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Combining Concept Mapping and Adaptive Advice to Teach Reading Comprehension

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Abstract: When driven by simple models of information processing, reading instruction focuses on basic decoding skills centering on words and sentences. Factoring in advanced cognitive studies adds at least two more dimensions. First, readers must learn a collection of strategies for constructing meaning from text. Second, and most importantly, readers must develop enough situational awareness to diagnose a text and know which strategy to deploy. Teaching intellectual crafts that involve not only base-line performative skills but also a repertoire of problem-solving heuristics, and the metacognitive maturity to orchestrate multi-leveled activities, works well in a master-apprentice model. However, one-on-one instruction is far too labor-intensive to be commonplace in the teaching of reading. This paper describes a computerized learning environment for teaching the conceptual patterns of critical literacy. While the full implementation of the software treats both reading and writing, this paper covers only the reading aspects of R-WISE (Reading and Writing in a Supportive Environment).

1 Reading Strategies and Metacognition

Research into the cognitive aspects of reading has led to something of a theoretical framework to guide instructional development. For example, awareness that good readers have a repertoire of problem-solving behaviors for various types of tasks and texts launched a new pedagogy for strategy acquisition. The literature for practitioners features a number of techniques for teaching young readers to diagnose levels of understanding and to repair mistakes in comprehension. These routines vary from rather elaborate mnemonics for complicated, multi-stepped procedures (as in the well-known S4R or SQ3R protocols) to thinking frames (graphic representations that support the deconstruction of text into units of meaning).

Unfortunately, strategy training has fairly low durability [Garner, 1987]. Part of the reason for this degradation may be, as suggested by Garner, that the teaching of a specific strategy becomes an end in and of itself, divorcing the skill from the multi-dimensional context of mature reading. For example, the concept diagrams advocated by Armstrong and Armbruster [Armstrong & Armbruster, 1991] require that the learner become comfortable with a sophisticated set of conventions for mapping out ideas. Additionally -- at least until the learner becomes proficient at using this new visual nomenclature -- the teacher must compose the empty maps for each piece of reading. The issue is that such essentially self-contained exercises seem to bear little resemblance to the dynamic, fluid process of comprehending a piece of text in the real world. The adept reader not only has a repertoire of strategies at hand but, more importantly, has the metacognitive ability both to anticipate and to detect abstract problem-types and then to deploy, adapt, combine, or abandon strategic cognitive solutions.

2 Software Components and Instructional Approach

The process model of text comprehension underscores the idea that good readers know that “making meaning” from prose is an interactive process while poor (or immature) readers attempt to slavishly “extract meaning” from the text by decoding word-for-word. Characterizations of these two modes of "reading" are almost diametrical. The poor reader (1) does not vary speed or technique based on text type, (2) does not know how to exploit the "signposts" built into conventional text forms, (3) cannot glean meaning for unfamiliar words and concepts from the context, (4) cannot tell when a statement makes no sense within the confines of its presentation, and (5) has difficulty making "text connecting" inferences as well as reasoning about probable outcomes of information presented in the text. The antithesis, as practiced by good writers, is characterized by (1) guided planning and situational diagnostics, (2) rich mental representations of text possibilities for a wide range of scenarios, and (3) a robust "executive control program" for allocating mental resources and for handling the tremendous cognitive load of deep-processing text.

R-WISE addresses these issues of critical literacy and teaches the use of language as a vehicle for critical thinking. We have developed a battery of "procedural facilitators" staged so as to promote progressively more sophisticated forms of reading comprehension. Specifically, R-WISE promotes three qualitatively different types of activities and models each for the student: (1) identifying concepts and units of meaning in a text, (2) formulating interpretations and making inferences, and (3) metacognitive control over performative skills. Admittedly, these are not definitive categories, and it is impossible to isolate totally the activities of one from those of another. Our purpose is to work with a process-based model that is sensitive to distinctions in knowledge about decoding, inferencing, text structures and text conventions, language, reading purpose, higher-order strategies, and self-monitoring. As described in Sections 2.1 through 2.5, five components make up the R-WISE cognitive architecture.

