancy feedback loop
Satisfaction-value feedback loop

Freedom to Learn:
Significant learning is evaluated by the learner
Self-criticism and self-evaluation are basic and evaluation by others is of secondary importance

An Agentic Theory of Self:
Cognitive self-guidance
Self-reactiveness
Self-reflection

Social

Vygotsky:
Self-realized difficulty or failure

Bandura:
Awareness of connection between consequences and actions
Vague kinesthetic cues and verbal reports [or modeling] of onlookers

Situated learning:
Check against reality
Self-evaluation- opportunities for understanding how well or poorly one's efforts contribute are evident in practice

Activity theory:
Contradictions manifest in the accepted practice
Results of analyzing the situation to understand the contradiction
Results of examining the proposed model as a potential solution
Results of reflecting on and evaluating the process by which the solution was found

Cognitive apprenticeship:
Natural consequence of actions
Feedback through coaching
Self-monitoring and correction
Articulation and reflection

Context. Aristotle's famous law of contiguity (Ross & Aristotle, 1906, p. 111) has held up for literally hundreds of years in the study of human learning and underlies the principle of association behind both behavioral and cognitive learning theory. Application of this law toward

the understanding of the role of *context* suggests that all elements apprehended in the total learning situation—individually, in permutation, and as a collective—become associated with whatever it is that is being learned. Based on his own observations of cats escaping from puzzle boxes Thorndike found general agreement with this position, clarifying, however, that certain features of a situation will assume prepotency with the animal over others based on the utility of those features in escaping from the box (Thorndike, 1914a, p. 134). Furthermore this association of contextual elements will persist from one box to another, and therefore, "due to assimilation of analogous elements between two stimuli, an animal will respond to a novel stimulus in the way it has previously responded to a similar stimulus"(p. 135). Thorndike also explained the teaching of ordinary animal tricks as possible due to bonds contracted with the total situation (p. 136). The psychical reactions investigated by Pavlov were associations that formed between the activity of the dog's salivary glands and all the properties of sorts of objects present in the surroundings in which the dogs were fed:

In the psychical experiments the animal is excited by properties of the external object which for the work of the salivary glands are unessential, or by even entirely accidental and unimportant properties. Visual, auditory, and even pure olfactory properties of our objects, *per se*, applied to other objects, remain without any influence on the salivary glands; for they, on their side, possess no business relation, so to speak, to these properties. In our psychical experiments there appear before us as stimulators of the salivary glands not only such properties (appearance, sound, odour, etc.) of the various objects which are unessential for the work of these glands, but absolutely all the surroundings in which these objects are presented to the dog, or the circumstances with which they are connected in real life. For example, the dish in which it is presented, the furniture upon which it is placed, the room, the person accustomed to bring it, and the noises produced by him—his voice, and even the sound of his feet—though at the moment he cannot be seen."(Pavlov et al., 1928, pp. 51-52)

Watson attributed conditions of the environment as both leading to the formation of new habits in response to environmental shifting (Watson, 1930, p. 197) and to the breakdown of

existing habits when established environmental conditions change (Watson, 1914, p. 49).

Skinner (1938) leveraged associations with specific properties in the environment to teach animals to respond only when certain properties of the stimulus were present (e.g., a tone or a light). This type of learning is referred to as discrimination learning. From his experiments Skinner formulated his laws of discrimination of the stimulus for both type S (p. 170) and type R (p. 228) conditioning.

To set the stage for, and enable the reader to appreciate, his discussion on the functional dynamics of compound conditioned stimuli, Hull (1943) gave an insightful analysis of the complex stimulus condition in the deceptively simple learning situation for a typical Pavlovian conditioned reflex:

As a matter of fact, the buzzer vibration makes up only a small part of the total number of stimulus components involved....Among the many additional components of the conditioned stimulus (*S*) not ordinarily mentioned are: the fact that the animal's two ears receive the buzzer vibrations with different intensity or in different phase, depending (1) the direction of the bell from the dog's head and (2) the orientation of the head at the moment; the pressure of the dog's feet against the table top upon which it stands; the pressure of each of the three or four restraining bands upon the skin receptors of the dog's neck, thighs, etc.; the biting of a number of insects which may be hidden in the dog's hair; the contact of the capsule over the fistula; the pressure of the muzzle against the dog's head; the pressure of the rubber tube in the dog's mouth; the odor of the rubber from which the tube is made, together with a large number of miscellaneous odors to which the human olfactory receptors may or may not respond; the multitude of visual stimuli of light, shade, spatial combinations, etc., arising from the laboratory lamps and reflected from millions of points within the dog's visual field; the proprioceptive stimulation arising from the external and internal muscles of the dog's eyes as they fixate one object after another about the laboratory; the infinite number and variety of proprioceptive impulses originating in the several parts of the other muscles of the animal's body as they are employed in the maintenance of the postures taken from moment to moment; the too-little understood stimulations associated with the bodily state resulting from food, water, and sexual privation, rectum and bladder pressure, etc.; and, finally, the preservative traces of all the multitude of stimuli recently acting, whether the stimulus energy is continuing to act at that moment or not. *The conditioned stimulus in the experiment under consideration includes all of the immensely complicated stimulus elements here enumerated and many more besides;* nevertheless this list, incomplete as it is, should aid

the reader somewhat in overcoming the misleading suggestion of singularity and simplicity otherwise likely to be conveyed by the *S* of the symbol, sH_R . (pp. 205-206)

Guthrie (1942, pp. 31-32) used Pavlov's conditioning technique as an example to reconcile the apparent conflict between his theory of one-trial learning and the obvious need for practice. By controlling the external stimuli in the situation, Pavlov was able to reduce the number of pairings required to establish an association. Guthrie also applied this to rote learning in the classroom, concluding that "effective practice is conducted in the general situation in which we desire the future performance to be given" (p. 32). Estes' stimulus sampling theory described a process by which environmental elements are paired, a few at a time, with a response simply by being present in the active stimulus situation when the response is made (W. K. Estes, 1950, p. 96).

Ebbinghaus spoke of involuntary mental reproductions being "brought about through the instrumentality of other, immediately present mental images" (Ebbinghaus, 1913, p. 2). Tolman (1948, pp. 203-205) demonstrated rats' use of contextual clues (the walls of the room and lights) to navigate a modified maze. He also noted that his rats did not "merely passively receive and react to all the stimuli which [were] physically present" (p. 201) but demonstrated an "active selective character"(p. 201) in the building up of their cognitive maps. The use of tools by Kohler's chimpanzees was highly contextual. He found that "the best tool easily loses its situational value if it is not visible simultaneously or quasi-simultaneously with the region of the objective" (Kohler, 1951, p. 53).

In cognitive information processing, context has been shown to have a marked effect on pattern recognition, with symbols being interpreted largely based on their surrounding context (Driscoll, 2000, pp. 86-87). It is also generally believed, according to the principle of encoding

specificity, that the probability of recall depends on the similarity of context during initial learning and the context during later recall—with the context being defined by (a) the material being learned, (b) the mental set derived from the material, (c) the environmental surroundings, and (d) the mood or prevalent emotion and feeling of the individual during learning and retrieval (Leahey & Harris, 1997, pp. 147-149). "You recall best if the circumstances of recall match the circumstances of encoding. Even seemingly irrelevant aspects of the learning environment can be encoded along with class information and can later function as retrieval cues." (Sternberg & Williams, 2010, p. 290) It is also believed that one of the reasons positive transfer is difficult to achieve is because all learning is situated (p. 335). Richard Spiro and his colleagues (1991) suggest that "revisiting the same material, at different times, in rearranged contexts, for different purposes, and from different conceptual perspectives is essential for attaining the goals of advanced knowledge acquisition" (as cited in Woolfolk, 1998, p. 348).

Ausubel et al. (1978) wrote that "the defining attributes of a concept are learned most readily when the concept is encountered in a large number of different contexts" (p. 113) and that "the proper balance between heterogeneity and consolidation can be achieved by promoting mastering within a given context or subcategory...before proceeding to another context" (p. 113). Transfer is facilitated by learning principles in as wide a variety of situations as possible (p. 200), and learning is enhanced "when the conditioned of practice closely resemble the conditions under which the skill or knowledge in question will eventually be used" (p. 342).

Rumelhart and Norman (1976, pp. 6-7) described two types of information in memory. Some information "is particular to the situation that it represents" (p. 6), other information is more general and is "an abstraction of the knowledge of particular situations to a class of situations" (pp. 6-7). As has already been discussed in chapter 3, the latter type of information is

the mental schemas we activate to interpret a given situation. The enacted schema provides a mental context of expectations by way of variables and default values. "The different variables in a schema are often constrained" (p. 9), for example, "we do not expect to find all possible plants or animals on a farm" (p. 9).

A task force of the American Psychological Association assigned to develop a set of guidelines for school redesign and reform recognized the importance of the context of learning by stating that "learning is influenced by environmental factors, including culture, technology, and instructional practices" (Learner-Centered Work Group of the American Psychological Association's Board of Education Affairs, 1997). And, a major tenet of constructive learning theory in general is that students should work on real-world problems (Sternberg & Williams, 2010, p. 449) "using multiple representations of content to help students....develop realistic, flexible, and useful mental representations of knowledge that are not artificially limited as a function of having been learned in a particular context" (p. 450). The constructivist approach to memory "recognizes that prior experience and context affect how we encode memories, how we recall things, and what we actually recall" (Alexander, 1996 Greeno et al., 1996, as cited in Sternberg & Williams, 2010, p. 297).

The importance of context and the environment in Piaget's theory of development should be quite obvious. External objects are used in the development of the reflexes:

In studying the use of reflexes we have ascertained the existence of a fundamental tendency whose manifestations we shall rediscover at each new stage of intellectual development: the tendency toward repetition of behavior patterns and toward the utilization of external objects in the framework of such repetition. (Piaget, 1963, p. 42)

In fact, external objects and a suitable environment are critical in both the development and preservation of the infant instincts and reflexes. Without a suitable environment, they are lost:

Only practice will lead to normal functioning. That is the first aspect of accommodation: contact with the object modifies, in a way, the activity of the reflex, and, even if this activity were oriented hereditarily to such contact, the latter is no less necessary to the consolidation of the former. This is how certain instincts are lost or certain reflexes cease to function normally, due to the lack of a suitable environment. (Piaget, 1963, p. 30)

Bruner's theory of discovery learning brings the manipulable external world into a manipulable mental model of the environment:

"Two matters will concern us. The first has to do with the techniques or technologies that aid growing human beings to represent in a manageable way the recurrent features of the complex environments in which they live." (J. S. Bruner, 1964, p. 1)

"If we are to benefit from contact with recurrent regularities in the environment, we must represent them in some manner." (J. S. Bruner, 1964, p. 2)

In a way, Bruner's mental models of the environment are similar to Tolman's cognitive maps in rats. Tolman's rats were able to use their previously obtained knowledge of a maze to quickly navigate their way to food, once it was introduced into the maze. Similarly the child's "manipulable model of the environment that is governed by rules of implication....permits him to go beyond the information before him" (J. S. Bruner, 1964, p. 13). How could any child build such a model without having any experience with the world which he is supposed to model?

Context is also important to perception and interpretation. Heider (1958) explained that a stimulus "which is ambiguous as long as it is given singly, may become unequivocal with the addition of further data" (p. 51) and that it is the world outside of a person that is "the source of many events that are evaluated by the person in terms of their causal and affective significance"

(p. 51). These evaluations lead to understanding of causal forces and a perception of self-worth and self-efficacy. Bandura (1977a) noted that context is critical in the development of self-efficacy inasmuch as independent mastery in varied context promotes *authentic* personal efficacy:

The more varied the circumstances in which threats are mastered independently, the more likely are success experiences to authenticate personal efficacy and to impede formation of discriminations that insulate self-perceptions from disconfirming evidence. (p. 202)

Vygotsky gave great emphasis to the importance of context when he declared the basic law of historical human development to be "that human beings are created by the society in which they live and that it represents the determining factor in the formation of their personalities" (Vygotsky, 1994c, p. 176). Although he viewed development to be "conditioned by outward influences" (p. 64) and "the function of socio-cultural experience of the child" (p. 64), he also described it as being subject to, and a convergence of, both internal (biological) and external (social) factors:

Only at a certain level of the internal development of the organism does it become possible to master any of the cultural methods. Also an organism internally prepared absolutely requires the determining influence of the environment in order to enable it to accomplish that development. Thus, at a certain stage of its organic development the child masters speech. At another stage he masters the decimal system. (Vygotsky, 1994b, pp. 63-64)

According to Vygotsky, situational constraints are predominant in the life of the young child (Vygotsky, 1978, p. 96). Lewin demonstrated "the great difficulty a small child has in realizing that he must first turn his back to a stone in order to sit on it" (p. 96). This predomination of situational constraints continues until freedom is found through learning to act in a cognitive realm, which is largely developed through imaginative play:

Action in imaginary situation teaches the child to guide her behavior not only by immediate perception of objects or by the situation immediately affecting her but also by the meaning of this situation. Experiments and day-to-day observation clearly show that *it is impossible for very young children to separate the field of meaning from the visual field* because there is such intimate fusion between meaning and what is seen. Even a child of two years, when asked to repeat the sentence "Tanya is standing up" when Tanya is sitting in front of her, will change it to "Tanya is sitting down." (Vygotsky, 1978, pp. 96-97)

In play, "the child sees one thing but acts differently in relation to what he sees" (Vygotsky, 1978, p. 96). "Thus, a condition is reached in which the child begins to act independently of what he sees" (p. 96). When such a condition is reached however, the environment does not, by any means, go away, but the relationship between the child and the environment change. Paired with limited cognitive resources, objects in the environment can be used to assist a child in solving inner problems—e.g., by use of task-irrelevant objects such as "paper, pins, string, [or] small shot" (Vygotsky, 1994b, p. 60). With the acquisition of speech and graphics systems, the child becomes able to employ "cultural mnemonics" (pp. 60-61) to mediate connections between forms.¹¹⁶ And through the use of tools and speech, he masters "not only...the items of cultural experience but the habits and forms of cultural behaviour, [and] the cultural methods of reasoning" (p. 57). Through speech the child "begins to master his surroundings...[and produce] new relations with the environment in addition to the new organization of behavior itself"(Vygotsky, 1978, p. 25). Through use of tools he interacts with

¹¹⁶ I have taken to calling this the *ABX* triangle, which depicts the association between *A* and *B* as being mediated by a cultural mnemonic *X*. This same triangle—later labeled by Vygotsky (1978, p. 40) as *SRX* to represent a mediated act in place of a simple stimulus-response association—is the same triangle that Engestrom (1987, p. 22) used as a precursor to his triangular model of human activity.

the environment, learns the ways of his culture, and is changed himself. Vygotsky's close associate and collaborator, Alexander Luria, stated it this way,

The tools used by man not only radically change his conditions of existence, they even react on him in that they effect a change in him and in his psychic condition. In the complicated inter-relations with his surroundings his organization is being differentiated and refined; his hand and his brain assume definite shapes, a series of complicated methods of conduct are being evolved, with the aid of which man adapts himself more perfectly to the surrounding world.

No development—that of the child included—in the condition of modern civilized society can be reduced merely to the development of natural inborn processes and the morphological changes conditioned by the same; it includes, moreover, that social change of civilized forms and methods which help the child in adapting itself to the conditions of the surrounding civilized community." (Luria, 1994, p. 46)

Bandura also described environmental influences as "partly [determining] which forms of behavior are developed and activated" (Bandura, 1989, p. 5). He also found that moral judgments are influenced by context:

Self-directed influences are not governed solely by moral standards. Actions give rise to self-reactions through a process of moral reasoning in which conduct is evaluated in relation to environmental circumstances as well as personal standards. Situations with moral implications contain many decisional ingredients that not only vary in importance but may be given lesser or greater weight depending upon the particular constellation of events in a given moral predicament. Thus, for example, judgments of the reprehensibility of conduct will vary depending upon the nature of the transgression; the degree of norm violation; the contexts in which it is performed; the perceived situational and personal motivators for it; the immediate and long-range consequences of the action; whether it produces personal injury or property damage; and the characteristics of those toward whom the action is directed and their perceived blameworthiness. (p. 52)

Given the contextual relativity of moral judgments, an important contribution Bandura has made toward the preservation of values in society is an understanding of the role that media play in creating a *symbolic environment*:

The video system has become the dominant vehicle for disseminating symbolic environments both within and across societies. Whereas previously, modeling influences were largely confined to the behavior patterns exhibited in one's immediate environment, television has vastly expanded the range of models to which members of society are exposed day in and day out. By drawing on these modeled patterns of thought and behavior, observers can transcend the bounds of their immediate environment. New ideas and social practices are now being rapidly diffused by symbolic modeling within a society and from one society to another. Whether it be thought patterns, values, attitudes, or styles of behavior, life increasingly models the media (Bandura, 1986; Pearl, Bouthilet, & Lazar, 1982). (Bandura, 1989, p. 22)

The focus of situated learning is on legitimate peripheral participation, contextualized in communities of practice in which "activities, tasks, functions, and understandings do not exist in isolation [but are] part of broader systems of relations in which they have meaning" (Lave & Wenger, 1991, p. 53):

These systems of relations arise out of and are reproduced and developed within social communities, which are in part systems of relations among persons. The person is defined by as well as defines these relations. Learning thus implies becoming a different person with respect to the possibilities enabled by these systems of relations." (Lave & Wenger, 1991, p. 53)

These same relations are true in activity theory, in which expansive learning (Engestrom, 1987) takes place in an everyday, real-world context, such as the workplace (Engestrom, 2001).

The position of cognitive apprenticeship theory regarding context is made clear in its name. "The term *apprenticeship* helps to emphasize the centrality of activity in learning and knowledge and highlights the inherently context-dependent, situated, and enculturating nature of learning" (J. S. Brown et al., 1989, p. 39). In considering the context provided by school classrooms, proponents of cognitive apprenticeship raise two concerns: (a) that classroom tasks do not supply necessary contextual features of authentic activity, and (b) that students come to rely on features in the classroom context that is foreign to the authentic activity:

Classroom tasks, therefore, can completely fail to provide the contextual features that allow authentic activity. At the same time, students may come to rely, in important but little noticed ways, on features of the classroom context, in which the task is now embedded, that are wholly absent from and alien to authentic activity. (J. S. Brown et al., 1989, p. 34)

Similar to Vygotsky's description of using external objects to solve inner problems (Vygotsky, 1994b, p. 60), cognitive apprenticeship theory describes how a portion of the cognitive task can be offloaded to the environment by manipulating available external objects (J. S. Brown et al., 1989, pp. 35-36). Two other key characteristics of cognitive apprenticeship are the social context in which learning takes place and the situated learning of tasks. Benefits of the social context are (from A. Collins et al., 1991, p. 2) (a) learners have access to models of expertise, often more than one; (b) learners understand from observing these models that tasks may be carried out in more than one way; and (c) learners are able to observe other learners with varying levels of skill and set benchmarks for their own progress. Benefits of the situated learning of tasks are (from A. Collins et al., 1991, p. 16) (a) the situated environment reflects multiple uses of knowledge being learned, (b) learners understand the purposes or uses of knowledge being learned, (c) learners actively use knowledge while learning, (d) learners learn the conditions of application, and (e) learners are able to abstract knowledge through multiple contexts. Table 9 summarizes the local principles from the theories reviewed that are subsumed by the universal principle *context*.

