On Conceptual Learning

Elisabeth H. Wiig & Karl M. Wiig,
Knowledge Research Institute, Inc. Working Paper 1999-1

CONCEPTUAL LEARNING CONSIDERATIONS

The Broad Objectives

From business and societal perspectives, our general objectives for learning are for recipients - the learners - to obtain appropriate attitudes, perspectives, skills, insights, and understanding to perform desired functions with proficiency in every respect. It is desired that the learning process be as effective and frictionless as feasible and that the content be as relevant to immediate and future requirements as possible.

We expect that an effective learning process will provide appropriate content and prepare learners to "function intelligently" in the tasks ahead. When these tasks involve further learning, we expect that during the earlier learning stages, learners will have built mental models, concepts, scripts, schemata, associations, perspectives, strategies, and so on - prior knowledge - sufficiently well to build additional knowledge effectively.[1] We also expect them to approach further learning "intelligently." That may include interpreting and appropriately selecting new information to be internalized, having curiosity and being innovative, seeking knowledge through discovery and experimentation, and building knowledge and understanding in many other ways.

We also need to be aware of other aspects of how people possess and use knowledge. Much of our script and schemata knowledge is embedded in representative "stories" or cases.[2] We may relate such stories or cases as examples of principles within scripts and schemata.

The objectives stated above apply equally to pre-schoolers and graduate students, to apprentices and masters. Life-long learning is a never-ending process. During the first decades of life, most learners construct "general" knowledge about the world. Later, they may build specialized knowledge to perform work-related functions. Clearly, at different stages of life and proficiency, the ability to learn and the level of sophistication of what is learned will vary greatly; but the process is much the same. Learners receive information about different aspects of the world and use prior knowledge to translate what they accept as relevant and believable into additional knowledge and deep understanding.[3]

To complicate matters further, the amount of specific knowledge that knowledge workers need to possess has steadily increased to make it possible for them to provide higher quality and more diversified work deliverables. In many - perhaps most - situations, the total amount of conceptual and factual knowledge that ideally should be commanded in order to deliver desired service paradigms exceeds the average worker's mental capacity as indicated in Figure 1. Long-term experts can possess the full complement of required knowledge, but only after they have been able to internalize and organize large bodies of knowledge over many years.

Our premise is that individuals need to possess and command requisite knowledge to be able to act intelligently, be it in learning situations as students or apprentices, or as knowledge workers within an organization. They need to be provided with a combination of conceptual knowledge and detailed factual knowledge. The conceptual knowledge they must have access to within their minds can be complemented with relevant factual knowledge that can be obtained readily whenever specific situations are addressed.

Work within any organization is primarily cognitive in nature. Even the experienced assembly line worker, who seems only to rely on impressive dexterity, uses knowledge in the form of deep understanding that are based on mental models, expectations, and methodologies to perform expertly to a much larger extent than the naïve observer can realize. To a larger degree than a few decades ago, all workers deal less and less with true routine work. Instead, they face continual challenges to deal with special requirements, "double loop" considerations, and even surprises.

We Must Provide Supporting Work Environments

As indicated in Figure 1, intellectual challenges associated with delivering the complex service paradigms in the modern work environment may require command of a body of knowledge that exceeds the average person's mental capacity. It may therefore be desirable to prepare workers with deep and general understanding of the content knowledge they are required to apply to deliver the breadth of work desired. Workers will not be able to possess all the detailed factual knowledge for all the known and unexpected situations they are responsible for handling. Consequently, it will often be required to provide people with work aids of various kinds to make the relevant, detailed factual knowledge and information available to them. These work aids may be provided in many forms. They may be computer-based information systems with more or less "intelligence," they may be reference books, coworker networks, and so on.

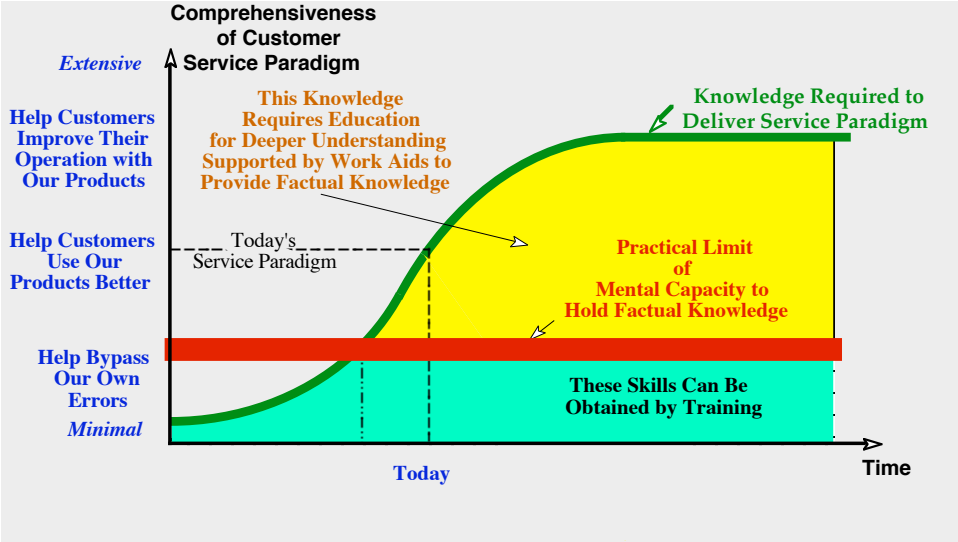


Figure 1. The Knowledge Pipeline Is Full! Today's Work Performance often Require Knowledge that Is Broader than Our Mental Capacities.

A Model for Using Knowledge

When people perform mental tasks - in learning or working, as preschoolers or master professionals - they decide what to do and how to act, based on the information and associations they have formed about the situation and on the knowledge and understanding that they deem to be relevant to address it. A model for how knowledge is used in these situations is presented in Figure 2. In this representation, the model only represents the "open-loop" application of knowledge. The continued feedback from how knowledge is applied to deal with the situation and what is learned as the situation evolves are omitted here, but are dealt with later.

The model uses categorization of knowledge along a mental model dimension, which ranges from concrete routines and specific operational models, to scripts, to semantic and functional schemata, to generalized abstractions on the high conceptual end. Implicitly, the model also relies on distinguishing between idealistic, systematic, pragmatic, automatic, and tacit subliminal knowledge in one dimension[4] and between factual, conceptual, expectational, and methodological knowledge in another.

Figure 2 indicates the conceptual levels of knowledge that are available and used by four categories of "knowledge workers." (As implied earlier, learners at all ages are knowledge workers. When dealing with learning situations, they apply much the same mental process while relying on some explicit, but mostly tacit prior knowledge.) In this figure, we indicate that novices will rely primarily on specific operational models and routines, which they have been trained to execute "automatically." Whereas they may not be presumed to have applicable scripts and schemata for their work situation, they, as all people, automatically develop abstract mental models in the form of tacit, generalized understandings which they may apply to some extent.

