Appendix A

Theory Under the Hood

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Abstract

This appendix provides an overview of psychological frameworks that should be considered in the design and development of learning objects. From acquisition of information to knowledge representation and accounting for types of knowledge, there are multiple ways that psychological concepts are expressed in an instructional product. This appendix is designed to provide an overview of constructs that are closely aligned with learning object-based instructional development.
Introduction

In any learning experience, the underlying psychological constructs frame the design, development, and implementation strategies of the environment. In this Appendix, an overview of psychological frameworks that should be considered in the design and development of learning objects are presented. From acquisition of information to knowledge representation and types of knowledge, there are multiple ways that psychological concepts can be incorporated into an instructional product. These materials are designed to provide an overview of constructs involved; readers are encouraged to extend their knowledge by reviewing psychological-based resources that are listed at the end of the Appendix.

Application and use of the constructs and theories in this presentation of psychological foundations of learning are critical to the success of the learning object and the resulting learning environment. It is not practical that a designer actually apply all of the psychological constructs contained in this Appendix. In reality, designers must devise their own heuristic that includes multiple elements of psychological foundations in the implementation of instructional strategies and embedded learning strategies.

Acquiring Information

Atkinson and Shiffrin (1968) divide the memory system into two categories of components: (a) permanent structural features and (b) control processes. Permanent features include the physical structures representing the basic short and long term memory stores and built-in processes, particularly for sensory stimuli. Control processes are individually constructed cognitive features that are activated in response to specific situations. Atkinson and Shiffrin identify three variables that affect the activation of control processes: (a) the context within which the information is received, (b) the meaningfulness of the information, and (c) the individual’s experience and history.

The robustness of information transfer from short-term store memory to long-term store memory is greatest when overt responses from the individual are required during the process. This proposition lends weight to the strategy of interactivity as a powerful instructional tool. Long-term store memory provides the foundation for cognitive structure. It is the place where information is fixed into a knowledge matrix, the permanence of which varies with factors such as decay, interference, or loss of strength (Atkinson & Shiffrin, 1968). Ausubel (1968), Jonassen and Henning (1999), and others propose that these factors are expressions of the relative
position of the information in the cognitive structure, its frequency of access, and the robustness of its connections to surrounding propositions.

Atkinson and Shiffrin (1968) identify two common strategies for encoding information into long-term store memory. The first strategy involves the incorporation of the new information into natural language structures. The second strategy facilitates the association of new information into long-term store memory through the use of visual imagery. Both of these strategies can be designed into learning environments when using learning object technology by using natural language structures and rich media that helps learners make links from “old” knowledge to “new.” Strategies that focus on these ideas can be implemented beginning with how knowledge can be represented to learners.

Knowledge Representation

Knowledge representation is critical in beginning to display messages to and share information with learners. Knowledge representation can be characterized through concepts of exemplars, generic tasks, and schema.

- **Exemplars:** The exemplar view of concept representation suggested by Bareiss (1989) proposes that concepts are learned by individuals through the collection and storage of examples of category members. The number of examples stored depends on the individual’s requirement for precision in the application of the concept; more examples may provide a more extensive set of features whose values appear to be defined with greater resolution (Bareiss, 1989). Rich examples included in the learning object permits the learner to attach meaning to the information and make linkages with currently-held knowledge.

- **Generic tasks:** Chandrasekaran (1989) applies a model similar to the exemplar model for knowledge representation, proposed by Bareiss (1989) to collections of knowledge-based reasoning tasks. He suggests that knowledge-based reasoning is an expression of combinations of generic reasoning building blocks. Each reasoning task, or strategy, possesses three elements: (a) the kinds of information required as an input and the resulting output information, (b) a way to present and organize knowledge required to perform the task, and (c) the process (e.g., algorithm, control, problem solving) that the task employs. Various combinations from among five generic tasks account for most knowledge-based reasoning operations according to Chandrasekaran (1989). The five operations are (a) hierarchical classification, (b) plan selection and refinement, (c) knowledge-directed information passing, (d) hypothesis matching, and (e) hypothesis assembly.
• **Schema:** West, Farmer, and Wolff (1991) build on Bareiss’ (1989) exemplar model for knowledge representation and Chandrasekaran’s (1989) generic tasks by embracing the notion of schema. They identify schema as information patterns, structures, and scaffolds of two basic types. They describe the first schema type as packets or bundles of either data or information about the state of data. They draw on the work of Rumelhart and Ortony (1977) to describe a second class of schema that represents procedures for handling or organizing data.

