Increasing Academic Motivation and Cognition in Reading, Writing, and Mathematics: Meaning-Making Strategies

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The Cognitive Approach to Teaching and Learning

The cognitive approach to teaching is a learner-centered approach that takes into consideration the environment or situational context in which the learner learns, the learner's knowledge base (as differences in knowledge may stem from varying linguistic and cultural backgrounds and/or learning disabilities), intrinsic motivation, in addition to improving the learner's ability to process information via cognitive and metacognitive approaches.

The teacher's role is one of facilitator, guide, or model, modeling the types of approaches or strategies that are essential to learning. Teaching is based on tapping prior knowledge, providing students with schemata and scaffolding, opportunities for peer/adult interaction, as well an awareness of the cognitive strategies that may be used to increase long-term memory capacity. Approaches include benefits of cooperative learning, reciprocal teaching, cognitive apprenticeship, anchored instruction, and jigsaw.

Patricia Alexander and Karen Murphy (1998) narrow down learner-centered principles to five themes: (1) knowledge base, (2) strategic processing or executive control, (3) motivation and affect, (4) development and individual differences, and (5) situation or context (p. 26).

Teachers need to have an understanding of the learner's *knowledge base* either through assessment, evaluation, prior teacher recommendations, and interaction with other teachers. Without knowing the knowledge base as well as how memory is processed, teachers will be at a disadvantage for helping students tap prior knowledge and develop schemata that can be applied to future situations.

Teachers need to facilitate learner *strategic processing or executive control*. In other words, teachers need to help students think about their thinking, reflect on the knowledge they possess, and show them how to apply specific strategies to particular situations. In doing so, students can learn to strategically process information in specific academic domains. For example, a student may approach an expository reading

assignment differently from a non-expository piece of literature. This metacognition is essential in processing information more effectively despite the intellectual level of the student.

To understand *motivation and affect*, teachers need to be aware of the situational as well as curricular context in which knowledge is to be transferred to the student. Knowing that intrinsic motivation is higher in problem-solving types of courses such as physics or chemistry but lower in critical thinking types of courses such as social studies is essential (Alexander & Murphy, 1998). Motivating students in physics courses is less demanding than in the social sciences. Teachers must use strategies that help students become engaged in the learning process. Examples of these strategies include cooperative learning, jigsaws, problem-solving, and mnemonics.

No longer can teachers or districts disregard varying learner abilities with the excuse that everything is in the form of bell-shaped curve. Instead *development and individual differences* must be taken into consideration especially when the student population has become so diverse in terms of culture, linguistics, and learning disabilities. What are the types of strategies or approaches that work best with all students? Knowing what specific strategies work well with the *majority* of students helps teachers differentiate the curriculum.

As mentioned under motivation and affect, the situation/context, or the environment the learner is exposed to influences the success of the learner. Social interaction not only with the curriculum, but peers, other teachers, home and neighborhood surroundings provides students with practice, feedback, and opportunities to apply what they have learned. What are the strategies that can be used to reach these students at school as well as at home? Providing information to parents and family members who have a 50% influence on the child's life is important. Secondly, teachers who have a 32% influence on students can begin by providing students with strategies for the context of specific domains of study (Bruning, Schraw, Roning, 1999).

Historical Development of Cognitive Approaches to Teaching and Learning

Prior to cognitive research concerning thought processes and memory, most educational research and its implications were based on the behaviorist approach. Behavior was the end-all to understanding learning via stimuli/response (operant conditioning). Thinking or "thought" was not included in this equation. However, because of the inability of behaviorist research to explain other variables that influenced the learning

process, radical behaviorists looked more at cognitive approaches to understanding learning while also taking into consideration environmental influences in the 1960s. This "round-about-face" caused not only a break among behaviorists but also a break in the educational field of linguistics and language development.

The advancement of cognitive psychological research parallels linguistic research. Although cognitive theorists from the cognitive psychological perspective might state the no single factor influenced the break from behaviorist psychology, I would tend to disagree. In the 1960s, Noam Chomsky broke with structural linguists who were influenced by and studied in the behaviorist tradition. In essence, Chomsky broke with structural linguists who were concerned with language output, as well as the idea that the human mind is a *tabula rasa* in which anything can be written upon, and that the best approach to language acquisition was the mim-mec method and rote learning.

