

A Schema Theoretical Approach to Understanding Map Readings

Joan Maier

This two-year study employed a modified grounded theory research methodology. Two questions guided this study: 1.) Could schema theory explain map reading? 2.) Could schemata and processing strategies for map reading be identified and characterized? The subjects voluntarily interpreted a familiar and then an unfamiliar map followed by probing questions that query the subject to think "out loud" in order to clarify their voluntary responses. Individual subjects' protocols were compiled for constant comparative analysis. These procedures resulted in (1) evidence that supports the application of schema theory to explain map reading; and the development of schemata and processing strategies categories.

Keywords: *schema theory, map reading, comprehension, geographic literacy, processing strategies*

Geographic educators believe that geography is the content that provides the knowledge and skills necessary to compete in the world's "global community." In previous decades results of numerous studies indicated that United States elementary, high school, and college students were achieving geographic knowledge at levels below expectation of geographic educators (Barrows, 1981; NAEP, 1979, 1988). The 1994 National Assessment of Education Progress (NAEP) geography assessment provided solid, extensive base-line data of United States students in grades 4, 8, and 12 that indicated the need to continue improving geographic literacy. One direction geographic educators are pursuing to improve geographic literacy is an application or development of learning theories supported by research that could explain how geographic knowledge and skills are learned. They believe that this approach would provide information that could aid the designing of more effective geography curricula, instruction, and assessment to employ with students, which in turn could improve geographic literacy.

Several of the geographic education studies that have been conducted are focused on map reading ability and are traditionally

based on the psychology of the learner as described by Piaget's models of spatial concept development and cognitive development (Cooke, 1979; Downs, Liben & Daggs, 1988; Eliot, 1972; Pufall & Shaw, 1973). However, theorists and researchers in various fields (Chi et al., 1982; Downs & Liben, 1991; Tomlinson-Keasey, 1982; Torney-Purta, 1991) have identified apparent shortcomings of Piaget's cognitive development theory and spatial concept development model. As a consequence, they have begun to utilize more inclusive explanations that focus on cognitive processes (e.g., assimilation, accommodation, and equilibration) of the learner and learning.

Schema theory from cognitive psychology is one of the approaches theorists have used to explain why and how humans go beyond the given in sensory input to bring order and meaning to the processes of perception, comprehension, learning, and remembering (Anderson & Pearson, 1984; Ausubel, 1960; Bartlett, 1932; Shank & Anderson, 1977). Schema theory is based on the following assumptions. It is assumed that learning is a cognitive process of giving personal meaning to public information. Second, it is assumed that every individual constructs a somewhat idiosyncratic meaning for information. Third, the knowledge and conceptions (and misconceptions) the learner brings to the learning task have substantial influence on learning. Prior knowledge, particularly that specific to the domain being studied, is important. Fourth, the process of acquiring meaning from text, oral discourse, or the social world and of remembering information is related to knowledge structures called schema (plural-schemata). Fifth, meaningful learning entails encoding oral or written discourse by relating it to existing knowledge structures (Torney-Purta, 1991).

For at least the past three decades, reading educators applied schema theory to the process of comprehension for reading written discourse. Research in reading education demonstrated that what is critical for comprehending written discourse is activated schemata (Anderson & Pearson, 1984; Anderson & Prichert, 1987; Devine, 1986; Johnston & Pearson, 1982). If schema theory, as applied to reading comprehension, is supported empirically to explain how students comprehend maps, then the interactive relationship between what the map-reader brings to the map reading task and the very nature of the map text itself is very important. The map-reader's

schemata govern the map text that is comprehended, learned, and remembered. The map text delimits the activation and construction of the map-reader's schemata. A schema-theoretic view of map reading would mean that map-readers do not comprehend graphic and linguistic information from maps a bit at a time until each bit finally comes together as understanding. Instead, they make sense of whatever they know about a map from the very beginning. Thus, without substantial prior knowledge to build on, the comprehension of and learning from maps is likely to be superficial, fragmentary, difficult to apply, and quickly forgotten.