The notion of schema activation is especially important in learning experiences. West et al. (1991) suggest that at any given moment, an individual has a certain mind set, literally, a limited set of schema, in consciousness. These active schemas govern what stimuli the individual perceives, and the initial interaction between new stimuli and the active schema determine what new schema are invoked, if necessary, to process and integrate the new information. Since patterns of internal representation drive cognition, the more complex the event or experience, the greater the influence of the schema in its integration. West et al. assert that the effects of poor matches between schema and events may be so profound as actually to preclude the activation of schema that may be the best fit for the new information. Furthermore, other constructs, such as affect and belief, may introduce resistance to schema activation. Knowledge representation is a fundamental building block of how information can be structured for learning. Another building block of this framework involves types of knowledge.

**Types of Knowledge**

West et al. (1991) propose that knowledge with different properties is processed and organized differently in cognitive structure. They support three broad categories or types of knowledge: (a) declarative, (b) procedural, and (c) conditional. Declarative knowledge is described by West et al. as being factual. This type is stored in the form of propositions and networks of propositions which are subdivided into semantic and episodic. The semantic network represents lists of elements whose access and recall is aided by their relative position in the network. Episodic networks are story related and support Anderson’s (1985) notions on episodic networks as representing connected chains of proposition whose relationships with each other are usually in the form of historical narrative.

A second type of knowledge, procedural, concerns processes. Specifically, procedural knowledge consists of order-specific, time-dependent, and sequential instructions that characterize knowing how to accomplish some task (West et al., 1991).
The final type of knowledge, conditional, permits individuals to make decisions. Prawat (1989) suggests that conditional knowledge represents a higher-order cognitive process in that it is concerned with the description of specific criterion combinations and contexts that may be matched to a range of responses to them. West et al. (1991) draw on this concept to conclude that conditional knowledge defines the knowing when and why to use a procedure. These types of knowledge can help designers organize and categorize information that they will use to help individuals learn.

**Mental Models**

Jonassen and Henning (1999) propose that learners model new knowledge through the adoption of allegory or metaphor to aid in structure mapping. Two assumptions made by Jonassen and Henning stand out when considering the design of a learning object. The first assumption is that the structural position of a concept with reference to others is a critical dimension of its meaning that plays an integral role in the encoding and recall processes. In other words, the organization of a series of knowledge or information concepts is very important to a successful transfer of knowledge from short- to long-term memory.

The second of Jonassen and Henning’s (1999) assumptions of interest is that social or collective meaning springs from the intersection of individual models. While variations in experience, prior knowledge, beliefs, and abilities account for individual differences in cognitive structure, the common elements of these features among a number of individuals assume a significance that is important to successful social discourse. Consideration of these elements in the design and subsequent development of learning objects helps to provide context in the learning environment.

The dynamic properties of mental models provide important clues about learning (Jonassen & Henning, 1999). Different contexts or states of activation at the moment new information is introduced may affect what portion of the learner’s cognitive structure processes it. The same element of information may play an important role in a number of interconnected submodels in the learner’s cognitive structure (Jonassen & Henning, 1999). The more roles the same information plays, Jonassen and Henning suggest, the more likely it is to become a stable point in the learner’s cognitive structure. They conclude that linearly structured mental models, lower dimensionality, and less robust metaphors negatively affect the individual’s problem-solving ability in a given knowledge domain. These elements provide clues as to how to help learners develop mental models for supporting the learning environment.
Knowledge Organization

Merrill (2000) suggests that for an individual to solve a problem or learn, both a schema for the mental representation and organization of knowledge in the learner’s mind and heuristics for manipulating components of that knowledge must be available to the learner. He identifies two sets of problems associated with establishing appropriate mental models and heuristics in the design of instruction using learning objects: categorization, and interpretation.

