Maps, Text, and Seventh-Graders: A Study of Spatial Learning

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The research reported here examines the effectiveness of maps in geography text for seventh grade students by asking them to study either the text alone or the text with maps and then answer questions about the material. We also investigate the influences on students' performance of gender, time of testing (immediate or delayed), and kind of knowledge required (memorization versus inference). Results reveal a consistent advantage associated with the presence of maps but not at levels which are statistically significant. Other findings include a slight advantage of females over males (again, not significant), the fact that inference questions are more difficult to answer than those requiring simple memorization, and (not surprisingly) that students' performance declines over time. We offer possible explanations for our findings, including some related to the research design and the fact that our subjects were seventh-graders.

INTRODUCTION

For more than two decades now, researchers in various disciplines have explored the relationship between text and accompanying illustrations. For cartographers, a better understanding of the interaction between text and maps offers theoretical insights into spatial communication processes, in general, and also may suggest ways of improving the design of maps embedded in text. Although considerable attention has been focused on the topic of maps and text, there are still many aspects of the issue which are not well understood due to differences among previous studies in methodologies, tasks, and subject groups.

The study reported here contributes to the overall fund of knowledge about maps and text by investigating whether a specific subset of map readers, seventh-grade students, are able to use maps to enhance learning from textbook-style geographical descriptions. In the study we examined the effects of four variables: 1) the presence or absence of maps in a geographical text; 2) the kinds of knowledge acquired by the subjects (simple memorization or the ability to make inferences from the learned material); 3) the sex of the subjects; and 4) how well the learned material is retained in memory after a week's time.

Maps are a common feature of social studies textbooks. For example, one survey found 993 maps in 26 social studies textbooks for children in kindergarten through eighth grade, with the majority of the maps provided at the fourth grade and higher (Young 1994a, 16-19). If one looks more specifically at geography and history texts at the secondary school level, the number of maps per textbook is even higher: an average of about 70 in each of the eight texts reviewed by Young (1994b, Figure 7). Given the additional production and printing costs associated with including maps in textbooks, publishers and authors must believe that those maps serve some useful purpose. The advantages attributed to illustrations are numerous, including helping to organize the textual material, decorating or enlivening the pages of text, engaging the reader's attention, enhancing retention of the material, and augmenting verbal

explanations by presenting material in a different (graphic) mode (Duchastel 1978, Gilmartin 1982, Kulhavy et al. 1993, Levie and Lentz 1982, Willows and Houghton 1987). Stock et al. (1995) state unequivocally that, " . . . people who study maps recall more facts than people who study unstructured arrays of landmarks, lists of landmark labels and/or icons, of [sic] fact texts alone . . . [P]eople who reproduce maps accurately recall more facts than people who don't . . ." (238).

On the other hand, some authors have found that maps either have no effect (Davis 1971) or may actually hinder learning from text by focusing readers' attention on map- related information at the expense of non-map-related text (Scevak et al. 1993,402). And Young has argued that maps in children's social studies texts, in general, are undervalued and fail to promote learning (1994b). Thus, although a fair amount of effort has been devoted to understanding the relationship between maps and text, there is still a great deal to be learned about the subject.

REVIEW OF RELATED RESEARCH[1]

Empirical studies aimed at measuring how the presence of maps in texts affects the information gathered by readers span almost thirty years. In one of the earliest such reports, Davis and Hunkins (1968) concluded initially that the presence of a map along with text did help junior high school students learn the geography of India. Davis later recanted that conclusion, however, after re-analyzing the data using the "more powerful" analysis of covariance instead of the univariate statistics originally employed (1971). The revised analysis, which controlled for differences in subjects' IQ and reading achievement scores, showed that students who were given both a map and text to study scored no higher on subsequent tests than students who had read the unillustrated text alone.

In contrast to Davis' conclusions, Gilmartin (1982) found a clear advantage for the use of maps with text in both immediate and delayed test conditions. The author asked college students to study either an unillustrated geography narrative, the same narrative with maps, or the narrative with maps and captions. The students were tested on their knowledge of the geographic material both immediately after having studied it and again a week later; in both cases those who read text with maps achieved significantly higher scores than students whose text contained no maps. In addition, Gilmartin found differences in the performance of men and women. Based on reading text without maps, men scored significantly higher than women; when maps were present, however, scores for women and men were almost identical.

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More recent research with high school students has highlighted the importance of map use instruction in enhancing the effectiveness of maps in text (Scevak, Moore, and Kirby 1993). After having received thorough training in using maps strategically as text organizers, students scored significantly higher on recall tests of textual material than subjects in a control group which received no such training.