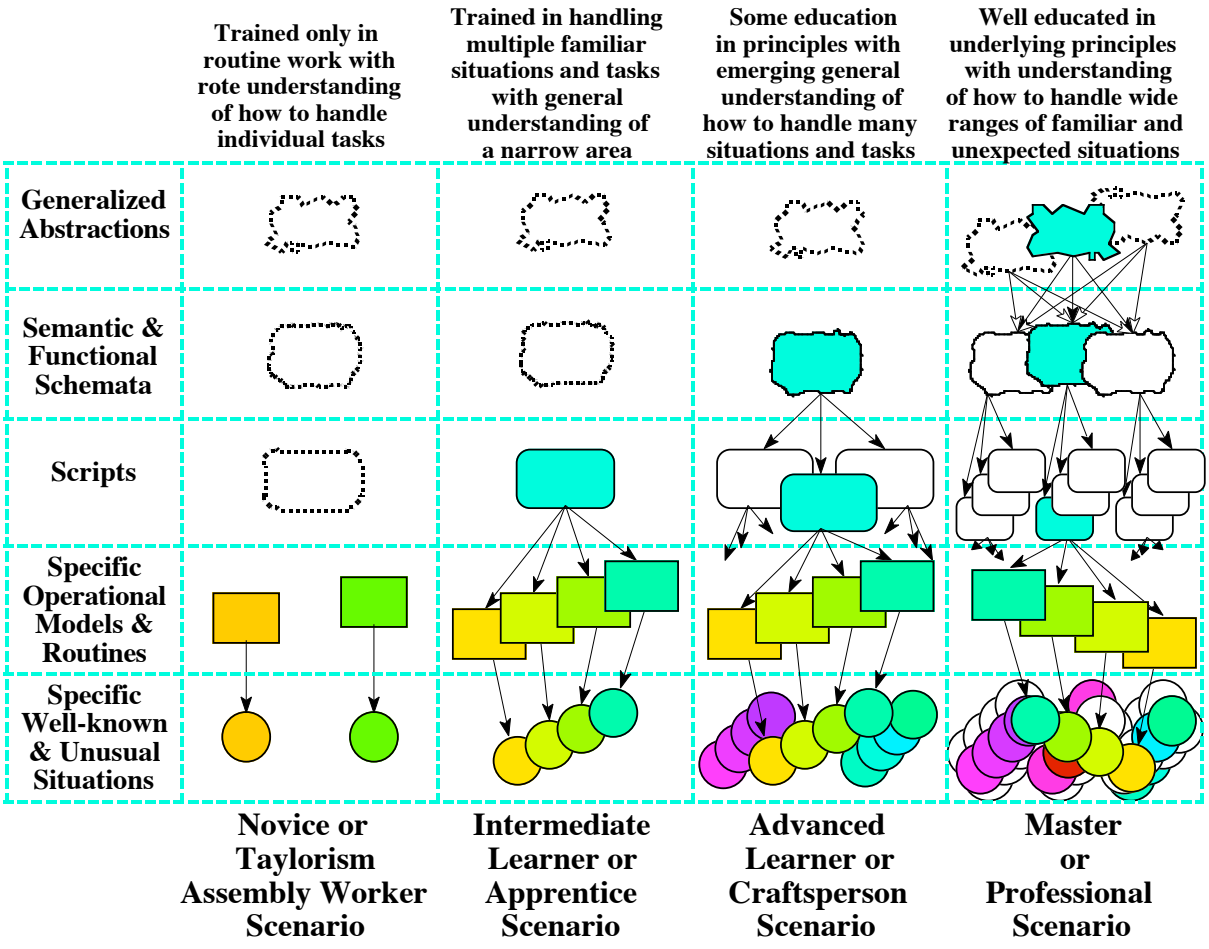


Figure 2. Model for the role of operational models, scripts, schemata, and generalized abstractions in the ability to handle individual or many well-known (routine) and unusual situations.

Recent cognitive research and observations of brain functions[5] indicate that human decision making and problem solving - "situation handling" - is mostly nonconsious (intuitive) and based on associations and abstract mental models. Translating this generalized and abstract "book"

knowledge to address practical situations is complex and requires practical insights. A particular notion within the model is the concept of "operationalizing" general understanding. People create, often new, operational models and routines for particular situations by translating related operational models, scripts, schemata, and generalized abstraction knowledge into applicable concrete understandings and action procedures. In practice, unless the situation is strictly routine, the knowledge the person possesses does not fully reflect the needs to be addressed. Therefore, it may be inappropriate to apply prior knowledge directly. Instead, by using general understanding to interpret the situation's characteristics and handling requirements, people will construct and implement one-time operational models by using prior knowledge and applying analogical and other reasoning methods. As Klein (1998) points out, this process is primarily nonconscious ("intuitive"), quite fast, based on nonconscious mental models, and often involves extensive mental simulations.

Figure 3 outlines a model for operationalizing general knowledge to address a particular non-routine target situation. Assuming that the person will use his or her general knowledge s/he will draw upon conceptual knowledge in the form of generalized abstractions, schemata, and scripts to create an operational model to handle the situation.

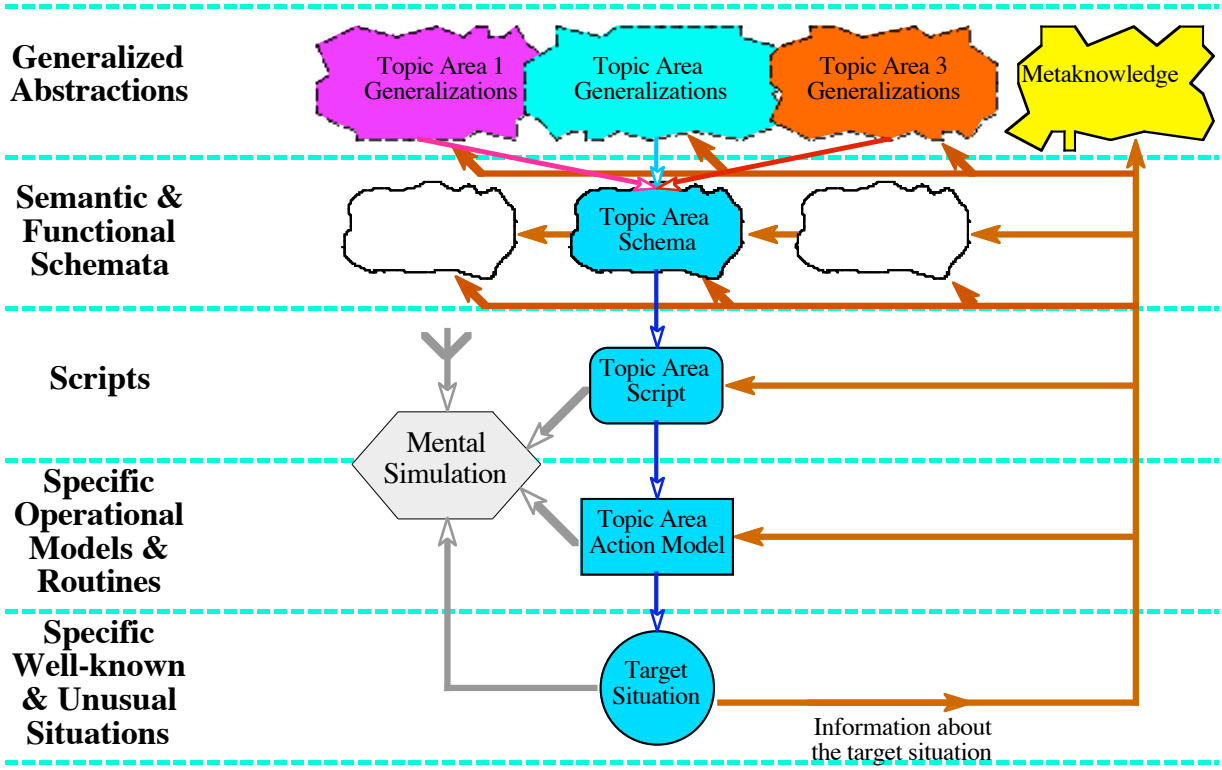


Figure 3. A model for operationalizing general knowledge to serve a particular non-routine and complex situation.

For most complex situations, people will draw upon mental models from many topic areas to incorporate different perspectives. Decisions of most kinds are often based on expectations and the strength of associations, rather than on a systematic decision making process.[6] These findings, by themselves, have strong implications for how we prepare people both to continue learning and for work. In particular, we need to provide them with the kind of knowledge that will facilitate their best performance - the highest degree of intelligent-acting possible.

As an illustration of intuitive decision making, if while driving my car on a winding mountain road, another car passes me and at the same time an oncoming car appears, I will be faced with a situation where I will need to address a complex problem setting. I must consider topics associated with how people (in the other cars) may react under such circumstances; what may be physically possible given the speed of the cars; the road surface; the terrain on the side of the road; the driving characteristics of my own car; and my own driving skills. Several generalized abstractions, several schemata, and several scripts may be involved in my thinking within a timespan of a second or less. I may also use metaknowledge (knowledge about what and how I know) to decide how I may handle the situation. I may retrieve a script from memory, and use that as a basis for generating a new, situation-specific script with a resulting operational model that I then may use to perform a mental simulation - if I have time before I need to act - to ascertain that my potential action will satisfice[7] the situation.

As indicated in Figure 3, mental simulation involves exploring if the operational or action model will satisfice by using expectations and perspectives from internalized conceptual knowledge. If the simulation results are unacceptable, the topic script, and its resulting action model, are modified.

A Model for Acquiring Knowledge - for Learning

Mechanisms and approaches to learning have been explored throughout historic times. In recent years a formal learning theory has emerged to provide a framework to understand learning. Learning theory postulates that all learning models consist of four principal parts: (a) a class of languages or other structured means of communication, one part of which is the "target of learning" (material to be transferred); (b) the learning environment that provides knowledge material to the learner; (c) a learning strategy that maps new knowledge material onto hypotheses based on prior knowledge; and (d) a success criterion that defines acceptability and correspondence between the learner's conjectures and the learned material. A simple learning model according to this theory is illustrated in Figure 4.