2.1 Setting Goals

The "decoder" views reading as if it were a straightforward exercise in stripping meaning from the page. For the expert, however, having an explicit, stated set of goals fosters a kind of filtering activity that focuses the task from the outset. In R-WISE, at the beginning of each new lesson, the student is asked to go through a preliminary activity that helps to (1) delineate the requirements of the task, (2) identify features of the text such as level of difficulty, structure, and aim of the discourse, (3) identify strengths (such as prior knowledge) and weaknesses (such as limited experience with the type of discourse) the reader brings to the situation. At this point, the student is working from a paper copy of the text and has read through the materials. A questionnaire helps the student to "preview" the elements of the task that will dynamically interact during the session. Though a truly novice user could spend much time in this preliminary activity, a more seasoned user of the software will work through the interface in a matter of minutes.

Metacognitive awareness has increasingly become an acknowledged component of performance in complex, tasks. In brief, metacognition means the ability to learn about learning. Though a bit fuzzy because such meta (or higher-order) forms of mentation are difficult to observe and measure directly, the explanatory power of this body of research has been championed by a number of researchers in the past decade [Weinert and Kluwe, 1987]. Metacognitive awareness is a kind of calibration among external demands, internal resources, and a desired outcome. Just as an athlete, poised before the beginning of an event, takes a moment to reflect and to visualize a goal and the path toward that outcome, so this introductory, goal-setting workspace for R-WISE encourages the student to formulate a loose plan for the cognitive task about to take place.

Just as importantly, this preliminary work sets the parameters for the software that supply the "intelligence" behind the adaptive advice. The tutor now has a "frame" or backplane of conditions against which further actions can be evaluated during the remainder of the session. (If the student changes goals, the frame is also updated.) Each major area has a number of subsets: Author's Purpose has five; Reader's Purpose has four; and Text Type has six. Clearly, the repertoire of rhetorical situations is rich -- 120 combinations (5x4x6) are tracked at this level. This number becomes even larger and the tutoring capability even richer as these preliminary combinations are conjoined with additional datapoints drawn from the student's subsequent activities.

2.2 Microworld

The second way R-WISE encourages the active construction of meaning during reading fits in with the current emphasis on "visual referents" for teaching abstract concepts, but is actually rooted in comprehension treatments devised as much as two decades ago. The interfaces of R-WISE represent visual organizers for specific intellectual processes. As explained by J. H. Clarke, "[f]rom the standpoint of cognitive theory, graphic frames mimic aspects of semantic memory structures or schemata, that learning theorists believe organize the mind" [Clarke, 1991]. For example, in R-WISE, a concept mapper workspace encourages the deconstruction of linear prose into a more symbolic or semantic network by helping the student tokenize higher-order mental manipulations.

Using standard GUI interface conventions, the student clicks on one of five different buttons located across the top of the concept mapper workspace. Four of these will pop out an icon representing one of four aspects of comprehension: (1) identify the main idea, (2) locate a major support statement, (3) identify a supporting detail, and (4) draw an inference from the text. Multiple occurrences of icons are acceptable and all icons are draggable, meaning that students can use placement of the tokens to construct a visual illustration of a verbal statement. The fifth button on the control panel allows the student to link the icons displayed in the workspace. Implicit in the link is the notion of hierarchical order: a detail attached to a detail is on the same level

(Association); a detail attached to a main idea shows subordination (Elaboration); an inference attached to a main idea shows superordination (Generalization).

Given the premise that most of the clients for R-WISE probably have learning preferences that are concrete/visual rather than abstract/language, we provide "objects" for obscure mental actions. Similar to "webbing" or "schematicizing" -- paper-and-pencil techniques used in the traditional classroom -- this technique encourages the student to formulate a "meta-view" in a simplified, visible language that cuts through much of the complexity of paper text. In addition, working with a malleable, graphical overview helps the student to recognize and to take control of the intellectual processes foundational to reading for comprehension.