According to Abler, Marcus, and Olson (1992), "maps have traditionally been connected to the core of geography in three ways: they are products of geographic inquiry, they are analytic tools, and they are themselves objects of study as a means of conveying information" (p. 3). Many geographers view maps as complex texts that convey information by using both linguistic and graphic symbols to represent particular spatial environments of Earth (Downs & Liben, 1991a; Natoli & Bond, 1985). Some geographic educators describe map reading as a cognitive constructive process that involves both spatial and linguistic knowledge (Castner, 1990; Downs, Liben & Daggs, 1988; Hardwick, McIntyre & Pick, 1976; Lynch, 1960; Mandler & Johnson, 1976; Okabayashi, 1983; Patton, 1997; Shimron, 1975; Thorndyke & Stasz, 1979). When maps and map reading are viewed from these perspectives, then the comprehension process as defined by schema theorists in reading education would be related to map reading.

While a review of the literature indicated the significant role of schema theory for explaining comprehension of written text, the research that related schema theory to the comprehension of map text is sparse. A schema-theoretic view of map reading would mean that map reading curriculum, instructional strategies, and the assessment of map reading would be based on a "learning theory model." This learning theory model would emphasize teaching map reading for understanding instead of simply "map skills." Teaching map reading for understanding could mean that more information on maps would be comprehended, learned and remembered. This research applied a schema-theoretic view to an understanding of map reading, which provided data for further studies and useful information for

educators seeking to improve the geographic literacy of their students.

RESEARCH DESIGN

The purposes of this study were (1) to discover if schema theory, as applied in reading education could explain map reading, (2) to discover if map-readers' schemata (prior knowledge structures) and processing strategies can be identified and characterized.

The following operational definitions, which were derived from an analysis of the literature, applied throughout the study.

- A. Map – A text that uses both complex linguistic and graphic symbols to represent particular spatial environments of Earth.
- B. Map reading – An interactive cognitive process between the map-reader and map text that involves interpretation by the map-reader of the linguistic and graphic symbols on a map.
- C. Schema (schemata-plural) – An abstract prior knowledge structure that summarizes information and represents the relationships among components for procedural, semantic, and episodic knowledge.
- D. Comprehension process – The interaction of prior knowledge with new information for the purpose of making sense.

A qualitative research design that employed modified grounded theory techniques, as described by Glaser and Strauss (1967), was chosen. This approach was chosen because the independent variables that could affect map comprehension had not been identified or characterized through previous research. It was assumed that the basic assumptions of schema theory could be applied to all categories of memory systems. It was assumed that although the form of written discourse and maps are different, both written discourse and maps function to communicate particular information and thus are comparable for investigating the cognitive process of comprehension.

A pilot study was conducted in Spring of 1992. In Spring of 1993, data for this study were collected. The sites for collection were rural, urban, and suburban schools in Illinois that provided subjects who were socio-economically diverse. Across all three sites, 104 seventh grade students were selected and administered the Geography Map Reading Test (Maier, 1993). Based on the test results and specified criteria a pool of 48 possible subjects from all three sites were identified. During teacher interviews the pool of 48 possible subjects was narrowed to the 24 subjects, 8 from each site. The 8 subjects identified from each site represented 4 males and 4 females. Average age of all subjects was 12 years and 6 months.

The 24 subjects participated individually in a map tasks session in which they were asked to interpret two previously selected physical-political maps (e.g., thematic maps depicting basic natural features and political boundaries) from the seventh grade Glencoe textbook, World Geography: A Physical and Cultural Approach (1989). The Glencoe, 1989, textbook was selected because the subjects or teachers in all three sites did not use it for instruction. The subjects' teachers rated six different physical-political maps from the Glencoe, 1989, geography textbook to determine the subjects' familiarity of maps. The two maps, one familiar and one unfamiliar, which received a near total of 95% consensus among all teachers, were used in the map tasks session. The teachers rated the United States maps as the "most familiar" and the map of South Asia as the "least familiar."

The use of familiar and unfamiliar maps represents an adaptation of a research model utilized in reading research to determine the effects of prior knowledge structures on comprehension (Wilson and Anderson, 1986). The two physical-political maps from the Glencoe, 1989, textbook were virtually identical in spatial and linguistic cartographic structure. The only manipulation was subjects' familiarity with the map content. It was assumed that the role of prior knowledge structures as applied to comprehension was operative during map reading if map content familiarity accounted for variance in map comprehension during both voluntary and probed responses of each subject.