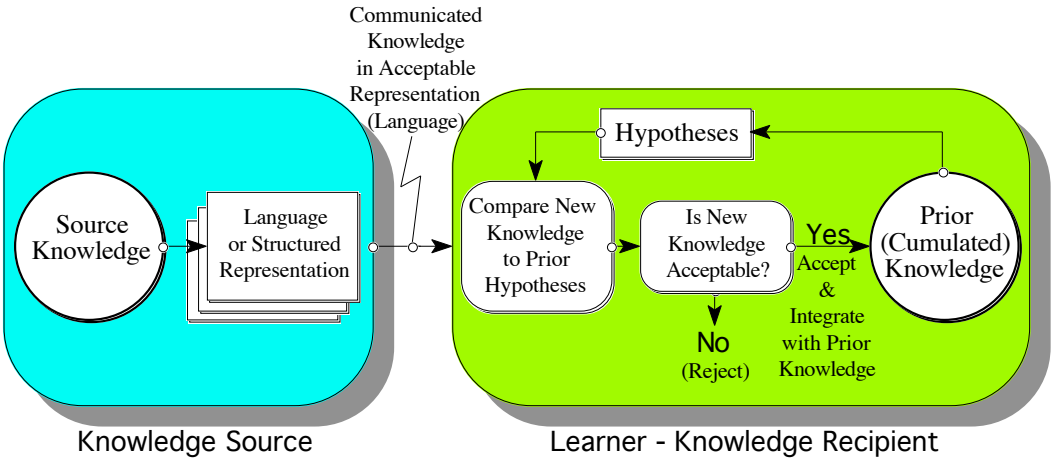


Figure 4. A simple personal learning model

A different perspective on how we learn from real life experiences is presented in Figure 5. In this scenario, learning takes place by obtaining feedback from interacting with, or by observing, the external environment. As observations and feedback are obtained on characteristics and behavior of the target situation, new features are incorporated as new knowledge in the form of new or modified

mental models, categorizations, perspectives, expectations, concepts, associations, and so on at different abstraction levels. This results in the formation of new or expanded scripts, schemata, and generalized abstractions.

In this figure, the basic learning model is depicted as a one-way communication from a knowledge source to a learner. In most situations, however, the knowledge source receives feedback from the learner on a variety of issues: Is the communication understood? Is the representation acceptable? Is the communicated knowledge appropriate? - and so on. In addition, most learning includes a much more complex process to verify and determine the relevance of the presented knowledge. This simple model does not distinguish between different types of knowledge. It does refer to prior knowledge, hypotheses, and acceptability of received information, and so on. Implicitly, it also refers to categorizations (as bases for making valid comparisons), expectations, conceptual knowledge (scripts, schemata, and generalized abstractions as bases for forming hypotheses), and associations (as driving forces for remembering what may be relevant).

Conceptual Learning Considerations

Unfortunately, learners differ considerably in both backgrounds and cognitive styles. This diversity requires that the teaching-learning processes must be versatile to take advantage of the learners' strengths and compensate for their weaknesses.

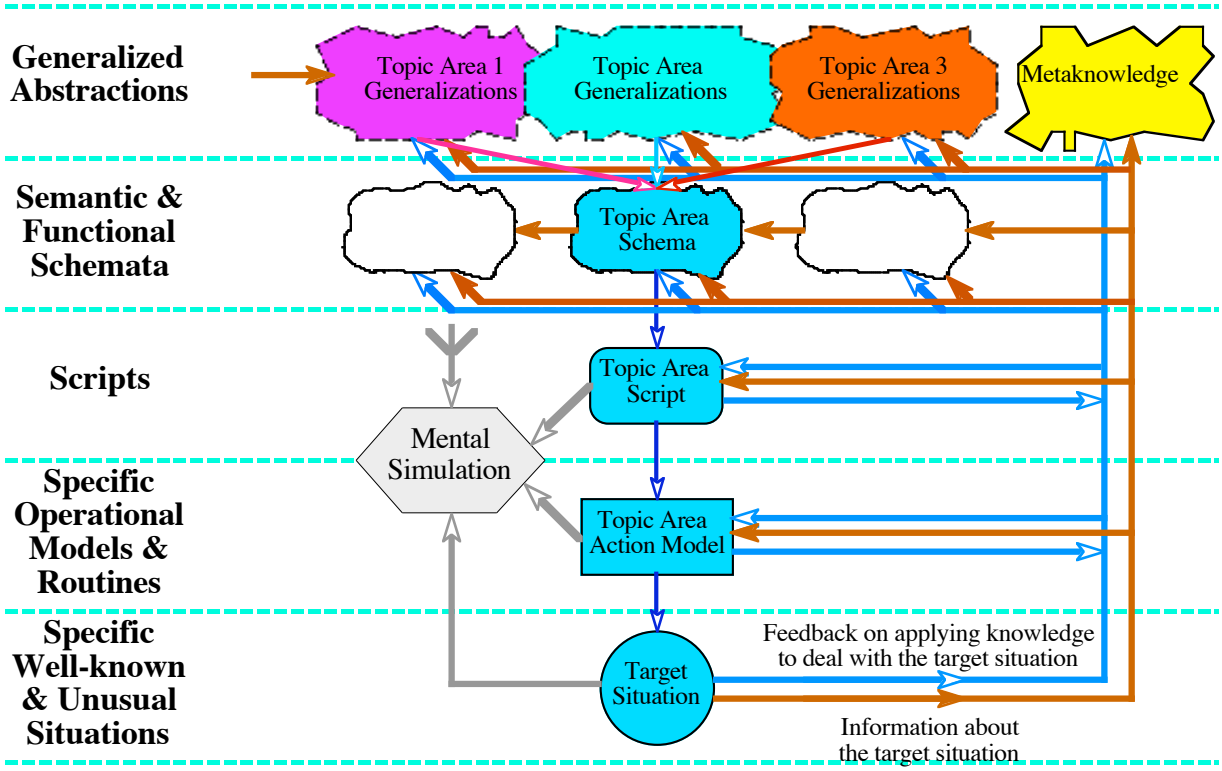


Figure 5. Learning by obtaining feedback from interacting with - or handling - particular situations.

A conclusion that must be drawn from our understanding of how people learn, is that the role of conceptual knowledge (in contrast to factual knowledge) is of utmost importance. Furthermore, people at all stages of development and expertise "automatically" tend to categorize concrete situations and real-life sensory inputs to place the new understandings into a generalized framework

- into mental models such as schemata and generalized abstractions.[8] Another aspect of this is that people, who are provided with only factual knowledge, or with direct observations of, and experimentation on their environments - will develop their own generalizations that are fully based on their own prior knowledge. Since backgrounds and prior knowledge of people vary considerably, the resulting mental models for the same situations will also vary, often considerably, and these generalizations will often be erroneous.

We are continually increasing our insights into how people learn and how they use knowledge to make decisions and act upon them. Recent findings indicate that people generally learn and remember concepts easier than they learn and remember facts. It also is found that people's decisions - to a much greater degree than previously realized - are based on tacit knowledge, rather than using explicit, systematic, and rational processes as had previously been assumed. To deliver intellectual work, people make myriads of "decisions-in-the-small," and only a smaller number of "decisions-in-the-large." As indicated above, the small "intuitive" decisions are made by using conceptual knowledge - schemata, scripts, associations, etc. They are heavily dependent upon the conceptual knowledge that the person possesses and less upon the understanding of appropriate decision making procedures, or factual knowledge about specific features and situations.

The characteristics of how people learn and use knowledge have direct implications for both what and how knowledge workers should be taught. In particular, the process of teaching and the application of knowledge to do work or learn further, become more effective when people are allowed to learn - or taught - underlying concepts rather than being trained to perform routinized operations or taught facts and information which they themselves have to organize and generalize.

INTERVENTION METHODS AND PROCEDURES

The Conceptual Mapping Process

Conceptual mapping is a teaching and intervention process that is conducted in settings where learners are supported by educators to address particular topic areas. The process uses visual tools in the form of topic-specific conceptual maps and is supported by cognitive mediation to develop understanding of the topic area and critical thinking abilities and strategies. The process is designed to build content-knowledge, asspociations, and concepts and develop abilities required for reasoning, problem-solving, critical thinking, and intelligent action.

The prominent role of associations in human decision making and problem solving [9] suggests that effective teaching and learning must foster the development of rich associative (semantic) networks. The associations in these networks must be immediate as well as remote and concrete as well as to support decision making and problem handling in a variety of contexts. The semantic nets formed must include associations among features, dimensions, relationships, processes, and dynamics of the tasks or situations to be handled. In other words, the associative networks must be built beyond the level of free or random associations to provide structured associations that will form a template for thinking. Conceptual mapping - a process which combines visual tools and cognitive mediation - is designed to elicit multiple associations in response to given concepts, themes, problems, or processes. The conceptual maps (visual tools) provide explicit structures for organizing the elicited associations to form templates for communicating and understanding a situation and acting effectively to handle it.

An essential feature of conceptual mapping is that it requires educators and students to identify important dimensions of a general problem or task, such as interpreting a text or communicating in a social context. It then requires them to identify and categorize the features and characteristics of

the task. The learners are guided to consider the problem or task from different perspectives and the process therefore fosters cognitive flexibility. Conceptual mapping requires teachers and learners to analyze and integrate information (analysis-synthesis), test alternatives for interpretation or action (evaluation), and implement a course of action (application). The dynamic aspects of teaching with conceptual mapping and cognitive mediation are created through the marriage of content and process.