In addition to the studies cited above, an extensive series of experiments involving maps and text has been conducted by psychologist Raymond Kulhavy and his associates. (For a cumulative review of this set

1. Numerous studies have been conducted to investigate the effect of non-cartographic illustrations, such as photographs, diagrams, and pictorial drawings, with text. Because maps are unique in symbolizing geographic relationships among phenomena - whereas these other kinds of illustrations are not primarily spatial representations - the relevance of such studies to the present one is limited and, thus, they will not be reviewed here. (However, see reviews of such articles by Samuels (1970), Levie (1987), Levie and Lentz (1982), Willows and Houghton (1987).)

of research, see Kulhavy et al. 1993.) These researchers, whose primary purpose is to investigate cognitive theories of how people encode and recall information, have concluded that a robust facilitative relationship exists between maps and text. Unfortunately, however, although Kulhavy's investigations have contributed significantly to our theoretical understanding of the interaction between maps and text, the practical relevance of the studies for geographers and cartographers is limited by certain characteristics of the experimental designs. First, in most instances, the tasks required of participants in the studies involve no explicitly spatial (geographic) learning. Rather, learning is usually measured either by counting how many events, activities, or adjectives subjects can free-recall from a text or by sentence completions involving recalling names of features, landmarks, objects, and the like. (For example see Kulhavy et al. 1985, Kulhavy et al. 1992, Peterson et al. 1991, and Schwartz and Kulhavy 1981). Even in the infrequent research design in which some spatial information is obtained, it is not the focus of analysis. For example, in a study by Kulhavy et al. (1993), which was published in a cartographic journal, the researchers measured subjects' cognizance of the map's spatial structure but used that measure as an independent variable to analyze recall of facts ("current and historical events" [153]) presented in the text. The authors found that ". . . the better people encode the structural characteristics of the map, the higher the probability of recalling text facts extrinsic to the map" (155) (our emphasis).

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Second, in many of their experiments the authors first provided a map to their subjects to study and then read a narrative to them– sometimes with and sometimes without the map still being present. (For example see Amlund and Kulhavy 1985; Kulhavy et al. 1985, Kulhavy et al. 1992, Peterson et al. 1991). While this procedure is appropriate in the context of the authors' main purpose–to investigate theoretical models of encoding and memory operations–it is not necessarily the best procedure to evaluate the pedagogical value of maps in a textbook or article. In actual application, such text is read much more often than heard, and the map is present continuously on the page; readers may peruse it before, during, or after reading the text or not at all.

The investigations of Kulhavy and his colleagues are valuable for having demonstrated that people's cognitive processing of maps and text supports Paivio's dual-coding model of cognition (Clark and Paivio 1991, Kulhavy et al. 1993, Paivio 1986). Dual coding theories assume, in general, that verbal material (text) and visual images (maps) are encoded and stored in memory in functionally distinct codes which can operate independently as needed. The theories assume, further, that there are associative connections between the verbal and nonverbal units, so that they are not limited to independent operations. Activation of one code may also invoke the other if relevant information exists in both stores. This model of cognitive functions provides a theoretical explanation for how maps in text might help readers learn and remember the textual material: the ability to encode and store information in either of two distinct modes, based on which mode is more appropriate for the kind of data involved, is more effective than encoding all data, regardless of their properties, in a single mode (Kulhavy et al. 1993, Paivio 1986).

The dual coding hypothesis would argue against one explanation that has been offered to explain any facilitative relationship between maps and text: that it is the repetition of material, rather than any unique advantage offered by maps, which results in increased learning. That is to say, subjects have two learning opportunities when they encounter the same material in both text and maps, compared to only one opportunity when

they simply read or hear text. Thus, perhaps the same improvements could be achieved without maps if the verbal material were presented to subjects more than once. The few researchers who addressed this possibility in their studies reported that the combination of prose and illustrations was more effective than two presentations of the verbal material (Kulhavy et al. 1985, Levin et al. 1976, Purnell and Solomon 1991, Schwartz and Kulhavy 1981). Nevertheless, because of differences in methods and goals between the study reported here and those studies cited above, we chose to offset any possible disadvantage created by a single text presentation by balancing the presence of maps in text with extra repetitions of the relevant material in the text without maps.

In spite of the numerous studies involving maps and text which Kulhavy and other psychologists have conducted, many issues remain unresolved for cartographers, geographers, and educators, for whom students' acquisition of spatial knowledge is of considerable interest. The following study was designed to address some of those questions.

