

SECONDARY STUDENTS' KNOWLEDGE OF TEXTBOOK METASTRUCTURE

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The concept of textbook metastructure has no direct research precedent in educational literature. There exist, however, several lines of inquiry which led to the present study. Research on metalinguistics has investigated learners' knowledge of the technical, linguistic vocabulary used to talk about language (Downing, 1972; Mattingly, 1972). Adopting this line of thought, metastructure has been defined as the technical, linguistic vocabulary used to talk about textbooks (Mateja & Wood, 1981).

Vernon's findings (1957) that reading problems were strongly associated with cognitive confusion and a lack of system were expanded by Downing (1979) into the Cognitive Clarity-Cognitive Confusion Theory. The major premise of the Cognitive Clarity-

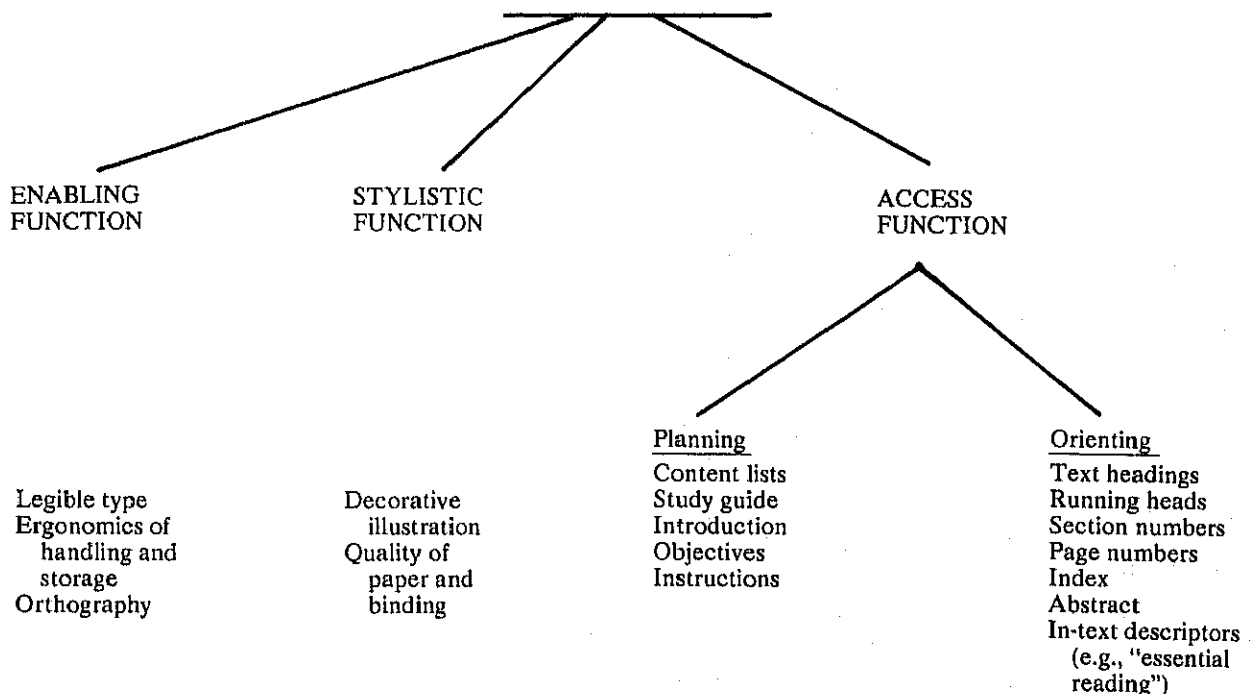
Cognitive Confusion Theory is that learners experience various degrees of cognitive understanding and cognitive bewilderment as they pass through stages of knowledge. In essence, learners are seen as simultaneously manifesting clarity and confusion—clarity with respect to those skills and knowledge which have been mastered, and confusion with respect to those skills and knowledge which need to be learned. In order to understand the nature of reading, therefore learners need to acquire two necessary abilities regarding its: 1) purposes and 2) technical characteristics (Vernon, 1971).