2.3 Strategic Elaboration of the Thinking Frame

The process of mapping (clustering and linking) is educationally powerful in that it helps the reader to see things from a higher level or as a synoptic overview. However, even deeper processing of the concepts of the text can be encouraged by having the student elaborate on the meaning for each icon. Clicking on an icon brings up what would be considered a "notecard" screen in a classic implementation of hypertext, but in this context the input screen becomes a "cognition enhancer," helping the student to probe beyond the surface. Instructional statements are generated through a kind of triangulation, based on the rhetorical situation (the several frame conditions set up in the goal-setting phase) and the moves made by the student in the microworld of the concept mapper. Monitoring the combination of rhetorical situation and place in the reading process creates a cognitive task map for firing rules that access instructional statements.

This reading tool captures six hundred unique instructional situations. In writing the attendant advice statements, we addressed each combination of the four strategic elements tracked by the system: (1) Reading Activity, (2) Author's Purpose, (3) Text Type, and (4) Reader's Purpose. Three factors -- Reading Activity (e.g. drawing an inference), Author's Purpose (e.g. attempting to persuade), Text Type (e.g. a poem) -- seemed to be of equal concern in deciding what advice to give to the student. However, Reader's Purpose (e.g. reading for enjoyment versus studying) appeared consistently to carry more weight in determining the exact nature of the instructional statement. Though this started for us as an intuition, the observation is supported in the research [Tierney and Cunningham, 1984]. The basic theoretical framework of metacognition in complex task analysis suggests that having a reason for working a task serves to activate appropriate psychological processes and to provide a basis for effective self-monitoring [Flavell, 1987]. Table 1 serves as an illustration of the advice statements delivered through the active pedagogy.

2.4 Just-in-Time Tutoring

While designing R-WISE, we carefully planned how to integrate the technology into a year-long curriculum. However, the software could be implemented as a classroom resource to be used by identified students while the teacher works with the majority of the class on another activity. As currently planned for group use in a computer laboratory, the tutor takes up about 20% of the course. The production skills necessary for reading (e.g., linear and literal decoding, word recognition and vocabulary, sentence structure and paragraph forms, variable speeds and access features of text, and other fundamentals) are not taught on the computer. This is a deliberate decision. To act as an accelerator or a learning environment, the computer has to support the *process* of literacy. Interrupting the process to teach the enabling skills (1) mixes levels, styles, and purposes of instruction, (2) creates breaks in the train of thought from which the student may not recover, and (3) results in a fairly unexciting electronic workbook.

While production skills and metacognitive skills are not interchangeable, they are correlated in that they must occur simultaneously in expert behaviors. As an extension of this, even though the tutor suggests a strategy in the prompt at the elaboration stage, the student may still be at a loss as to what to do. Recognizing that students may need more explanation, we have embedded short, interactive CAI components that promote focused practice in intellectual activities foundational to critical reading. Drawing from Palincsar and Brown's model of mental activities necessary for critical reading [Palincsar & Brown, 1985], the Just-in-Time Tutoring units (JITTs) offer coordinated instruction in four areas:

Plans and Goals	Node	Adaptive Advice
Author's Purpose: Expository Reader's Purpose: Logic Text Type: Text and Graphics	Detail to Detail Association	Which detail comes first and why? For example, if you are reading about a process, are these details linked either in time or in space?
Author's Purpose: Expressive Reader's Purpose: Aesthetic Text Type: Poem	Inference to Detail Generalization	How does this detail contribute to the interpretation you have made? Does the detail form part of a pattern or does it call attention to itself because it is different?
Author's Purpose: Persuasion Reader's Purpose: Information Text Type: Newspaper Article	Key Idea to Main Idea Specification	How does this key cluster "unpack" the main idea? If the topic were divided into parts, does this cluster deal with a central issue? Does the cluster introduce arguments for and against the claim in the main idea?