RESEARCH METHODS AND MATERIALS

The purpose of this study was to determine what effect, if any, the inclusion of maps in text has on seventh graders' learning. We also looked for any influence due to time of testing (immediate versus delayed), gender, and kind of learning (memorization versus inference), resulting in a 2 (maps present/absent) X 2 (time of testing) X 2 (gender) X 2 (question type) design.

Subjects. Subjects in the experiment were 123 seventh grade students, 60 males and 63 females, enrolled in a public school in Columbia, South Carolina. Average age for the group was 12.7 years. Previous research has shown that children of this age and much younger are able to comprehend basic reference and thematic maps (Boardman 1990, Kulhavy et al. 1985, Trifonoff 1995). Seventh graders at this school are required to enroll in a World Geography class; in addition, about 90% of the subjects reported that they had received map-reading instruction as part of their normal schooling. Thus, the subjects were quite familiar with the type of material used in this study, which was administered late in the school year. The tests were given to students during their regular World Geography classes, resulting in six groups of about twenty each administered at various times throughout the day. The six classes were later collapsed into two experimental groups based on whether they had been given text and maps to study (referred to hereafter as Group A) or only text (Group B).

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Materials. Material for the experiment consisted of geography texts, five maps, a set of questions with an answer form, and a questionnaire requesting demographic information. All were composed and revised in collaboration with the seventh grade geography teachers who cooperated in the study; they approved all material before it was used. In addition, we conducted a pre-test with nine students (who did not participate in the final research) in order to establish reasonable time limits for tasks and to verify that the test materials and instructions were clear and appropriate for seventh grade students.

The text described the regional geography of an imaginary island-country, Grand Isle. Topics included climate, topography, economy, landuse, and descriptions of important cultural and physical features such as cities, rivers, mountains, and the like. For the reasons discussed earlier, the basic text was modified for the non-map group so that each fact about which they would be questioned appeared twice within the narrative, versus once for the subjects whose text included maps.

The maps were simple black and white reference and thematic maps (see Figure 1) whose subject matter reflected the content of the text. The

maps were about 9 cm square and were placed as close to the relevant text as possible (always on the same page). References within the text prompted subjects to refer to the appropriate maps.

Text and maps or text alone were compiled into test booklets, on the covers of which were printed instructions outlining the procedures and time limits for the experiment. Instructions for subjects who received the text with maps included specific directions to study the maps as well as the narrative.

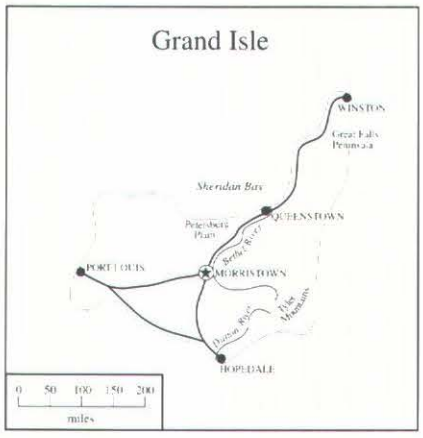
Questions about Grand Isle were of three different types: non-spatial, spatial-memory, and spatial-inference. Three questions referencing non-spatial information in the text were included so that we could compare the overall reading comprehension of subjects in the two experimental conditions (maps-no maps). That is, we wanted to be sure that any significant differences found in subjects' performance on spatial questions would not be confounded by differences in basic reading comprehension between Groups A and B. Spatial-memory questions, of which there were six, referred to spatial locations or relationships specifically described in the text (and depicted on maps for Group A). The six spatial-inference questions addressed spatial information not stated directly but which could be inferred from the information provided. All questions were of the multiple choice format. Examples of the three types are:

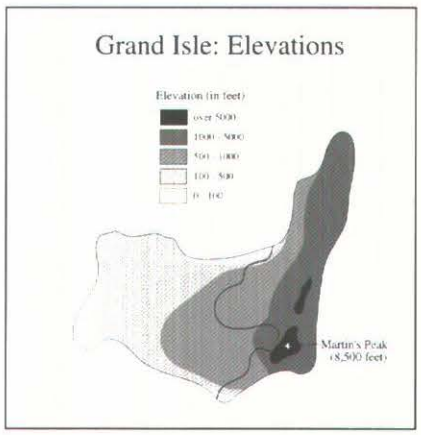
Sample non-spatial question:
What percent of the population of Grand Isle lives in urban areas?