Table 9

Principles of Learning Subsumed by the Universal Principle of Context

Theory Group	Local principles
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Behavioral

Aristotle:

Law of contiguity (things experienced together become associated)

Thorndike:

Features of a situation

Assimilation: analogous elements between stimulus situations

Bonds contracted with the total situation

Pavlov:

All surroundings and properties of objects come to stimulate an anticipatory salivary reflex

Watson:

Break down in habit with change of conditions (e.g., removal to another room)

Skinner:

The law of the discrimination of the stimulus in type R

Hull:

Functional dynamics of compound conditioned stimuli

Guthrie:

Practice is necessary to the extent that the response must be elicitable from a variety of situations

Estes:

Effective sample of stimulus elements on a given learning trial

Cognitive

Ebbinghaus:

Mental states are brought about through the instrumentality of other, immediately present mental images

Tolman:

Active selection of significant stimuli

Use of contextual cues to navigate a modified maze

Kohler:

Situational value of a tool

Cognitive Information Processing:

Effect of context on pattern recognition

Probability of later recall depends on the similarity of context during initial learning and the context during later recall

Vocabulary best learned in context

Positive transfer is difficult to achieve because learning is situated

Advanced knowledge acquisition requires revisiting the same material at different times, in rearranged contexts, for different purposes, and from different conceptual perspectives

Ausubel:

The defining attributes of a concept are learned most readily when the concept is encountered in a large number of different contexts

Multicontextual learning facilitates the abstraction of commonality and strengthens the generality and transferability a concept

Balance between heterogeneity and consolidation
Transferability depends on application of a principle to as many specific contexts as possible during learning
Learning is enhanced when the conditions of practice closely resemble the conditions under which the skill or knowledge will be used

Schema Theory:

Some information in memory is particular to the situation it represents, other information is more general
Particular information is encoded with constant values substitute for variables of a general scheme
Variables in a schema are constrained
Default variable values

Constructive

General:

Environmental factors, culture, technology, and instructional practices
One way of creating student-centered learning environments is by presenting content in several contexts
Real-world context (accepting complexity)
Learning free of artificial context
Prior experience and context affect how we encode memories

Piaget:

Generalizing assimilation
Contact with the environment is necessary for the preservation, development, and coordination of reflexes
Utilization of external objects in the development of the reflexes
Signals developed through physical and visual contact with objects in the environment

Bruner:

Child's manipulable model of the environment and going beyond the information present
Structure of a subject
Language provides a release from immediacy
Recurrent features of complex environments

Human

Attribution Theory:

Otherwise impossible interpretation becomes possible through additional data
The world outside the person

Self-Efficacy:

Independent mastery in varied context promotes authentic personal efficacy

Social

Vygotsky:

Cultural improvement of psychological functions
Solving inner problems by means of exterior objects
The organism masters the means of cultural behavior supplied by the environment
Cultural mnemonics (the ABX triangle)
Development is conditioned by outward influences
The psychogenesis of cultural forms of behavior

Human beings are created by the society in which they live and it represents the determining factor in the formation of their personalities
Situational constraints of the young child
Freedom from external things through learning to act in the cognitive realm
Use of tools
The child produces relations with the environment through speech and tool use
Role of object and social environment in development

Bandura:

Environmental influences on behavior
Symbolic environment created by media (e.g., video games, TV, etc.)
Judgments of conduct influenced, in part, by context

Situated learning:

Legitimate peripheral participation in communities of practice
Systems of relations

Activity theory:

Every day, real-world context

Cognitive apprenticeship:

Reliance on classroom v. authentic context features
Off-loading part of the cognitive task to the environment
Learner's reliance on whatever context is available
"Indexicalized" representations
Context-dependent nature of learning
Social context of learning
Situated environment reflects multiple uses of knowledge being learned
Students understand the purposes or uses of knowledge being learned
Active use of knowledge while learning
Students learn conditions of application
Abstraction of knowledge through multiple contexts

Engagement. Aristotle described all men as having an inborn desire know.

All men by nature desire to know. An indication of this is the delight we take in our senses; for even apart from their usefulness they are loved for themselves; and above all the sense of sight. For not only with a view to action, but even when we are not going to do anything we prefer sight to almost everything else. The reason is that this, most of all the senses, makes us know and brings to light many differences between things. (Aristotle & Ross, 1908, line 980a)

Thorndike (1914a) described engagement as a matter of set or attitude (p. 133), a principle of readiness (p. 54), a possession of original tendencies from the very start of life (pp. 2-4, 6, 14), and "original satisfyingness of some states of affairs and annoyingness of others" (p.

50). He also highlighted the effects of mental effort and fatigue on persistence in learning. Mental effort, he said, is "the initiation or continuance or prevention or cessation of a certain response in spite of the intrinsic relative unsatisfyingness of that behavior" (p. 314). Mental fatigue is "the temporary deterioration of mental functions due to exercise without rest—its amount, rate and changes in rate, the factors constituting it, the conditions by which it is influenced, and the effect of such deterioration in one function upon the efficiency of others" (p. 283).

Inasmuch as his experimental subjects were compelled to participate in the conditioning of reflexes and the elicited responses were involuntary, Pavlov did not really address the topic of engagement. However, one interesting observation from his experiments that bears relevance is this: in some cases the significance of a situation demands a higher level of engagement than others, for example, the difference in the type and level of response between putting stones versus sand in the dog's mouth:

The stones are easily ejected and nothing remains in the mouth. But if you throw some sand in the dog's mouth (the same stones but pulverised) , there is an abundant flow of saliva. It is apparent that without fluid in the mouth, the sand could neither be ejected nor passed on to the stomach." (Pavlov et al., 1928, p. 48)

Watson (1914), in reviewing tests of the acquisition of simple motor habits on humans, such as "learning to typewrite, to toss and catch balls, to shoot with the long bow, etc." (p. 201) explained "plateau and breathing places" (p. 202) in some of the curves as a "failure to control incentives" (p. 202). With this explanation he called attention to the strength of motivation that arises from basic needs:

No such plateaux or resting places are to be found in the curves illustrating the motor acquisitions of animals. When an animal has to work or remain hungry; to make a correct

response at an alley or be punished, etc., the incentive may be said to remain at a maximum. The situation is clearly different when human beings are forced to learn to typewrite....If a man's food (reactions to sex stimuli, shelter, etc.) were dependent upon acquiring skill in a certain line—conditions which we can now control in the animals—such resting places and plateaux would in all probability disappear from his learning curves. (p. 202)

Skinner's studies were focused almost exclusively on the maintenance and development of behavior through careful schedules of contingent reinforcement. He described a reinforcer as "something your subject wants" (Skinner, 1961e, p. 413) or anything that "increases the chances that the animal will repeat the behavior" (p. 413). The reinforcer may be nature or conditioned. A conditioned reinforcer is "one an animal has observed in association with food(p. 413). More formally,

A reinforcing stimulus is defined as such by its power to produce the resulting change. There is no circularity about this; some stimuli are found to produce the change, others are not, and they are classified as reinforcing and non-reinforcing accordingly. A stimulus may possess the power to reinforce when it is first presented (when it is usually the stimulus of an unconditioned respondent) or it may acquire the power through conditioning. (Skinner, 1938, p. 62)

Skinner (1961f) cautioned that "it is dangerous to assert that an organism of a given species or age cannot solve a given problem" (p. 136), since "as the result of careful scheduling, pigeons, rats, and monkeys have done things during the past five years which members of their species have never done before" (p. 136), not because they were incapable, but because "nature had simply never arranged effective sequences of schedules" (p. 136). Behavior which is performed but not reinforced falls into extinction (Skinner, 1938, p. 21).

Although it is common to think of reinforcers in terms of food or punishment in the form of an electrical shock Skinner also described the reinforcing nature of social conditions, that is, how the actions of one person can serve as a reward or punishment to reinforce the behavior of

another (Skinner, 1961f, p. 138). Skinner described the historical techniques of education, one type of reinforcement in social interaction, as a revolving around escape from a threatening world:

The techniques of education were once frankly aversive. The teacher was usually older and stronger than his pupils and was able to "make them learn." This meant that they were not actually taught but were surrounded by a threatening world from which they could escape only by learning. (Skinner, 1961h, p. 28)

Skinner (1938) also made an incomplete list of other factors that influence engagement in learning, including: emotion (p. 406), drugs (p. 409), "general fatigue, asphyxiation, and disease" (p. 416), sleep (p. 417), and age (p. 417).

Hull (1943) explained engagement in terms of innate behavioral tendencies (p. 66), habit strength (p. 178), primary motivation (p. 253), reaction potential (Hull, 1943, p. 253; Hull, 1951, p. 59; Hull, 1952, p. 7, equation 8), innate and learned inhibition (Hull, 1943, p. 300), the learned response of not responding—i.e., that not responding can be rewarding (Hergenhahn, 1982, p. 136; Hull, 1943, p. 300)—incentive motivation (Hull, 1952, p. 7), and stimulus-intensity dynamism (p. 7). In addition, because none of the explanations listed provided a perfect predictor of performance Hull added a factor into his equations for "chance oscillation" (Hull, 1943, p. 319), intended to account for random inhibitory uncorrelated variance that he observed.

Guthrie spoke of three sources of excitement: intense stimulation, accumulated effects, and interference:

There are three ways in which excitement may be produced. One of these is by intense stimulation of any sort....The second origin of excitement is through a series of stimuli which leave accumulated effects. One prod from the boy behind may not have at all the effect of the fifth prod. Each has left behind a slight increase in muscular tonus and general excitement and these have accumulated so that the response to the fifth prod is a howl of rage or vigorous reprisal.

The third method is through interference with action that is going on. A child is annoyed by interference or by obstacles in his way when he is occupied. His actions are reinforced and more vigorous." (Guthrie, 1942, p. 21)

He explained that states of excitement "play an important part in learning because they intensify action, and by intensifying action alter its results and bring new stimulation" (Guthrie, 1942, p. 22). Excitement, he said, "is often the essential condition of adaptation and learning because it means vigorous action and new behavior" (p. 22). He also described motives as "stimulus situations that keep the individual active until some specific goal is reached" (Guthrie, 1942, p. 59). One source of motivation is interest by others in one's performance. Guthrie cited a study by Bryan and Harter in 1899 as evidence, in which it was discovered that "telegraphers of long experience whose rate of sending and receiving had been stationary for years took a new spurt and reached new high levels when interest was shown in their rates of performance" (Guthrie, 1960, p. 166). He described practice at any skill as based on an intention to accomplish something:

Practice at any skill thus assumes an intention to accomplish something....Being built around an intention, every skill has a core of maintaining stimuli. These may change from one moment to the next....All these intentions betray themselves in anticipatory movements....Every person who has taken part in physical contest knows the important part played by the intention to win. This intention is by no means a mental affair in the sense that it is not of the body; it lies in the way the game is played. (p. 170)

In his experiments with cats, he found that advertant responses—such as clawing or biting the post to escape— transferred readily to a new post position while inadvertent responses—such as backing into the post—did not (Guthrie, 1960, pp. 283-284).

In cognitive learning, Ebbinghaus noted the effect of the intensity of attention and interest on retention and production (Ebbinghaus, 1913, pp. 3-4). Tolman described engagement as

purpose, or a "persistence until" character in normal behavior (Tolman, 1925a, p. 37). When Kohler's chimpanzees began to tire and lose interest in obtaining the food objective of his experiments he found that he could maintain their interest by improving the objective—for example, by adding additional food such as a slice of orange. He found that this technique, particularly in lengthy experiments, maintained engagement and mitigated "the risk that fatigue will intervene and spoil the result" (Kohler, 1951, pp. 42-43).

An interesting source of motivation in cognitive information processing is found in the attention to oneself or one's interests by others. For example, even when engaged in a conversation in a noisy room "when you hear your name spoken or someone else talking about a topic that interests you, your attention shifts" (Driscoll, 2000, p. 81). The level of difficult or amount of effort required in a task can also influence one's involvement, which may be less likely in the face of a difficult or seemingly impossible task in which "the items may be presented at a very fast rate so that input and reorganization time encourage too far upon rehearsal time" (R. C. Atkinson & Shiffrin, 1968, p. 38).

Ausubel et al. (1978) believed that "motivation, although not indispensable for limited and short-term learning, is absolutely necessary for the sustained type of learning involved in mastering a given subject-matter discipline [with its effects] largely mediated through...attention, persistence, and increased frustration tolerance" (p. 397). They noted, however, that "much learning is apparently neither energized by motivation nor reinforced by drive satisfaction" (p. 400). As an example they cited classical or Pavlovian conditioning which "merely depends on temporal contiguity of the conditioned and unconditioned stimuli" (p. 400) as well as "a good deal of learning...[which] occurs incidentally without any explicit intention to

learn" (p. 400). Where motivation is a factor in learning, Ausubel et al. believed it a mistake to apply the homeostatic drive reduction of animal learning to humans:

Even where motivation is clearly operative in human learning, it is misleading to extrapolate the familiar paradigm of homeostatic drive reduction that is characteristically used to explain animal learning (Harlow, 1953). Such drives are quickly satiated and, when accompanied by intense affect, disrupt learning (Harlow, 1953). Hence, hunger, pain, and the like, rarely motivate human learning." (Ausubel et al., 1978, p. 400)

In addressing material versus intrinsic rewards, Ausubel et al. expressed a view that "although material rewards are often effective, intrinsic (task-oriented) and ego-enhancing motives increasingly tend to dominate the motivational picture with advancing age" (Ausubel et al., 1978, p. 400). They further described material rewards as taking on a symbolic quality, becoming "less ends in themselves than symbols of earned or attributed status and sources of self-esteem (p. 400).

Predominant in their views of motivation are an explanation of the composite nature of achievement motivation. "Achievement motivation, contrary to much current thinking in the area, is not a unitary variable. It consists...of varying proportions of (1) cognitive drive, (2) affiliative drive, and (3) ego-enhancement motivation." (Ausubel et al., 1978, p. 398). They defined cognitive drive as "the desire to know and understand, to master knowledge, to formulate and solve problems" (p. 402). This is "potentially the most important and stable of the three components because it is largely inherent in the task itself...[meaning] successful learning per se is its own reward, apart from any extrinsic considerations of reward or approval" (p. 398). Affiliative drive is "expressive of a pupil's need to do well in school in order to retain the approval (and the continued derived status this signifies) of the superordinate figure (parent, teacher) with whom he identifies in an emotionally dependent sense" (p. 398). Affiliative drive is

increasingly important as the child moves through adolescence. The third component, ego-enhancement motivation, "reflects the need for the earned status achieved by one's own competence or performance ability" (p. 398). Ausubel clarifies that this type of motivation "need not necessarily have an ego-aggrandizing flavor" (p. 398). One additional aspect of motivation discussed by Ausubel et al. is that of perceived need. This source of motivation comes in to play with a delayed review strategy:

In the first place, after a longer retention interval, when more material is forgotten, the learner is more highly motivated to profit from the opportunity for review. He or she is less likely to regard this opportunity as unnecessary and superfluous, and is therefore more disposed to take good advantage of it in terms of effort and attention. (Ausubel et al., 1978, p. 319)

In schema theory, learning is considered in terms of the creation and ongoing maintenance of mental schema through accretion, tuning and restructuring (Rumelhart & Norman, 1976). There are two cases that motivate this adjustment: (a) when the schema is poor at describing the situation, and (b) when there is a discrepancy between the schema and real-life events:

When a schema is sufficiently poor at describing the situation, a new schema must be sought. (Rumelhart & Norman, 1976, p. 11)

The more discrepant the arriving information from that described by the available schemata, the greater the necessity for change. If the information is only mildly discrepant, tuning of the schemata may be sufficient. If the material is more discrepant, schema creation is probably required. (Rumelhart & Norman, 1976, p. 21)

Turning to constructive learning one sees that three of the fourteen principles proposed by the Learner-Centered Work Group of the APA's Board of Educational Affairs deal with motivation. Principle seven states that "what and how much is learned are influenced by the

learner's motivation [and that] motivation to learn, in turn, is influenced by the individual's emotional states, beliefs, interests and goals, and habits of thinking" (Learner-Centered Work Group of the American Psychological Association's Board of Education Affairs, 1997,#7). Principle 8 deals with intrinsic motivation to learn—"the learner's creativity, higher-order thinking, and natural curiosity all contribute to motivation to learn" (#8)—and Principle 9 speaks to the effects of motivation on effort, that the "acquisition of complex knowledge and skills requires extended learner effort [and] without the learner's motivation to learn, the willingness to exert this effort is unlikely without coercion" (#9). Applied constructive learning theory in the classroom suggest that student engagement is to be found by allowing "student responses to drive lessons, shift instructional strategies, and alter content" (Brooks & Brooks, 1993, p. 105); encouraging "student inquiry by asking thoughtful, open-ended questions and encouraging students to ask questions of each other" (p. 110); building on students' "natural curiosity through frequent use of the learning cycle model [discovery, concept introduction, concept application]" (p. 116); and posing problems of emerging relevance by "the structuring of the lesson around questions that challenge students' original hypotheses presents students with the initial sparks that kindle their interest" (pp. 37-38).

Piaget described engagement in development in terms of autoexcitation (Piaget, 1963, p. 33); a natural or fundamental tendency toward repetition of behavior (p. 42); circular reactions motivated by interesting results (Piaget & Inhelder, 1969, p. 10); procedures to make interesting sights last (Piaget, 1963, p. 201); increasing awareness (Piaget & Inhelder, 1969, pp. 5-6); desirability (Piaget, 1963, p. 11); affectivity (Piaget & Inhelder, 1969, pp. 21, 158); satisfaction (p. 23); an innate need for understanding (p. 109); equilibration as a balance between assimilation and accommodation (p. 157); and the need to grow, assert oneself, love, and be

admired (p. 158). Though each of these sources of motivation was discussed in length in his writings, it was the final item on the list that he proposed as the ultimate motive force behind intelligence:

In the last analysis it is the need to grow, to assert oneself, to love, and to be admired that constitutes the motive force of intelligence, as well as of behavior in its totality and in its increasing complexity. (Piaget & Inhelder, 1969, p. 158)

A complimentary view, that of Bruner, suggests that the best stimulus to learning is an "interest in the material to be learned" (J. S. Bruner, 1960, p. 14), and the best way to create interest in the subject is to "render it worth knowing, which means to make the knowledge gained usable in one's thinking beyond the situation in which it has occurred" (p. 31). Also, because it is the nature of the child to "go about discovering things for himself" (J. S. Bruner, 1961, p. 22), as an additional source of motivation he also calls out the self-rewarding nature of discovery (p. 26), and suggests that there are "powerful effects that come from permitting the student to put things together for himself, to be his own discoverer" (p. 22).