Table 1: Examples of Instructional Statements for Linking

- *Predicting:* Somewhat akin to probabilistic reasoning, this activity requires that the student draw a conclusion or forecast an outcome based on interpretation of a pattern of cues within the passage. JITTs in this category tutor two specific areas: (1) activating background knowledge (or schema) as cognitive frameworks for generating likely outcomes, and (2) awareness of textual structures (e.g. transitions, sentence patterns, and other devices of coherence) for bridging informational gaps in prose presentations.

- *Clarifying:* Many studies report that readers -- even mature and accomplished adults -- view text as infallible. Failure either to detect or to acknowledge informational inconsistencies increases with less mature and less sophisticated readers. Therefore, JITTs in this category tutor (1) both the ability and the appropriateness of demanding clarity from texts, and (2) how to generate a useful "fix up" strategy once a misunderstanding has been detected. Instruction is clustered around three types of obstacles to comprehension: lexical difficulties, external inconsistencies, and internal inconsistencies [Garner, 1987].

- *Generating Questions:* In traditional instruction in reading comprehension, students are often asked to answer a set of questions about the targeted passage. Advocates of higher-order instruction in critical reading maintain that reversing the process is more effective. In this cluster of JITTs, students are given a role and a purpose emulating real-world situations and are asked to generate specific types of questions that are instrumental in solving a particular problem. JITTs in this category tutor (1) locating salient information based on a specific frame of reference, and (2) understanding the difference among prompts (e.g. questions that require recall and ones that require interpretation or insight).

- *Summarizing:* Summarizing in traditional instruction can degenerate into a kind of proforma note-taking activity. Used as a self-monitoring strategy, however, guided review becomes a means for the student to check recall of important concepts and integration of the parts into a meaningful whole. JITTs in this category tutor (1) macrorules for constructing a summary (e.g. deleting trivia and redundancy; finding superordinate categories, supplying missing main ideas), and (2) techniques for backgrounding and foregrounding information based on specific situational demands.

The student accesses a JITT from the elaboration prompt interface by clicking on the "Help" button. This action indicates that the reader wants instruction on powerful patterns for reasoning and thinking. Each of the seven reading activity nodes (detail, key idea, main idea, inference, and three types of linking) associates with instruction. A student having difficulty finding a main idea, for example, asks for help. A very brief thinking frame -- demonstrating how to use one of the four reasoning skills to find a main idea -- appears. The choice of

Summary, Clarification, Questioning, Prediction is random. If the student cannot work with the suggested operation, she asks for another and the system moves to the next option in the stack of four.

Palincsar and Brown [Palincsar & Brown, 1983] advocate the teaching of a minimal set of enriched thinking activities, as applied to a variety of text situations. Thus, we constructed 28 separate JITTs. Because of the common thread of the four mental manipulations, however, the JITTs work more like four themes (each with seven variations) than as 28 separate entities.

2.5 Notebook Consolidation

All the elaborations the student makes on icons in the elaboration interface are transferred to a notebook where they are available for review. Each map is associated with a span of paragraphs, whose number might vary from a single unit to all the paragraphs in the text. Notes are then displayed hierarchically, in descending order, starting with inference nodes. Any links made to a node are presented immediately after the target node. The type of relationship (Specification, Association, Generalization) is also indicated. The student may go to the notebook and inspect the contents at any time. These notes are more than glosses or annotations. The computer-mediated prompts emulate powerful teaching concepts and initiate a processing that is deeper and more probing than paraphrase or summary [Bretzing and Kulhavy, 1979 and 1981]. These reworked versions of the text are more than a superficial variation on the original's content and connections; they are new knowledge structures combining both the organization and information of the text with enriched reworkings by an active reader.

3 Conclusions

Pairing "concept mapping" with "node elaboration" provides a loop that (1) partners with the student to reduce the mental load and (2) helps the student to enter into a self-prompting episode. This loop takes a very sophisticated, open-ended problem and pares it down to a manageable set of options for the inexperienced reader. In brief, working in tandem with a synoptic overview and with sponsored elaboration creates a rich learning environment that nurtures the following elements crucial to reading comprehension:

- The elaboration segment encourages students to examine and interlink their previous knowledge with the new knowledge presented in the text. For example, the student may be prompted to compare through analogy a point in the content with something previously known and to come up with a superordinate proposition that encompasses and explains both. Such bridging activities discourage a simple rote incorporation of the text into memory.