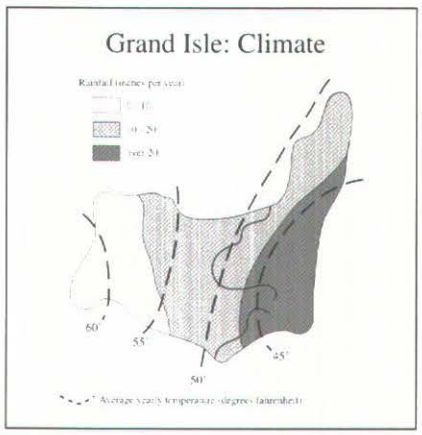
Sample spatial-memory question:
Which city is located on Sheridan Bay?

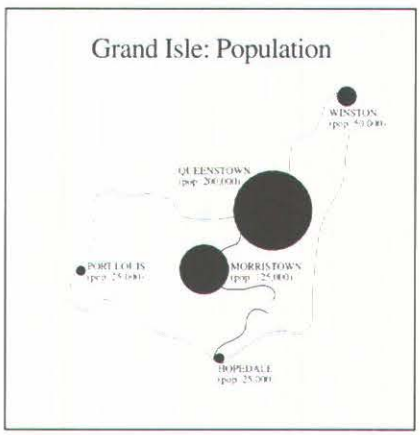
Sample spatial-inference questions:
What type of land-use is found along the Bethel River?

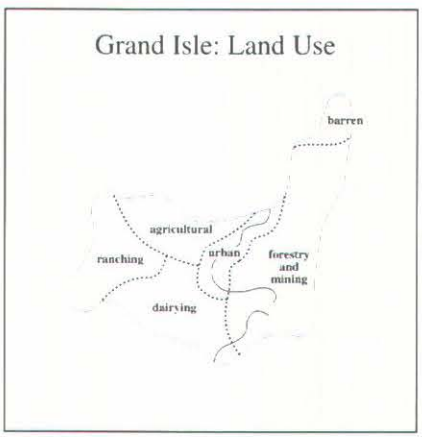
Figure 1. The five maps used in the study (reproduced here at 60% of original size).











Procedures. A general introduction and description of the project were read to the participants, and they were then asked to fill out a questionnaire asking for their age, sex, and some information about their map-use experience. When those forms were completed, they were given a test booklet containing either maps and text or text only about Grand Isle. The written instructions appearing on the cover of the booklet were read aloud to the students and they were given an opportunity to ask questions about anything they did not understand. When instructed to do so, students opened the booklets and were given 15 minutes to study the material, after which all reading material was collected and question and answer sheets were distributed. Participants had five minutes to answer the 15 multiple choice questions.

In order to assess any effects of maps on memory for spatial information, the same experiment was repeated using the same procedures and subjects one week later. Seven students were absent at the time of the re-test, resulting in 116 responses (56 from males and 60 from females) for that part of the study.

ANALYSES AND RESULTS

Answers to all questions were scored manually, with one point given for correct and zero points for incorrect answers. These data were then entered into the SAS statistical analysis package for further summaries and analyses.

Univariate statistics were calculated and the means used in Tukey's method of "outer fences" to identify and eliminate "extreme" values in the data set (Tukey 1977). These are individual scores that lie so far away from the mean for the group (i.e., beyond Tukey's outer fences) that their inclusion in the overall analysis might skew the results. This procedure eliminated five subjects, leaving 118 in the first test and 111 for the re- test.

Next, in order to determine whether Groups A (text and maps) and B (text only) represented the same population in terms of basic reading ability for the narrative used in the study, we compared the scores for the two groups on the non-spatial questions. The mean percent correct for Group A was 48.6 percent and for Group B, 53.2 percent, a difference which was not statistically significant ($Pr > F = 0.3348$). Thus we could then proceed to analyze the scores for the spatial questions.

Univariate statistics and analyses of variance (ANOVA) were calculated for the 2 (text/map condition) X 2 (spatial question type) X 2 (gender) X 2 (time of test) data model. A repeated measures analysis of variance was used to compare scores in the immediate versus delayed test condition.

Table 1 summarizes the mean percent correct for all independent variables in the study. As is evident from this table, in general, Group A scored higher than Group B, females performed better than males, inference questions were more difficult to answer than memory questions, and (not surprisingly) scores were lower on the delayed test. The only exception to this pattern is for gender on inference questions in the delayed test for Group B, where males scored just slightly higher than females: 21.1 percent correct compared to 19.9 percent.

Although there are clear overall patterns in the scores, as summarized in Table 1 and noted in the preceding paragraph, few of the

Table 1. Mean percent correct for all variables in the study.