Because human learning theories are primarily partial theories of learning¹¹⁷ heavily focused on factors of motivation, agency, and the learner as a whole person, there are numerous insights to be gained from human learning theory regarding various aspects of engagement. These will not be summarized here—that was the purpose of the human learning theory section in chapter 3—but some highlights and trends will be noted.

¹¹⁷ Meaning they do not attempt to account for the process of learning as a whole, but only part of it—typically the motivational portion, and sometimes only one type of motivation.

First, human learning is rarely, if ever, motivated directly by homeostatic drive reduction. In fact, this was one of Maslow's (1943b) fundamental propositions. He rejected any physiological drive (including hunger) as a centering point for a human theory of motivation, since "any drive that is somatically based and localizable was shown to be atypical rather than typical in human motivation" (p. 370):

Obviously a good way to obscure the 'higher' motivations, and to get a lopsided view of human capacities and human nature, is to make the organism extremely and chronically hungry or thirsty. Anyone who attempts to make an emergency picture into a typical one, and who will measure all of man's goals and desires by his behavior during extreme physiological deprivation is certainly being blind to many things. (p. 375)

Ausubel et al. also noted the misappropriation of homeostatic drive reduction as an explanation for the impetus of human learning:

Even where motivation is clearly operative in human learning, it is misleading to extrapolate the familiar paradigm of homeostatic drive reduction that is characteristically used to explain animal learning (Harlow, 1953). Such drives are quickly satiated and, when accompanied by intense affect, disrupt learning (Harlow, 1953). Hence, hunger, pain, and the like, rarely motivate human learning. (Ausubel et al., 1978, p. 400)

Human learning is motivated not by drives—at least not directly—but rather, by goals (Covington, 1998, p. 32; Maslow, 1943b, p. 371). Some goals may, of course, be drive relevant, e.g., going to college in order to get a job, and working to provide for basic needs such as food, shelter, and safety. Others will stem from psychological needs such as: autonomy, competence, and relatedness (Deci & Ryan, 2000, pp. 233-235); the need for exploration and manipulation (Fuller, 1962, p. 39); the need for "deeper levels of understanding" (Heider, 1958, p. 125); insatiable curiosity (Rogers, 1969, p. 3), and "certain more intellectual desires" (Maslow, 1943b, p. 394). They might also come from affective needs to give and to receive love (p. 381), to find

acceptance through achievement (Covington, 1998, p. 78), to protect one's self-esteem (p. 16) or to fulfill one's self-actualization potential (Maslow, 1943b, p. 382). They can also be based on aspirations to succeed (Covington, 1998, p. 28); desire " for strength, for achievement, for adequacy, for confidence in the face of the world, and for independence and freedom" (Maslow, 1943b, p. 381); or desire for "reputation and prestige (defining it as respect or esteem from other people), recognition, attention, importance or appreciation" (p. 382).

Second, in addition to sources of *motivation*, such as those listed above, human learning theory also gives an account of certain *conditions* necessary for engagement. For example: self-confidence (Covington, 1998, pp. 28-29; Heider, 1958, p. 94); a feeling of competence (Heider, 1958, p. 94); realistic challenges (Covington, 1998, p. 30); an intrinsic tendency to achieve success that is higher than one's intrinsic tendency to avoid failure (J. W. Atkinson & Feather, 1966, p. 328), or a positive extrinsic tendency sufficient to outweigh the negative net difference between the two (J. W. Atkinson & Feather, 1966, p. 333); a perception that one's capability is sufficient to meet the task (Bandura, 1986, p. 393); an "estimate that a given behavior will lead to certain outcomes" (Bandura, 1977a, p. 193); feelings of self-efficacy (p. 193); and the absence or acceptance of threat to self (Rogers, 1969, p. 161).

In social learning, Vygotsky cited the child's interests as the best source of engagement, going so far as to say that the child's interests should be our allies. In speaking particularly of the deaf and dumb child but in general application to all children he said,

It is necessary to organize the child's life in such a way as to make speech necessary and interesting. The teaching must appeal to the children and should not be directed against them. We must make the children's interests our allies and not our enemies. Desire for speech should be created, and the child is more likely to learn to speak when it is urged by necessity; this very motive is being completely destroyed by the traditional school which separates the deaf and dumb children from normal surroundings and places it in a

special environment, where everything is adapted to its infirmities; thus, the circle of its interests becomes very narrow and this encourages unsociable instincts. (Vygotsky, 1994a, p. 24)

Bandura tells us that "among the countless responses acquired observationally, those behaviors that seem to be effective for others are favored over behaviors that are seen to have negative consequences" (Bandura, 1977b, p. 28). Additionally, the self-evaluative reactions of the model toward their own behavior are of influence (pp. 27-28). In other words, the vicarious consequences learned from observing others and how they react to their own behavior can make a person more or less likely to adopt the observed behavior himself. Bandura also described reinforcement as playing a role in observational learning but "mainly as an antecedent rather than a consequent influence" (p. 37). By antecedent influence he meant to say the "anticipation of reinforcement" (p. 37).

In situational learning, motivation is largely in the form of "acceptance by and interaction with acknowledged adept practitioners" (Lave & Wenger, 1991, p. 110). In the situated setting, apprentice learners are also able to see that "there is a field for the mature practice of what they are learning to do" (p. 110), and they are able to make contributions of value while learning—"a value which increases as the apprentice becomes more adept" (p. 110). The major source of motivation in situated learning, however, is the intrinsic reward of becoming part of the community (p. 111) and the identity and membership the learner gains in doing so (p. 122).

Activity theory describes the motive of human activity in terms of the object of the activity. The following quote gives an example of the patient as object in a medical care facility:

The object in an activity system is a source of motivation. For example, for frontline primary care and hospital staff, the object is the patient. "What observably more than anything arouses involvement, effort, emotion, excitement, frustration, and stress among

frontline primary care and hospital staff is daily encounters with real, live patients, no matter how cynical or instrumentally oriented the individual employee may be. The object of medical work is the patient, with his or her health problems and illness....Without patients the activity would cease. (Engestrom, 2000a, p. 964)

The object "is the true carrier of the motive of the activity...[thus] in expansive learning, motives and motivations are not sought primarily inside individual subjects—they are objects to be transformed and expanded" (Engestrom, 2010, p. 4). This motive is deeply communal and drives the activity of the collective system (Engestrom, 2000a, p. 964). An additional source of motivation in activity theory is not the motivation to act, but the motivation to engage in expansive cycles of learning. The source of this motive is internal contradiction. Such contradictions are "the driving force of change and development in activity systems" (Engestrom, 2001, p. 135). Expansive learning is "triggered by double binds generated by contradictory demands imposed on the participants by the context" (p. 142), and "a crucial triggering action in the expansive learning process...is the conflictual *questioning* of the existing standard practice" (p. 151).

According to cognitive apprenticeship theory, learners are motivated, in part, by an understanding of the finished product:

When tasks arise in the context of designing and creating tangible products, apprentices naturally understand the reasons for undertaking the process of apprenticeship. They are motivated to work and to learn the subcomponents of the task, because they realize the value of the finished product. (A. Collins et al., 1991, p. 3)

Another source of motivation is the fact that they are actively using knowledge as it is learned (A. Collins et al., 1991, p. 16), making it relevant to them. Additionally, as participants in a community, learners are motivated by a sense of ownership, personal investment, and mutual dependency. Inasmuch as cognitive apprenticeships are set up in the classroom setting, it

becomes important to establish "learning environments in which students perform tasks because they are intrinsically related to an interesting or at least coherent goal, rather than for some extrinsic reason, like getting a good grade or pleasing a teacher" (p. 16). Table 10 summarizes the local principles from the theories reviewed that are subsumed by the universal principle *engagement*.

Table 10

Principles of Learning Subsumed by the Universal Principle of Engagement

Theory Group	Local principles
Behavioral	<p><i>Aristotle:</i> Pleasure and pain Desire to know</p> <p><i>Thorndike:</i> Set or attitude Original tendencies (reflex, instinct, and capacities) Original attentiveness Satisfiers and annoyers (wants, interests, and motives) Principle of readiness Mental fatigue and mental effort</p> <p><i>Pavlov:</i> Significance of the situation may demand engagement</p> <p><i>Watson:</i> Failure to control incentives Basic needs as motivation</p> <p><i>Skinner:</i> Conditioned reinforcer A reinforcing stimulus Something a subject wants Whatever increases the chances that the animal will repeat the behavior Intermittent reinforcement Animals engaging in performance never before seen, due to reinforcement Reinforcing social conditions Escape from aversive conditions Positive reinforcement Drive Inhibition Other variables: emotion, drugs, general fatigue, asphyxiation, disease, etc... The law of conditioning</p>

The law of extinction

Hull:

Innate behavioral tendencies
Habit strength – effect of prior learning on likelihood of future engagement
Primary motivation
Reaction potential
Inhibition build up with each response
Not responding can be rewarding
"Chance" oscillation
Stimulus-intensity dynamism
Incentive motivation
Delay in reinforcement

Guthrie:

External interest shown in performance results in engagement
Intention to accomplish something
Advertant and inadvertent responses
Intense stimulation
Accumulated effects
Interference
States of excitement intensify action and bring new stimulation
Motives: stimulus situations that keep the individual active until some specific goal is reached

Estes:

Anticipation of reward
"Effective" stimulus elements
Motivation affects the composition and magnitude of the effective stimulus elements

Cognitive

Ebbinghaus:

Attention and interest

Tolman:

Purpose

Kohler:

Improvement of the objective

Cognitive Information Processing:

Interest

Level of difficulty or effort

Ausubel:

Perceived need

Motivation

Drive reduction (human learning rarely motivated by drive reduction)

Material rewards vs. intrinsic rewards

Achievement motivation

Cognitive drive

Affiliative drive

Ego-enhancement motivation

Much learning is neither energized by motivation nor reinforced by drive satisfaction
It is misleading to apply homeostatic drive reduction to human learning
Relative ineffectiveness of homeostatic or material rewards in human learning

Schema Theory:

Need: when a schema is sufficiently poor at describing the situation, a new schema must be sought

Discrepancy

Constructive

General:

Student responses drive lessons, shift instructional strategies, and alter content

Student inquiry

Natural curiosity

Posing problems of emerging relevance

What and how much is learned is influenced by motivation—emotional states, beliefs, interests and goals, and habits of thinking

Intrinsic motivation stimulated by novelty and difficulty, relevance, choice, and control

Without the learner's motivation to learn, the willingness to exert this effort is unlikely without coercion

Piaget:

Autoexcitation

Circular reaction motivated by interesting results

'Procedures' to make interesting sights last

Natural or fundamental tendency toward repetition of behavior

Increasing awareness

Desirability

Affectivity

Satisfaction

Innate need for understanding

Equilibration – balance between change of self and interpretation of universe

Need (to grow, assert oneself, love, and be admired)

Bruner:

Interest

Value (worth knowing; general usability)

Autonomy: powerful effects from permitting student to be his own discoverer

Self-reward of discovery

Human

Maslow's Hierarchy of Human Needs:

Somatically based drives are atypical in human learning motivation

Acts typically have more than one motivation

All organismic states are both motivated and motivating

Human needs arrange themselves in hierarchies of prepotency

Man is a perpetually wanting animal

Human learning is motivated by goals rather than drives

Physiological needs

The need for safety

The need to give and receive love

The desire for strength, for achievement, for adequacy, for confidence in the face of the world, and for independence and freedom

The desire for reputation and prestige, recognition, attention, importance or

appreciation

The need for self-actualization

The desire to achieve or maintain the various conditions upon which basic needs rest

Once a need is satisfied, the next prepotent ('higher') need emerges

Gratified needs are not active motivators

Intellectual desires

Biological Motivation:

Expressive and preemptive drives

Not one need for food, but numerous requirements for specific substances

Emotions (fear, anger, pleasure)

Fear may not be a good source of motivation for learning

Men can temporarily override, but not escape their subjection to humoral agents entirely

Need for exploration and manipulation

Excessive novelty may activate the nervous system without organizing a directed response

Repetition produces habituation, a decrease of activation

Achievement Motivation:

Levels of aspiration

Self-confidence

Expectancy

Realistic challenges

Self-generated goals

Control of one's own progress

Tendency to achieve success

Tendency to avoid failure

Positive extrinsic tendency may override a net intrinsic tendency to avoid

Performance level should be greatest when there is greatest uncertainty about the outcome

People with strong achievement motive should prefer intermediate risk

Persons in whom the motive to avoid failure is stronger should avoid intermediate risk

Attribution Theory:

Man is motivated to understand the causal structure of his environment, to know why an event occurred, and to what source the event can be ascribed

Ability

Effort

Task Difficulty

Luck

Stability

Locus of causality

Controllability

Strong urge to push toward deeper levels of understanding

Own wish

For the sake of some ulterior goal, even if neutral or even disagreeable

Asked to do it by a friend

For somebody he likes without having been asked

Somebody in authority told him to do it

Because he thinks he ought to do it, because he feels obliged to do it

Because he wishes to establish or maintain a certain reputation

Induced motivation – motivation from outside the person himself

Desire for prediction and control
Tendency to attribute enjoyment to the object rather than oneself
Adequate attribution requires an adequate data pattern of condition-effect changes
Perception of task difficulty inferred from performance of a single individual
Cognition of *can* through action
Attribution to opportunity or luck
Ability is a main power factor
Degree of ability measured by one's standing in the group
Degree of ability measured by irrational spreading of ability in one area to ability in other areas
Self-confidence
Pervasive mood of confidence
Despondent mood
Philosophical view
Fatigue
Social and legal cast
Possessions
Physical position
Opinion and suggestion
Laziness or lack of will
Motivation aroused simply through the appearance of the idea

Self-Worth Theory:

The highest human priority is the search for self-acceptance
Worth, in our society, is usually equated with achievement
Maintaining a positive self-image of one's ability (not necessarily achieving)
Feelings of worthlessness arise from the disclosure of incompetency
Motivation to protect one's self esteem
One's sense of worth depends heavily on accomplishments
One's sense of worth also depends on perception of ability
Success from one's own efforts is valued more highly than success with help
Making an effort, puts one at risk of failure
The absence of behavior may be motivated by a need to protect one's self-esteem

Self-Efficacy:

Outcome expectancy
Efficacy expectation
Future consequences represented in thought
Goal setting and self-evaluative reactions
Self-inducements and discrepancies
Expectancy without a sense of self-efficacy may not lead to action
Efficacy expectations are a major determinant of peoples' choice of activities, assuming appropriate skills and adequate incentives
Successes build self-efficacy, failures undermine it

Self-Determination Theory of Motivation:

Three innate psychological needs: autonomy, competence, and relatedness
Feelings of competence will not enhance intrinsic motivation unless accompanied by a sense of autonomy
Conditions of threat, evaluation, and deadlines undermine intrinsic motivation
Conditions of choice enhance intrinsic motivation and augment confidence
Positive feedback enhances competence and intrinsic motivation
Negative feedback decreases competence and intrinsic motivation
Relatedness provides a backdrop sense of security to support intrinsically motivated

activity

Extrinsic motivation may become internal motivation, internalized to varying degrees

Extrinsic motivation may be regulated externally, introjected, identified, or integrated

In an amotivational state people either do not act, or just go through the motions

In an intrinsically motivated state the source of behavior is completely internal, and is regulated by interest, enjoyment, or inherent satisfaction

With externally regulated extrinsic motivation behavior is performed only to satisfy external demands or reward contingency

Introjection involves taking in a regulation but not fully accepting it as one's own

Integration involves fully assimilating external regulations to oneself

Intrinsic aspirations (affiliation, personal growth, community contributions)

Extrinsic aspirations (wealth, fame, image)

ARCS:

Motives

Expectancy

External effort to influence motives

Attention – perceptual arousal, inquiry arousal, variability

Relevance – goal orientation, motive matching, familiarity

Confidence – learning requirements, success opportunities, personal control

Satisfaction – natural consequences, positive consequences, equity

Freedom to Learn:

Insatiable curiosity

Meaningless learning "from the neck up" versus meaningful experiences

Significant learning: personal involvement, pervasive, self-evaluated, meaningful

Significant learning takes place when the subject matter is perceived by the student as having relevance for his own purposes

Learning which involves a change in self organization—in the perception of oneself—is threatening and tends to be resisted

Those learnings which are threatening to the self are more easily perceived and assimilated when external threats are at a minimum

When threat to the self is low, experience can be perceived in differentiated fashion and learning can proceed

Self-Efficacy:

People avoid tasks they believe exceed their capabilities

People undertake and perform assuredly tasks they judge themselves capable of handling

When self-efficacy is lacking, behavior is ineffective, even if a person knows what to do

Social

Vygotsky:

The child's interests should be our allies

Bandura:

Valued outcomes

Vicarious consequences

Self-evaluative reactions (self-satisfying versus disapprove)

Reinforcement as facilitation

Situated learning:

Acceptance by and interaction with others
Connection with learning and real-world application
Valued contributions
Intrinsic reward-becoming part of the community

Activity theory:

The object is the true carrier of the motive of the activity
Object as a source of engagement (e.g., patients as the object of medical activity)
Deeply communal motive
Internal contradictions

Cognitive apprenticeship:

Motivated to work by understanding value of the finished product
Active use of knowledge while learning
Sense of ownership, personal investment and mutual dependency
Creation of environments which are intrinsically motivating
Cooperative problem solving

Agency. The concept of agency in learning is not a recent one. This principle covers both the agency of the learner as well as the agency of others who may affect, in some way, that person's learning. Although advocates of the behavioral approach to the study of learning were generally silent in regards to agency of either the learner or of others who influenced the experience of the learner in some way, some spoke strongly against it, while others openly acknowledged it. For example, Skinner (1961b; 1961d; 1961h) strongly rejected and opposed any notion of human will:

Every discovery of an event which has a part in shaping a man's behavior seems to leave so much the less to be credited to the man himself; and as such explanations become more and more comprehensive, the contribution which may be claimed by the individual himself appears to approach zero. Man's vaunted creative powers, his original accomplishments in art, science, and morals, his capacity to choose and our right to hold him responsible for the consequences of his choice —none of these is conspicuous in this new self-portrait. Man, we once believed, was free to express himself in art, music, and literature, to inquire into nature, to seek salvation in his own way. He could initiate action and make spontaneous and capricious changes of course. Under the most extreme duress some sort of choice remained to him. He could resist any effort to control him, though it might cost him his life. But science insists that action is initiated by forces impinging

upon the individual, and that caprice is only another name for behavior for which we have not yet found a cause. (Skinner, 1961d, pp. 7-8)

As an alternative example, Thorndike recognized a discretionary power that he believed to be characteristic of human learning: "All man's learning, and indeed all his behavior, is *selective*. Man does not, in any useful sense of the words, ever absorb, or re-present, or mirror, or copy, a situation uniformly" (Thorndike, 1914a, p. 157). It is "the condition of the man" (p. 144), a condition which the man can to one degree or another control, that determines the change made by any acting agent.¹¹⁸ It is the "the attitude or set of a person [that] decides not only what he will do and think, but also what he will be satisfied and annoyed by" (p. 145). The man can choose which elements of a situation will be prepotent in effect:

One of the commonest ways in which conditions within the man determine variations in his responses to one same external situation is by letting one or another element of the situation be prepotent in effect. Such partial or piecemeal activity on the part of a situation is, in human learning, the rule. Only rarely does man form connections, as the lower animals so often do, with a situation as a gross total—unanalyzed, undefined, and, as it were, without relief." (Thorndike, 1914a, p. 147)

Pavlov explicitly noted his own role as a controlling agent in the learning of his experimental subjects:

We observe and intentionally participate in building new reactions on this fundamental conduct [instincts], in the form of so-called habits and associations, which now increase, enlarge, become complicated and refined. (Pavlov et al., 1928, p. 42)

¹¹⁸ Agent is used here in the way Thorndike (1914a) used it to convey the idea of a "stimulating agent" (p. 98), which may be, but is not necessarily, another human being.