Applied to textbooks, the logical place to investigate learners' abilities would be in their presentation functions. For example, Waller (1977a) identified three types of presentation functions: 1) enabling, 2) stylistic and 3) access. Access structures were further divided into two types—those which helped readers plan their strategies and those which helped readers execute their strategies. (See Figure 1) Waller's structural arrangement contains many of the complex, conceptual units relating to content area textbooks. Macdonald-Ross (1978) reasoned that access structures provided parallel guidance from typography (microtypography, macrotypography) as provided by text meaning units (micropropositions, macropropositions) (Kintsch & van Dijk, 1978; Kintsch & Vipond, 1979). Whalley (1980) posited that readers could avail themselves selectively of both the linguistic and extralinguistic cueing systems in order to learn efficiently from discourse. Such signals may provide information to readers for relevance assignment (van Dijk, 1979), especially if they are made explicit in the text processor system via numbering, boldening or footnoting (Whalley, 1980).

Research on the effects of textbook layout and organization has confirmed much of the intuitive thinking on typographic

Figure 1

Text Presentation Functions



cuing systems. Results suggest that various visual organizational patterns influence learners' comprehension (Hartley & Burnhill, 1977; Wendt, 1979; Holley *et al.*, 1981). Additionally, more complete graphic aids under conditions of forced study improve learners' recall (Dean & Kulhavy, 1981; Schwartz & Kulhavy, 1981). These studies point toward learners' developing feature-location skills for remembering graphic-discourse arrangements because neither reading achievement nor academic success guarantees facility with study skills (Hawkins, 1977; Johnson & Crano, 1978).

The idea of replacing all the letters and numbers on the printed pages with *x*s or *X*s has been suggested by some learning experiments. *X*s have been employed in studies of pattern recognition for concept formation (Garner, 1974; Royer & Garner, 1966, 1970) and of spacing conditions for meaning stimulus span during eye fixations (McConkie & Rayner, 1975). They have also been used in demonstrations of teaching the concept of textbook organization (Binkley & Gerhard, 1980) and of notation systems for graphic variables (Twyman, 1981). Mateja and Wood (1981) have termed such a modification to textbook layouts "content-deleted text" because it maintained the concept of overall surface structure (i.e., visual, spatial and syntactic) while it eliminated the discourse's deep structure (i.e., propositional and semantic). Research with normal text consistently has found that younger and poorer readers have attended to the surface structure to the detriment of meanings (Canney & Winograd, 1979; Garner, 1980), although little difference has been found between groups on their use of syntactic and semantic cues to make corrections until the materials increased in difficulty (D'Angelo, 1981).

Purpose

The purpose of this study was to assess secondary students' knowledge of the technical, linguistic vocabulary used to refer to the access structures of textbooks as well as the relationships between and among particular access structures, graphics and text. Students were assessed with a content-deleted text so that interactions with information in the text would be minimized, but also, so that differences in reading achievement and text readability would be somewhat controlled.

METHOD

Subjects

A total of 156 students, 67 seventh- and 89 twelfth-graders were selected as subjects. Subjects were tested in heterogeneous, intact content area classrooms during normal class periods. The classroom teachers (1 @ 7th, 1 @ 12th) provided a reading ability rating for each student. The study was conducted near the end of the academic year to enable teachers to identify students' reading levels with greater confidence and accuracy, and also to ensure that twelfth-graders would have reached their maximum public school potential before graduation and that seventh-graders would have had almost a year's experience in a departmentalized setting.

Materials

The stimulus materials consisted of a two-page, content-deleted excerpt from a middle-school, science textbook (Heimler & Lockard, 1977). The content was deleted by replacing all letters and numbers with *x*s or *X*s of equal point size and weight. This was done to minimize the interaction between readers and the content in the text, but also, the highlight the textbook's access structures. Graphics were masked enough to reduce content, yet allow for locational identification as place holders.

Assessment instrument

A 20-item, multiple-choice assessment instrument was developed to measure subjects' knowledge of access structures

and the language used to refer to them in the content-deleted text. Specifically, test items measured subjects': a) recognition of particular access structures and b) understanding the relationships between or among access structures, graphics and text. Cronbach's Alpha Indices (test-retest) revealed a reliability coefficient of .78 for the instrument.

Procedure

Subjects were given a 10-minute training session with a normal and a content-deleted personal letter as well as sample questions. Afterwards, subjects were allowed five minutes to study the two-page, content-deleted excerpt. Finally subjects were issued the assessment instrument and were instructed to use the content-deleted text to answer the questions. Subjects were allowed to work at their own rate, and all subjects completed the assessment instrument by the end of the period.