Table 1. Overview of selected knowledge domains and practical applications.

Domain	Conceptual Knowledge	Applications
Words and Concepts	Associations, meaning features, categories, hierarchies, and abstract or figurative uses	Listening and reading comprehension Conversation Story telling and writing
Theme Structure	Associations, categories, hierarchies, main ideas, supporting themes and information	Reading comprehension Spoken and written communication Literature and social studies
Discourse Structure	Underlying plans (scripts & schemata) for overall organization, specific devices and conventions for discourse	Story telling and written discourse Conversation and written dialogue
Pragmatics and Social Interaction	Effective use of communication modes, functions and intents, social rules, conventions, and characterization	Listening and reading comprehension Written expression English literature Social interaction
Social Structures	Existing structures in family, community, or society; expectations for social behaviors and hierarchies; moral judgment and value and belief systems	Family and parenting Law, order, crime, and punishment Organizational structure Social, cultural, religious and political systems
Structure of Emotions	Perspective taking, social awareness, empathy, and self-regulation	Counseling Psychology Behavior management

Conceptual mapping and cognitive mediation can be applied to a broad range of contexts, subject areas, and learning tasks to construct knowledge and build mental models (e.g., scripts or schemata). This is because conceptual maps represent generic models that can be applied to reasoning and problem solving tasks in most learning and real-world settings. We focus on a few knowledge domains that are based in language and communication, identify the supportive conceptual knowledge, and indicate some areas for practical application in Table 1.

Intervention Tools

Conceptual mapping uses two tools in parallel. The first is the conceptual map and the second the cognitive mediation process. Each of the components plays a significant role in conceptual mapping. We will therefore describe the components in greater detail.

Conceptual maps are topic-specific visual, diagrammatic representations that serve as organizers for constructing and sharing knowledge. The maps are external, physical representations of events or problem situations that: (a) give an organizing structure for teaching and learning that manages complexity; (b) serve as an organizing principle that allows a learner to structure complex ideas or processes; and (c) provide a context for quick identification of conceptual (semantic) and stage-based (procedural) knowledge.

Table 2. Overview of a taxonomy for conceptual maps.

Category	Purpose	Design Features	Outcomes
Associative Maps	Provide a meta-structure for eliciting associated words or concepts	Centered oval with many boxes for responses	Knowledge of associative links and semantic nets
Concept Maps	Provide meta-structures for knowledge of dimensions and features	Centered oval with from four to six surrounding boxes for responses	Knowledge of dimensions and their associated attributes or meaning features
Comparison and Contrast Maps	Provide meta-structures for knowledge of shared and non-shared aspects	Centered ovals with one box for shared features and two for differences	Knowledge of similarities and differences between concepts, entities, or themes
Theme Maps	Provide meta-structures for knowledge about and multiple interpretations of text	Centered oval for the theme with from four to six related boxes for responses	Knowledge of critical details and logical relations (how, why), and evaluation of text
Underlying Structure Maps	Provide meta-structures for knowledge of the underlying organization	Identification of structure with sequenced boxes for analyzing segments of it	Knowledge of scripts or schema for, among others, literary or scientific texts
Process and Sequence Maps	Provide meta-structures for procedural know-ledge for process implementation	Identification of the process in an oval, followed by a sequence of boxes for sequencing	Knowledge of components steps and sequences in given processes
Dynamic Relations Maps	Provide meta-structures for knowledge of dynamic and changing inter-relations	Identification of a central change and related boxes for recording driving forces and dynamics	Knowledge of factors, sources, and dynamics in relationships or in evolutionary processes

Conceptual maps are explicit and structured and represent inner images, schemata, or processes - so-called mental models. Mental models are internal, reduced dimension projections or representations (abstractions) of events or problem situations that: (a) provide a method to filter and classify input to manage information overload; (b) serve as an organizing structure to help manage complexity in learning and problem solving; and (c) represent an inherent ability to place items in the environment into a part-whole structure (e.g., pattern, gestalt, image, script, or schema). We can think of conceptual maps as “best possible” visual representations of mental models that reside first in the minds of experts and are “mined” in a mediated team process (Wiig & Kusuma-Powell, 1998).

Conceptual maps come in different formats to serve various functions. They are essentially visual tools for constructing knowledge about concepts, events, processes, relationships, or dynamics associated with language and communication in real-life activities and interactions. Conceptual maps can be described within a taxonomy. Different conceptual map types can be combined and sequenced to form larger teaching units. The major categories in the taxonomy of conceptual maps are described and shown in Table 2.

Associative maps are also called webs or semantic nets and the process is referred to as ‘mind mapping’ (Buzan, 1989; Wyckoff, 1991). The main characteristic is that the maps elicit free associations in response to a given stimulus. Associative maps may be used to identify and categorize related meanings for words, concepts, expressions, and themes. This can give insight into the amount of prior knowledge individual students or classrooms have about the verbal stimulus.

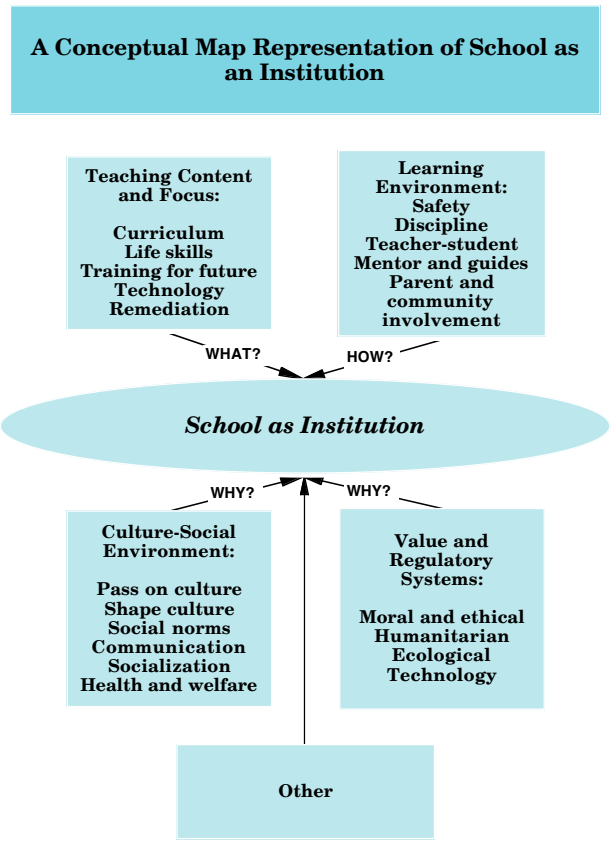


Figure 6. An Example of a Conceptual Map.

Conceptual maps (Figure 6) focus on analyzing the meaning features of words, concepts, or expressions. The main characteristic is that the maps elicit an analysis of from four to six categories (dimensions) of meaning for a given verbal stimulus.

The format has its theoretical basis in work by Pareto (1935) and Parsons (1951, 1958). Concept maps can be used for analyzing and constructing meaning for concrete and abstract words, concepts, expressions, and themes and to start the process of creating a broader meaning base. Comparison and Contrast maps (Figure 7) differ in the complexity of the design, depending on whether the comparisons involve two or several related words, concepts, or themes. The Venn diagram is a familiar basic example. Comparison and contrast maps are used to identify and record similarities and differences in meanings, features, or attributes between two words, concepts, expressions, or themes.

Theme maps (Figure 8) for analyzing oral and written discourse use a format similar to the concept maps described above. The main characteristic is that the maps are designed to elicit analysis of categories (e.g., components, dimensions, or aspects) of a single theme or of multiple themes in a text.