Chomsky's break with structural linguists, who were followers of B.F. Skinner, changed the dominant perception of how language is acquired. Chomsky developed the idea of that every individual has a language acquisition device (LAD). Cognitive psychologists cite the metaphor of the computer and the onset of the technological age as another influence in terms of changing frames of reference in the research community (Bruning, Schraw, Ronning, 1999).

Whether the influence is based on psychological research or whether linguistic research and/or psychological research influenced educational research in the area of cognition is debatable. What we are sure about is that the break from behaviorist empiricism gave way to new ideas in the field of teaching. This break can be seen in the field of education, specifically in the field of second language learning and/or second language acquisition. A number of researchers in this discipline include Stephen Krashen and Jim Cummins who were influenced by natural/authentic approaches that were more acceptable after the behaviorist/cognitive split. Stephen Krashen is known for a number of theories that he developed in the 1970s. In his development of the Monitor Theory he talks about how learners can and do monitor their own language development by noticing errors in their language acquisition and then self-correcting for them. This parallels the research of cognitive theorists who promote self-monitoring during learning and self-regulation, a form of metacognition which would occur when acquiring information from specific academic domains. In order for students to participate in this self-regulation it is important to give them strategies that increase their metacognition and in turn their information acquisition. Secondly,

Krashen also promotes the Din Hypothesis states that continued exposure to authentic language interaction and discourse in the target language will cause the "Din," so to speak, go off in the head of the person, causing the person to have more fluidity in the target language. Krashen states that authentic exposure takes one to one and one-half hours before the "Din" occurs. This is interesting in that this hypothesis parallels, to some extent, the idea of exposure to interaction discourse promoted by cognitivists.

Interaction discourse among peers reinforces memory acquisition. Students are not just receiving input from the teacher but interaction concerning a subject may be discussed among peers. This leads to a greater chance of long-term memory acquisition. So, rather than memorize things by rote, interactive discussion allows for repeat learning of a particular academic domain or subject, which reinforces the learner's knowledge--thus, the importance of adding an interactive component to learning.

It must also be noted that Lev Vygotsky, a Russian psychologist, also promoted the idea of social interaction and its connection to language development and thought long before Krashen and is one of the major proponents of constructivist learning. Social interaction allows for reconstructive learning which helps tap long-term memory storage and retrieval.

Stephen Krashen also promoted his theory of the *i*... + 1 approach which calls for learning within the reach of the child. In other words, a child who is reading at the third-grade level would not be given a book to read at the fifth-grade level as the child might find it too difficult and give up. If the child is given a third-grade level book, there is no challenge and he/she might become disinterested. Thus, the notion of intrinsic motivation for learning is based on the students ability to have not only the feeling of success in learning but material that is challenging enough for them at just one step beyond their level.

Prior to Krashen, Vygotsky formulated a similar theory called the Zone of Proximal Development (ZPD). In doing so, he called for guidance and coaching that would lead the child to his/her next step of development. The differences between the two theories are none too different. While Krashen is talking about the acquisition of a second language, Vygotsky is talking more generally about all forms of language or informational acquisition.

Krashen also believes in guidance and coaching and calls for "caretaker" speech when working with learners who have newly immigrated to a new country. Caretaker speech—speech without use of

idioms when instructing second language learners—is often described as simplified speech for the newcomer who is a second language learner. However, this speech is not intended to be simple but to support the initial acquisition of student language development, much like a coach would guide informational acquisition in a specific domain of study. Caretaker speech, the theory of *i*... + 1 is also connected to the idea of lowering the "affective filter" of the learner. The more supported and guided the learner feels with consistent coaching and reinforcement, the sooner the child will lower his/her affective shield and be more responsive to language input. Cognitivists (psychologists), in their own right, talk about lowering the level of anxiety that students experience and how this can affect their memory. There is a parallel between what the American Psychological Association has defined as affective and individual learning and Krashen's idea of the "affective filter."

Patricia Alexander and P. Karen Murphy comment on motivation and its connection with affect (1998, p. 35) concerning learner-centered teaching practices, "[...] it is not for teachers to merely pique the attention or interest of their students without consideration of potential ramifications. Rather teachers' attempts to motivate must consider the personal goals and interests of the students (Dewey, 1913) and the relative value of the content (Wade et al., 1993), along with the desired outcomes of the instructional process (Alexander, in press-b)."