The map tasks sessions were approximately 40 minutes in

length, and each subject's responses were video tape and audio tape recorded for later transcription and analysis. The subjects were told that the purpose of the study was to learn how seventh graders read maps. They were provided the following map task directions in verbal and written format:

1. You will be given a map to read.
2. As you read, at anytime, say aloud what you would tell someone this map is mainly about?
3. Discuss anything about the map or how you are reading it.
4. You will not be stopped or assisted once you begin.
5. When you finish reading and talking about the map, I will ask you some questions about the map.

Next, they were given an opportunity to practice responding to "think aloud" questioning techniques on a topic other than geography. The above directions were repeated and then the subject was shown the familiar map.

The map of the United States was presented first to the subjects for their unassisted and uninterrupted response. When ready, the subject began talking about the map. The researcher recorded the length of time for uninterrupted and unassisted reading (voluntary responses) of each map. After the subject finished voluntarily telling the researcher about the United States map, the researcher asked the subject probing "think aloud" type questions related directly to the subject's initial responses. When the subject finished answering the "think aloud" probing questions for the United States map, the map of South Asia was then presented and the previously described procedures were followed.

The researcher employed "think aloud" questioning techniques as a metacognitive approach to access the schemata and procession strategies the subjects used to assimilate or accommodate the meaning of the map. These "think aloud" questions related directly to the subject's voluntary, uninterrupted responses for both maps. The framework for the researcher's "think aloud" questioning with each subject for both maps was:

Extending Understanding

What do you mean by _____?

You said _____, tell me more?

How did you figure _____?

Tell me how you made _____ decision?

Elaborating Understanding

What helped you understand this map?

Would you change anything on this map? Why?

The constant comparative method (Glaser & Strauss, 1967) was used to analyze and reduce the data into codifiable categories and properties. The techniques of constant comparative method that were employed included analytic induction, axial coding, negative cases, memoing, constant comparison, and taxonomic analysis. This researcher conducted the in-field and post-field analysis. Then, 88 randomly selected quotes were highlighted and left embedded in eight randomly selected subject protocols to be analyzed by an independent panel of experts. The panel of experts was instructed to analyze the quotes for prior knowledge structures' categories and processing strategies that were identified and characterized previously by the researcher. A modified Delphi method was used to reach a consensus with consensus being defined as agreement by 2 of the 3 members of the panel. Interrater reliability was recorded as percents that represent 2 out of 3 agreements on all categories and processing strategies.

FINDINGS AND IMPLICATIONS OF THE STUDY

Data from this study supports the interpretation of schema theory applied in this study, in that, the process by which written discourse is comprehended is analogous to the process by which maps are comprehended. In common parlance with written discourse one "reads" a map. The role of prior knowledge structures as applied to comprehension of written discourse was operative during map reading because map content familiarity accounted for differences in map comprehension.

The greater frequency and median of correct information units that all subjects expressed for the familiar map compared to the greater frequency and median of confused information units and no information units that all subjects expressed for the unfamiliar map pro-

vide evidence of the effects of prior knowledge structures on map comprehension (Table 1). Correct information units, confused information units, and no information units were coded and calculated by subjects' idea units expressed while reading the United States and South Asia maps.

The definition of idea units that emerged from the data was a dependent or independent clause with a stated or understood subject that, together with its modifiers, formed a single idea (see, Pritchard, 1990 p. 278). Subjects often did not speak in complete sentences but rather in strings of clauses connected by the conjunction "and". For example, Subject 5 said, "It's the United States and it shows regions, and it shows big cities and capitals, and rivers, lakes, and oceans and there's the Atlantic Ocean, Pacific Ocean and the Great Lakes." This string of clauses was analyzed for the stated or understood subject(s), together with modifiers that formed a single idea unit. The example provided above was coded as having four idea units.

The correct information units category involves subject responses that were accurate idea units about the maps. For example, the verbatim subjects' responses listed below were codified as correct information units:

Subject 1	This is a physical and political map of the United States.
Subject 6	The key show (that) the white color is the highest land.
Subject 24	Capitals is where the government is located.

The confused information units category involves responses that range from completely incorrect information to partially correct information or correct information that lacks a salient focus. These verbatim subjects' responses provide an example of idea units that were codified as confused information units:

Subject 2	...the scale tells you what the map is about.
Subject 8	The Hawaiian Islands at one time was connected to the mainland of the

United States, but an earthquake caused them to drift away out into the Pacific Ocean about 90 miles away from the west coast.