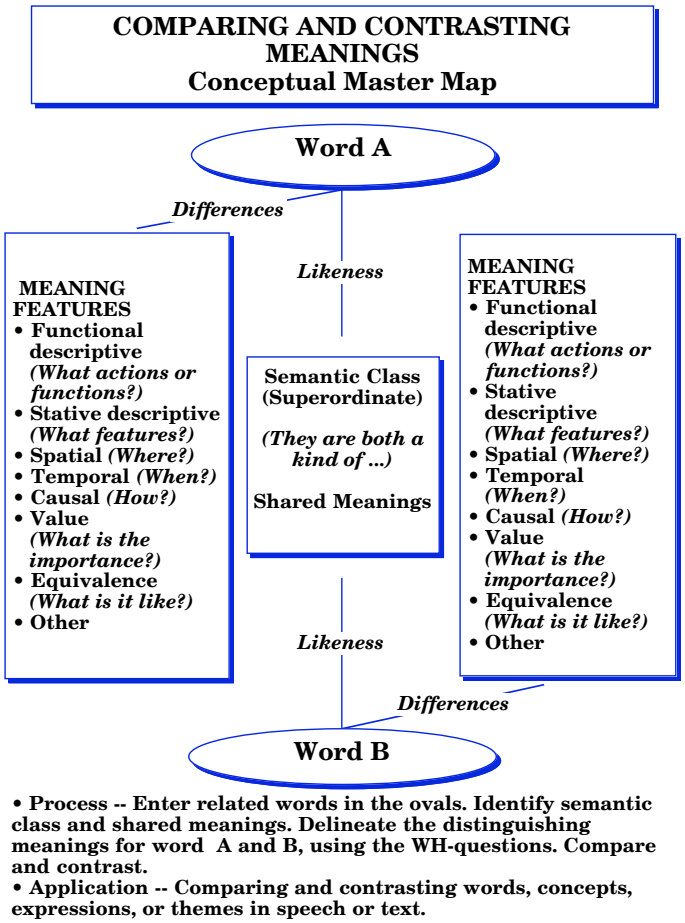


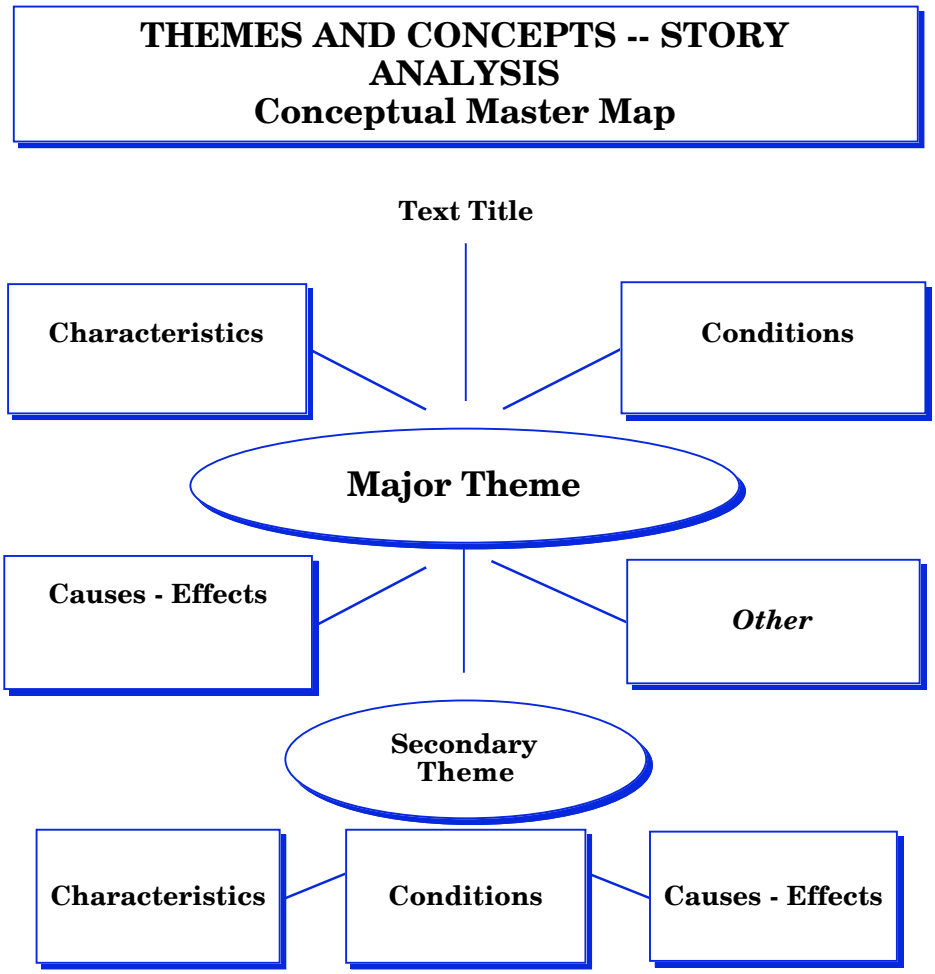
Figure 7. An Example of a Comparison and Contrast Map.

Underlying Structure maps (Figure 9) represent components of the underlying structure of fixed expressions such as verbal analogies and metaphors, dialogue, discourse, or narrative. They show the organization of the unique components of a given task, expected product, or interaction. An underlying structure map can help students visualize and internalize the organization as a script or schema. Verbal analogies and metaphors are examples of expressions with fixed underlying structures. The way we conduct conversations, tell stories, or write essays is also guided by the underlying structures.

Process and Sequence maps (Figure 10) represent segments or components of an evolving process. These maps may show a series of steps for completing, for example, a written paper, lab report, or vocational study assignment. The main characteristic is that it builds awareness and assists in constructing knowledge about steps or stages in an overall procedure. The intent of the conceptual map is to enhance the students' procedural knowledge. Maps in this category need to be constructed to represent identifiable or separate components of a given process and establish the sequence the process should follow.

Dynamic Relationship maps (Figure 11) represent changing or evolving interactions or relationships. The purpose is to assist students in seeing relationships, identifying and analyzing sources of change over time, and construct knowledge about the whole of an interaction or relationship. A dynamic relationship map usually shows a turning point and identifies the conditions, before, during, and after a critical action or event has caused the relationship or evolutionary process to change. Dynamic relationship mapping can be used for interactive character

analysis in stories, novels, and plays, analysis of changing relationships, and knowledge about socialization processes.



• Process -- Identify and label major and secondary themes and dimensions covered by the themes Identify and record important and unfamiliar words and concepts associated with the themes. Discuss the themes and interpret and define the recorded words and concepts.
• Applications -- Analysis and interpretation of text for themes, dimensions covered by the themes, and significant concepts.

Figure 8. An Example of a Theme Map.

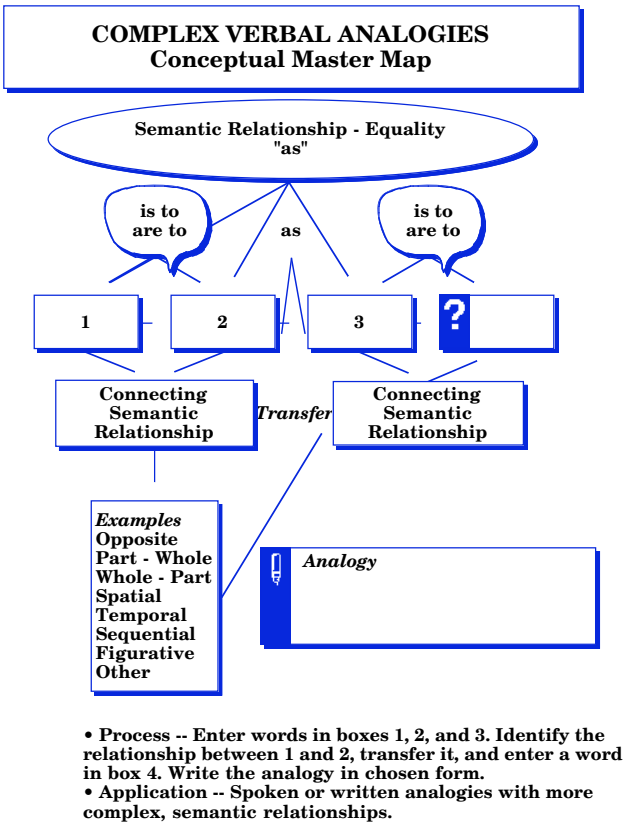


Figure 9. An Example of a Map of Underlying Structures in Verbal Analogies.

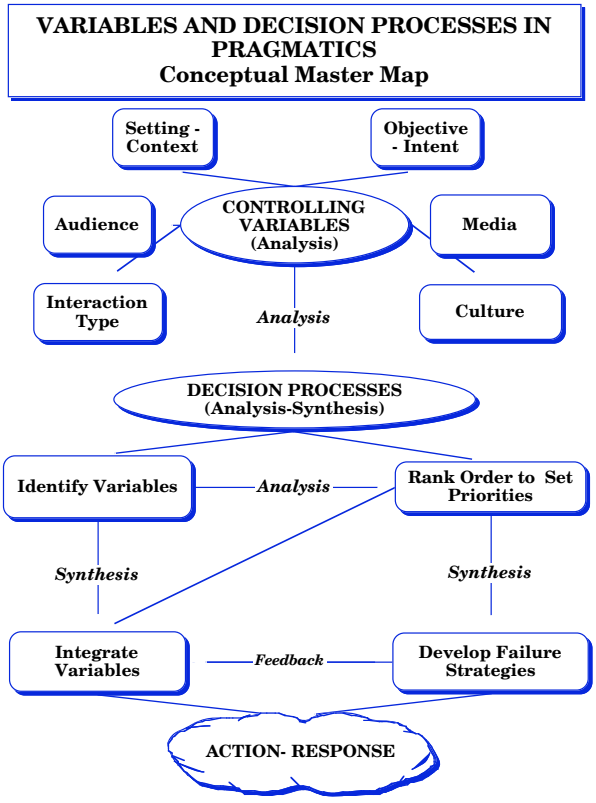


Figure 10. An Example of a Process and Sequence Map for Pragmatics.