Watson played a similar role in his experiments of conditioning with animals and children, and Skinner, though he too acted in this capacity, denied any concept of "will," instead deferring all explanation of action to external causes. In *Science and Human Behavior* (Skinner, 1953) he set up the basis for this position based on Descartes suggestion that "the spontaneity of living creatures was only apparent and that behavior could sometimes be traced to action from without" (p. 47), and the later discovery that the tail of a salamander, though severed from the body, would "move when part of it was touched or pierced" (p. 47). This, he felt, was the first "clear-cut evidence that [Descartes] had correctly surmised the possibility of external control" (p. 47). He went then went on to paint a somewhat dramatic picture of the diminished role of the inner will as an acceptable explanation of behavior:

As more and more of the behavior of the organism has come to be explained in terms of stimuli, the territory held by inner explanations has been reduced. The "will" has retreated up the spinal cord, through the lower and then the higher parts of the brain, and finally, with the conditioned reflex, has escaped through the front of the head. At each stage, some part of the control of the organism has passed from a hypothetical inner entity to the external environment. (p. 47)

Any influence of other people in the learning of an individual was described as a "social stimulus" (Skinner, 1953, p. 301) and the concept of the self was reduced to a "functionally unified system of responses" (p. 285):

The self is most commonly used as a hypothetical cause of action. So long as external variables go unnoticed or are ignored, their function is assigned to an originating agent within the organism. If we cannot show what is responsible for a man's behavior, we say that he himself is responsible for it. (p. 283)

Whatever the self may be, it is apparently not identical with the physical organism. The organism behaves, while the self initiates or directs behavior. (p. 284)

The best way to dispose of any explanatory fiction is to examine the facts upon which it is based. These usually prove to be, or suggest, variables which are acceptable from the

point of view of scientific method. In the present case it appears that a self is simply a device for representing *a functionally unified system of responses*. (p. 285)

Estes, a reformed behaviorist (see his own account in W. K. Estes, 1982a, pp. 13-19), came to recognize "the flexibility of higher organisms in selecting adaptively among alternative responses that are all associated with the same drives but lead to different reinforcing events" (p. 16), and later highlighted the ability of the learner to exercise agency in determining what action to take in a give situation by saying, "In any choice situation the individual is assumed actively to scan the available alternatives and to be guided to a choice by feedback from anticipated rewards" (W. K. Estes, 1982b, p. 60).

Ebbinghaus (1913) did not comment on learner agency but clearly demonstrated it in setting and carrying out his experiments on memory. Tolman described the use of a previously acquired cognitive map being "employed by 'intervening brain processes' in the selective attention to stimuli by the nervous system, and the execution of responses" (Tolman, 1948, p. 192). His view of learner choice was also highlighted in his criticism of trial and error learning:

Our final criticism of the trial and error doctrine is that it is its fundamental notion of stimulus-response bonds, which is wrong. Stimuli do not, as such, call out responses willy nilly. Correct stimulus-response connections do not get "stamped in," and incorrect ones do not get "stamped out." Rather learning consists in the organisms' "discovering" or "refining" what all the respective alternative responses lead to. And then, if, under the appetite-aversion conditions of the moment, the consequences of one of these alternatives is more demanded than the others—or if it be "demanded-for" and the others be "demanded-against"—then the organism will tend, after such learning, to select and to perform the response leading to the more "demanded-for" consequences. But, if there be no such difference in demands there will be no such selection and performance of the one response, even though there has been learning. (Tolman, 1932, p. 364)

Learner agency appears in cognitive information processing theory as a variety of memory control processes and various metacognitive functions. "Subject-controlled memory

processes include any schemes, coding techniques, or mnemonics used by the subject in his effort to remember" (R. C. Atkinson & Shiffrin, 1968, p. 30). Control processes in the sensory register include making choices regarding which sensory register to attend to, making choices regarding which portion of the available incoming information to transfer to STS, and selectively employing strategies for matching information in the sensory register "against the long-term store and thereby identifying input" (p. 32). In the short-term store include decisions regarding search, storage and retrieval; choices regarding what and how to employ rehearsal techniques to preserve new information in STS and transfer it to LTS; and selection of "grouping, organizing, and chunking strategies" (p. 40).

"Metacognition is knowing about and having control over cognitive processes" (Eggen & Kauchak, 1999, p. 268). "The concept of metacognition includes learners' knowledge and beliefs regarding their own cognitive processes, as well as their attempts to regulate those cognitive processes to maximize learning and memory" (Ormrod, 2003, p. 261). Self-regulated learning includes the following processes (pp. 355-356):

1. *Goal-setting*. Self-regulated learners know what they want to accomplish when they read or study.
2. *Planning*. Self-regulated learners determine ahead of time how best to use the time and resources they have available for a learning task.
3. *Attention control*. Self-regulated learners try to focus their attention on the subject matter at hand and to clear their minds of potentially distracting thoughts and emotions.
4. *Application of learning strategies*. Self-regulated learners choose different learning strategies depending on the specific goal they hope to accomplish.
5. *Self-motivational strategies*. Self-regulated learners keep themselves on task with a variety of strategies, such as competing against their own prior performance, finding ways to make a boring activity more interesting or challenging, imagining

themselves completing an activity successfully, or varying the procedures they use for successive tasks or problems.

6. *Solicitation of outside help when needed.* Truly self-regulated learners don't necessarily try to do everything on their own. On the contrary, they recognize when they need other people's help and seek out such assistance; they are especially likely to ask for the kind of help that will enable them to work more independently in the future.
7. *Self-monitoring.* Self-regulated learners continually monitor their progress toward their goals, and they change their learning strategies or modify their goals if necessary.
8. *Self-evaluation.* Self-regulated learners determine whether what they have learned fulfills the goals they have set for themselves.
9. *Intrinsic motivation.* Self-regulated learning requires intrinsic motivation.

Agency of the learner is not the only agency involved in the learning ecology. Agency of others also plays a role. In commenting on the role of the teacher in learning, Ausubel et al. (1978) expressed a view that although it has been suggested that teachers fill many different roles, their dominant role is still that of directing learning activities.

In recent times the scope of the teacher's role has been vastly expanded beyond its original instructional core to include such functions as parent surrogate, friend and confidante, counselor, adviser, representative of the adult culture, transmitter of approved cultural values, and facilitator of personality development. Without any sense disparaging the reality or significance of these other subsidiary roles, however, it is nevertheless undeniable that the teacher's most important and distinctive role in the modern classroom is still that of director of *learning activities*. (pp. 500-501)

Two of the fourteen principles proposed by the Learner-Centered Work Group of the APA's Board of Educational Affairs refer to motivation. Principle 5 deals with learner agency and states: "Higher-order strategies for selecting and monitoring mental operations facilitate creative and critical thinking" (Learner-Centered Work Group of the American Psychological Association's Board of Education Affairs, 1997,#5). Principle 11 relates to the role of other

agents in the learning process: "Learning is influenced by social interactions, interpersonal relations, and communication with others" (#11).

The role of peers is manifest in constructive teaching strategies that employ various types of group work:

Student-centered learning often involves social interactions with other students in varied formats, including **group instruction**, in which students learn, process, and discuss material in groups. Group discussions are conversations among students in which students pose and answer their own questions; the teacher does not play the dominant role. Thus learning becomes a socially mediated and facilitated activity. (Sternberg & Williams, 2010, pp. 449-450)

In group discussion "students do not just respond to teacher-initiated questions; they also respond to one another's questions in an open discussion format" (Sternberg & Williams, 2010, p. 455). Groupwork "entails small groups of students working together on tasks in relatively informal settings" (p. 457), which gives every student more of a chance to actively participate.

Cooperative learning is similar to groupwork, but more highly structured by the teacher and under tighter teacher control (Sternberg & Williams, 2010, p. 457). It often involves some type of competition between groups to complete a goal and performance is evaluated by time to completion or group performance on post-learning assessments.

In another type of group work, reciprocal teaching, students are first taught four steps to improve understanding of what they read: summarizing, asking a question about an important point in the text, clarifying the difficult portions of what was read, and predicting what is likely to come next (Sternberg & Williams, 2010, p. 459). Once they have learned the method, students take turns teaching and leading the class or group.

An important function of the teacher in constructive discovery learning is to guide the process, since unstructured discovery often leads to confusion, frustration, and inappropriate conclusions:

Unstructured discovery occurs when students make discoveries on their own. **Guided discovery** occurs when the teacher assists the students in making discoveries. Guided discovery is more practical and effective; unstructured discovery often leads students to become confused and frustrated and may result in students' drawing inappropriate conclusions. (Sternberg & Williams, 2010, p. 455)

Piaget spoke of the role of the "social group" in transforming sensorimotor intelligence into reflective intelligence (Piaget, 1963, p. 356). Bruner addressed both the agency of the learner and the influence of others. Regarding learner agency he said there are "powerful effects that come from permitting the student to put things together for himself, to be his own discoverer" (J. S. Bruner, 1961, p. 22) and that "left to himself, the child will go about discovering things for himself within limits" (p. 22). He further described the learner as taking an active role in learning:

The student is not a bench-bound listener, but is taking a part in the formulation and at times may play the principle role in it. He will be aware of alternatives and may even have an "as if" attitude toward these and, as he receives information he may evaluate it as it comes. (J. S. Bruner, 1961, p. 23)

Bruner described the role of others in individual learning in terms of the cultural transmission of techniques and skills (J. S. Bruner, 1964, p. 1). He also described how others have an influence on the control and freedom of the learner; that "there are certain forms of child rearing, certain home atmospheres that lead some children to be their own discoverers more than other children" (J. S. Bruner, 1961, p. 22); and that the aim of the teacher should be to give the student as firm a grasp of a subject as possible and then "make him as autonomous and self-

propelled a thinker as we can—one who will go along on his own after formal schooling has ended" (p. 23). He also stated the importance of having a model:

Thus, within the culture the earliest form of learning essential to the person becoming human is not so much discovery as it is having a model. The constant provision of a model, the constant response to the individual's response after response, back and forth between two people, constitute "invention" learning guided by an accessible model. (J. S. Bruner, 1971, p. 69)

Human learning theory addresses the learner as a complete person. A person that not only senses, and thinks, and feels, but one that has the power to choose. The learner is an agent. And the agency of the human learner is so powerful that people have been known to "give up everything for the sake of a particular ideal, or value" (Maslow, 1943b, p. 387). It's also true, however, that primary drives can, under extreme conditions or where the will is not sufficiently strong, preempt the higher pursuits of man (Fuller, 1962, p. 100). There is an interplay between motivation (external or internal influence) and choice (exercise of will). As has been described in chapter 3, this dynamic was explored deeply as the founding principle of self-determination theory:

As an organismic view, SDT conceives of humans as active, growth-oriented organisms, that innately seek and engage challenges in their environments, attempting to actualize their potentialities, capacities, and sensibilities. However, this organismic tendency toward actualization represents only one pole of a dialectical interface, the other being social environments which can either facilitate the individual's synthetic tendencies, or alternatively wither, block, or overwhelm them. (Ryan & Deci, 2002, p. 8)

Self-determination theory posits that learners are generally curious, self-motivated, agentic, and inspired—striving to learn, to extend themselves, to master new skills, and to apply their talents (Ryan & Deci, 2000, p. 68). Similarly, self-regulation theory views the learner as an active participant in their own learning process, able to choose whether or not to participate,

selectively employ metacognitive and self-motivational strategies, select desired performance outcomes and self-monitor progress toward objectives (Schunk & Zimmerman, 1994, p. 8).

Rogers described human learners as "curious about their world, until and unless this curiosity is blunted by their experience in our educational system" (Rogers, 1969, p. 157). He said that significant learning is maximized when a learner "chooses his own directions, helps to discover his own learning resources, formulates his own problems, decides his own course of action, [and] lives with the consequences of these choices" (p. 162); He also said that the most lasting and pervasive learning is self-initiated learning that involves the whole person (pp. 162-163).

In addition to the view that the learner is his or her own agent in the learning process, human learning theory also describes the role of other people acting in that process. For example, Rogers¹¹⁹ (1983) viewed the role of the teacher as being one of facilitation and said "the primary task of the teacher is to *permit* [italics added] the student to learn, to feed his or her own curiosity" (p. 18). One person can induce another person to do something by persuasion (Bandura, 1994a, p. 3) or by otherwise producing conditions of action in the person (Heider, 1958, p. 245). Even vicarious experience through the observation of others can influence a person's belief in their own ability to succeed, or provide a target for them to aim toward in their own learning (Bandura, 1994a, p. 3). This idea leads to the larger picture of learning in a social context.

¹¹⁹ The son of Carl Rogers.

Vygotsky described a unique social nature of humans "by which children grow into the intellectual life of those around them" (Vygotsky, 1978, p. 88). His view was in contrast to the predominant belief of his day that the mental development of a child can only be measured in terms of what the child can do alone. As an alternative, he suggested that the zone of proximal development created by learning "awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers" (p. 90). Based on these ideas, he explained that "the bringing up and education of children must proceed within society, through society, and for society" (Vygotsky, 1994a, p. 24). Vygotsky also emphasized the value of modeling and the role of imitation in learning:

A full understanding of the concept of the zone of proximal development must result in reevaluation of the role of imitation in learning. An unshakable tenet of classical psychology is that only the independent activity of children, not their imitative activity, indicates their level of mental development. This view is expressed in all current testing systems....But recently psychologists have shown that a person can imitate only that which is within her developmental level. For example, if a child is having difficulty with a problem in arithmetic and the teacher solves it on the blackboard, the child may grasp the solution in an instant. But if the teacher were to solve a problem in higher mathematics, the child would not be able to understand the solution no matter how many times she imitated it. (Vygotsky, 1978, pp. 87-88)

Bandura, of course, demonstrated the role of others in learning through modeling in his work on observational and vicarious learning (see, for example Bandura & Ross, 1961; Bandura et al., 1963; Bandura & McDonald, 1963; Bandura & Mischel, 1965; Bandura, 1965; Bandura, Grusec, & Menolve, 1966; Bandura, 1971; 1977b; 1989). In his more recent work (Bandura, 2001; 2008b; 2008c), he has focused on describing social cognitive theory from an agentic perspective, thereby emphasizing learner will and choice:

In the agentic sociocognitive view, people are self-organizing, proactive, self-reflecting, and self-regulating, not just reactive organisms shaped and shepherded by external events. People have the power to influence their own actions to produce certain results. The capacity to exercise control over one's thought processes, motivation, affect, and action operates through mechanisms of personal agency. (Bandura, 1999a, p. 2)

In social cognitive theory, people are agentic operators in their life course not just onlooking hosts of internal mechanisms orchestrated by environmental events. They are sentient agents of experiences rather than simply undergoers of experiences. (Bandura, 1999a, p. 4)

As part of this shift in emphasis to the learner as an agent, Bandura (2006b) described three modes of agency: individual, proxy, and collective:

Social cognitive theory distinguishes among three modes of agency: individual, proxy, and collective. Everyday functioning requires an agentic blend of these three forms of agency. In personal agency exercised individually, people bring their influence to bear on their own functioning and on environmental events. In many spheres of functioning, however, people do not have direct control over conditions that affect their lives. They exercise socially mediated agency, or proxy agency. They do so by influencing others who have the resources, knowledge, and means to act on their behalf to secure the outcomes they desire (Baltes, 1996; Brandtstadter & Baltes-Gotz, 1990; Ozer, 1995). People do not live their lives in individual autonomy. Many of the things they seek are achievable only by working together through interdependent effort. In the exercise of collective agency, they pool their knowledge, skills, and resources, and act in concert to shape their future (Bandura, 2000a). People's conjoint belief in their collective capability to achieve given attainments is a key ingredient of collective agency. (p. 265)

The three remaining social learning theories reviewed for this study are similar. Situated learning focuses on the learner as a person-in-the-world, but in the context of a sociocultural community. This focus "promotes a view of knowing as activity by specific people in specific circumstances" (Lave & Wenger, 1991, p. 52). Activity theory focuses on the activity system in which "[Learning] is accomplished in and between multiple loosely interconnected activity systems and organizations" (Engestrom, 2004, p. 15), and is "crucially dependent on the contribution of the clients or users" (p. 16). Thus, in the activity theory view of expansive

learning, learning is dependent on the contributions of others, interacting through a process of knotworking (Engestrom, 2000b, p. 532).