Looking at language development and learning in terms of its cognitive nature, Jim Cummins talks about the need to provide students with BICS (basic interpersonal communication skills) and CALP (cognitive academic language proficiency). BICS for language learners is the acquisition of language via social interaction among primarily peers. CALP, on the other hand, is the acquisition of academic language in a specific academic domain. Unless students understand academic language, learners' chances for classroom success decrease. This coincides with the need for schematic development, the tapping of prior knowledge through scaffolding promoted by cognitive theorists, as well as contextual learning. "Students are in constant contact with peers and with other adults during the course of instruction. Rather than overlook this fact, various researchers have systematically investigated how these classroom interactions can be perceived or orchestrated to contribute to greater learning [...]" (Alexander & Murphy 1998, p. 41).

So, cognitive theorists as well as second language researchers have promoted the contextual nature of knowledge and comparison of the human to computer that processes information (influenced by Chomsky's book: *Aspects of the Theory of Syntax).* Chomsky's radical split from

structural linguists (behaviorists) went counter not only to behaviorist theory and learning but influenced educational research, specifically, second language research.

What is being questioned in second language research today (as well as in cognitive psychology) concerns "knowledge about how, when, and why to use particular strategies[...]" (Lambert & McCombs, 1998, p. 10). It appears that psychology has influenced education but that education has also influenced psychology as seen by the parallels between first- and second-language acquisition research and cognitive psychology.

The cognitive approach is different from other approaches used in education as it is not based on behaviorism but is constructivist in nature. What role does reconstructive memory play in cognition? What are the implications of cognition in terms of increased long-term memory retention?

Memory and its Role in Cognition

One cannot talk about cognition without first talking about memory. The study of memory began with Hermann Ebbinghaus in the late 1900s. He reduced memory to the most elementary units, and like others who came after him, did not see memory in its fullest terms. In the 1950s, the Modal model of memory was based on the idea of the brain as the computer processor of information. "The Modal model makes an important distinction between memory structures, such as short-term memory, and memory processes such as encoding and retrievaL" (Bruning, Schraw & Ronning, 1999, p. 19).

In the Modal model, stimuli is perceived by sensory memory and then stored in short-term memory (as meaning is encoded) and then stored in long-term memory for retrieval at a later date in short-term memory or what would later be called "working memory."

Incoming stimuli _short-term memory (working memory) _ long term memory

Thus, short-term memory was replaced by the concept of working memory. Working memory, on the other hand, consists of more complicated subprocesses or holding tanks whereby memory of selective items would be retained. Incoming stimuli would be processed by sensory memory and sorted and organized according to how it is perceived (the type of pattern that is recognized based on prior or pre-existing patterns via *pattern recognition).* Then once, the pattern is recognized it is looped back to short-term (working memory) for a while until *assigned meaning* and then it is selectively stored in long-term memory or it is cast away.

The information will be more easily retained if a pattern is recognized based on prior knowledge and prior patterns of contextual situations. Additionally, research has shown that not only the activation of prior knowledge and context is essential in processing and actually storing information but that the amount of the information received in a variety of sensory formats—e.g., auditory, visual, kinesthetic—can greatly increase the amount of information that can be perceived and processed. "The short duration of memory in the sensory registers should remind us of the need for teachers to limit the amount of information they present to students" (Bruning, Schraw, Ronning, 1999, p.23).

Research studies show that 7 +/- 2 pieces of information can be held visually for less than one-half second, but that 7 +/- 2 pieces of information can be held auditorily for four seconds (Miller, 1956 as cited in Pressly &Wharton-McDonald, 1997). Providing curriculum in a variety of formats increases the learner's ability to retain information.

Thus, chunking information in various ways and in a variety of formats (e.g., auditory, visual), tapping prior knowledge, and providing scaffolding with which to increase student schemata can influence a learner's increased memory retention. Another way of increasing memory retention is to automatize certain processes. For example, by automatizing or knowing automatically how to structure a five-paragraph essay (procedural knowledge) increases memory capacity so that the writer can devote more time to developing the content of the essay from long-term memory.