Results

Subjects' protocols were analyzed in terms of gender membership (male, female), age-for-grade in the sample (average and above average, below average), grade level (7th, 12th) and reading ability rating (above average, average, below average).

Table 1

MEANS AND STANDARD DEVIATIONS FOR TWO AGE GROUPS

Age	n	\bar{X}	sd
Below average	48	11.48	3.68
Average or Above average	108	10.55	4.35
(BA + A,AA)	N = 156		

Table 2

MEANS AND STANDARD DEVIATIONS FOR TWO GENDERS

Gender	n	\bar{X}	sd
Male	85	11.22	4.20
Female	71	10.37	4.12
(M + F)	N = 156		

Table 3

MEANS AND STANDARD DEVIATIONS FOR TWO GRADE LEVELS

Grade Level	n	\bar{X}	sd
Seventh (7th)	67	9.42	3.71
Twelfth (12th)	89	11.90	4.19
(7th + 12th)	N = 156		

Table 4

MEANS AND STANDARD DEVIATIONS FOR THREE READING ABILITY LEVELS

Reading Level	n	\bar{X}	sd
Above Average (AA)	74	12.70	3.97
Average (A)	44	10.68	3.55
Below Average (BA)	38	7.37	2.77
(AA + A + BA)		N = 156	

Data were analyzed using a $2 \times 2 \times 2 \times 3$ factorial (age \times gender \times grade level \times reading level) ANOVA with an unbalanced design. Results for the four variables are reported in Tables I-IV.

There were not statistically significant interactions between or among gender, age, grade level and reading level. No statistically significant differences were found for gender [$F(1,133)=.18$; $p < .67$] or age [$F(1,133)=0.01$; $p < .98$]. Statistically significant main effects were found for both grade level [$F(1,133)=24.98$; $p < .0001$], and reading level [$F(2,133)=28.97$; $p < .0001$] with reading level accounting for a greater proportion of the variance. A series of Scheffe *post hoc* multiple comparison tests revealed that the above average readers scored statistically significantly higher than both the average and below average readers. Average readers, meanwhile, scored statistically significantly higher than below average readers. Finally, twelfth-graders' scores on the criterion measure were statistically significantly higher than seventh-graders' scores. Tests of importance (Cohen, 1965) revealed that reading level and grade level accounted for approximately 42% of the variance in scores on the criterion measure.

Discussion

In terms of extending the Cognitive Clarity-Cognitive Confusion Theory to middle and high school students' knowledge of textbook metastructure, the data support the notion that readers continue to experience differential states of clarity and confusion. Above average readers generally appeared to be in a state of cognitive clarity across grade levels. However, below average readers generally appeared to be in a state of cognitive confusion in spite of grade level. Average readers generally appeared to experience varying degrees of clarity and confusion, with twelfth-graders enjoying greater clarity and seventh-graders encountering greater confusion. On the whole, twelfth-graders were characterized by greater clarity and seventh-graders by greater confusion. Both boys and girls and students at different ages within grades generally appeared to experience similar states of clarity of confusion.

Whereas the data lend general support to the Cognitive Clarity-Cognitive Confusion Theory, the phenomena seem to be a more function of achievement than development, at least for knowledge of textbooks' access structures. The results support the importance of facility with print over the chronological development for the ability to use textbook metastructure. From this perspective, it appears that above average readers have gained understanding of the technical concepts needed for talking and thinking about the tasks involved in acquiring the skillful use of textbook metastructure (Vernon, 1971; Fitts & Posner, 1967). These results would appear to support the value of world knowledge and prior experiences (Vernon, 1970) for perceptual-cognitive flexibility and behavior (Thurstone, 1944).

The results also support other research on metacognition, metalinguistics and metacomprehension (Brown, 1978, 1980; D'Angelo, 1981) which finds that better and older readers not only prove more facile when engaging in problemsolving with print, but also that they possess greater awareness of their understanding or misunderstanding as they work through problems. It would appear that above average and older readers are able to spontaneously generate coping strategies which are both complex and varied enough to solve tasks which require simultaneous processing of visual, configural and relational stimuli. In this respect, above average and older readers can be associated with greater flexibility in their search, location and utilization of alternative solutions when presented with print-related problemsolving tasks. Above average readers, in particular, seem to have mastered the two phases of knowledge as identified by Vygotsky (1962) in that they possess both an automatic unconscious acquisition of knowledge and an active conscious control over their learning.