Cognitive apprenticeship focuses primarily on the role of the teacher as agent in the learning process of the apprentice. The teacher provides support to this process through modeling, coaching, and fading (J. S. Brown et al., 1989, p. 39). However, both the teacher and peers may serve as models:

In modeling, the apprentice observes the master demonstrating how to do different parts of the task. The master makes the target processes visible, often by explicitly showing the apprentice what to do. But as Lave and Wenger (in press) point out, in traditional apprenticeship, much of the learning occurs as apprentices watch others at work. (A. Collins et al., 1991, p. 2)

The "thread running through the entire apprenticeship experience" (A. Collins et al., 1991, p. 2) is coaching, which includes the following activities:

1. Choosing tasks
2. Providing hints and scaffolding
3. Evaluating the activities of the apprentices and diagnosing the problems they are having
4. Challenging them
5. Offering encouragement
6. Giving feedback
7. Structuring the ways to do things
8. Working on particular weaknesses

Cognitive apprenticeship also recognizes the role of peers in cooperative problem solving. Cooperative problem solving "refers to having students work together in a way that fosters cooperative problem solving. Learning through cooperative problem solving is both a powerful motivator and a powerful mechanism for extending learning resources" (A. Collins et

al., 1991, p. 16). Table 11 summarizes the local principles from the theories reviewed that are subsumed by the universal principle of *agency*.

Table 11

Principles of Learning Subsumed by the Universal Principle of Agency

Theory Group	Local principles
Behavioral	<p><i>Aristotle:</i> Teachers provide guidance</p> <p><i>Thorndike:</i> The attitude or set of a person decides not only what he will do and think, but also what he will be satisfied and annoyed by One of the commonest ways in which conditions within the man determine variations in his responses to one same external situation is by letting one or another element of the situation be prepotent in effect All man's learning, and indeed all his behavior, is selective</p> <p><i>Pavlov:</i> Pavlov and his team observed and intentionally participated (as agents) in building new reactions in the animals they worked with</p> <p><i>Skinner:</i> External control: although Skinner did not recognize "will," like Pavlov, he participated as an agent in conditioning the subjects he worked with Others as a social stimulus Note that Skinner argued against the self, or inner determination, describing the self as an "organized system of responses"</p> <p><i>Estes:</i> Adaptive selection of higher organisms among alternative responses In choice situations individuals choose based on feedback of anticipated rewards</p>
Cognitive	<p><i>Ebbinghaus:</i> Demonstrated self-directed learning in carrying out his experiments on memory.</p> <p><i>Tolman:</i> Selective attention to stimuli and execution of responses Learning does not consist of the "willy nilly" stamping in and out of responses, but rather of the organism discovering what the alternative responses lead to and selecting the appropriate response leading to the more demanded-for consequences at the time the choice is made</p> <p><i>Cognitive Information Processing:</i> Control processes in the sensory register Control processes in the short-term store</p>

Control processes in the long-term store
Memory skills improve due to knowledge about the domain and understanding of one's own memory
Metacognition: knowing about and having control over cognitive processes
Metacognition: regulation of cognitive processes to maximize learning and memory
Self-regulated learning

Ausubel:
Teacher role as "director of learning activities"

Constructive

General:
Selecting and monitoring
Influence by others
Group work
Value of teacher guidance

Piaget:
The role of the "social group" in transforming previously acquired intelligence, through language, into "reflective intelligence"

Bruner:
Techniques transmitted by the culture
Self-driven discovery
Learner is an active agent
Influence of others on control and freedom of the learner
Importance of a model

Human

Maslow's Hierarchy of Human Needs:
The integrated wholeness of the organism
Sometimes people will give up everything for the sake of a particular ideal or value

Biological Motivation:
Primary drives can preempt the exercise of agency toward higher goals

Attribution Theory:
One person can induce another to do something by producing conditions of action in the other person

Self-Efficacy:
Verbal or social persuasion
Vicarious experiences through observance of social models

Self-Determination Theory:
The human organism both acts on internal and external forces, and is vulnerable to those forces
People are generally curious, self-motivated, agentic, and inspired; and striving to learn, to extend themselves, to master new skills, and to apply their talents

Self-Regulation Theory:
Learners selectively use of metacognitive and motivational strategies
Learners select, structure, and create learning environments
Learners choose form and amount of instruction needed

- Learners are active participants in their own learning process
- Learners choose to participate
- Learners choose method of learning
- Learners choose performance outcomes
- Learners choose or control physical and social environment
- Learners are intrinsically or self-motivated
- Learners utilize planned or automatic methods
- Learners are self-aware of performance outcomes
- Learners are environmentally and socially sensitive and resourceful
- Learners' self-motivation is derived from setting goals, a sense of self-efficacy, and values
- Learners self-monitor and self-record
- Learners structure their environment and self-select exemplary models to observe
- Goal setting
- Strategic planning
- Self-efficacy beliefs
- Goal orientation
- Intrinsic interest

Freedom to Learn:

- Human beings have a natural potentiality for learning
- Learning is facilitated when the student participates responsibly in the learning process
- Self-initiated learning which involves the whole person of the learner—feelings as well as intellect—is the most lasting and pervasive.
- A continuing openness to experience and incorporation into oneself of the process of change
- Role of teacher as facilitator

An Agentic Theory of the Self:

- The human capability to exert influence over one's functioning and the course of events by one's actions
- Intentionality
- Forethought
- Self-reactiveness
- Self-reflection
- Self-efficacy is a prerequisite for the exercise of agency

Social

Vygotsky:

- Value of modeling, and role of imitation in learning
- Growing into the intellectual life of those around them
- Some internal developmental processes are only able to operate when the child is interacting with people in his environment
- Role of society in education

Bandura:

- People have the power to influence their own actions to produce certain results
- Agentic operators
- Modes of agency

Situated learning:

- The learner is a "person-in-the-world"

Activity theory:

Multi-voicedness

Management

Knotworking

Association through cultural artifacts

Cognitive apprenticeship:

Teacher modeling, coaching, fading, and support (also peer support)

Role of teacher as master to apprentices

Master or others may demonstrate a task

Coaching

Community of practice leads to a sense of ownership, personal investment and mutual dependency

Cooperative problem solving

In the next chapter, the ten principles identified will be organized into a conceptual framework of learning.

Chapter 5: Discussion

In this chapter the principles that have been identified in the present study are organized into a conceptual framework of learning that defines the relationships between them and provides a foundation on which domain-specific theories of learning might be created. The conceptual framework is defined by the ten principles identified in chapter four that *facilitate* learning, plus four additional principles of my own introduction: (a) one that states the possibility of progression (*potential*), (b) one that accounts for orientation of learning toward a specific goal (*target*), and (c) two structural principles (*change* and *practice*) that provide organization for some of the principles that facilitate learning. This conceptual framework is the "So what?" that gives unique meaning to the previous four chapters, and constitutes an original contribution of knowledge, based on the theoretical foundation of principles of learning that has been established.

A Conceptual Framework of Principles of Learning

There are many ways by which the general process of learning might be modeled or described. The ultimate value of any particular model is its accuracy, utility, and range of convenience in anticipating, predicting, and explaining learning in a variety of contexts. What follows is a description of 14 principles of learning: seven of which provide its primary structure, and seven of which describe its inner mechanism. The seven structural principles of learning are (a) potential, (b) target, (c) change, (d) practice, (e) context, (f) engagement, and (g) agency. The remaining seven, certainly no less significant than those already mentioned—and perhaps even more so in regards to the degree to which they determine whether or not learning will be successful—are (a) repetition, (b) time, (c) step size, (d) sequence, (e) contrast, (f) significance, and (g) feedback. Together these fourteen principles, by way of the manner in which they are

articulated and the contextual relations into which they are set, constitute a conceptual framework of the complete process of human learning.

Principle #1 – Potential. *Humans are endowed with an inherent potential for increase in capacity, the establishment of habit, and the definition of being.* This is the first principle of learning, upon which all others are predicated.

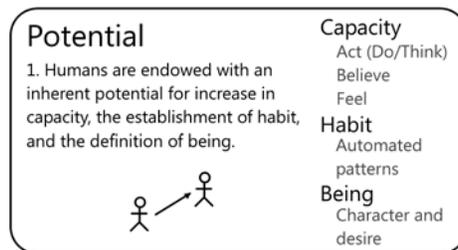


Figure 1. Human potential for increase of capacity, establishment of habit, and definition of being

That every person has *capacity* is a self-evident reality. As used here, capacity refers to one's ability to *do*, to *think*, to *believe*, and to *feel*. Doing and thinking are both ways of *acting*. To act by *doing* is to interact with the external world. To act by *thinking* is to interact with the contents of one's mind and soul. Thus, *capacity to act* refers to the extent of one's ability to interact with both the shared external and the private internal worlds. Similarly, *capacity to believe* is the extent of one's ability to hope, to dream, or to have faith. *Belief* determines the self-prescribed bounding limits of one's actions. *Capacity to feel* is the extent of one's ability to connect with people, events, places, or things. *Feeling* determines both the depth and richness of one's experiences.

It is the primordial function of human life, to extend the capacity and establish the habits of the individual, whether by his or her own intention, the intention of another, or by happenstance. Figure 1 depicts this potential for increase, with the stick figure in the lower left representing one's current state, and the stick figure in the upper right representing some potential state.

Except in very rare and unusual circumstances, a person's capacity to act, to believe, and to feel has potential for increase. Capacity can increase both in *range* and *degree* (Figure 2). An increase in range is a horizontal expansion that provides for greater flexibility or broader application. An increase in degree is a vertical expansion that brings greater accuracy, efficiency, depth, or intensity. An increase in range enables a person to do *more*; to think about *more*; to believe in *more*; and to feel, or emotionally respond, to *more*. An increase in degree enables a person to *do it better*, to *think more effectively or more profoundly*, to *believe with greater endurance*, and to *feel more deeply*.

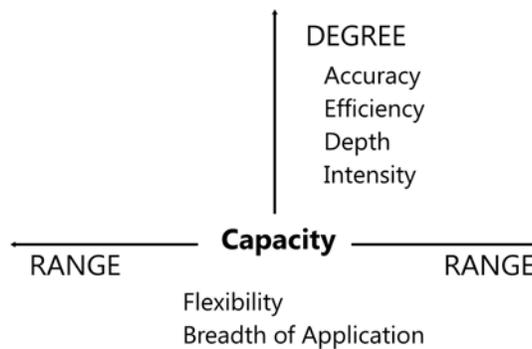


Figure 2. Capacity can increase both in range (horizontally) and degree (vertically)

Habits are automated patterns of doing, thinking, believing, and feeling. Just as capacity can be increased through the process of learning, so too can habits be established; and they can be changed. Not only does the human potential allow for increase in capacity and establishment of habit, but even the very *being* of a person can change. As used here, *being* refers one's character, nature, and perpetual desire. Thus, *learning is the process by which a stable and enduring increase in capacity, the establishment of habit, and the definition of one's being, is produced.*

Principle #2 – Target. *Human potential may be channeled intentionally toward a specific, predetermined target of learning, or will otherwise follow incidentally from the conditions to which a person is subjected.* This second principle, which has been added to the framework as shown in Figure 3, deals with determination of the target toward which learning activity will tend. It states that human potential will be either (a) channeled, intentionally, toward a specific target of learning,¹²⁰ or (b) shaped incidentally by circumstance. An intentional learning target is one that is selected and defined in advance of engaging in activity that will lead to the desired learning outcome. An incidental target, on the other hand, is not selected in advance, but is a culminating, consequent result of whatever activities a person engages in.

¹²⁰ Which channeling may be executed by the person himself, or by another (see principle #7, Agency)

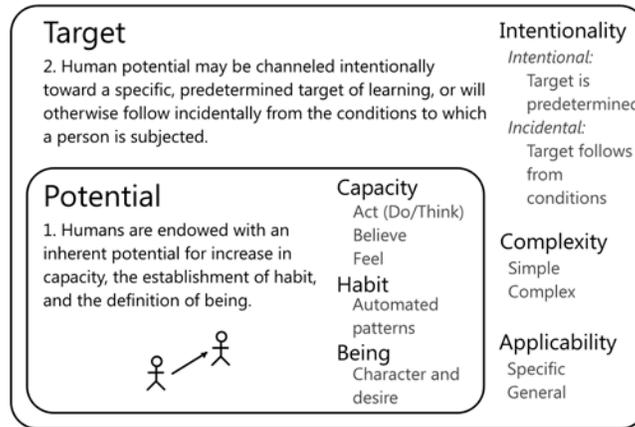


Figure 3. A target of learning may be selected intentionally or follow incidentally

A target may also be considered in terms of its complexity and applicability. The *complexity* of a target is defined by the number of sub-targets into which it may be divided, recursively. A target of minimal complexity (i.e., a *simple* target) cannot be subdivided. All other targets are divisible into two or more immediate sub-targets, each of which, if also complex, is further divisible, recursively (Figure 4). The *applicability* of a target is a measure of the number of complex targets in which it participates as a sub-target. A target with limited applicability is the sub-target of only one, or a few targets of greater complexity. A target with broad applicability is a sub-target of many targets.

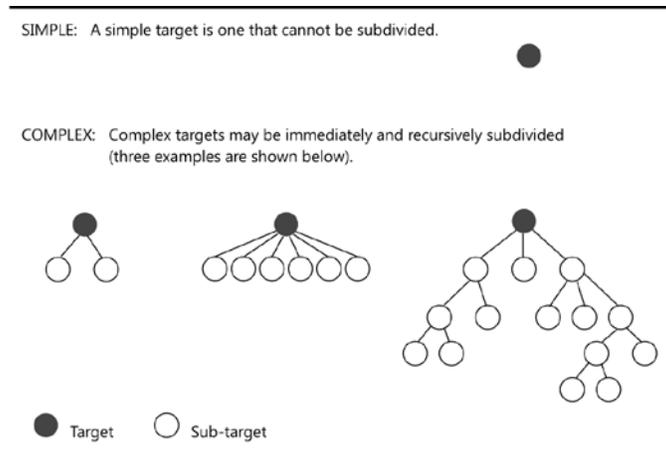


Figure 4. Simple and complex targets of learning

Principle #3 – Change. *Learning is a specific type of change, which is governed by principles of (a) repetition, (b) time, (c) step size, (d) sequence, (e) contrast, (f) significance, and (g) feedback.* These principles of change have been added to the model in Figure 5.

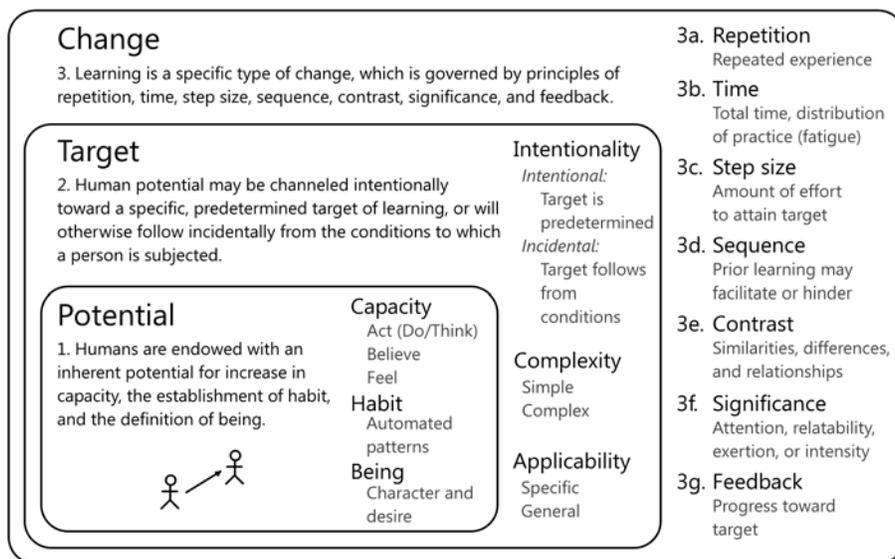


Figure 5. Seven principles of change by which the inner mechanism by which learning is facilitated

These seven principles of change are the inner mechanism by which learning is facilitated; in other words, the constraints and requirements of each of these principles must be satisfied in order for learning to take place. At first, changes in capacity and habit may be somewhat ephemeral and unstable. However, in accord with the seven principles of change which will now be discussed, these changes become long lasting and stable.

Principle #3a – Repetition. *Learning is facilitated by repeated experience.* Repetition in learning is much more than the redundant drill and practice by which it is so often characterized. Beyond its application to learning by rote, repetition plays a significant role in the acquisition of knowledge and skills in the unplanned, informal, experiential learning of our lives. Where there exists a similarity across objects or events, there exists a pattern. Where there exists a pattern, there exists the possibility of anticipating reoccurrence of the event characteristics that make up the pattern. As we recognize these patterns we are able to respond to them in systematic and automatic ways, refining and improving our response over time. Recognition comes by way of repeated exposure to the pattern. Thus, by the same principle of repetition which makes possible the rote memorization of discrete facts we might also develop higher order skills such as closing a complex sales transaction, managing personal or business finances, or delivering a public speech. It is primarily through repetition that patterns become well established and are differentiated from what has already been learned.¹²¹

¹²¹ Where there is greater significance (Principle #3f), or more easily attained contrast (Principle #3e), there is a decreased need for repetition.

Principle #3b – Time. *Learning takes time.* Time does not cause learning to happen but provides a necessary condition for it to take place. This foundational role of time in learning was well stated by McGeoch (1932) when he said,

Time, in and of itself, does nothing. It contributes, rather, a logical framework in terms of which we can describe the sequence of observed events. Certain spans of it are necessary in order to give other and effective factors a chance to operate, and time, thus, figures largely in scientific description, but not as a factor in causal laws nor is itself active in any way. (p. 359)

There are two important aspects of time in learning. First is the total amount of time required to attain the learning target. Second is the distribution of learning activity within that span of time. Because of mental and physical fatigue, it is generally not feasible to reach a sizable target in one continuous session of practice. Instead, sufficient time must be allowed for the learning target (i.e., the pre-determined change in capacity) to be achieved, and then practice must be distributed within that span of time as necessary to allow for recovery from physical and mental fatigue.¹²² Distribution of practice is also necessary because massed, repeated exposure results in temporary automaticity, meaning the activity may be performed without attention. Until firmly established however, this automaticity is fleeting.