Thus four useful strategies I would use for instruction would be to (1) tap prior knowledge by focusing on episodic or childhood experiences, use advanced graphic organizers (e.g., K-W-L, Venn diagrams, story mapping) to brainstorm so that information can be processed in meaningful chunks and assimilated into existing memory structures; (2) provide students with visual, auditory, and kinesthetic stimuli to increase memory capacity (e.g., overhead projector, movie clips, writing prompts); (3) show students how to use mnemonic (e.g., rhymes, sayings) or key-word methods to learn lists of information or vocabulary which also frees up memory for storing and retrieving other information; and, (4) provide opportunities for over-learning and massed practice which will not only automatize declarative knowledge but "is [also] more likely to affect positive motivation for performing a task (Bruning, Schraw, Ronning 1999, p. 124, citing Ericsson 1996).

A Reading Program Based on Cognitive Principles

The main components of a reading program that is based on cognitive principles should include not traditional phonics methods based

on decoding and isolated vocabulary development but a combination of decoding, vocabulary/concept development within the context of the word, sentence, paragraph, and text comprehension.

Along with the cognitive tradition, learning to read is seen holistically in emerging literacy with pre-readers. These pre-readers are exposed to print in various forms on billboards, on television (e.g. brand name recognition), grocery stores, and have seen reading modeled by their parents or someone around them. The learner knows that these words have particular meanings and are cues that convey meaning before they even go to school. This emerging literacy is seen when pre-readers contextually identify words such as "Coca-Cola" via visual cues.

Concept sorts are beneficial for pre-kinder and kindergarten students to help build pre-phonemic awareness. After children have built pre-phonemic awareness via concept sorts and are aware visual cues have meaning, then learners usually begin associating letters with sounds and may write bed as bd. From that point they begin decoding through, hopefully, skilled assistance and facilitation by teachers.

Pre-reading engagement can be fostered at home as well. Parents can set up a visually appealing pre-reading environment by providing children with plenty of illustrated books and read books to their children. English learners need to be exposed to books as well whether they are provided in English, Spanish or some other language as the goal and the outcomes will be the same—increased interest in reading. Whether these books are provided in English or another language is not important. This is especially important since parents have a 52% impact on their children, while teachers influence children 32% of the time (as mentioned above). Teachers can also work with parents providing students with take-home packets containing pre-phonemic concept word sorts which help readers categorize and organize visual information according to sound, type, color, etc. In addition, numerous opportunities should be provided for pretend read and exposure to print so that the child is ready to learn alphabetic sounds and can start decoding.

Decoding is important in the initial stages of reading literacy as it helps increase automaticity of this type of declarative knowledge (systematized factual knowledge). Initially massed decoding practice in various formats (short/long vowel sound sorts, word concept sorts, word sorts in the context of reading via a matrix) should accelerate decoding.

Studies have shown that by increasing the automaticity with which a learner reads increases the speed (Bruning, Schraw, & Ronning, 1999). This automaticity offers the student time to focus on the meaning

whereas the poor reader who lacks this automaticity has limited capacity to capture the meanings of words and usually ends up not comprehending. The majority of the time is spent on just decoding. "Breznitz & Share (1992) and Swanson (1992) have argued that slower-than-normal speeds of word decoding may place higher-than-normal demands on working memory and interfere with meaningful reading" (Bruning, Schraw, & Ronning, 1999, p. 246).

More important than understanding that instructional methods are key in promoting early literacy is assessment. Roland Good III, Deborah Simmons, and Sylvia Smith (1998) would argue that, in addition, early assessment and academic intervention strategies must be consistent and uniform (e.g., using DIBELS—Dynamic Indicators of Early Literacy Skills) to identify deficiencies and correct for them. Thus, a phonics program combined with early assessment as well as a meaningful reading and writing program is essential.

"Reading is a meaning-making activity in which all kinds of knowledge are used. Sentence and passage meaning facilitates decoding whereas decoding is the route to sentence and passage meaning. Thus instructional methods stressing only a single approach to learning to read may handicap children who need multiple keys to unlock the meaning of words, sentences, and stories" (Bruning, Schraw & Ronning, 1999, p. 252).