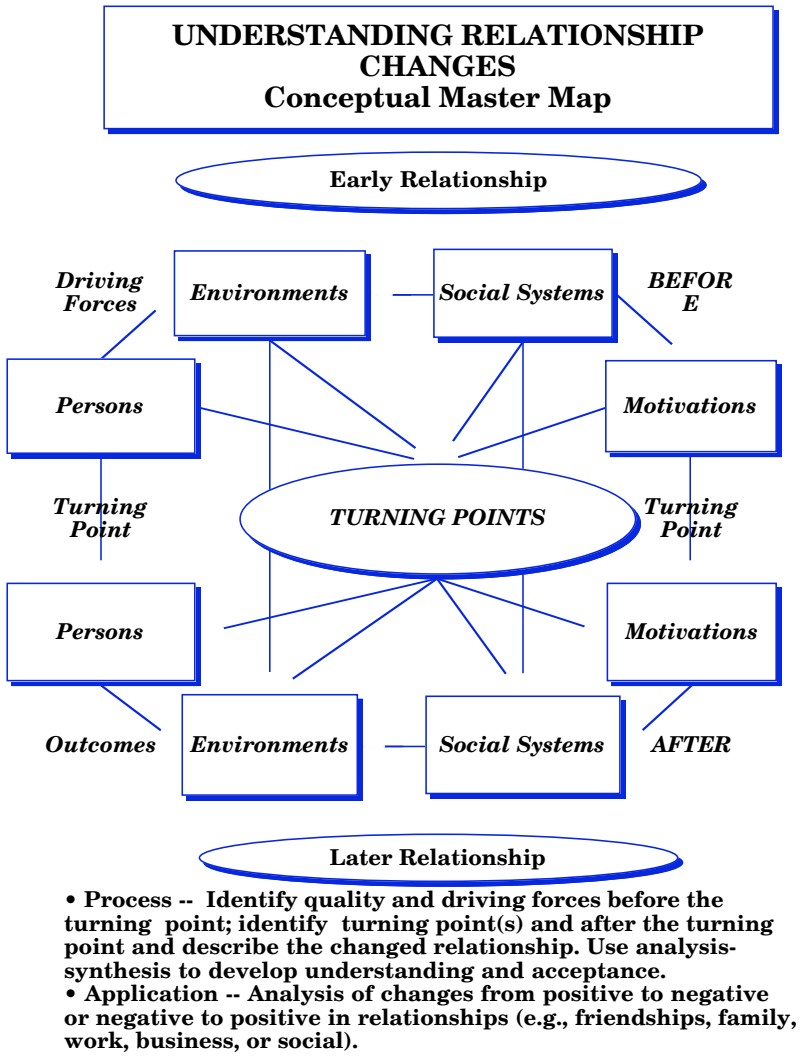


Figure 11. An Example of a Dynamic Relationship Map.

Cognitive Mediation

Cognitive mediation brings life to teaching with conceptual maps and transforms the teaching process into "conceptual mapping." The conceptual maps provide structure and organization for thinking and act as visual tools for guiding and recording the results of a critical thinking process. The maps are by themselves explicit but static and do not contribute to the development of critical thinking without the verbal script provided by "cognitive mediation." The use of cognitive mediation is supported by recent developments in brain research and the implications these have for education (Caine & Caine, 1991, 1997).

Cognitive mediation provides the dynamic guidance for learners on how to think critically. Direct imparting of a teacher's knowledge by giving students information or answers, without involving them in a problem-solving process, is not enough to support the development of critical thinking. This is because imparted information may not be processed and integrated, and therefore may not become the ownership of the learner. Conceptual mapping with cognitive mediation fosters critical thinking and allows learners to construct their own knowledge. They come to own the new knowledge and this in turn empowers them. The teacher or educational specialist must learn to use

cognitive mediation as part of a constructive teaching process. They must learn to serve first as mediators and later as facilitators do in the creative process of constructing knowledge and developing mental models for life.

The role of the teacher, special educator, or speech-language pathologist is to serve first as mediator and then as facilitator of the process of constructing knowledge. The teacher should serve as mediator in the early stages of acquiring knowledge through conceptual mapping. The role as facilitator should be limited to contexts, where the students have acquired or possess the knowledge needed to work with conceptual maps as facilitating tools.

As a cognitive mediator, the educator or clinician needs to be knowledgeable about the content and subject mater. She/he must listen actively and without bias and not show judgment of students' contributions. The cognitive mediator can give positive, constructive content contributions. She/he must guide the critical thinking process step-by-step, provide control to keep participants in line, keep the process flowing, and make sure every contributor is heard.

As a facilitator, the educator or clinician needs little or no subject matter knowledge. She/he must listen actively and without bias and not show judgment of contributions. The facilitator gives few or no content-related contributions -- only process related directives. She/he guides and controls the conceptual mapping process and makes sure every contributor is heard. The list below describes some strategies for the cognitive mediation.

- Guide the learner to see, understand, and accept the usefulness of the new knowledge for her/him
- Question the learner continuously by using guided questioning techniques to help reframe and refine the student's contributions
- Make thinking explicit by using think-aloud, drawing, diagramming, or webbing
- Facilitate responses by identifying a "hook" and eliciting the learner's prior knowledge or experiences
- Guide the learner through the process of completing conceptual maps in active, multi-directional, iterative or recursive, and structured ways
- Do not comment on or judge learner's responses or suggestions, as the final judgments must occur through peer- or self-evaluation.

Ideal Intervention Outcomes

In essence the outcomes of teaching with conceptual mapping and cognitive mediation is critical thinking. There is consensus that critical thinking involves several skills and processes. Halpern (1989) uses the term critical thinking to describe "a process of thinking that is goal directed, purposeful, and reasoned." She emphasizes that the word critical is used to indicate that the thinking involves evaluation. She also points out that critical thinking involves abilities such as formulating inferences, calculating likelihood, setting priorities, and making decisions. What is more, she provides extensive empirical evidence that critical thinking can be taught.

Conceptual mapping and cognitive mediation touch on all aspects of the critical thinking features in these models (Figure 12). The first component of critical thinking consists of the ability to analyze a given task. This means pulling features, meanings, relations, and processes inherent in the task apart. This analysis responds to the question, "What are the facts and details?"

The second component consists of the ability to categorize facts and details. It involves grouping the identified features, meanings, patterns, relations, and processes in meaningful ways. This categorization responds to the question, "What are the larger groups or patterns?"

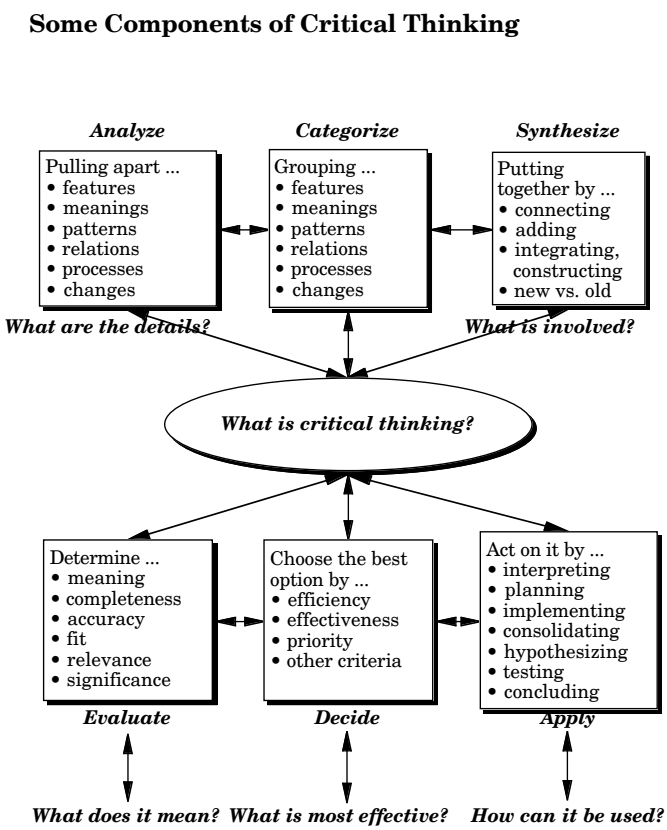


Figure 12. Example of a Critical Thinking Conceptual Map.

The third component consists of the ability to synthesize the outcomes of the analysis and categorization. It involves tying together the details and groupings by connecting, adding, integrating, and distinguishing the new from the old (i.e., prior knowledge). This synthesis responds to the question, "What is involved on a larger scale?"

The fourth component consists of the ability to evaluate. It requires determination of broader meanings, completeness, accuracy, fit, relevance, and significance. This evaluation responds to the question, "What does it all mean?"

The fifth component involves decision-making. The thinker must choose the best option for interpretation, action, or implementation based on criteria for, among others, efficiency, effectiveness, and priority. This component responds to the question, "What would be most effective?"