Subject 24

The dots mean it was a capital before.

The no information units category represents when subjects were unable to give any information during follow-up probes. The subjects either gave no reply or stated that they “did not know.”

Differences were found among the correct information units, confused information units, and no information units categories between the United States map and the South Asia map reported by all subjects in Table 1. Even though the minimum correct information units for the United States map was 12 idea units, all subjects reported more correct information units for the United States map than the South Asia map. The difference of the correct information units median of 36 for the United States map and the median of 18 for the South Asia map represented a 2:1 ratio. The subjects expressed more confuse information units for the South Asia map than the United States map. The difference of the confused information units median of 7 for the United States map and 14 for the South Asia map was a ratio of 2:1. The subjects’ expressed 119 total no information units for the South Asia map as compared to a total of 48 for the United States map. The no information units difference between the median of 1 for the United States map and the median of 4 for the South Asia map was a ratio of 3:1.

The frequency with which correct information units, confused information units, and no information units were used differed according to whether the subjects were reading the familiar map (United States) or the unfamiliar map (South Asia). The greater number and median of correct information units subjects expressed for the United States map compared to the greater number and median confused information units and no information units subjects expressed for the South Asia map provide evidence of the effects of prior knowledge on map comprehension. When reading the familiar map, readers were more likely to use their prior knowledge to comprehend more accurately map information. These findings suggest that hav-

ing relevant prior knowledge for a map facilitate the comprehension process. The greater number of confused information units and no information units in the subjects' interpretation of the unfamiliar map also supports the importance of schemata in map comprehension. These findings suggest that having non-relevant or no prior knowledge for a map limits the comprehension process. Predicted by schema theory, comprehension occurs when the map-reader evokes prior knowledge structures that explain the whole map message (Table 1).

The second finding was that similar domain-specific prior knowledge structures and processing strategies used by these subjects while reading two physical-political maps could be identified and characterized. As the subjects talked about the maps and responded to probing "think-aloud" questions, they revealed "what" (knowledge structures) they understood and "how" (processing strategies) they understood the whole map message. Two classifications developed represent the core categories of domain-specific knowledge structures and processing strategies used across all twenty-four subjects at least three times on both maps. Accuracy of the information or effectiveness of the schemata and processing strategies were not a property for identifying these core categories. What schemata and processing strategies did the subjects have and use was the initial focus of interest for developing two of the classifications. The other two classifications developed represent the core categories that characterized the accuracy, quality, and extent of the knowledge structures and processing strategies used across all 24 subjects at least three time on both maps.

Because the classifications were developed from the subjects' map reading, they do not represent all possible knowledge structures and processing strategies to comprehend physical-political maps or different types of maps. Nevertheless, they do represent a list of the schemata and processing strategies, which emerged from these subjects attempting to construct their individual interpretations of the two physical-political maps used in this study. These findings suggest that map reading is a content-specific activity; that is, when the content of map materials changes, different knowledge structures and processing strategies could emerge. Together these classifications provide a starting point for understanding knowledge structures and processing strategies used to comprehend physical-political maps.

Correct Information Voluntary & Probed Responses		Confused Information Voluntary & Probed Responses		No Information Only Probed Responses	
United States Familiar	South Asia Unfamiliar	United States Familiar	South Asia Unfamiliar	United States Familiar	South Asia Unfamiliar
Sum 960	523	250	386	48	119
Range 12-83	9-60	0-29	1-40	0-7	0-15
Median 36	18	7	14	1	4

Table 1. Coding frequencies of idea units expressed for United States and South Asia maps.

As an example of the classifications that emerged from the data, the domain-specific prior knowledge structures used by these subjects along with representative subject quotes is reported in this paper. Domain-specific knowledge structures are identified in this study as the schemata that summarize information and represent the relationships among components of procedural, semantic, and episodic knowledge. In other words, "what" the subjects know to make sense of the information represented on these maps. The interrater agreement on 88 embedded excerpts from subjects' protocols on domain-specific schemata across all three panel of experts members was 82 percent.

DOMAIN-SPECIFIC KNOWLEDGE STRUCTURES FOR TWO PHYSICAL-POLITICAL MAPS

Listed below are the six core domain-specific knowledge structures that emerged from the data along with representative quotes from subjects' protocols.