Students transitioning from the "learning to read" stage to the "reading to learn" stage are often ill equipped with strategies that increase vocabulary acquisition and text comprehension especially in academic domains. Students in California are not introduced to science until the third grade and history until the fourth grade. The predominant focus at this time is on non-expository literature or fiction. Stories, rhymes, poems, and simplified book and semantic mapping diagrams are in place. There is less focus on how to comprehend expository text.

When working with expository text in academic domains, teachers need to make students aware of text signals that provide selective/visual perception clues as to what is important in the text. In addition, students need to realize that titles and subtitles can lead them to predict the information they will study in the text that can be used as a preview strategy. Students need to be provided with opportunities to practice identifying these types of text signals and using the information gleaned to predict textual meaning.

Hopefully, students are already exposed to advanced organizers in the primary grades (e.g., Venn diagrams, semantic maps, word webs,

group experience charts) that help generate ideas by activating prior knowledge from long-term memory.

Another basic reading and memory strategy that can be applied to learning long lists of information, vocabulary or dates is mnemonics. "Columbus sailed the ocean blue in 1492" is an example of a rhyme that helps us remember the date Columbus discovered America. Or, "Every Good Boy Does Fine" can help a student memorize a musical scale.

It is essential that these types of basic reading skills strategies be taught explicitly so that students recognize the reasons why they are applying them within the various academic domains. These are basic reading strategies that help students make meaning, but these modes alone are not the sole answers to increased reading comprehension or helping students reflect about their thinking—metacognition.

A meta-analysis conducted by H. Lee Swanson and Maureen Hoskyn (2000) came up with a number of studies that showed that, in addition to these main components, the type of instruction given by teachers is essential for increasing information retention. After reviewing the literature for the highest effect sizes, they found that the Combined Model of direct instruction and strategy instruction reported higher effect sizes. By receiving these two interventions, children with learning disabilities outperformed their counterparts that did not receive the interventions. This model that has recently been promoted in the mainstream also promotes success for students with learning disabilities.

A couple of teaching methods that apply direct instruction, guided instruction, as well as procedural and strategy instruction include (1) Question/Answer/Relationship (QAR), and (2) Reciprocal Teaching which help students activate prior knowledge and activate their schemata before, during, and after reading.

Question/Answer/Relationship was developed by Raphael in 1984 to help students tap prior knowledge by understanding how to use specific types of questioning strategies to glean information. The goal is to provide students with shorter pieces whereby the QAR method is applied and then increasingly longer more complicated texts can replace the initial focus on shorter pieces. Thus, teachers would move from shorter to longer pieces so that learners become accustomed to the QAR method and become more prepared for more complicated selections from texts.

After reading a particular selection, the student will ask the teacher a question. After the teacher (or another student) replies, the student states the type of question he/she asked and defines the type of

question he/she posed. The three types of questions he/she could have posed include the (1) "right there" question (a question in which one could provide an answer directly or is explicitly gleaned from the text), (2) a "think and search" question (a question whereby information must be pieced together or inferred from various sections of the text), (3) an "on my own" (a question which can only be answered by using one's personal background), and (4) the "writer and me" question (a question that can only be answered via personal background knowledge and text knowledge).

The QAR method is a great way to have students metacognitively recognize the types of questions they are asking while at the same time increasing textual comprehension. Reciprocal teaching is similar in that it also promotes metacognition using four types of strategies (1) generating questions, (2) summarizing, (3) clarifying, and (4) predicting.

Research has shown that question generation leads to increased comprehension as does summarizing and predicting (Bruning, Schraw, & Ronning, 1999). In addition, it can be applied to various classroom formats. In a cooperative group format, poor readers should work with successful readers who can act as peer mentors. Students read, formulate questions, summarize, and predict what will happen next. Then the teacher and/or leader of particular groups ask questions they have posed. Then the student leader or teacher summarizes all the while others can add information. The process is not complete until students ask questions that clarify inconsistencies or anything they may have had trouble with ranging from the difficulty of the reading to a particular concept.

Following questioning, summarization, and clarification, students then predict what will happen next in the text. Then students read another two paragraphs and start the process all over again. This type of engaging process promotes self-questioning, reflection, and inclusive social interaction with peers to make meaning of text.