The last component is to apply the new knowledge. Application involves acting on decisions. Interpreting, planning, implementing, consolidating, hypothesizing, testing, and making conclusions does this. The last component responds to the question, "How can the knowledge best be used or represented?

The four abilities below summarize what makes a critical thinker. They are:

- Ability to analyze data by manipulating, abstracting, subsuming parts, and categorizing.

- Ability to identify the data needed to clarify a given subject or topic by accessing, processing, and developing understanding.
- Ability to relate new and old knowledge by seeing connections, similarities and differences, and allegorizing.
- Ability to make inferences and predictions, and hypothesize, apply, and create new visions.

Intervention Elements, Scope, and Sequence

Critical thinking involves abilities, processes, and components that are similar to those needed for creative thinking. Conceptual mapping and cognitive mediation assist in structuring the opportunities for critical thinking. The specific teaching principles for critical thinking below are adapted from principles for teaching creative thinking (Finke, Ward, & Smith, 1992). The essential elements are to:

- Avoid demand characteristics by having no preconceived expectations for specific answers or solutions
- Provide appropriate constraints for the beginning experiences in critical thinking, for example, by guiding initial brain storming and later structuring the output by conceptual mapping with cognitive mediation
- Encourage hypothetical exploration by fostering divergent thinking (Guilford, 1968)
- Assess and accept individual differences. Among examples of differences are multiple intelligences (Gardner, 1982) and intellectual styles (Sternberg & Lubart, 1991)
- Overcome the fear of thinking critically and of problem solving by minimizing evaluation and maximizing discovery
- Generate intimacy by fostering intimate engagement (Levine 1987), commitment, active involvement, and empowerment
- Provide internal sources of motivation by supporting the joy of discovery, the surprise at one's own knowledge and abilities, and the acceptance of oneself as a critical thinker
- Foster mental flexibility by supporting a wide range of representations, responses, categories, and perspectives
- Promote insightfulness through conceptual mapping and cognitive mediation in different knowledge domains (e.g., literature, social studies, sciences, and social or cultural systems)
- Model and promote insight into how critical thinking and conceptual mapping processes can be applied and what types of products can result
- Anchor the critical thinking efforts in the prevailing academic, cultural, and social environment
- Develop higher-level abstractions from concrete examples (anchors), and transcend specific contexts in general (global) applications

During intervention, a scope and sequence model emerged for developing underlying concepts, scripts and schema for language and communication. Based on this, the lessons and units used in intervention centered around social stories from Room 14 (Wilson, 1993) and assigned texts from the curriculum. The content and materials were selected to meet Jane's needs as indicated by testing, observations, and teacher and parent reports. The scope of intervention scope covered four central domains: pragmatics, semantic processing, reading-listening comprehension, and narrative production. In the schematic (Figure 6), the central domains are arranged in the approximate sequence in which they were emphasized during intervention. The domains, pragmatics, semantic processing, and listening comprehension were introduced and emphasized concurrently. Reading

and comprehension and narrative writing were introduced when basic goals were established for the three basic language and communication domains.

The intervention emphasized each of the components listed within each domain at some point. Intervention started by emphasizing the concepts that are basic to listening (e.g., Pragmatics and Semantic Processing). This included analysis observable listening behaviors (e.g., body language) as well as internal behaviors (e.g., focussing attention, interpreting content, and forming associations). This was because the teacher stated that her most immediate need was to acquire better listening strategies in the classroom.

After the initial analyses for listening were completed, the intervention focus shifted to the domains of Semantic Processing and Reading Comprehension. At this point assigned texts from the language arts curriculum provided the content for intervention. Among components that were emphasized first were prior knowledge, making meaning for key words and concepts, analysis of characters, settings, time lines, episodes, and themes. The emphasis then shifted to synthesizing, evaluating, and applying the given information and new knowledge.

The narrative component was introduced last in the sequence. It focused on writing a sequel to the story or using the social skills to write a story about how a given character solved a specific problem related to the content of the unit from Room 14 (Wilson, 1993).

A Model for Intervention with Conceptual Mapping

We wanted to support the construction of new knowledge about language and communication effectively and quickly, and therefore developed a macro-model for intervention with conceptual mapping and cognitive mediation. The model is motivated by the work of Singley and Anderson (1989) and is in part based on, related work (Wiig & Freedman, 1993; Wiig & Wilson, 1994, 1998). It has its basis in the understanding of top-down learning in which underlying principles, schema, or strategies can be detailed and made usable by developing understanding of underlying concepts (e.g., “trust”), scripts (e.g., introducing yourself and others), or routines (e.g., classroom or social). At the same time, the model is based on bottom-up learning in which specific instances or events are observed through use of contextual illustrations (Wilson, 1993) or modeling, internalized, and integrated to form concrete models (routines and scripts) for how to interpret and deal with familiar and novel situations in social and academic problem solving contexts.

The teaching process is illustrated in Figures 13 and 14. It contains several stages with examples and activities in which conceptual mapping and cognitive mediation are used as tools. The first stage focuses on eliciting prior knowledge about social or story themes, highlighting key vocabulary, and making basic predictions.

The second stage uses thinking aloud, guided questioning and scaffolding procedures to create awareness and understanding of, among others, concepts, associations, relationships, and cause-effect chains. The activities focus on concrete information and knowledge (e.g., characterization and analysis of context and relations) but may move from the concrete to more abstract levels (e.g., making inferences, interpreting metaphors). Within each stage there is a movement of building the learner’s knowledge to a high point and then bridging to the next stage of intervention with examples, modeling, and related activities.

LANGUAGE INTERVENTION MODEL WITH CONCEPTUAL MAPPING AND COGNITIVE MEDIATION - PART 1.

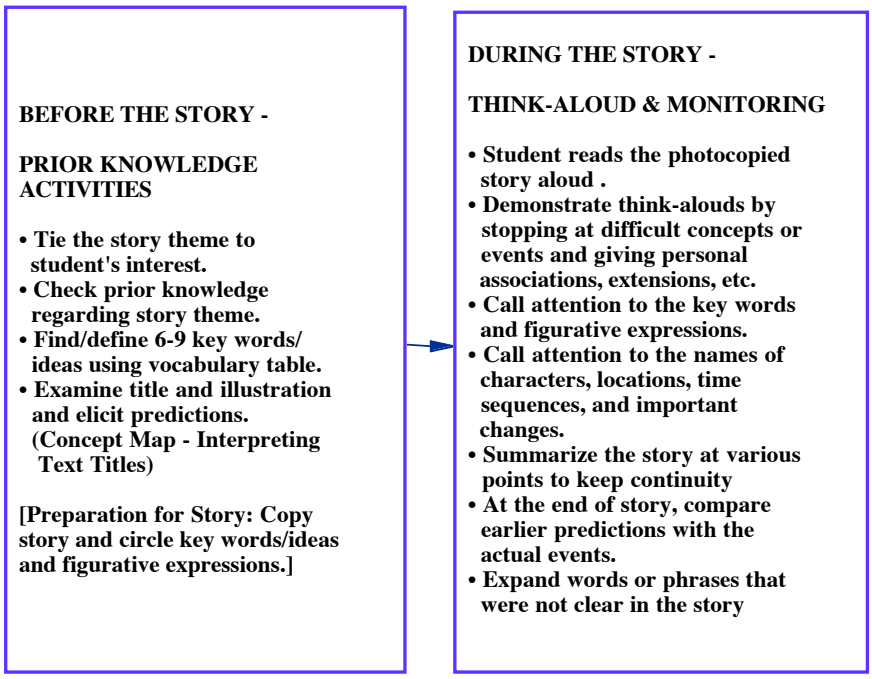


Figure 13. Teaching Process with Conceptual Mapping and Intervention - Part 1.

LANGUAGE INTERVENTION MODEL WITH CONCEPTUAL MAPPING AND COGNITIVE MEDIATION - PART 2.