Implications

If knowledge and experience represent the distinguishing factors between clarity and confusion in regard to the technical, linguistic vocabulary used in conjunction with textbooks, then the most obvious educational implication is training, with an especially heavy emphasis on vocabulary (Davis, 1941). Research on instruction in visual spatialization tasks supports the notion of students' amenability to learning (Goodson, 1981; Johnson & Crano, 1978; Kerst & Howard, 1978). Similar results are reported for training students to utilize text structure and organizational patterns (Meyer, 1975; Meyer, Brandt & Bluth, 1980; Meyer & Freedle, 1979).

Using Waller's taxonomy of access structures (1977a,b) for micro- and macro-typography, teachers can help students to become aware of and utilize such cueing systems. Direct teacher intervention might take the form of a six-step, full-processing model in which the teacher 1) models his/her behaviors on a sample textbook, 2) provides an initial teacher-and-students practice session with more modeling, 3) provides a second teacher-and-students practice session for students to share their strategies with each other, 4) provides a third practice session for students to use their own and others' strategies, 5) provides students with a practice session in which they work alone and then check their work and 6) plans for systematic followup on a regular basis. On all occasions the teacher needs to supply knowledge of results to students as well as employ a variety of materials for a variety of purposes.

Whatever learning strategy is employed in teaching textbook metastructure, it appears that students' self-awareness, self-knowledge and self-monitoring can be raised by emphasizing problemsolving, troubleshooting and bookhandling skills. To be effective, every strategy might benefit from including: 1) each student's basic learning techniques, 2) the rules regulating textbook layout, 3) the many, different uses and purposes of textbooks, 4) direct experiences with a variety of textbooks under kaleidoscopic conditions and 5) the importance of bringing to bear world knowledge and prior experience in learning from textbooks.

REFERENCES

- Binkley, M. & Gerhard, C. Relationships found in reading and teachable through the arts. Paper presented at the Twenty-fourth Annual College Reading Association Conference, Baltimore, Maryland, 1980.
- Brown, A. L. Knowing when, where, and how to remember: A problem of metacognition. In R. Glaser (Ed.), *Advances in instructional psychology*. Hillsdale, N.J., Lawrence Erlbaum Associates, 1978.
- Brown, A. L. Metacognitive development and reading. In R. J. Spiro, B. C. Bruce, and W. F. Brewer (Eds.), *Theoretical issues in reading comprehension*. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1980.