The link between reading and writing cannot be de-emphasized. One way to tap prior knowledge is to have students write oral histories and autobiographies. Oral histories offer learners opportunities to activate prior knowledge and their own general knowledge about themselves and their family, provides opportunities for writing practice, and opportunities to share their autobiographies and stories with classroom peers. These are the types of activities that help link an activity that integrates the two domains of reading and writing. Thus, to achieve critical literacy one must use all facets of language development ranging from reading, speaking (interactive and social communication), listening, and writing.

A Writing Program Based on Cognitive Principles

A writing program based on the cognitive model of writing developed by Linda Flower and John Hayes (1996) emphasizes writing as a problem-solving process not just a step-by-step retelling often shown by poor readers. The models three components include (1) the task environment involving the writing assignment and external storage of any resources or information related to or accessed by the student, (2) working memory where planning (goal-setting, organizing and idea generation are consistently being revised throughout the planning process), translation of ideas onto paper, and reviewing in terms of reading and editing, and (3) activation of prior knowledge of the topic, audience, and prior writing schemas from long-term memory (Flower & Hayes, 1984; 1996 as cited by Bruning et al., 1999).

Translating Flower and Hayes model into practice is not so evident. Eventually, the expectation is that good writers already implicitly understand this model and already apply these strategies to writing. Poor writers/novices (not linked necessarily with academic deficiency but lack of writing practice and writing strategies) generally are not aware of this interactive writing model. So, it is essential that teachers not only understand this model but also relate this model to students in a way that is accessible.

A writing program based on community learning would serve this purpose for promoting interaction and dialogue between the teacher as well as peers. The main components of such a writing program as such would include (1) writing topics that tap prior knowledge or student world knowledge (autobiographies, family histories, etc.), (2) opportunities for explicit teacher instruction concerning the procedural aspect of writing based on the Flower and Hayes model (with the hopes that this type of writing structure can become automatic and useful for all writing genres as well as allow more time to focus on the meaning of the writing assignment).

Two specific strategies that can promote this procedural model include (1) teacher modeled peer-editing and (2) one-on-one student teacher conferencing, interaction, and dialogue. Peer-editing provides opportunities for the teacher to explicitly model writing assignments via Hayes and Flowers' model (how to plan and revise while creating a cooperative learning environment), offers increased feedback concerning writing assignments by peers, and the interaction itself is engaging and motivating. Thus, differentiating the curriculum is not an issue with this

writing model as students develop writing at their own pace in a non-competitive but positive, sharing environment.

Kristi Kraemer, a teacher and presenter at an Advancement via Individual Determination (AVID) conference (San Jose State University, 1998) introduced a peer-editing method that consisted of four components: (1) *writing*, (2) *response*, (3) *(highlight) revision* (add, delete, substitute, rearrange), and (4) *editing*. In Step 1, the students are given about 15 minutes to *write* the topic. Students respond to the writing in Step 2 by highlighting (*responding to*) the sentences they perceive to be good (students taught not to highlight everything first!). In Step 3, students move into groups of three to *revise* their work based on the portions that were highlighted, possibly moving the introductory paragraph that was not highlighted to the body as a detail, deleting a redundant phrase, or adding more information they weren't able to provide in the first 15 minutes. They may ask other members for help. By Step 4, students are ready to have their work edited by peers. Students either verbally read each other's work and the student makes changes, or the students write corrections, changes, additions in the margins with the student's permission. Students return to Step 1, rewrite their first draft based on their own writing style and the information given by others. If papers look unfinished and/or poorly edited, they go back to the student again.

During the initial stages, a teacher should model the editing process and be accessible to students. By becoming part of the process, the teacher will see the possible need for mini-lessons including (1) how to ask questions, (2) different types of forms—leads, body, conclusions, etc., (3) and how to use editing marks. Although there is increased social dialogue, interaction and mentoring among peers, it is the teacher's responsibility to conduct one-on-one conferencing as well to facilitate writing growth in addition to strategy practice.

Another strategy that provides opportunities for synthesis is called "sentence combining." Students learn how to recognize redundancies in sentences and how to summarize information. Take the following example:

The boy walked.
The boy went inside the yellow house.
The boy went inside the yellow house and sat down in the living room.

Students could work in groups of three to combine these sentences. Student teams of three and four can compete with one another to come up with the most brief and concise information without losing the meaning of all three sentences. (According to Robert Slavin, 1994, competition between groups does not interfere with motivation as does individual

competition).