- The object-oriented nature of the tutor provides a visualization for obscure mental operations. Through mapping and elaborating, the process becomes sufficiently deliberate so that the student can become both an observer and a participant in these higher-order thinking skills.

- Model building and simulations are popular concepts in today's educational software. Yet, as pointed out by Salomon, et al. [Salomon, Globerson, & Guterman, 1989], merely giving the student the capability to construct a visual representation is not as powerful as combining the manipulations of constructing a model with expert-like guidance. As typical of a computer-mediated learning environment, R-WISE's interactive feedback "[provides] superordinate functions of self-appraisal, [gives] knowledge about one's knowledge, and [initiates] self-management of cognitive activity" [Salomon, Globerson, & Guterman, 1989].

- At first glance the highly segmented nature of the adaptive advice may seem to promote short and choppy episodes of text processing. However, the embedded cueing more accurately represents the "contingency management" process of text processing characteristic of the expert. Additionally, these sprint-like activities facilitate modifying or abandoning a strategy, if necessary. And the opportunistic nature of the prompting keeps any single strategy from expanding into a workbook activity, such as the many check lists, acronymic formulas, and visual templates that seem to become ends rather than means in traditional classroom instruction.

4 References

[Armbruster & Anderson, 1982]. Armbruster, B. B., & Anderson, T. H. (1982). Ideamapping: The technique and its use in the classroom, or simulating the "ups" and "downs" of reading comprehension. (Tech. Rep. No. 36). Urbana: University of Illinois, Center for the Study of Reading.

[Bretzing & Kulhavy, 1981]. Bretzing, B. B., & Kulhavy, R. W. (1981). Note-taking and passage style. *Journal of Educational Psychology*, *73*, 242-250.

[Bretzing & Kulhavy, 1979]. Bretzing, B. B., & Kulhavy, R. W. (1979). Note taking and depth of processing. *Contemporary Educational Psychology*, *4*,145-153.

[Clark, 1991]. Clarke, J. H. (1991). Using visual organizers to focus on thinking. *Journal of Reading*, *34* (7), 526-534.

[Flavell, 1987]. Flavell, J. H. (1987). Speculations about the nature and development of metacognition. In F. E. Weinert, & R.H. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 21-29). Hillsdale, NJ: Lawrence Erlbaum Associates.

[Garner, 1987]. Garner, R. (1987). *Metacognition and reading comprehension*. Norwood, NJ: Ablex.

[Palincsar & Brown, 1985]. Palincsar, A. S., & Brown, A. L. (1985). Reciprocal teaching: Activities to promote 'reading with your mind.'" In T. L. Harris, & I. J. Cooper (Eds.), *Reading, thinking and concept development*: *Strategies for the classroom* (pp. 147-160). New York: The College Board.

[Palincsar & Brown, 1983]. Palincsar, A. S., & Brown, A. L. (1983). Reciprocal teaching of comprehension-monitoring activities (Tech. Rep. No 269). Urbana: University of Illinois, Center for the Study of Reading.

[Salomon, Globerson, & Guterman, 1989]. Salomon, G., Globerson, T., & Guterman, E. (1989). The computer as a zone of proximal development: Internalizing reading-related metacognitions from a reading partner. *Journal of Educational Psychology*, *81* (4), 620-627.

[Tierney & Cunningham, 1984]. Tierney, R. J., & Cunningham, J. W. (1984). Research on teaching reading comprehension. In P. D. Pearson (Ed.), *Handbook of reading research* (pp. 609-655). New York: Longman.

[Weinert & Kluwe, 1987]. Weinert, F. E., & Kluwe, R. H. (Eds.). (1987). *Metacognition, motivation, and understanding.* Hillsdale, NJ: Lawrence Erlbaum Associates.

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