- (1) Spatial configuration and location knowledge,
 - A. Initial Spatial configuration on Earth
Subject 5 "It's the United States."
 - B. Existence on Earth
 1. Name recognition

- Subject 11 "...I've heard of St. Louis..."
 - 2. Visual recognition
 - Subject 12 "I've seen maps of the U. S. before..."
 - 3. Direct experience
 - Subject 16 "Since I've lived here..."
 - C. Relative location
 - Subject 1 "Well, it's (U.S.) by the Pacific Ocean and the Atlantic and it's between Mexico and Canada."
- (2) Place Knowledge
 - A. Cultural features- type, configuration, purpose
 - Subject 8 "...India has people on it with different languages, different cities, and there's three capitals."
 - B. Physical features- type, configuration, purpose
 - Subject 16 "The Rocky Mountains are right here and they're the biggest in the United States."
- (3) Map Structure Knowledge
 - A. Symbolic representation of place
 - 1. Linguistic
 - Subject 24 "Reading the words Rocky Mountain hit me first and I know the Rockies are in United States..."
 - 2. Graphics
 - Subject 11 "...the most important mountains are bolded out..."
- (4) Map elements- scale, title, legend, directional indicators
 - Subject 4 "...the scale shows..."
 - Subject 9 "...the title...says South Asia"
 - Subject 11 "...the key it shows a dot stands for..."
 - Subject 18 "...this has N right here, means north..."
- (5) Map function
 - Subject 16 "...this map could tell me where different places are located...and I could see

where to mail something..."

- (6) Personal Perspective Knowledge- viewpoint, opinion
Subject 12 "...I think most Americans are
Christian and Jewish...I think Indians are a
different religion..."

THEORETICAL IMPLICATIONS AND RECOMMENDATIONS FOR RESEARCH

The study extended the scope of the application of schema theory, as it is used to explain the comprehension of written discourse, to the comprehension of physical-political maps by twenty-four seventh grade students. Comprehending a map is a matter of activating or constructing knowledge structures that provide an explanation of the whole map message. This view of map reading underscores the importance of the map-reader's prior knowledge and the incomplete nature of any map text.

A schema-theoretic view of map reading suggest that "map skills" (e.g., skills for using symbols, skills for measuring distance, skills for noting directions, skills for using scale) are integrated in the comprehension process of reading a map and are probably only a portion of the prior knowledge activated to comprehend a map. That is, defining map reading as "map skills" alone does not provide a comprehensive explanation of the information, skills, and processes needed to comprehend, learn, and remember information represented on maps. The more inclusive nature of schema theory to explain map reading as comprehension should help provide insights into the issues of geographic illiteracy as future research is conducted on this topic.

Future investigations need to address different populations and types of maps. A great deal remains unexplained regarding the relationship between the knowledge structures and processing strategies map readers use and the comprehension they achieve. Results suggest that four domain-specific knowledge structures are utilized to comprehend these maps, but their significance in terms of importance is not suggested by these data. Preliminary results from this study suggest that differences in comprehension may be related to the differences in the quality and extent of knowledge structures and

processing strategies map-readers activate and employ. However, if future research continues to support this schema-theoretic view of map reading as comprehension, then, curriculum, instruction, and assessment of map reading and possibly the design of maps should be impacted. A more extensive understanding of how students comprehend, learn, and remember geographic information represented on maps could potentially influence geographic literacy.

PEDAGOGICAL IMPLICATIONS AND RECOMMENDATIONS FOR RESEARCH

Teaching map reading for understanding would mean that successful map reading programs should include at least three components: (1) large amounts of time for actual map reading, (2) learning experiences to facilitate the activation and construction of knowledge structures used to comprehend maps, and (3) occasions for students to talk with a teacher(s) and one another about their responses to map reading.

The first benefit of more time for map reading is the opportunity to manage the knowledge, skills, and processing strategies that are important to comprehend, learn, and remember map information. It appears from this study that the more map information one already knows, the more one comprehends; and the more one comprehends, the more one would probably learn new knowledge to enable comprehension of an even greater array of different maps. Thus, the more time spent reading maps may be largely attributable to the knowledge base that grows through map comprehension. How much time should be devoted to map reading to improve map comprehension is a question for future research. But, of the time set aside for map reading instruction, students should have more time to actually read maps than the time allocated for learning about map reading.