Another similar strategy is sentence expansion. Instead of synthesizing information, now you take sentences and elaborate providing increased detail. This helps students with adjectival use, conjunctions and other parts of speech within the learner's context. This strategy can also be used with teams of students in whole-group scenarios. (More detail and practice can be found in Robert Strong's book, *Sentence Combining and Paragraph Building*, 1981.)

A Math Program Based on Cognitive Principles

Math programs in the past have been based on traditional methods of computation versus procedural knowledge necessary to problem-solve. In addition, the methods used have generally included few manipulatives (except in the lower grades) and realia—to make authentic or real-world connections. "Experts in the field also associate poor math achievement with poor instructional techniques and confusing or poorly written textbooks" (Carnine, 1991; Russell & Ginsburg, 1984 as cited by Fleischner & Manheimer, 1997, p. 399).

Within the last four to five years, however, there has been a change in the type of the math curriculum being introduced by school districts. Impact math and other math programs feature problem-solving analysis. The goal is the acquisition of conceptual as well as procedural knowledge. Yet, there may be some teachers who are as unfamiliar with the new concepts of math as the students who are being asked to apply these methods in the seventh to twelfth grades—students who may have been initially exposed to more traditional answer-finding methods.

Traditional methods include finding the solution, not caring about the processes and how one arrived at the solution so as to self correct or analyze and repetition of the same types of problems without allowing for flexibility in problem-solving which can hamper further math comprehension at the higher grade levels (algebra being the cut-off point as to whether you progress in math or not). "Near automatic performance obscures their [students'] basic problem-solving nature" (Bruning, Schraw, & Ronning, 1999, p. 327).

The main components of a math program based on cognitive principles would (1) provide ongoing staff development and training for math teachers to garner conceptual and problem-solving math strategies, (2) teach students how to apply conceptual as well as problem-solving strategies flexibly versus having students come up with wrong or right answers, and (3) facilitate student growth via comprehension-based approaches that provide a schema so that students authentically place the

information with prior knowledge in long-term memory.

One strategy is the "bugs" or *error analysis* approach (Fleischner & Manheimer, 1997). By detecting errors in the way students proceed to solve problems, we can become aware of conceptual issues. Bruning, Schraw, & Ronning (1999) show how when some children subtract they use they can misuse proper algorithm (p. 327).

(1)	(2)	(3)	(4)
8	23	47	52
-3	-16	-35	-17
5	13	12	45

Problems (1) and (3) are correct but (2) and (4) are not. By following the procedure "take the smaller number from the larger in each column," which the child has done with individual numbers, has confused the child. Isn't she taking the smaller number 3 from 6 in problem 2? By discovering these conceptual errors, teachers can better inform and come up with conceptual ways that are not confusing.

The problems with textbooks is that students can be taught keyword problem-solving methods that have inherent inconsistencies which can end up confusing kids on similar types of word problems that may be worded differently but have the same meaning. Thus conceptual strategies taught must be more flexible for various word-problem scenarios. Providing a schemata for representing word problem sets may be the answer such as one provided by Kinstsch and Greeno, 1985 (as cited by Bruning, Schraw, and Ronning, 1999, p. 334) to solve word problems.

Thus, the learner would have to be taught and understand the linguistic concepts in order to apply this type of procedural knowledge. Kintsch and Greeno continue to say by providing a mental representation or schema via these set-building strategies, the information is more easily stored into long-term memory. In addition, there is the idea that by using the visual sensory memory the memory capacity is stretched.

A third mathematical strategy is to provide students with graphic organizers. Graphic organizers such as pocket charts can be used for counting hundreds, tens and ones in whole number computations (Fleishner & Manheimer, 1997).

	7		0		3
	hundreds		tens		ones

(Students can also use charts to self-regulate and self-monitor their improvement and progress—a method that can be authentically applied to other academic domains.) The use of visuals such as charts and schema will help free up the brain to work on the actual math procedures as is noted in studies previously mentioned concerning the use of visual and auditory sensory methods. By automatizing procedural knowledge, more memory is freed up to work on problem-solving. The strategies mentioned combined with teacher modeling, think-alouds, and mnemonics instruction

Slot	Value
Object	(noun)
Quantity	(number), SOME, HOW MANY
Specification	(owner), (location), (time)
Role	start, transfer, result; superset, subset; largest, smallest, difference

Jill has three marbles. Jack has five marbles. How many marbles do they have altogether.