- **Categorization**: Merrill (2000) divides categorization into two types, classification or generalization. When presented with a series of different examples of subclasses of a particular concept, the learner must recognize the properties and values distinguishing each category. The learner must also be able to assign a new example to the correct category. Conversely, generalizations require the learner to synthesize common properties and values from different examples into a new, previously unrecognized superordinate conceptual class.

- **Interpretation**: The other large set of problems identified by Merrill (2000) relates to interpretation, which is subdivided into three smaller classes of problems: explanation, prediction, and troubleshooting. Explanation requires the learner to use features including property, value, portrayal, condition, and consequence to characterize a mental model of a concept. Predictions involve the identification of the conditions that are relevant to the consequence of the prediction and an if <condition(s)> then <consequence> statement, that anticipate changes in property values. Troubleshooting is essentially a sequencing problem for applying predictive conditional statements. Implications of categorization and interpretation to designers who must forecast how their future learners participate in the learning experience.

Knowledge Relationships in Cognitive Structure

Piaget (1952) proposes that “Learning involves the reciprocal assimilation of existing schemata as new objects are subsumed by them” (p. 236). Ausubel (1968) defines subsumption as the “process of linking new information to pre-existing segments of cognitive structure” (p. 58). Ausubel proposes that such modification of cognitive structure assumes a critical role in learning efficiency because associated knowledge at the point of modification of cognitive structure can have direct and specific relevance for subsequent learning tasks. From this perspective, existing structures provide stability for anchoring newly learned details and meanings. Extending this
concept to embrace new information, new facts are organized around a common theme that integrates them both with themselves and with existing knowledge. Ausubel (1968) classifies new knowledge into derivative and correlative propositions. The distinction between the two types is based upon the effect they have on existing cognitive structure in the learner. Propositions are defined as derivative knowledge when new meaning to existing knowledge is implied through a distinct example. Such a proposition increases the density of information clustered around a specific point in the cognitive structure.

Correlative knowledge extends, elaborates, modifies, or qualifies existing knowledge structure because it is neither present nor implied in existing propositions (Ausubel, 1968). Cognitive structure expands in some direction as the result of the incorporation of such knowledge.

Knowledge Relationships in Cognitive Structure

Ausubel (1968) describes the relationships in cognitive structure among propositions implied by his definitions of derivative and correlative knowledge through the use of the terms, superordinate and combinatorial. A new proposition may assume a superordinate position under which several existing propositions may be subsumed or attached in conceptually subordinate positions. Likewise, new propositions may be subsumed under a pre-existing superordinate concept. Propositions are combinatorial when they assume a nonspecific relationship to existing ideas that share a general relevance but have no sharply defined superordinate proposition. Decisions on how to build these propositions are critical to the presentation of information.

Ausubel (1968) summarizes the practical differences between propositions superordinally and combinatorially related as the former representing problem-solving knowledge and the latter being problem-setting knowledge. Superordinally configured knowledge is useful as problem-solving knowledge in that clearly defined structures provide the foundation for an efficient search path strategy. Combinatorially configured knowledge, meanwhile, permits problem setting based on the idea that the introduction of this type of new knowledge forces a re-examination of the loose collection to find a precipitant superordinator (Ausubel, 1968). Ausubel draws support for the role combinatorial relationships among propositions plays from the chunk sequencing research of Miller and Selfridge (1950) who establish that elements of meaningless discourse broken into a sequence of chunks can be recalled better than a continuous stream because the sequence of chunks itself provides relevant cues. Ausubel further explains that related material may be presented in a sequence such that each successive proposition is not dependent on the learner’s mastery of the previous one. The learner benefits from the organization of the material itself because the organizational structure orients the learner in subsequent attempts to access the
propositions from memory. Overt organization of information, knowledge, data, and so forth facilitates learner performance.