Principle #3c – Step size. *Smaller increments of attainment are more easily and more quickly achieved than larger ones.* Intuitively, one might be inclined to find fault with this principle by citing the very large amount of time and effort required for someone working at an expert level to refine their performance—for example, the hours and hours and hours of practice

¹²² Time is primarily a function of repetition (Principle #3a), or, the duration and frequency of whatever practice models, exercise, or experience (Principle #4) is necessary to effect the desired change in capacity (Principle #2).

that go into shaving a mere few hundredths of a second off a race time or making very subtle changes in posture to perfect one's form in gymnastics or dance. These examples seem to be in direct contradiction to the principle as stated. In fact, it can easily be argued that *most* of the work that goes into training for world champion athletes, expert craftsmen, or top notch professionals, is required at the high end of performance in which the *least* amount of gain is realized. The misunderstanding here, however, is in regards to the metric of attainment. Step size of attainment is not a measure of the amount of time taken off the clock, or the magnitude of change in effective displacement toward refinement of a physical movement or posture. It isn't the change in degree of precision in communication, execution of a medical procedure, or preparation of a technical specification. To the contrary, *step size of attainment is a measure of effort*. It's not the size of the resulting change, but rather, the amount of effort required to make it happen.¹²³

Principle #3d – Sequence. *Prior learning may facilitate or hinder ensuing attainment.*

This principle captures two ways in which prior learning might affect new learning. In the first case, something that has been learned previously can be applied in a beneficial way toward learning something new. For example, previous experience wakeboarding behind a boat means one does not have to acquire basic board skills (i.e., posturing, balance, speed control, and steering) when learning to kiteboard. Since full attention can be devoted to learning to control the kite and respond to wind and water surface changes, a person who has prior wakeboarding

¹²³ The amount of effort required is relative to what has previously been learned (Principle #3d) and is also a function of the degree of difficulty an individual might experience in achieving a particular learning target due to physical, psychological, or emotional traits and conditions, as well as previously established habits of engagement or aversion (Principle #6).

experience will be able to take up kiteboarding more quickly, all other things being equal, than someone who does not. The same analogy can be used to consider the second case, where previous learning may hinder learning something new. The learner with previous wakeboarding experience comes into kiteboarding with a habit of using the rope handle to bear his weight and pull him across the surface of the water. This presents a problem in the kiteboarding situation however, as the in-and-out motion of the handle is used to control kite speed, which is the surface area of the kite that is exposed to the oncoming wind stream. When taking up kiteboarding, the wakeboarder will need to fight the urge to pull on the handle and instead learn to sit back into the waist harness to which the kite is attached, leaving his arms free to vary kite speed as needed by moving the handle up or down.¹²⁴

***Principle #3e – Contrast.** That which is to be learned must be differentiated from and related to that which has already been learned, or from that which is similar, but critically different.* The principle of contrast applies to the learning of factual knowledge, the understanding of concepts, the execution of physical movements, and performance of complex tasks, as well as to the formation of beliefs and the cultivation of feeling. When new knowledge, skills, or beliefs are perceived as being no different from existing knowledge, skills, and beliefs, the salient features of what is new will be ignored and will be lost. Learning will not take place because what is new will be discounted as simply another case of what is already known. To

¹²⁴ The facilitating effects of sequence are dependent on recognition of how what is currently being learned relates to what has already been learned (Principle #3e) as well as the degree of effort (Principle #3c) required to coordinate previously acquired knowledge and skills. Maximal facilitating effects of sequence are realized when the coordinating effort is minimal, or fully automatic, and there is full and accurate recognition of how what is currently being learned is related to what has been learned previously.

prevent this, differences between what has already been learned, or between new things which are similar, must be accurately and fully recognized by the learner.¹²⁵

Principle #3f – Significance. *That which is to be learned must be significant in some way to the learner.* Significant learning experiences are those which claim the attention of the learner, those which are connected to prior experience and knowledge, those which require the exertion of effort, or those which are accompanied by an intensity of sensation or emotion. Significance through meaning can result from repetition (i.e., the establishment of familiarity of a previously unfamiliar pattern, as described in Principle #3a) but may also initiate it. For example, the occasional experience which has a certain novelty, demands great effort, or is accompanied by strong intensity or emotion will often be rehearsed repeatedly in the mind, related in communication with others, and even acted out. Mental rehearsal permits learning with apparently, but not actually, less repetition than might otherwise be expected¹²⁶ since internal rehearsal takes the place of external reenactment. As previously noted (Principle #2), significance that stems from novelty, intensity, and effort wanes with repetition, as the mind and body adjust and provide automatic, but temporary, ways of responding.

Principle #3g – Feedback. *Feedback is the means by which learning is directed toward a specific target of attainment.* All intentional or directed learning is aimed at the attainment of some target. Feedback is the means by which the learner, or any other agent directing the

¹²⁵ Both repetition (Principle #3a) and significance (Principle #3f) facilitate the process of differentiation: repetition provides multiple opportunities for comparison between similar instances; significance, through attention, brings to light salient similarities and critical differences.

¹²⁶ With greater significance and contrast (Principle #3e), fewer acts of repetition (Principle #3a) are required since once the critical features are understood, it is no longer necessary to discover them.

learning process, ascertains whether or not progress is being made toward the end goal, and whether or not the goal has been reached. Feedback may come in many forms but, when effective, always provides an indication of (a) whether or not the target has been attained, (b) whether or not the learner is making progress toward the objective, and (c) what needs to happen in order for the learner to move forward.

It is also true that feedback also plays a role in incidental learning—i.e., learning in which the target is not intentional, but rather, is incidental to circumstances to which the learner is subjected. By this definition, there are two cases to consider. First is the case in which a person has no intention to learn, but engages in various activities for some other reason (e.g., to earn money, to pursue pleasure, to get a high score, to avoid negative consequences, or to get something for nothing). In this case, the feedback that person will be attending to is feedback regarding whether or not they are meeting their goals. Under these circumstances adjustments may be made that result in an increase of capacity or establishment of habit, and thus, learning will occur. As an example, many people have little interest in technology per se, but are very interested in maintaining social connections and interacting with their friends. In pursuit of new means by which to engage, they incidentally acquire knowledge about, skill to use, and habits of engaging with mobile devices and online social networks. The second case where feedback plays a role in incidental learning is when a person is actually working towards a predetermined learning target (i.e., an *intentional* target), but makes incidental attainment of other targets along the way which may or may not be incremental steps toward the end goal itself.

Principle #4 – Practice. *Principles of change are activated and aligned with learning targets through models of practice, exercise, or experience.* It is in the componential features of practice activities that principles of change are realized and are aligned with learning targets

(Figure 6). Just as learning targets may be determined intentionally or incidentally, so too are various types of practice activities determined, with or without intention. As used here, *practice models* refers to activities that are specifically designed or selected to move a person toward a predetermined target of learning. Similarly, *exercise* is used to refer to the type of repeated activity that is intended to build up strength or precision—which are two examples of vertical capacity increase that enable a more advanced level of performance.

Experience refers to unplanned, incidental activities that are not coordinated with specific learning targets and that lack intentional accounting for implementation of the principles of change which govern learning. Learning occurs in such activities as the result of any adjustment made by a person to adapt to aspects of the experience which are beyond their current limits of capacity; or to modify their patterns of acting, believing, or feeling, thereby establishing new habits. Because it is not directed toward a specific target of learning, incidental learning through unplanned experience is not as efficient as learning through designed or selected models of practice and exercise in the attainment of specific targets. In fact, many learning targets would never be attained without such direction. Note, however, that *designed* practice models should not be misinterpreted to mean *artificial*, or *decontextualized* models of practice activity. On the contrary, the most effective models of practice are those in which practice activities are *exactly the same as*, or *provide genuine approximation of*, the activities of performance which they are intended to make possible or improve. It is certainly possible to design a practice model which simultaneously maximizes learning and approximation of expected activities of performance, though doing so may require some effort.

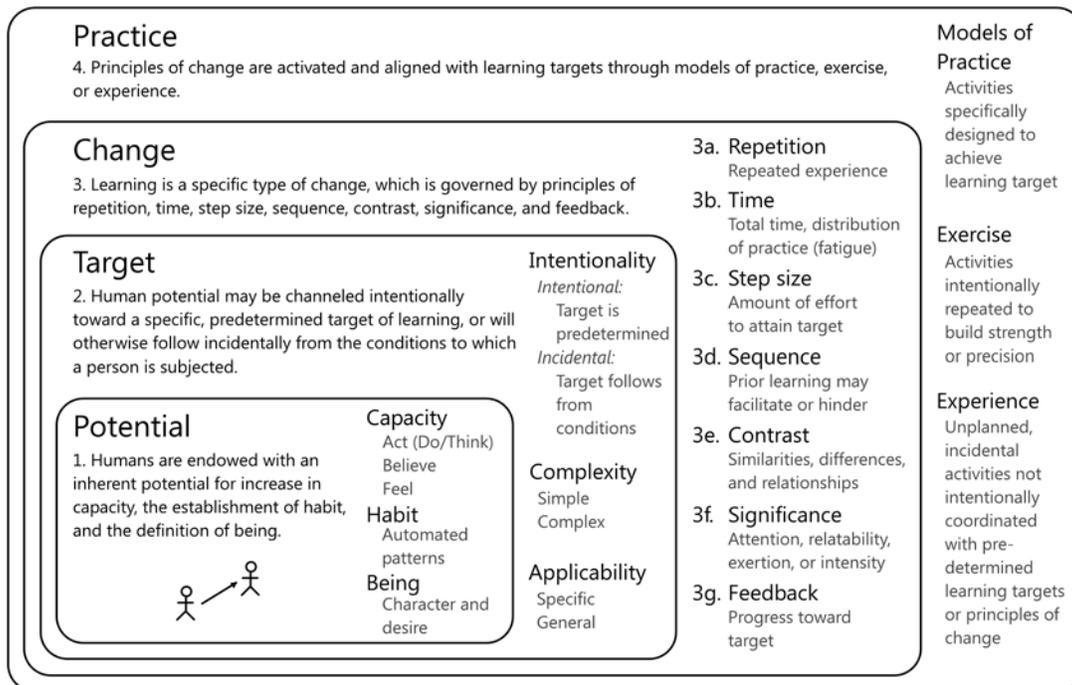


Figure 6. Principles of change are activated and aligned with learning targets through models of practice, exercise, and experience

Principle #5 – Context. *Learning is facilitated by a context of practice that is the same as, or accurately represents, the context of performance.* The principle of context has been added to the model in Figure 7.

Just as models of practice are most effective when they are the same as, or genuinely approximate, the activities of performance which they are intended to improve, so too, a *context* of practice which accurately represents the context of performance is more effective than one that does not. Any limited or artificial context of practice used to manage the step size of learning should (a) be constructed with great attention to specific details of what is omitted, included, or modified relative to the authentic context; (b) should be utilized judiciously with

specific purpose; and (c) should not replace the complete, expected context of performance for longer than is necessary. There are two reasons for moderate use of limited or artificial context. The first is that artificial contexts typically do not supply all of the necessary features of authentic activity. The second is that learners come to rely on features in the artificial context that will not be available to them in the authentic context of the activity.

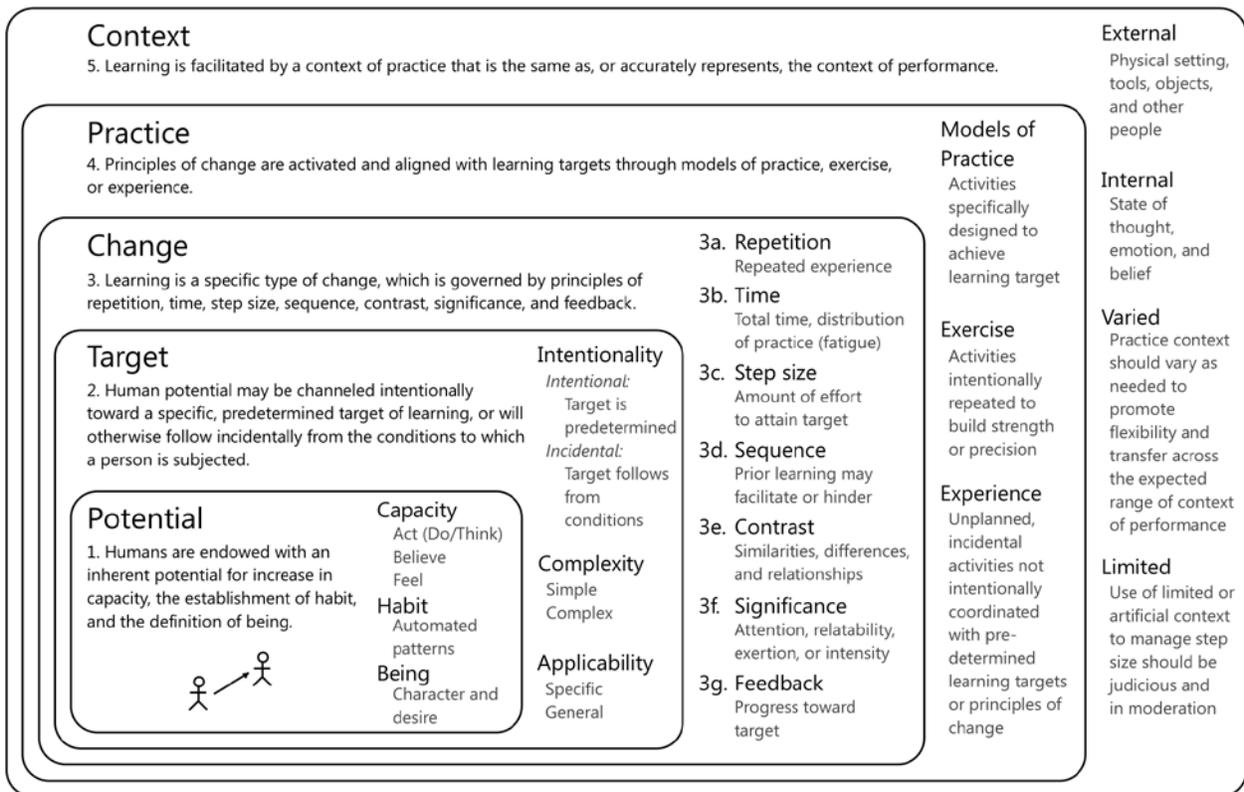


Figure 7. Learning is facilitated by a context of practice that is the same as, or accurately represents, the context of performance.

Not all features of context are important. Hence, in many cases, part of what is practiced in learning is constant discrimination between salient and non-salient contextual features, and

learning to respond to changes in a dynamic context. Because of this, the context of practice may need to vary, both to give learners a chance to identify and respond to critical elements, and to facilitate transfer of skills across all relevant variations which are expected.

A useful distinction is made in the framework between internal context and external context. Internal context is defined by one's state of thought, emotion, and belief. External context is defined by the presence of other people, the physical setting, and any tools or objects present.¹²⁷ Context for acts of thinking, believing, and feeling may stem from external sources, but may also manifest as the result of internal factors. For example, specific thoughts might induce certain feelings, and specific feelings might give rise to certain thoughts or beliefs. Context for acts of doing is largely external. Internal context is primarily induced through elements in the external context and sensory input received through interaction, however, internal context which is induced internally is also a factor in acts of doing, and accounts for phenomena such as *chickening out* or *psyching oneself up* to meet a formidable challenge.

Principle #6 – Engagement. *Learners will often engage in certain activities as a matter of habit, though they are also influenced by their current capacity to engage, as well as factors of motivation and inhibition related to the activity as a whole, part of the activity, its circumstances, or its expected results.*

¹²⁷ Although tools are a type of object, a distinction is highlighted here between objects which might be *used* in some way to perform an activity and objects which serve only an *interpretive* purpose in the activity—for example, a street skateboarder will *ride* the skateboard object, and *slide down* a stair rail. In this activity, these two objects constitute tools of use. Other objects in the scene along with their physical attributes—such as a trash can, rocks on the ground, a nearby picnic table, the sheen of the paint on the rail and whether or not the paint is chipped—are objects that provide an interpretive context for the skateboarder to estimate the height of the drop, the slipperiness of the rail, and the best launch and landing point. The term objects is used here to include both animate and inanimate objects.

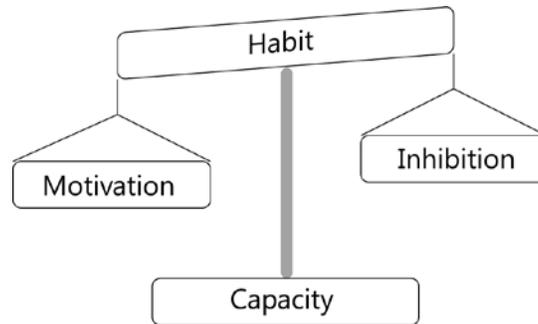


Figure 8. The relationship between the four components of motivation

As shown in Figure 8, engagement is divided into four components: (a) capacity, (b) habit, (c) motivation, and (d) inhibition. The necessary condition for engagement in any learning activity is that the learner must possess sufficient physical, mental or emotional capacity to do so. Where capacity is insufficient it may, in most cases, be acquired through (a) antecedent learning (e.g., the acquisition of pre-requisite knowledge and skills), (b) biological maturation (e.g., growing taller and stronger, or developing coordination), (c) recovery (e.g., from fatigue or injury), or (d) supplementation (e.g., prosthetics, ergonomic affordances, reference material, guides, drugs, or assistance from others). In other cases, the learning activity itself may need to be adapted in order to accommodate learners with limitations that may not be overcome through one of the four ways listed above.

There are many and various reasons for which a person might engage in, or avoid, a given learning activity. It is usually the case that a person will engage in certain activities, do things in a certain way, or avoid certain activities, based on previously established habits. Habits of activity, however, are subject to current levels of capacity, factors of motivation, and factors of inhibition. Given sufficient capacity, habits of engagement are swayed by factors of

motivation or inhibition. An enumeration of these factors is given below, which enumeration is derived from the local principles of engagement presented in chapter four.

Any factor which draws learner engagement is a factor of *motivation*. Motivational factors are represented in the principles-of-learning framework by the following five categories of motivation, not in any particular order:

1. *Pleasant Sensation* – intellectual, emotional, or physical pleasure
2. *Pleasant Affiliation* – interaction and relationships with others
3. *Positive Validation* – establishment and validation of one's identity, self-worth, self-efficacy, self-esteem, or reputation
4. *Extension* – increase in one's capacity (learning itself can be motivating¹²⁸)
5. *Opportunity* – the future possibility of engagement in some activity which brings pleasant sensation, pleasant affiliation, positive validation, extension, or additional opportunity

Any factor which deters engagement is a factor of *inhibition*. Inhibitory factors are represented in the model by five categories of inhibition:

1. *Unpleasant Sensation* – unpleasant intellectual, emotional, or physical sensation
2. *Unpleasant Affiliation* – unpleasant interaction and relationships with others
3. *Negative Validation* – diminution of one's identity, self-worth, self-efficacy, self-esteem, or reputation
4. *Interference* – conflict with a more preferred activity

¹²⁸ As Merrill (2009) said, "Perhaps the greatest motivator of all is learning itself. Human beings are wired to learn." (p. 21)

5. *Responsibility* – any future social or moral obligation incurred through increase in capacity, including the need to consistently meet or exceed one's own self-established standard

Each factor of motivation and inhibition may be associated with (a) the learning activity as a whole, (b) one or more parts of the learning activity, (c) the circumstances in which the learning activity takes place, or (d) the expected results of the learning activity. While *pleasant sensation* and *pleasant affiliation* are motivational factors of the activity itself, *positive validation*, *extension*, and *opportunity*, are associated primarily with the results of the learning engagement. If pleasant sensation and affiliation are not authentic or inherent to the learning activity, they may compete with or detract from it. Hence, motivation in these two categories that is artificial to the learning activity should probably be avoided. At a minimum, it must be conducive to true engagement, or actual learning may be derailed.