Slot	Value
Object	(noun) = ***marbles***
Quantity	(number), SOME, HOW MANY = ***3 (Jill) 5 (Jack)***
Specification	***(owner= Jill, owner= Jack),*** ~~(location), (time)~~
Role	~~start, transfer, result;~~ superset **(two sets: a set of 3 for Jill and a set of 5 for Jack**, ~~subset; largest, smallest, difference~~

will help students retrieve information for later use. In addition, conceptually thinking helps students think in more elaborate and flexible ways as they progress to higher levels of math. Applying cognitive principles can make the difference between a student's advancement into upper levels of math (past algebra) and may have an effect of whether the learner becomes a have or have-not in society.

Achievement Motivation

Up until this point, this instructional manual has indirectly provided information on how to intrinsically motivate learners to learn. Providing students with opportunities for problem solving, critical thinking, and learning strategies makes students feel successful. Success breeds successful feelings. It all boils down to principles based on (1) effective teaching methods (goal-oriented, mastery-based and academically focused), (2) teaching activities that promote social interaction, and (3) curricular materials that are within the learner's zone of proximal development and related to their world/prior knowledge.

Effective teaching methods also help students promote self-monitoring by setting goals. "Numerous studies have found that students who adopt task-focused or mastery goals are more likely to engage in deep cognitive processing (e.g., thinking about how new knowledge relates to previous knowledge). In contrast, students who adopt ability-focused or performance goals tend to use surface-level strategies, such as memorization of the facts" (Blumenfeld, 1992 as cited by Gettinger and Stoiber, 1999, p. 949).

Effective teaching methods based on goals gives learners the freedom to take control of their learning (choose what they want to learn) whether the goals are overarching or specific to academic assignments. It is important to note, however, goal-setting strategies need to be explicitly taught and modeled using think-alouds for whole instruction as well as teacher-student goal-setting conferences for individualized teaching in order to increase automaticity.

Learners become metacognitive (think about thinking) when they set goals for themselves, but even before beginning this process, they need to have a sense of success. Students who are not successful have a tendency to give up. Providing learners with a curriculum that is within their zone of proximal development is essential. "Errors are detrimental to motivation when they are thought to represent failure. When errors are perceived as attempts to derive meaning or to solve challenging problems, they signal cognitive and motivational efforts that are desirable for meaningful learning. In fact, Schunk (1994) states that "errors are a natural and inevitable consequence of being highly motivated and

ambitious in learning" (as cited by Gettinger and Stoiber, 1999, p. 948).

In addition to helping students set goals and develop confidence, teachers need to provide students with opportunities for social interaction so they can make meaning with others and text. Cognitive strategies (reading as problem-solving, reciprocal teaching, DRTA, etc.) that do not focus on errors but on meaning making should be promoted.

Reading as a problem-solving strategy is a way students can work in small groups and resolve issues concerning a particular topic that is meaningful. Students discuss among themselves about what worked, what they did not understand, and ask why. Teacher direction in terms of how students are to interact socially in this group context is important. Thus, direct instruction and teacher modeling should be provided before students begin to conduct these discussions on their own.

Cooperative grouping helps students gain immediate feedback. Using literature circles to analyze literature, reciprocal teaching (as well as QAR, DRTA, and SQ3R strategies) to analyze expository text and self-reflect help increase cognition and are motivating by their inherent interactive nature.

Research conducted by Palinscar & Brown (1984) and Palincscar et al. (1993) found that reciprocal teaching improved children's independent work with new materials, and at a three-month follow-up, the reciprocal-teaching group showed an average gain of 15 months in reading comprehension [at] grade level" (Gettinger & Stoiber, 1999, p. 953). Massed practice will help students internalize and automatize these procedural strategies, leaving room for the brain to process more information in working and long-term memory.

The overlap of cognitive principles and inherently motivational strategies used to increase memory retention can be seen in reading, writing, and math. These are just of the few principles and corresponding strategies that can be used to increase academic motivation as well as increased cognition—strategies that are based on meaning making that can be applied to a variety of academic domains to promote effective teaching and learning.

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