**A Cognitive Structure Taxonomy**

Ausubel (1968) defines assimilation as the interaction between new information and cognitive structure. He describes taxonomy of cognitive structure variables that define the parameters and character of the assimilation process in a systematic way. It is the properties of these variables that Ausubel asserts influence new learning and resulting information retention. Ausubel derives the framework for the assimilation model from the notions of lateral and vertical transfer proposed by Gagné (1965). He notes Gagné’s assertion that lateral transfer of meaning is the extension of generalizable properties to information related tangentially and that the vertical transfer of meaning is the requirement that the learner master subordinate knowledge in order to assimilate related higher order information.

One of the variables Ausubel (1968) describes as critical to the fixing of new knowledge into cognitive structure is relevance (also a strong component in motivational themes). He suggests that learned propositions whose connections to existing cognitive structure are weak or tangential are less stable, consequently, far less likely to be recalled in context, and more likely to decay into inaccessibility than those links with strong connections. He notes that relevance is a measure of the strength of the relationship between existing knowledge and new information, not a property of the new information itself. Furthermore, Ausubel asserts that new information, which may in fact be highly relevant to the learner’s existing information, has little chance of gaining stability unless the learner recognizes that relevance.

Another factor that influences the relevance of new information is the stability and clarity of the appropriate superordinate proposition, or anchoring idea. Ausubel (1968) describes a type of cognitive bridge that extends from the anchoring point of general and inclusive information to new propositions, thus fixing it into the learner’s cognitive structure. This bridge can be seen in the use of advance organizers which help learners see the relationships between prior learning and the upcoming learning experiences.

An equally important variable affecting the relevance of new material is the degree to which it can be differentiated from propositions that are already part of the learner’s cognitive structure. Ausubel (1968) states that new knowledge must be “discriminable from the established ideational system” (p. 169). As the instructional strategies are put into place, careful review of the format of the information and the ultimate presentation of that information helps the learners to make those differentiations and integrate new knowledge into old.
Jolley (1973) capitalized on Ausubel’s (1968) notions of anchor points and sub-
summation to establish an early systematic organizational structure for knowledge
that reduces each classification step to a binary choice in perception. The model’s
aim is to bridge between cognitive structure and search, retrieval, manipulation, and
analysis algorithms for computer-based expert systems. While Jolley’s effort at a
binary knowledge classification system provides an encoding methodology suitable
for knowledge base expert systems, its extension to a model for addressing cognitive
structure and learning becomes problematic. The issues of accumulated exemplar
sets proposed by Bareiss (1989), the role individual experience plays in the schema
activation model described by West et al. (1991), and the multidimensional character
of Ausubel’s anchor point clusters suggest that individual differences play too large
a role in cognitive structure to remain unaddressed.

**Negotiation in Cognitive System Linkages**

Rescher (1979) addresses the nature of interconnecting linkages in a cognitive system
by dividing linkages into probative and justificatory. Probative, or evidential linkages,
explore the ontological reason of why something is so by defining its specifications.
Justificatory, or explanatory, linkages define the epistemological reasons, or why
something is believed to be true, for relationships among propositions. Rescher
takes care to warn, however, that an explanation of why something should be true,
taken by itself, does not automatically make that thing true. He suggests that the
negotiation of linkage classification reflects a human predisposition to reconciling
the discrepancies between what individuals expect according to mental plans in use
and what individuals encounter in reality.

Rescher (1979) proposes that the process of inquiry requires a system that uses a
mental map of the individual’s cognitive terrain, and that systematization is the
prime instrument of error avoidance—a kind of cognitive quality control. He sug-
gests that the cognitive map serves both to keep the wrong things out and to let the
right things in, since if a proposition can be integrated into the cognitive system,
then it must be accepted as true. The system itself, in Rescher’s model, becomes
the arbiter of knowledge.