- Canney, G., & Winograd, P. *Schemata for reading and reading comprehension performance*. (Tech. Rep. No. 120). Urbana, Ill: Center for the Study of Reading, University of Illinois at Urbana-Champaign, 1979.
- Cohen, J. Some statistical issues in psychological research. In B. B. Wolman (Ed.), *Handbook of clinical psychology*. New York: McGraw-Hill Book Co., 1965.
- D'Angelo, K. Correction behavior of good and poor readers. *Reading World*, 1981, 21, 123-129.
- Davis, F. B. *Fundamental factors of comprehension in reading*. Unpublished doctoral dissertation, Harvard University, 1941.
- Dean, R. S., & Kulhavy, R. W. Influence of spatial organization in prose learning. *Journal of Educational Psychology*, 1981, 73, 57-64.
- Downing, J. Children's developing concepts of spoken and written language. *Journal of Reading Behavior*, 1972, 4, 1-19.
- Downing, J. *Reading and reasoning*. New York: Springer-Verlag, 1979.
- Fitts, P. M., & Posner, M. I. *Human performance*. Belmont, Calif.: Brooks/Cole Publishing Co., 1967.
- Garner, R. Monitoring of understanding: An investigation of good and poor readers' awareness of induced miscomprehension of text. *Journal of Reading Behavior*, 1980, 12, 55-64.
- Garner, W. R. *The processing of information and structure*. Potomac, Maryland: Lawrence Erlbaum Associates, 1974.
- Goodson, F. E. The plasticity of the perceptual process. *Bulletin of the Psychonomic Society*, 1981, 19, 26-27.
- Hartley, J., & Burnhill, P. Understanding instructional text: Typography, layout and design. In J. A. Howe (Ed.), *Adult learning: Psychological research and application*. London: J. A. Wiley & Sons, 1977.
- Hawkins, J. A., Jr. How should reading and study skills tests scores correlate? *Journal of Reading*, 1977, 20, 570-572.
- Heimler, C. H., & Lockard, J. D. *Focus on life science*. Columbus, Ohio: Charles E. Merrill Publishing Co., 1977.
- Holley, C. D., Dansereau, D. F., Evaris, S. H., Collings, K. W., Brooks, L., & Larson, D. Utilizing intact and embedded headings as processing aids with nonnarrative text. *Contemporary Educational Psychology*, 1981, 6, 227-236.
- Johnson, C. D., & Crano, W. D. Effects of spatial skills training on reading performance. *Journal of Experimental Education*, 1978, 46, 25-28.
- Kerst, S. M., & Howard, J. H., Jr. Memory psychophysics for visual area and length. *Memory and Cognition*, 1978, 6, 327-335.
- Kintsch, W., & van Dijk, T. A. Toward a model of text comprehension and production. *Psychological Review*, 1978, 85, 363-394.
- Kintsch, W., & Vipond, D. Reading comprehension and readability in educational practice and psychological theory. In L. G. Nilsson (Ed.), *Perspectives on memory research*. Hillsdale, N.J.: Erlbaum & Assoc., 1979.
- Macdonald-Ross, M. Language in texts: The design of curricular materials. In L. S. Shulman (Ed.), *Review of research in education*. Itasca, Illinois: F. E. Peacock Publishers, Inc., 1978.
- Mateja, J. A., & Wood, K. D. Middle and high school students' awareness of textbook metastructure. Paper presented at the Twenty-fifth Annual College Reading Association Conference, Louisville, Kentucky, 1981.
- Mattingly, I. G. Reading, the linguistic process, and linguistic awareness. In J. F. Kavanaugh & I. G. Mattingly (Eds.), *Language by ear and by eye*. Cambridge, Mass: MIT Press, 1972.
- McConkle, G. W., & Rayner, K. The span of the effective stimulus during a fixation in reading. *Perception and Psychophysics*, 1975, 17, 578-586.
- Meyer, B. J. F. Identification of the structure of prose and its implications for the study of reading and memory. *Journal of Reading Behavior*, 1975, 7, 7-47.
- Meyer, B. J. F., Brandt, D. M., & Bluth, G. J. Use of top-level structure in text: Key for reading comprehension of ninth-grade students. *Reading Research Quarterly*, 1980, 16, 72-103.
- Meyer, B. J. F., & Freedle, R. *The effects of different discourse types on recall*. Princeton, N.J.: Educational Testing Service, 1979.
- Royer, F. L., & Garner, W. R. Perceptual organization of nine-element auditory temporal patterns. *Perception and Psychophysics*, 1970, 7, 115-120.
- Royer, F. L., & Garner, W. R. Response uncertainty and perceptual difficulty of auditory temporal patterns. *Perception and Psychophysics*, 1966, 1, 41-47.
- Schwartz, N. H., & Kulhavy, R. W. Map features and the recall of discourse. *Contemporary Educational Psychology*, 1981, 6, 151-158.
- Thurstone, L. L. A factorial study of perception. *Psychometric Monographs*, No. 4, 1944.
- Twyman, M. Typography without words. *Visible Language*, 1981, 15, 5-12.
- van Dijk, T. A. Relevance assignment in discourse comprehension. *Discourse Processes*, 1979, 2, 113-126.
- Vernon, M. D. *Backwardness in reading*. London: Cambridge University Press, 1957.
- Vernon, M. D. *Perception through experience*. New York: Barnes & Noble, Inc., 1970.
- Vernon, M. D. *Reading and its difficulties*. London: Cambridge University Press, 1971.
- Vygotsky, L. S. *Thought and language*. Cambridge, Mass.: MIT Press, 1962.
- Waller, R. H. *Three functions of text presentation*. Milton-Keynes, U.K.: Institute of Educational Technology, The Open University, 1977(a).
- Waller, R. H. *Typographic access structures for educational texts*. Milton-Keynes, U.K.: Institute of Educational Technology, The Open University, 1977(b).
- Waller, R. H. How does typography aid comprehension? Paper presented at the Annual Meeting of the American Educational Research Association, Boston, Mass., 1980.
- Wendt, D. An experimental approach to the improvement of the typographic designs of textbooks. *Visible Language*, 1979, 13, 108-133.
- Whalley, P. A partial index of text complexity involving the lexical analysis of rhetorical connectives. Paper presented at the Sixth International ALLC Symposium, London, England, 1980.