Like their motivational counterparts, *unpleasant sensation* and *unpleasant affiliation* are associated with the activity itself, as is *interference*. *Negative validation* and *responsibility* are associated with its results. Unlike their counterparts in motivation, however, unpleasant sensation and unpleasant affiliation discourage engagement regardless of whether they are inherent to the activity or artificially added in the practice model.

Presumably, motivation stemming from the complete learning activity itself will produce the most significant (Principle #3f) engagement, followed by motivation stemming from only a portion or part of the activity, followed by motivation stemming from the expected results of the activity, and then by motivation from circumstances in which the activity takes place. In the third case, circumstantial motivation, the actual source of motivation is incidental to, but not part of, the activity—occurring immediately before or after the activity, occurring in parallel with but

separate from the activity, or appearing briefly on the scene in tangential fashion. Proximal effects of inhibition are presumed to mirror those of motivation. That is, inhibition stemming from the activity as a whole will produce the greatest aversion to participation, followed by inhibition stemming from only part of the activity, followed by inhibition stemming from the expected results of the activity, and finally, followed by circumstantial inhibition. This presumed ordering of effect for both motivation and inhibition is assumed to be generally true, but by no means absolute.

In many cases, some parts of an activity may be the cause of inhibition while other parts simultaneously give cause for motivation to engage. Although the ultimate determination for engagement is learner choice, as will be discussed next (Principle #7), it is assumed in the model that choice is strongly influenced by the net strength of combined factors of capacity, habit, motivation and inhibition. When capacity is truly lacking, engagement cannot occur. When habit of engagement or aversion has been previously established, that same pattern will generally persist unless influenced by factors of motivation or inhibition. When total motivation outweighs total inhibition, learners will engage. When total inhibition outweighs total motivation, the learner will either abstain from engaging entirely, or will engage and participate in an amotivational state, simply going through the motions¹²⁹ but without significance.

Principle #7 – Agency. *Learners are not passive recipients of learning, but active agents with the ability to choose how they will apply their attention and effort, and to choose what learning activities they will engage in. Others may exercise their agency to promote or inhibit*

¹²⁹ See Deci and Ryan (2000, p. 72).

the agency of the learner, and may play a role in facilitating or impeding successful learning. As shown in Table 12, the principles-of-learning framework distinguishes between four agent roles: (a) learner, (b) peer, (c) mentor, and (d) administrator. The *learner* is assumed to be an active agent, able to determine his or her own learning targets, practice models, contexts of practice, and reasons for engagement. A learner is also able to choose whether or not to engage with learning opportunities that are determined by others, and to decide what level of effort to give. The roles of peer, mentor and administrator are defined with regard to their impact on the learner. The terms mentor and peer are used here in a broad sense, defined by their function in this relationship, as opposed to any concomitant connotation of occupational or enrollment status in a formal institution of education.

When a person is co-experiencing learning with the learner and working toward the same or very similar learning goals, they are acting in the role of *peer*. Peers can be a major determinant of learner engagement by providing motivation in the form of pleasant affiliation and positive validation or inhibition in the form of unpleasant affiliation and negative validation. Peers may also provide examples of emerging or successful models of target performance, and function as observational models to facilitate vicarious learning. Interactive models of practice might also involve peer participation. In some cases, peers will function as human participants in the learning context, without any direct interaction with the learner.

Table 12

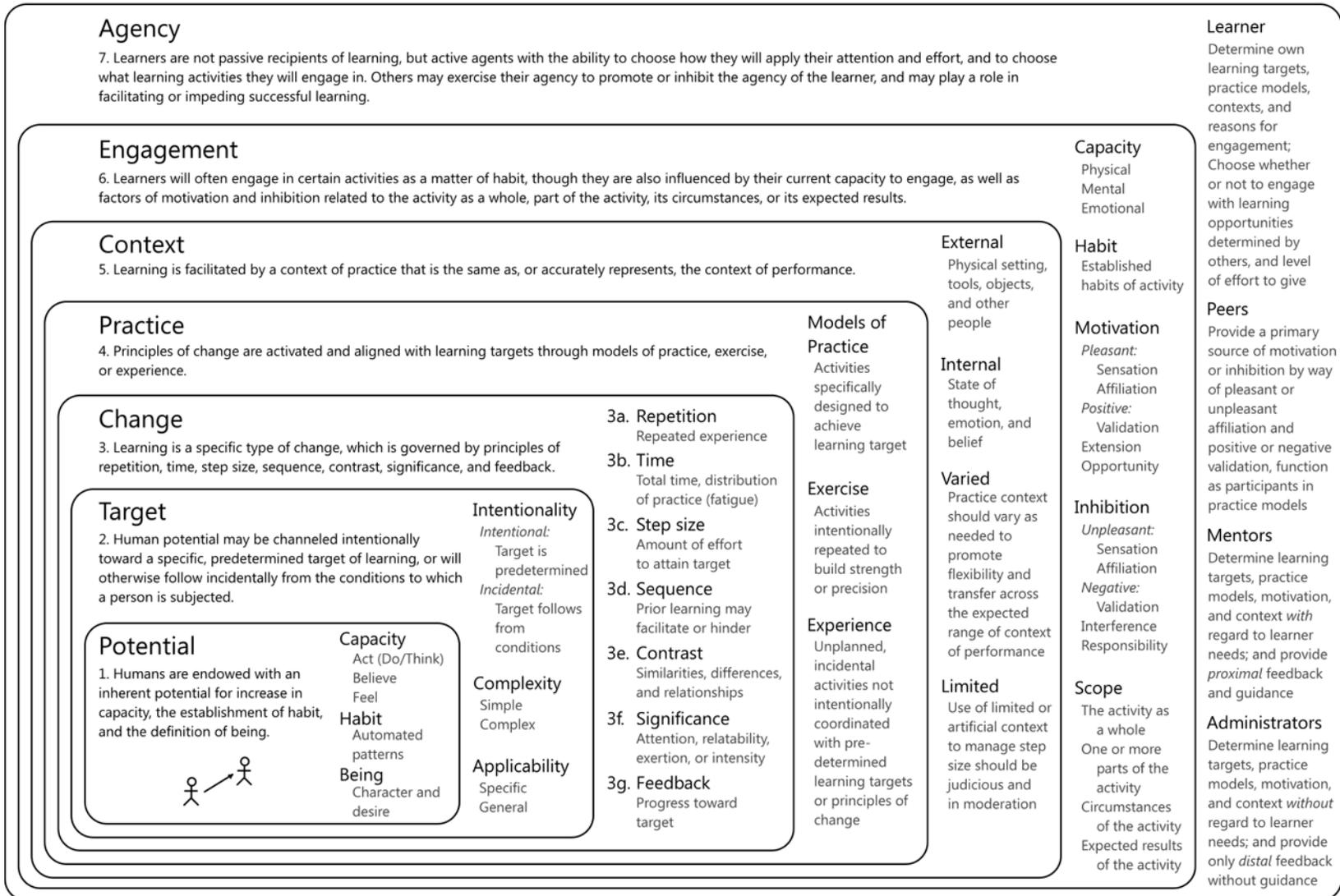
Four Roles of Agency in the Principles-of-Learning Framework

Learner	Peer	Mentor	Administrator
Determine own learning targets, practice models, contexts, and reasons for engagement	Provide a primary source of motivation or inhibition by way of pleasant or unpleasant affiliation and positive or negative validation	Determine learning targets, practice models, motivation, and context <i>with</i> regard to current capacity and individual nature of the learner	Determine learning targets, practice models, motivation, and context <i>without</i> regard to current capacity and individual nature of the learner
Choose whether or not to engage with learning opportunities determined by others, and level of effort to give	Function as participants in practice models	Provide <i>proximal</i> feedback and guidance □	Provide <i>distal</i> feedback without guidance

When a person determines learning targets, models of practice, motivators of engagement, and context of practice *with regard to the current capacity and individual nature of the learner*; and when they provide proximal feedback, assistance, and guidance directly to the learner; they are acting in the role of *mentor*. In contrast, a person that determines learning targets, models of practice, motivators of engagement, and context of practice *without regard to the current capacity and individual nature of the learner*; and provides only distal feedback (e.g., grades, certificates of completion or graduation); is acting in the role of *administrator*. Though agents in both roles set the parameters of the overall learning experience, mentors do so with attendance to the specific needs of the individual learner, while administrators do not. The completed principles-of-learning framework is shown in Figure 9.

PRINCIPLES OF LEARNING

A Conceptual Framework for Domain-Specific Theories of Learning



Relationships Among Principles

The nested structure of the principles-of-learning framework is intended to represent certain relationships between principles. First, potential for capacity increase and the establishment of habits *may be channeled toward* a specific target of learning. Second, a target of learning *is attained by way of* principles of change. Seven of the principles of learning identified in the present study are principles of change, or principles that directly facilitate the process of learning and are necessary in order for learning to occur. Third, principles of change *are embodied in* models of practice. Fourth, practice always *occurs in* one context or another. Fifth, the current capacity of the learner, habits of engagement and aversion, as well as various factors of motivation and inhibition, *strongly influence learner participation* in a given model of practice. And finally, sixth, it is learner agency that ultimately *determines engagement* and the level of effort and attention given.

In addition to the relationships named above, other relations between principles have been noted during the course of this study. The following list is illustrative, but not presumed to be comprehensive.

1. *Potential, Target* and *Agency* – Channeling of potential (Principle #1) toward a specific target (Principle #2) may be guided by the learner, a mentor, or an administrator (Principle #7).
2. *Significance, Contrast* and *Repetition* – Where there is greater significance (Principle #3f), or more easily attained contrast (Principle #3e), there is a decreased need for repetition (Principle #3a).
3. *Time, Repetition, Practice,* and *Target* – Time (Principle #3b) is primarily a function of repetition (Principle #3a), or, the duration and frequency of whatever practice

- models, exercise, or experience (Principle #4) are necessary to effect the desired change (Principle #2) in capacity or establishment of habit. As the need for repetition increases, the amount of time required also increases.
4. *Step Size, Sequence, and Engagement* – The amount of effort required (i.e., step size, Principle #3c) is relative to what has previously been learned (Principle #3d) and is also a function of the degree of difficulty an individual might experience in achieving a particular learning target due to physical, psychological, or emotional traits and conditions (i.e., current capacity, also Principle #3d), as well as previously established habits of engagement or aversion (Principle #6).
 5. *Repetition, Significance, and Contrast* – Both repetition (Principle #3a) and significance (Principle #3f) facilitate the process of differentiation (Principle #3e): repetition provides multiple opportunities for comparison between similar instances; significance, through attention, brings to light salient similarities and critical differences.
 6. *Engagement and Significance* – Presumably, motivation (Principle #6) stemming from the learning activity itself will produce the most significant (Principle #3f) engagement, followed by motivation stemming from the expected results of the activity, and then by motivation from circumstances in which the activity takes place.
 7. *Step Size, Repetition, and Time* – As step size increases (Principle #3c), repetition (Principle #3a) and time (Principle #3b) also increase.
 8. *Sequence, Contrast, and Step Size* – The facilitating effects of sequence (Principle #3d) are dependent on the learner recognizing how what is currently being learned relates to what has already been learned (Principle #3e) as well as the degree of effort

(Principle #3c) required to coordinate previously acquired knowledge and skills.

Maximal facilitating effects of sequence are realized when the coordinating effort is minimal, or fully automatic, and there is full and accurate recognition of how what is currently being learned is related to what has been learned previously.

Using the Principles-of-Learning Framework in Practical Application

At the end of chapter two, five activities were listed to which the conceptual framework might be applied: (a) communicating about the learning process, (b) evaluating instructional products and methods, (c) diagnosing very specifically why a particular product or method fails to result in effective or efficient learning, (d) developing effective instructional products and methods, and (e) conducting research to investigate meaningful hypotheses suggested by the framework.

The principles-of-learning framework facilitates communication by the names and explanations of seven principles that make up the complete structure of learning (potential, target, change, practice, context, engagement, and agency) and seven principles of change that facilitate it (repetition, time, step size, sequence, contrast, significance, and feedback). These fourteen principles provide both a common vocabulary and a checklist of accountability for any conversation on learning: (a) their names and explanations provide lexical and semantic reference, and (b) one who is familiar with the framework cannot talk about the process of learning in ignorance of any of its component parts or their holistic function as a complete set. In this way the framework provides a measure of accountability. Likewise, when talking about any specific part of the process, the framework provides a contextual background of reference to better understand its individual role in the learning process as a whole.

The principles-of-learning framework can also be employed in evaluation, diagnostic or development tasks by asking questions such as those shown in Table 13. In evaluation the framework would be used to conduct a complete examination of an instructional product or method, resulting in a full report. In diagnostic activity the framework would be used similarly, but with the goal of identifying only specific points of failure, rather than a complete description. Similar questions would be asked in development tasks, but would be oriented toward defining features and functions of the product or method being developed with reference to principles of learning. Opportunities for research are abundant in the framework, suggested both by individual principles, combinations of principles, relationships between principles, and of course, in utilizing the framework as a whole.

Table 13

Sample Questions for Using the Principles-of-Learning Framework in Evaluation or Development

Principle	Questions
Potential	<p>Is potential to be realized an increase in capacity, establishment of habit, or definition of being?</p> <p>If capacity, is the expected increase one of <i>doing, thinking, believing, or feeling</i> and is it a vertical or horizontal expansion?</p> <p>If habit, is the expected pattern a habit of acting, thinking, or feeling?</p> <p>If being, what is the desire or character to be cultivated?</p>
Target	<p>What are the learning targets and are they intentional or incidental?</p>
Change	<p><i>Repetition:</i> What type and amount of repetition is expected?</p> <p><i>Time:</i> What total duration of time can be expected in order to attain each target? Is practice distributed to allow recovery from physical and mental fatigue and to maximize significance through novelty and perceived need?</p> <p><i>Step Size:</i> How much effort is required to attain each target? Should it be broken down into</p>

smaller (or combined into larger) steps?

Sequence:

What prior capacity can be leveraged? Does the sequence of what is to be learned enable prior learning to facilitate subsequent learning?

Contrast:

How is what is being learned differentiated from or related to what has been learned previously, or similar knowledge and skills to be learned simultaneously?

Significance:

How is what is being learned significant to the learner?

Feedback:

What forms of feedback are available to the learner or other agents directing the learning process?

Practice models	Do practice models fully implement necessary principles of change and are they the same as, or an accurate representation of, expected models of performance?
Context	Is the context of practice the same as, or an accurate representation of the expected context of performance?
Engagement	Do learners possess the current capacity necessary to engage? Is there a habit of engagement or aversion? What factors of motivation and inhibition are present, and do they relate to the activity as a whole, parts of the activity, tangential circumstance, or expected results?
Agency	Is the learner aware of the learning targets? What role might others play in the learning process?

Domain-Specific Theories of Learning

The title of this dissertation needs some explanation. Specifically, it remains to be clarified what *domain-specific theories of learning* are, and how they are related to the principles-of-learning framework that has been described. To begin, Van Oers (1998) described a transition of learning theory in past decades from "being an oversimplified general theory...[to] a complex theory with several parameters that need to be specified for different real-world conditions" (p. 473):

The idea that all kinds of learning processes in any situation can be accounted for by one limited general set of laws or mechanisms, has been replaced by a view on learning that

acknowledges the importance of the content of learning, as well as the nature of the learning situation. Domain specificity and situatedness are now generally recognized as major parameters of any theory of learning. Context has become a hot issue in modern educational science. (Van Oers, 1998, p. 473)

According to Mayer (2002), this transition of focus from grand theories of learning to domain-specific theories of learning began as early as the mid-20th century:

Throughout the first half of the 20th century researchers sought to build grand theories of learning that could account for all forms of learning, but by mid-century it became clear that such efforts had failed (Mayer, 2001). Instead, today scholars focus on domain-specific theories of learning, such as trying to understand how people learn how something works or how to carry out a given procedure. Gone are the days when grand theories of learning dominated psychology and education, replaced today with more focused and modest theories of learning. (pp. 101-102)

Mayer attributed this transition of focus as a response to the challenge from the field of education to psychology "to build theories of learning that account for academic performance" (Veronikas & Shaughnessy, 2005, p. 185):

The result has been the emergence of psychologies of subject matter in which the goal is no longer to create general theories of learning and development but rather to focus on how students develop and learn in specific subject areas. For example, we now have research-based theories of how students learn to read words, to comprehend passages, to write essays, to solve math problems, or to think scientifically. Domain-specific theories of learning and development have been far more successful than classic general theories, producing an advance to psychological theory and educational practice. (p. 185)

These statements might give one the impression that there is a flurry of activity toward the mass creation of domain-specific theories. However, in my own experience, that does not seem to be the case. Though there certainly appears to be a general abandonment of the in-tact use of grand theories of learning, but I was hard pressed to find many formal definitions of

domain-specific theory or evidence of methodological and disciplined creation of such theories. In fact, I am aware of only two significant efforts, and will briefly summarize each.

Cobb, Confrey, diSessa, Lehrer, and Schauble (2003) described design experiments¹³⁰ in educational research as a method for developing domain-specific theories of learning, or in their words, "crucibles for the generation and testing of theory" (p. 9). In their article, they referred to domain-specific theories of learning as "humble" (p. 9), "not merely in the sense that they are concerned with domain-specific learning processes, but also because they are accountable to the activity of design" (p. 10). They explained that in comparison with general philosophical orientations—e.g., behaviorism, cognitivism, constructivism, humanism, and socialism—which "often fail to provide detailed guidance in organizing instruction" (p. 10), and in comparison with "high' theory [which tends] to pass over what may be important details in an effort to paint phenomena in uniform terms" (p. 13), these theories "must do real work" (p. 10). Their claim is that theories developed by method of the design experiment, because of its practical nature, are sure to be both relevant and specific, meaning they "do real work in practical educational contexts" (p. 13).