**Preferences in Patterns and Styles of Knowledge**

Goldman (1986) raises important questions about the implications for cognitive
processing that structural organization and systematization theories present. Goldman
asks whether there may be preferred patterns and styles of knowledge construction
and whether these may impose constraints on mental representation. He proposes
that a nearly universal feature of all theories of mental representation, consistent with the notion of patterns and styles of knowledge construction, is the breakdown of experience into discreet parts and the construction of new parts. Goldman (1986) supports the proposition that individuals have preferences for patterns in the creation and segmentation of knowledge by drawing on the philosophical foundations of Gestalt theory in defining five features that characterize preferred or natural patterns of knowledge creation. These features are:

1. **Proximity**: Things that are perceived by an individual to be closer together tend to be associated with each other more often than things that are farther away from each other.

2. **Similarity**: Things that are perceived by an individual to possess characteristics that are like those of others are more closely associated with each other than with those that are different.

3. **Continuity**: Things that follow one another more closely in time or in logical sequence are more likely to be associated with each other by an individual than those which are separated by more time or sequence order.

4. **Closure**: Things that can be grouped together with a sense of completeness are more likely to be associated with each other by an individual than with groups of things that cannot.

5. **Form**: Groups of things that make regular shapes, express symmetry, or balance are more likely to be associated with each other by an individual than groups of things that do not.

**Human Preferences for Hierarchical Knowledge Representation**

Goldman (1986) extends the idea of organizational preferences and draws parallels between the features of natural language and those of hierarchical knowledge representation by suggesting that sentence structure is an expression of a hierarchy of concepts dependent on semantic memory. He also associates the notion of class inclusion arrays, or taxonomies, with visual and temporal knowledge. Goldman asserts that the natural parts of a collection of propositions in an individual’s memory provide strong retrieval cues for the original whole to the extent that good cues are up to five times more effective in retrieving information than bad ones.

Goldman (1986) illustrates the pervasiveness of human preference for hierarchical representation through citation of Restle and Brown’s (1970) examination of the way musicians learn music. Restle and Brown found that music is an expression
of hierarchical representation, and that musicians learn new music in a top down hierarchy of patterns, not as a sequential string of tones. Goldman addresses the complexity of working from a knowledge hierarchy model by expanding the notion of hierarchy to include features supported by the proposition that the brain possesses an innate computational mechanism for constructing shapes, especially shapes in motion and in three dimensions. He uses as an example of such a feature the common preference for symmetry. The inference Goldman draws from the evidence for human preference for symmetry is that individuals actually employ a rather narrow set of representation-forming operations and have preferences for the sequence in which those representation-forming operations are performed. This inference is consistent with the notion of generic task sets in knowledge-based reasoning as proposed by Chandrasekaran (1989).

**Representation-Forming Operations**

Goldman (1986) identifies three types of representation that serve as the foundation for the narrow set of representation-forming operations: (a) temporal strings, (b) spatial images, and (c) abstract propositions. Temporal strings involve the fixing of information in sequence along a time line. Spatial images place items of information in relation to each other with varying degrees of proximity. Abstract propositions involve an iterative process of placing new knowledge into relational slots and then attempting to fill in missing slots with existing information or queries for new information.

Linguistic patterns are useful to Goldman (1986) in demonstrating evidence of the pervasiveness of analogy as a form of abstract proposition. He suggests that analogy in the form of linguistic patterns is critical to problem solving and that the abstract proposition feature of relational slot substitution is the key preferred operation in the process.

A significant issue with hierarchies and natural preferences in concept representation is the potential for the rejection of certain propositions when their properties fall outside the range of the individual’s preferences (Goldman, 1986). Goldman also suggests that the complete failure to perceive certain propositions as meaningful is another possible consequence of individual preferences in representation formation.

The role that the notion of originality plays in the development of concept representations in the individual is one that Goldman (1986) explores by suggesting that an individual usually finds some new ideas more attractive than others. Goldman suggests that the metric at work in the establishment of a notion’s attractiveness as it is processed by the individual has four important features:
1. The preference ranking of processing operations is not universal for all individuals.
2. Individuals are persistent in applying existing, familiar operations.
3. Individuals apply operations in combinations to process information and tend to use familiar combinations.
4. Individuals tend to apply the same set of operations to different sets of initial ideas.