Second, to improve map reading, teachers need to focus instruction on the prior knowledge that students use to make sense of maps. In order to accomplish this goal, teachers should develop curriculum and instruction for map reading based on these questions: (1) What prior knowledge and experiences will the students need in order to comprehend this map?, (2) What information on the map, that is not explicitly presented, will the students need in order to

comprehend this map?, (3) What learning experiences will activate or construct the students' prior knowledge to comprehend this map? A couple of instructional strategies from the field of reading education that relate to these questions that teachers could adapt to map reading instruction are Question-Answer Relationships (QAR) Method (see Pearson & Johnson, 1978) and Reciprocal Questioning (ReQuest) Method (see Manzo, 1969).

Finally map reading programs should allow time for students to express to a teacher(s) and other students what they comprehend about information represented on a map. When students engage in meaningful discussions about their comprehension of a map, they should have an opportunity to: use literal to critical and evaluative questions and responses; clarify the basic meaning of the map; and use the opinions of others to help clarify their thinking about a map. Repeated opportunities in which students explain their understandings of a map will internalize effective map comprehension strategies. Internalizing effective map comprehension strategies would affect positively map comprehension, which in turn should affect positively what is learned and remembered. All three of the components described here should improve map comprehension. It is through such map reading programs that students can experience successful learning that will motivate future map reading and geographic understandings of Earth.

REFERENCES

- Abler, R. F., Marcus, M. G., and Olson, J. M. 1992. Contemporary American geography. In eds., R. F. Abler, M. G. Olson, & J. M. Olson, *Geographer's Inner World: Pervasive Themes in Contemporary American Geography*, p. 3. New Brunswick: Rutgers University Press.
- Anderson, R. C., and Pearson, P. D. (1984). A schema-theoretic view of basic processes of reading. In ed., P. D. Pearson, *Handbook of Reading Research*, pp. 268-289. New York: Longman.
- Anderson, R. C., and Prichert, J. W. 1978. Recall of previously unrecallable information following a shift in perspective. *Journal of Verbal Learning and Verbal Behavior*, 17:1-12.

- Ausubel, D. 1960. The use of advance organizers in the learning and retention of meaningful verbal material. *Journal of Educational Psychology*, 51:267-262.
- Bartlett, F. C. 1932 *Remembering*. Cambridge: Cambridge University Press.
- Barrows, T. S. 1981. College students' knowledge and beliefs: A survey of global understanding (the final report of global understanding project). *Educational Testing Service*. New Rochelle: Change Magazine Press.
- Boehm, R. G., and Swanson, J. L. 1989. *World Geography: A Physical and Cultural Approach*, pp. 402, 602-603. Glencoe, Macmillan/McGraw Hill.
- Castner, H. W. 1990. *Seeking new Horizons: A Perceptual Approach to Geographic Education*, p. 5. Kingston: McGill-Queen's University Press.
- Chi, M. T., Glaser, R., and Rees, E. 1982. Expertise in problem solving. In ed., R. J. Sternberg, *Advances in the psychology of human intelligence, Vol. 1*. Hillsdale: Lawrence Erlbaum Associates.
- Cooke, K. G. 1979. The relationship between spatial cognition development levels and the achievement of map skills and concepts. (Doctoral Dissertation, State University of New York at Albany, 1978). *Dissertation Abstracts International*, 39:2023-A.
- Devine, T. G. 1986. *Teaching Reading Comprehension: From Theory to Practice*. Newton: Allyn and Bacon.
- Downs, R. M., Liben, L. S., and Daggs, D. G. 1988. On education and geographies: The role of cognitive developmental theory in geographic education. *Annals of the Association of American Geographers*, 78, no. 4:680-700.
- Downs, R. M., and Liben, L. S.. 1991. The development of expertise in geography: A cognitive-developmental approach to geographic education. *Annals of the Association of American Geographers*, 81, no. 2:304-327.
- Downs, R. M., and D. Stea 1977. *Maps in Minds*. New York: Harper & Row.
- Eliot, J. 1972. Some research possibilities. *Journal of Geography*, 71:366-375.