Unfortunately, with their focus on the process of conducting a design experiment, Cobb et al., only hinted at a definition of domain-specific theories of learning by noting the importance of "conjectured starting points, elements of a trajectory, and prospective endpoints" (p. 11), accompanied by "conjectures about both significant shifts in student reasoning and the specific means of supporting those shifts" (p. 11). Thus, a domain-specific theory by this definition

¹³⁰ Cobb et al. (2003, p. 9), acknowledge the term *design experiment* to Brown (1992, p. 141) and Collins (1990), although they also note that pedagogical design has informed the development of theory for several decades.

accounts for (a) the learner's starting point, (b) their prospective endpoint, (c) the trajectory between the start and end points, (d) progressive shifts toward the endpoint, and (e) an instructional theory of how to support those shifts. An example of the type of design experiment described in Cobb et al. (2003) can be found in Cobb, McClain, and Gravemeijer (2003) in which the expected initial trajectory, process of validation, and modified trajectory are described.

In comparison, Bunderson (2003; 2011) has provided a much more detailed and complete articulation of domain-specific theories of learning, with an emphasis on measurement and construct validity. His description begins with the introduction of the term *domain theory*, by Messick:

The boundaries and structure of the construct domain can be addressed by means of job analysis, task analysis, curriculum analysis, and especially domain theory, in other words, **scientific inquiry into the nature of the domain processes and the ways in which they combine to produce effects or outcomes. A major goal of domain theory is to understand the construct-relevant sources of task difficulty**, which then serves as a guide to the rational development and scoring of performance tasks and other assessment formats. At whatever stage of its development, then, domain theory is a primary basis for specifying the boundaries and structure of the construct to be assessed. (as quoted in Bunderson, 2011, p. 3)

Out of respect for Sam Messick, Bunderson has frequently used the term *domain theory* in his writing, but to avoid confusion with other definitions of the term, such as those used in computer science and chemistry (2011, p. 4), he has also introduced the more descriptive label *learning theory of progressive attainments*, occasionally appending to it *in X domain*, in order to "identify the local learning domain where the theory has context" (p. 4). The occasion reference to *local learning theory* is also used.

To define *domain*, Bunderson (2011) adopted McShane's cognitive developmental definition:

The term “domain” ... denotes a collection of tasks that share a common representation system and a common set of procedures for operating on these representations to perform tasks. Thus, for example, number is a domain of cognition, so is language...On this account, chess is a domain; music also... domains may overlap, either by having similar representations...or similar procedures. (McShane, 1991, as quoted in Bunderson, 2011, p. 4)

Bunderson (2011) also described the collection of tasks within a domain as being ordered, where "increasingly difficult tasks may be performed by persons who have progressed greater distances along important dimensions of the domain" (p. 4). He combined these ideas to produce the following definition of domain theory:

Domain theory (or learning theory of progressive attainments) is a descriptive theory of the contents, substantive processes, dimensional structure, and boundaries of a domain of human learning or growth that gives an account of construct-relevant sources of task difficulty, and conjointly, an account of the substantive processes operative in persons at different levels of learning or growth along the scale(s) that span the domain. A domain theory is associated with one or more measurement instruments, technological devices that can come in contact with learners at different levels of progress, and in so doing, can associate states of the learner with levels of attainment defined for each dimension in the domain.

It is important to note that theories of progressive attainments "give a *conjoint account* [italics added]of both person proficiency and task difficulty" (Bunderson, 2011, p. 13), with person proficiency ranging from the most novice within the domain (person alpha) to the most advanced (person omega), and with tasks ranging from easiest (task alpha) to the most difficult (task omega). An example of a design experiment which used Bunderson's conception of domain theory to develop a theory of progressive attainments in the domain of fluent oral reading with expression is described in both Bunderson (pp. 15-20) and Bunderson, Wiley, and McBride (Bunderson, Wiley, & McBride, 2009, pp. 334-345).

Bunderson's description of domain theory is the most complete description of domain-specific theories of learning that I am aware of. In compliment to what he has already described, I would like to add my own provisional definition in terms of the principles-of-learning framework of the present study. This definition mirrors some of the criteria already mentioned, but in different terms, and adds additional criteria which I believe are necessary components of the more complete picture.

According to the principles-of-learning framework, a domain-specific theory of learning must account for

1. The various types of increase in capacity and changes in habit that are possible within the domain, from the most basic levels at which participation is possible (in terms of both person ability and task difficulty, and for all tasks in the domain), to the most advanced extent where all potential for capacity increase or change is fully realized.
2. All possible targets of learning, both interim targets that enable subsequent progression in the domain and end-goal targets at which full potential is reached, as well as various learning progress pathways through the domain along which those targets lie.
3. General expectations of range of variability of, and common values for, parameters of change, specifically (a) the expected number of repetitions, (b) the amount of time necessary to attain each target along a learning progress pathway, (c) the expected granularity of step size, (d) the sequence of targets and connected pathways of learning, (e) anticipated similarities and differences between what has already been learned and what is being learned simultaneously, (f) factors of significance, and (g)

- integrated methods of feedback that allow for informed, dynamic adjustment of the parameters of change to meet the needs of the individual learner.
4. Various practice models and exercises that provide for graduated progression along a pathway of learning toward a specific target.
 5. Variations of context in which domain performance is expected to occur, including any limited context that might be used to control step size and sequence (i.e., providing scaffolding by holding certain context variables constant or by introducing performance aids of some kind).
 6. Current capacity, habits of engagement or aversion, and general factors of motivation and inhibition; as well as a model for dynamic, ongoing reappraisal of, and compensation for, the same.
 7. The roles and agency of the learner and others acting and interacting in the domain, both during practice and in authentic performance or participation.

In short, a domain-specific theory of learning should account for each component in the principles-of-learning framework. It should describe not only the learning pathways through the domain with the task models they represent and instruments for measuring and reporting progress, but it should also describe the means by which attainments are made (i.e., the seven principles of change and expected values), the context of practice, factors of engagement, and the roles of agents involved. Without detracting from the five practical uses to which the principles-of-learning framework might be applied that were described in the previous section (namely, communication, evaluation, diagnosis, development, and research), I submit that its role in the creation of domain-specific theories of learning might be its most valuable application of all.

Chapter 6: Conclusion

Although the process of learning is generally complex it is not entirely unpredictable, and its genuine importance to human culture and the advancement of technology and life makes it a most worthy subject of study. This pursuit has been approached from a variety of perspectives, the five most prominent being (a) behavioral (accepting only observable performance as evidence of learning), (b) cognitive (with a focus on memory structures and mental processes), (c) constructive (emphasizing self-constructed mental representation and discovery), (d) human (recognizing the learner as a whole person and independent agent), and (e) social (acknowledging the learner as a member of society and the social influence on individual learning). From these various approaches to the study of learning have emerged a great many theories attempting to explain how learning occurs. And yet, from among all these, there does not seem to be even one that is both broad enough to account for all types of learning, and yet specific enough to be maximally useful in practical application. Perhaps this dichotomy is the reason for the apparent gap between existing theories of learning and the practice of instructional design. The example of a shift toward principles in the fields of clinical psychology and language teaching, and the work by David Merrill to identify and validate first principles of instruction, has inspired in me an alternative way of thinking about learning theory that might help to close this gap.

Accomplishments of the Present Study

In the present study, the need for a principle-based approach to learning theory has been articulated. More than thirty five prominent theories of learning from the behavioral, cognitive, constructive, human, and social traditions were subjected to a textual review and constant comparative analysis in search of common themes that represent *universal* and *fundamental*

principles of learning. These two criteria were used as the methodological lens to identify specific instances—local to each learning theory reviewed—of more general principles of learning. Ten themes were identified: (a) repetition, (b) time, (c) step size, (d) sequence, (e) contrast, (f) significance, (g) feedback, (h) context, (i) engagement, and (j) agency. Can it be said conclusively that these principles are universal and fundamental? Any unbending and absolute claim is not warranted from the evidence reviewed. However, assuming the reader is willing to accept the unavoidably subjective analysis and interpretative nature of the present study, one fact is certain: the principles identified are present in various forms in multiple theories of learning, spanning more than a century of time. Several hundred quotations from the original sources of literature in which the reviewed theories are presented have been selected, categorized and documented to provide an audit trail of supporting evidence for the themes identified. They are available by request to anyone who wishes to draw their own conclusion. In my own evaluation thus far, by way of thought experiment and comparison of the model against observed events in real-world learning, the principles do appear to be both universal and fundamental, as long as one considers not only the isolated moment of learning observed or experienced, but also all that has been learned or experienced prior to that moment.

All items of evidence supporting the results presented in chapter four are linked to specific quotes accompanied by reference citations that direct the reader to the very page of the source from which they are taken, thus providing a means for an in-context evaluation of the original intent and meaning of each quote. No pretense is made that my own interpretation should be unanimously or blindly accepted, and no attempt is made to obscure the trail that I have walked. In fact, on the contrary, I have gone to great lengths of time and effort to illuminate it and provide a roadmap. Perhaps of greater importance though, is the *intent* of the present

study. My goal is not to summatively conclude the final chapter of the history of learning theory, but rather to write a preface for its continued advancement. In fulfillment of this goal, and as a further contribution, I have attempted to organize the principles identified into a practically useful tool by setting them into a conceptual framework of learning that is defined by the ten principles identified in chapter four that *facilitate* learning, plus four additional principles of my own introduction: (a) one that states the possibility of progression (*potential*), (b) one that accounts for orientation of learning toward a specific goal (*target*), (c) and two structural principles (*change* and *practice*) that provide organization for some of the facilitative principles. This *principles-of-learning framework* highlights important relationships between the principles and constitutes a practically useful tool for (a) communicating about the learning process, (b) evaluating instructional products and methods, (c) diagnosing very specifically why a particular product or method fails to result in effective or efficient learning, (d) developing effective instructional products and methods, and (e) conducting research to investigate meaningful hypotheses suggested by the framework. Additionally, it has been explained how the principles-of-learning framework might be used in the creation of domain-specific theories of learning, and suggested that this might be its most valuable application of all.

Limitations of the Present Study

Like any research endeavor, especially those in the social sciences, this study is not without its limitations. On one hand, it stands susceptible to the risk of being dismissed for lack of novelty or mystery. As Anita Woolfolk (2010) observed, "In many cases, the principles set forth by educational psychologists—after spending much thought, time, and money—sound pathetically obvious. People are tempted to say, and usually do say, 'Everyone knows that!'" (p. 10). However, Lily Wong (1987, as cited in Woolfolk, 2010) "demonstrated that just seeing

research results in writing can make them seem obvious" (p. 11). Perhaps this is the very reason for which many of the principles identified in the present study are so often overlooked in the design and development of instructional products and methods, and in the practice of teaching. What really matters, of course, "is not what *sounds* sensible, but what is demonstrated when the principle is put to the test in research" (Gage, 1991, as cited on p. 12).

On the other hand, the nature of the present study is such that its results do not fall in the realm of empirically provable, undeniable fact, and thus it may be preemptively dismissed by those who prefer to consume only the tested-and-tried, shrink-wrapped, microwaveable, ready-to-eat products of waterfall science, rather than to participate in the process themselves and make a study of their own. With results such as those herein presented, and the proposed framework of principles of learning, I believe it is more fruitful and productive to play at *the believing game*, rather than *the doubting game*. "In the believing game we return to Tertullian's original formulation: *credo ut intelligam*: I believe in order to understand. We are trying to find not errors but truths, and for this it helps to believe....To do this requires great energy, attention, and even a *kind of inner commitment*" (Elbow, 1998, p. 149). The results have not been proven, but a logical argument has been made, evidence has been cited in favor of the existence of ten universal and fundamental principles that facilitate learning, and those principles have been organized into a conceptual framework of learning with might now be tested, in whole, or in part, to see whether or not it is of worth.

Perhaps a more obvious limitation of the present study, however, is both the number of theories and the number of sources of literature that I could feasibly review within the limits of time and space available. As I expressed in chapter two, in my review of both printed and digital libraries, it had become apparent early on in my study that a man could quite literally spend his

entire life reading, at his swiftest pace, never visiting the same lines of text twice, never stopping to rest, never stopping to eat, and never stopping to sleep, and still he could not possibly review all that has been written which bears interest on the subject of learning. I found this to be increasingly true as the study progressed. It was a constant challenge requiring a very disciplined effort to be judicial in the selection of what would and would not be included in my review. Though I covered as many theories as possible—and selected them based on pre-established criteria of clarity, stability, utility, impact, and durability—the number of theories not reviewed far outweighs the number that were.

Another limitation is the state of validity of the framework of principles of learning presented in chapter five. The framework itself is intentionally broad, so as to represent the complete process of learning. I have organized the principles identified in the present study and supplemented them with four additional principles to create a framework that I believe will be useful in many ways. The organization presented, and the relationships between the principles that have been described is the result of many iterations of stating, testing, and revising the principles and their relationships. In each iteration I checked the usefulness, accuracy, and clarity of the framework against test cases in the literature and test cases in my own experience as a learner and teacher, both reflecting on my own learning and observing the experiences of peers and students.

I have informally validated the framework many times using a range of different types of learning, several of which I subjected myself to for this very purpose. The types of experiences used for informal validation include, but are not limited to: learning to play a difficult song on the piano, composing original music on the acoustic guitar, and learning to play an electric lead guitar solo; learning a foreign language to the point of intermediate fluency, acquiring foreign

language vocabulary, mastering difficult pronunciation of foreign language sounds, and learning to perform tasks in a foreign language such as selling English pronunciation classes from a cultural arts festival booth; skiing, kiteboarding, men's gymnastics, and Latin fitness dancing; breaking old habits and establishing new ones; learning to brush my teeth with my left hand; electrical wiring, finish carpentry, and interior painting; gardening; professional photography; the buying, selling, and marketing of real estate; conducting due diligence in precious mineral investments; coordinating investment in joint-venture development projects; producing technical specifications for the design of software programs; conducting onsite customer training and managing technical support for pre- and post-sales activity in a high tech company; developing a deeper sense of gratitude; learning to respond with greater patience when treated unkindly by others; strengthening self-control and will power to deny physical appetite; and learning to walk and use my hands without feeling and very limited strength following an acute attack of inflammatory demyelinating polyneuropathy (Guillain-Barre) . However, in spite of this fairly extensive informal validation of the framework against test cases in literature and personal experience, I believe the principles-of-learning framework is not in a state of polish, but rather, just good enough to warrant testing and use on a larger scale and by a larger audience. As Heider said,

We could go about this in the Baconian way, that is, by seeking further empirical and experimental facts. We side, however, with those who think that we shall not attain a conceptual framework by collecting more experimental results. Rather, conceptual clarification is a prerequisite for efficient experimentation. (Heider, 1958, p. 4)

Finally, as has already been acknowledged elsewhere in this report, the conclusions drawn from this study are based on my own subjective interpretation of the theories reviewed.

Due to the volume of literature covered my reviews cannot possibly be considered comprehensive in either breadth and depth. I have tried to select a diverse set of theories that would lend multi-dimensional perspective to the process of learning. I have tried to go deep enough with each to capture the major themes, and even some of the more important subtle ones. I have tried to not misrepresent the position of the theorists in any way. However, this report cannot be considered a replacement for the body of literature that has been reviewed. Through the experience of my own study I have developed a great respect for those who have dedicated several years of their lives to the study of only one or two of the theories that have been reviewed in the present study over the course of only a few years. A great deal has been written on the process of learning. Many times during the course of this study I have had to very consciously fight the desire to read more, and to read more deeply, instead focusing my attention on those theories and sources of literature would be of greatest value. I have learned for myself that there are many valuable insights from learning theorists throughout recorded history—including a vast wealth of knowledge that has been produced in the past 125 years alone—that have been lost to the overwhelming majoring of present generation practitioners and, like gems in the earth, await rediscovery.

Directions for Future Application and Research

It has often been observed that a weakness in one situation can sometimes be a strength in another. Such is the case with the present study. While on the one hand the validity and usefulness of the principles-of-learning framework remains to be demonstrated, on the other hand, this provides a great many opportunities for applied research. For example, any one of the principles in the framework might be singled out and studied in isolation to better understand its dimensionality and effects—i.e., its various manifestations, characteristics, or forms and the

individual role it plays in the facilitation of learning. Groups of principles might also be studied together, to examine their combined effects and the interrelations between them. And, of course, the framework can also be applied and studied as a whole, examining its usefulness for evaluation, diagnosis, and development activities. Of greatest interest to me, is the application of the principles-of-learning framework to create a variety of domain-specific theories of learning. This activity, I believe, will drive the model to maturation more quickly than any other, and is the initial direction for my own continued research.

A Note Regarding Quotes

The narrative of this dissertation is woven using many direct quotations from the theories reviewed. In fact, the use of quotes is extensive. I would like to say a word about this approach that I have taken. There are three important reasons for which I opted to use direct quotations rather than my own restatements or summaries. First, they provide a more direct grounding of the study to the context of existing theory. Second, direct quotes with page-specific references enable others to retrace and re-evaluate the study and its conclusions. Third, I felt that direct quotes would convey not only the meaning of the ideas but also their intent, by including both the style and manner in which they were originally articulated. I would ask the reader to take note, however, that my goal was not to create a patchwork theory of quotations, but to provide contextualized, specific examples, and to acknowledge the source from which the themes of the present study have been distilled. The unpublished words of Vygotsky reflect my own sentiment regarding the importance of applying oneself in a most individual and original way to provide a contribution to our understanding of learning. He said,

I don't want to discover the nature of the mind by patching together a lot of quotations. I want to find out how science has to be built....In order to create such an enabling theory-

method in the generally accepted scientific manner, it is necessary to discover the essence of the given area of phenomena, the laws according to which they change, their qualitative and quantitative characteristics, their causes. It is necessary to formulate the categories and concepts that are specifically relevant to them—in other words, to create one's own *Capital*...[from unpublished notebooks]. (Cole & Scribner, 1978, p. 8)

It is my hope that what has been presented in this dissertation, especially the content of chapters four and five fits the bill of providing some real *Capital* to work with. Capital in the form of a foundation, which suggests central questions to focus subsequent efforts that will improve our understanding of learning and how it might be facilitated.

For the most part, the originators of the theoretical ideas which have been reviewed, have passed from this world and left only their legacy behind. On behalf of those whose bones lie in dusty coffins, unable to speak for themselves as to the accuracy of my interpretation of their ideas, let me be the first to suggest the possibility of great error in the same. However, in truth, my interpretations are of little consequence, for it is in the application of the principles-of-learning framework herein presented that its fruitful or barren nature may be proven. In the words of Edwin R. Guthrie (1960), "Theories are not true or false. They are useful or less useful" (p. x). Regardless of their root, and the soil in which they are planted, all ideas, in the end, must stand on their own. *Ad vitam aut culpam*.

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