Recognition that learners have preferences in the manner in which they organize and process knowledge is important to instructional system designers. That those preferences can be persistent, yet open to modification given certain conditions, also informs designers of instructional systems of the criteria for effective system design. These concepts help designers build that extremely heuristic as they approach designing instructional products, especially when applying the learning object construct, using building blocks to structure learning experiences.

**Problem Solution Planning**

Davidson, Deuser, and Sternberg (1996) suggest that there are three important characteristics of problem solution planning. One such characteristic is that problem solution planning is most likely to occur in cases where the problem has new elements or is complex. In other words, solution planning often follows when preferred cognitive processing approaches, as described by Goldman (1986), prove inadequate. Another characteristic is that planning is an abstract activity, not concrete, and is fluid in that its character is dependent on situational context. This notion is consistent with Chandrasekaran’s (1989) ideas about generic task structure. Finally, problem solution planning follows a cost and benefit model. If the problem solver selects a lower order planning strategy for a complex problem, the intended time and effort savings driving such a poor choice are doubly lost if the solution fails and the problem solver has to begin again with a more involved strategy (Davidson et al., 1996). Such a model is facilitated by the multidimensional anchor point cognitive structure proposed by Ausubel (1968). The implication for designers of learning systems is that the problem-solving strategies embedded in the instruction must not only prove challenging enough to trigger solution planning, but must also reflect the varied approaches and cue the learner to invest the appropriate level of effort in deriving the solution plan.
Knowledge and Social Context

One direction of thought in cognitive theory reflects the conviction that since few people ever develop in complete isolation from others, the information processing functions of the individual cannot be meaningfully examined without taking into account the effect of the person’s experience. The evolution of this line of thought begins with early concepts of symbolic representation and interaction with the environment.

Vygotsky (1962) addresses concept formation by suggesting that it is a cyclic and dynamic movement of thought between the particular and the general and back again. He stresses that it is not the simple interplay of associations within the cognitive structure that forms a concept, but a specific and unique combination of a diverse range of cognitive functions, taken all together. Scheffler (1965) addresses fundamental issues regarding context by examining the epistemological function of knowledge. He divides that function into two classes, the state of knowing *that* and the state of knowing *how*.

A feature of competence, a measure of knowing how, that Scheffler (1965) identifies as important is concerned with the interpretation of knowledge within context. Furthermore, Scheffler distinguishes between facility and skill in discussing competence. He proposes that facility occupies one end of a spectrum in which activity is routine, or procedural, while the other end of the spectrum is occupied by critical skills that involve an engagement of judgment in performance. Simple facility relies heavily on the assumption of rigidity in the context of performance, while critical skills require a thorough re-examination of situational context, building upon past experience and connections to existing knowledge to estimate the best approach to a new task (Scheffler, 1965).

Ramsey (1992) traces an evolutionary path through empiricist, rationalist, quasilinguistic, and monadic models to arrive at structural holism as a meaningful philosophical account of propositional representation. The essence of Ramsey’s discussion lies in the development of one line of philosophical thought about mental representation that has moved from a focus on universal, discrete, granular elements of information arranged in various combinations, through common clustered elements similar to linguistic phrases and idioms, to complete sets of representation structures unique to the individual. Ramsey suggests that it is not possible to pinpoint a single element in cognitive structure that accounts for a specific belief or behavior. The implication is that there are no discrete propositional states; rather, each person possesses a single holistic belief state, individual propositions of which are simply localized, characteristics of that state. In effect, propositions are not components of belief states, simply features of them.