- Glaser, B. G., and Strauss, A. L. 1967. *The Discovery of Grounded Theory: Strategies for Qualitative Research*. New York: Aldine Press.
- Hardwick, D. A., McIntyre, C. W., and Pick, H. L., Jr. 1976. The Content and manipulation of cognitive maps in children and adults. *Monographs of the Society for Research in Child Development*, 41: 1-55
- Lynch, K. 1960. *The Image of the City*. Cambridge: M.I.T. Press.
- Maier, J. N. 1993. A Qualitative Study of Adolescent Students' Comprehension of Maps: An Application of Schema Theory to Map Reading, (Doctoral Dissertation, Illinois State University, 1994). *Dissertation Abstract International*, A 55/11, p. 3606.
- Mandler, J. M., and Johnson, N. S. 1977. Remembrance of things parsed: Story structure and recall. *Cognitive Psychology*, 9:111-151.
- Mandler, J. M., and Parker, R. E. 1976. Memory for descriptive and spatial information in complex pictures. *Journal of Experimental Psychology: Human Learning and Memory*, 2:
- Manzo, A. V. (1969). The request procedure. *Journal of Reading*, 11:123-126.
- National Assessment of Educational Progress. 1979. *Summaries and Technical Documentation for Performance Changes in Citizenship and Social Studies Assessment, 1969-1976*. Denver: U.S. Department of Education.
- National Assessment of Educational Progress. 1988. *The Geography Learning of High-School Seniors*. Washington, DC: U.S. Dept. of Education, Educational Testing Service.
- National Council for Geographic Education Test Development Committee. 1980. *The National Council for Geographic Education Competency-Based Geography Test, Intermediate Level Parts I, II, and III*. National Council for Geographic Education.
- National Assessment Education Progress Geography Consensus Project. 1994. Washington, DC: Council of Chief State School Officers, National Council for Geographic Education, National Assessment Governing Board U.S. Department of

- Education.
- Natoli, S. J., and Bond, A. R. 1985. Geography in internationalizing the undergraduate curriculum. Association of American Geographers. State College, PA: Commercial Printing.
- Okabayashi, H. 1983. Spatial Memory: Recall of map information. (Doctoral Dissertation, University of Georgia, 1982). *Dissertation Abstracts International*, 44/08, p. 2420-A.
- Patton, D. 1997. The effects of prior-knowledge on the learning of categories of maps. *Professional Geographer*, 49:126-36.
- Pearson, P. D. & Johnson, D. 1978. *Teaching Reading Comprehension*. New York: Holt, Rinehart and Winston.
- Pufall, P. B., and Shaw, R. E. 1973. Analysis of the development of children's spatial reference systems. *Cognitive Psychology*, 5:151-175.
- Schank, R., and Abelson, R. 1977. *Scripts, Plans, Goals, and Understanding*. Hillsdale: Lawrence Erlbaum Associates.
- Shimron, J. 1975. *On Learning Maps*. Technical report, La Jolla: University of California, Center for Human Information Processing.
- Thorndyke, P. W., and Stasz, C. 1979. *Individual Differences in Knowledge Acquisition From Maps*. A report for Office of Naval Research. Santa Monica: Rand Corp.
- Tolman, E. C. 1948. Cognitive maps in rats and men. *Psychological Review*, 55:189-208.
- Tomlinson-Keasey, C. 1982. Structures, functions, and stages: A trio of unresolved issues in formal operations. In S. Modgil, & C. Modgil, *Jean Piaget: Consensus and Controversy*. New York: Holt, Rinehart, & Winston.
- Torney-Purta, J. 1991. Schema theory and cognitive psychology: Implications for social studies, theory and research on social education. *The College and University Faculty Assembly of the National Council for the Social Studies*, 19, no. 2:189-210.
- Wilson, P. T. and Anderson, R. C. 1986. What they don't know will hurt them: The role of prior knowledge in comprehension. In ed., J. Orasanu, *Reading Comprehension: From Research to Practice*, pp. 31-48. Hillsdale: Lawrence Erlbaum Associates.

Joan N. Maier received her Ed.D. in Curriculum and Instruction from Illinois State University. She is currently an Assistant Professor of Curriculum and Instruction at the University of Houston-Clear Lake in Houston, Texas. She teaches curriculum and instructional design, elementary and secondary social studies methods, and global geography. She also is the director of the Space Image Institute for Geography and Earth Science teachers.