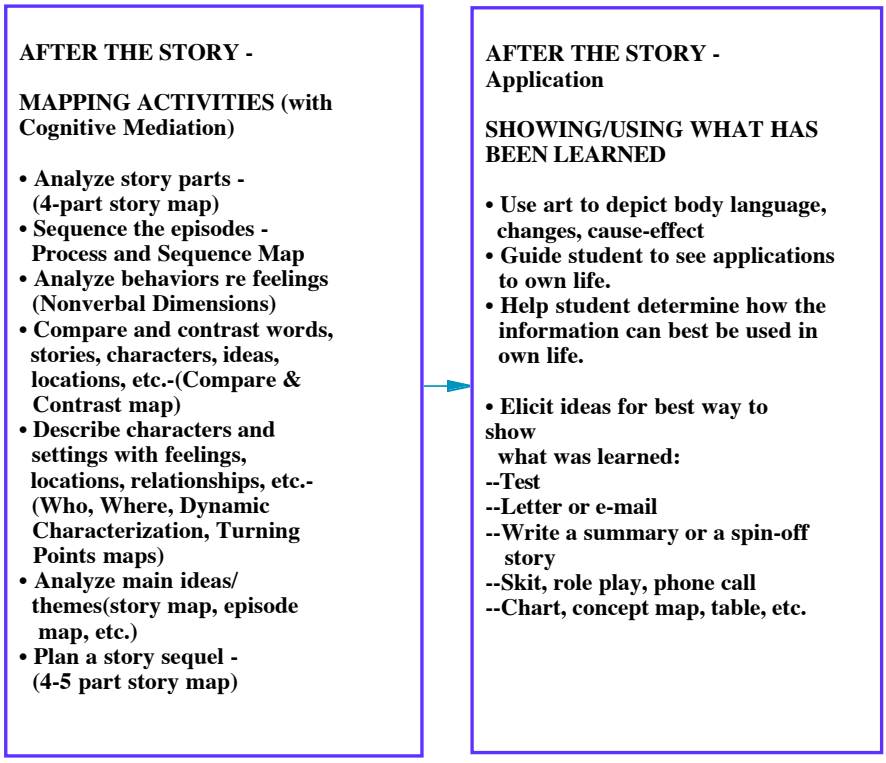


Figure 14. Teaching Process with Conceptual Mapping and Intervention - Part 2.

The third stage focuses on using conceptual mapping and cognitive mediation, developing questions and answers, and using related activities for practice and transfer to new contexts. The conceptual mapping activities make use of structured maps constructed specifically for the purpose or selected from Visual Tools for Language and Communication (Wiig & Wilson, 1998) to analyze content, structure, process, and sequence, compare and contrast critical aspects (e.g., changes in relationships before and after a turning point), and synthesize the new knowledge to plan for future applications. The questions and answer and related activities segments focus on comparing and contrasting, eliciting descriptions, identifying primary and secondary information, and summarizing.

The fourth stage emphasizes application of old and new knowledge to new contexts (e.g., own life), representations (e.g., tables or charts), media (e.g., e-mail messages), or goals (e.g., developing your own test). This stage is designed to develop meta-knowledge (e.g., knowledge about what knowledge has been gained), meta-strategies (e.g., novel and innovative ways of using the new knowledge), and meta-cognition (e.g., knowledge of which reasoning approaches will be most effective for solving a given problem). All activities used at this stage are related to the unit theme and brings the new knowledge to a higher level of complexity and/or abstraction.

REFERENCES AND RESOURCES

Bechara, Antoine; Damasio, Hanna; Tranel, Daniel; & Damasio, Antonio R. (1997) "Deciding Advantageously Before Knowing the Advantageous Strategy." **SCIENCE, 275**, 1293-5.

Costa, A. L. (1991). **Developing minds. 2nd. ed**. Alexandria, VA: Association for Supervision and Curriculum Development.

Damasio, Antonio R. (1994) **Descartes' Error: Emotion, Reason, and the Human Brain**. New York: Grosset/Putnam.

Gardner, H. (1991). **The unschooled mind: How children think and how schools should teach.** New York: Basic Books.

Hyerle, D. (1996). **Visual tools for creating knowledge**. Alexandria, VA: Association for Supervision and Curriculum Development.

Johnson-Laird, P. N. (1983). **Mental models**. Cambridge, MA: Harvard University Press.

Klein, Gary (1998) **Sources of Power: How people make decisions**. Cambridge: MIT Press.

Lakoff, George (1987) **Women, Fire, and Dangerous Things: What categories reveal about the mind**. Chicago: University of Chicago Press.

Margolies, N. (1991). **Mapping inner space.** Tucson, AZ: Zephyr Press.

Quinn, James B.; Anderson, Philip; & Finkelstein, Sydney (1996) "Managing Professional Intellect: Making the Most of the Best." **Harvard Business Review**, March-April, 71-80.

Semel, E., Wiig, E. H., & Secord, W. A. (1995). **Clinical evaluation of language fundamentals - 3.** San Antonio, TX: The Psychological Corporation.

Semel, E., Wiig, E. H., & Secord, W. A. (1996). **Clinical evaluation of language fundamentals - 3: Observational rating scales.** San Antonio, TX: The Psychological Corporation.

Senge, P. M. (1990). The fifth discipline. New York: Currency Doubleday.

Schank, Roger C. (1990) **Tell Me a Story: A New Look at Real and Artificial Memory**. New York: Charles Scribner's Sons.

Simon, Herbert A. (1976) **Administrative Behavior: A Study of Decision-Making Processes in Administrative Organizations** (3rd Edition) New York: The Free Press.

Wiig, E. H. (1989). **Steps to language competence: Developing metalinguistic** competence. San Antonio, TX: The Psychological Corporation.

Wiig, E. H. (1992). **Language intervention for school-age children: Models and procedures that work.** Chicago, IL: Applied Symbolix.

Wiig, E. H., & Freedman, E.(1991). **The WORD book: Developing words and concepts across the curriculum.** Austin, TX: Pro-Ed.

Wiig, E. H., & Secord, W. A. (1992). **Test of word knowledge.** San Antonio, TX: The Psychological Corporation.

Wiig, E. H., & Wilson, C. C. (1997). **Ladders to interpretation: Assessing and developing text comprehension.** Chicago, Ill.: Applied Symbolixs.

Wiig, E. H., & Wilson, C. C. (1997). **Visual tools for developing language and communication: Content, use, and interaction.** Arlington, TX: Schema Press.

Wiig, K. M. (1993). **Knowledge management foundations: Thinking about thinking.** Arlington, TX: Schema Press.

Wilson, C. C., Lanza, J. R., Evans, J. S., & Wiig, E. H. (1997). **Concept power.** Chicago, IL: Applied Symbolix.

Wycoff, J. (1991). **Mindmapping.** New York: Berkley Book.

---

[1] **Script:** A *general event sequence* which underlies a *referenced type of situation.* Scripts are flexible, somewhat abstract, and include general expectations and directions. Typically, scripts consist of several steps made up of episodes and events.

Scripts are in many ways similar to *operational models* and *routines*. The main difference is that scripts and their steps are general, broad, and flexible compared to the routines' specific and unvarying steps.

Schema: A broad and conceptual *plan or scheme* for a *class of situations.* Schemata are concepts or mental models by which a static or dynamic situation can be characterized and understood. They are typically abstract models of a generalized situation. One or more scripts can be generated from the same schemata to form more definite expectations for evolutions of specific situations. It is a generalized concept which defines our understanding of the underlying structure, nature, or principles of a general type of story, situation, or "system."

"Schema: A spatially and/or temporarily organized structure in which the parts are connected on the basis of contiguities that have been experienced in space or time. A schema is formed on the basis of past experience with objects, scenes, or events and consists of a set of (usually nonconscious) expectations about what things look like and/or the order in which they occur. The parts, or units, of a schema consists of a set of variables, or slots, which can be filled, or instantiated, in any given instance by values that have greater or lesser degrees of probability of occurrence attached to them. Schema vary greatly in their degree of generality - the more general the schema, the less specified, or the less predictable, are the values that satisfy them." (Adapted from Mandler, 1979, p. 263)

[2] See Schank (1990) for a theory of stories as mental models.

[3] These perspectives correspond to our general understanding of how all learning takes place. For further explanations, see for example Wiig (1993) pages 207-210.

[4] We distinguish between the knowledge levels, with the most important one first. Presented in brackets are four corresponding knowledge levels proposed by Quinn et al (1996):

- Goal-Setting or Idealistic Knowledge - Vision and Paradigm Knowledge "Understanding why" - [Quinn: Self-motivated creativity (care-why)]
- Systematic Knowledge - System, Schema, and Reference Methodology Knowledge "Knowing why and how" - [Quinn: Systems Understanding (know-why)]
- Pragmatic Knowledge - Decision Making and Factual Knowledge "Knowhow", - [Quinn: Advanced Skills (know-how)]
- Tacit Automatic Knowledge - Routine Working Knowledge "Know what" - [Quinn: Cognitive knowledge (know-what)]
- Tacit Subliminal Knowledge - Emerging or Not-Yet-Understood Knowledge ("Glimpsed" Knowledge) - [Quinn: Not considered]

For further descriptions of knowledge levels, see Wiig (1993).

[5] See Bechara et al (1997) and Damasio (1994).

[6] See Klein (1998) for extensive discussions on how people make decisions in real life.

[7] When a decision maker looks for an option that is just *"good enough"* s/he satisfices. Herbert Simon introduced the concept of ***satisficing*** to characterize the expedient behavior of decision makers who stop short of finding the best solution that fulfills all criteria to the best degree.

[8] See Lakoff (1987) on how people categorize and generalize their understanding of the world as they receive new information and as their understanding increases through the processes of "thinking through" and internalizing knowledge.

[9] See Bechara et al (1997) and Damasio (1994).