While the structural properties of representation in his holistic model play an important role in cognitive processes, Ramsey (1992) proposes that a more critical element is the degree to which a proposition is activated or “causally implicated in
the structure’s internal processing” (p. 257). The invocation of different propositions may result in different states of activation of representational elements and thus produce belief states with very different structural properties. Ramsey uses the tenets of structural holism to build the concept of connectionist representation. Connectionism characterizes representational networks in terms of the interaction among units. Ramsey defines these units as the prototypical properties of things, lexical concepts, and propositions arrayed in a network for learning.

Ramsey (1992) classifies them into three different types: input units, intermediary layers of hidden units, and output units. The intermediary units are hidden because the individual is unaware of the associative processes and activation patterns at work in response to the input units and only becomes conscious of the change in state between input and output units. Ramsey proposes, nonetheless, that representations are determined by the activity patterns of the hidden units. An important feature of Ramsey’s model that is consistent with West et al.’s (1991) schema activation model and Chandrasekaran’s (1989) generic task structure ideas is the notion that a relatively small number of units may produce a very large number of activation patterns, thus producing a very large number of different representations.

Ramsey (1992) proposes that a connectionist view of learning involves the process of modifying the cognitive system so that hidden unit activation patterns formed from unusable initial inputs are replaced with functionally useful states as the individual’s network of representational experiences organizes them into portioned classes or groups. The line of thinking that illustrates the interconnectedness of knowledge and the importance of those connections to learning has significance for developers of an instructional design tool based on collections of knowledge objects. Schank and Abelson (1995) carry this line of thinking to a logical terminus by assigning critical importance to the framing of knowledge into coherent stories.

### Distributed Intelligence

Petraglia (1998) discusses the dynamic, socially interactive nature of cognition through the concept of distributed intelligence. The individual serves as a node in this model within the ecology of a larger cognitive network. Petraglia suggests that tools and other beings extend the range of our cognition and, in some cases, allow us to bypass normal cognitive processes as in the examples of unconscious awareness of spatial relationships and object significance. The outcome of Petraglia’s (1998) discourse on the sociocultural underpinnings of cognition and his general dissatisfaction with other transmission models is his advocacy of a constructivist metatheory based on authenticism. He summarizes his position in this way: “Knowledge is constructed
from prior knowledge and experience derived from participation in activities distributed across social, cultural, and material dimensions” (p. 55).

Petraglia (1998) proposes that tasks and solutions are always equivocal in the real world and that there are always multiple pathways through the problem space. Cognitive flexibility is a requirement because no single perspective is adequate for representing ill-structured problems. Furthermore, problems are often revisited over time from within rearranged contexts.

Cobb and Bowers (1999) examine the underlying assumptions of situated and cognitive perspectives in terms of the individual in the world, much as material objects are situated in relation to each other in physical space. They propose, however, contrary to the cognitivist assumption, that not all skills require a social context to be learned and that individual actions are elements of a social system and are part of that system even when the individual is physically removed from others in the system. Cobb and Bowers suggest that “learning is synonymous with changes in ways that an individual participates in social practices” (p. 6). They extend this line of thought to suggest that knowledge is embodied in activities such as perceiving, reasoning, and talking. They conclude that the portability of reasoning skills and knowledge is necessarily dependent on the degree of fidelity of the new context to the one in which learning originally takes place. They use this intimate relationship between activity and learning to propose that researchers focus less attention on the relationship between theory and instructional design prescriptions and more attention on the relationship between theory and practice (Cobb & Bowers, 1999).

Jonassen and Henning (1999) also address the proposition that situated social practice shapes cognition and thinking. Their position is that “Knowledge is embedded in the activities and processes that people engage in and the discourse used to make meaning of the activities” (p. 40). They go further to suggest that objects in the world assume a role in cognitive structure. “Knowledge is embedded in physical artifacts that are the objects of activity” (p. 40). These three elements—activities, processes, and objects—play a fundamental role in the development of mental models because they possess the capacity to fix meaning into cognitive structure.

In instances where social construction supports learner performance use of strategies that promote interaction, collaboration, and cooperation in the learning environment can be based on social context and knowledge constructs. As designers consider psychological aspects of social context, they can use appropriate strategies to help learners meet stated goals and objectives.