		Immediate Test			Delayed Test		
Group	QT	Male	Female	Mean	Male	Female	Mean
A	Memory	40.0	43.0	41.5	34.5	38.9	36.7
	Inference	37.8	40.3	39.1	27.0	30.6	28.8
	Mean	38.9	41.7	40.3	30.7	34.7	32.7
B	Memory	37.4	38.1	37.7	34.0	36.5	35.3
	Inference	27.0	29.2	28.1	21.1	19.9	20.5
	Mean	32.2	33.6	32.9	27.6	28.2	27.9

differences reached the Pr > F =.05 level of statistical significance, either for main effects or for interactions. Table 2 shows the ANOVA results for the immediate and delayed tests. Only one main effect was significant: the higher scores for memory questions (36.0 percent) compared to inference questions (24.6 percent) on the delayed test.

The repeated measures ANOVA, comparing the scores for the same subjects between the immediate and delayed tests, reveals that only the main effect was significant (36.6 percent on the immediate test vs. 30.3 percent on the delayed test). (See Table 3.) Somewhat surprisingly, the interaction between question type and time of test did not reach the probability criterion of 0.05.

To summarize the results of this study, the only significant differences found were in the scores for the delayed test, which were lower than on the immediate test, and for the question-type in the delayed test, where students answered memory questions more accurately than inference questions. The other differences in scores (Group A higher than Group B, females outscoring males, and memory questions answered more correctly, overall, than inference questions) did not reach significance at alpha = 0.05, probably because of the amount of variation in the data, even though five extreme observations were omitted from the analysis.

DISCUSSION OF RESULTS

Certain results of the study were quite predictable. It is logical that scores would decline on the re-test, administered a week after the students had read the text. We also anticipated that scores would be lower for inference questions than for memory questions, simply because inference requires reasoning and more depth of understanding. We were more uncertain about what to expect from gender

Source			Immediate Test Mean	Immediate Test Pr > F	Delayed Test Mean	Delayed Test Pr > F
Group		A	40.3		32.7	
				0.1547		0.2458
		B	32.9		27.9	
Gender		M	35.5		29.2	
				0.6798		0.5782
		F	37.6		31.5	
Question		Mem	39.6		36.0	
				0.2411		0.0089 *
		Inf	33.6		24.6	
Group	A	M	38.9		30.7	
		F	41.7		34.7	
x				0.8965		0.6877
Gender	B	M	32.2		27.6	
		F	33.6		28.2	
Group	A	Mem	41.5		36.7	
		Inf	39.1		28.8	
x				0.4839		0.4110
Question	B	Mem	37.7		35.3	
		Inf	28.1		20.5	
Gender	M	Mem	38.7		34.2	
		Inf	32.4		24.1	
x				0.9629		0.7764
Question	F	Mem	40.6		37.7	
		Inf	34.7		25.2	

Table 2. Results of ANOVA for main effects and two-way interactions for immediate and delayed tests.

source	Pr > F
time	0.0059 *
time x group	0.5633
time x gender	0.9641
time x question type	0.2295

Table 3. Results of repeated measures ANOVA for immediate and delayed tests.

because the results of related studies have been so ambiguous, if not downright contradictory. The fact that females in this study scored somewhat higher than males in every category except one (but not significantly so) is interesting and suggestive but not a basis from which to draw clear conclusions. Such results may say as much about differences in the seriousness with which females and males approached the task as about their abilities to learn spatial information from maps and texts.

. . . what we were really most interested in was the effect on spatial learning–and any interactions with the other independent variables–of maps embedded in a regional geography text, compared to an unillustrated text.

But what we were really most interested in was the effect on spatial learning–and any interactions with the other independent variables–of maps embedded in a regional geography text, compared to an unillustrated text. Based on the statistical analyses of the results, we must conclude that there is no effect. Nevertheless, it is difficult to ignore the 7.4 and 4.8 point advantage, overall, for Group A on the immediate and delayed tests, respectively, and the much better performance on inference questions when maps were present (34 percent) than when they were not (24.3 percent). Although these differences were not large enough to be statistically significant, they do represent a pattern of better performance with maps which holds across all interactions with question type, sex, and time of test. It seems unlikely that such a consistent pattern occurred by chance.

Recall, also, that for the purposes of this experiment, the unillustrated text was composed so that the information on which the subjects would be tested appeared twice within the text. This technique would not be a practical alternative in actual textbooks, however, because it would double the length of the book and be very tedious for students to read. Differences between Groups A and B probably would have been greater if this procedure had not been followed (i.e., if the information had been presented only once rather than twice in the text). As noted earlier in this paper, several researchers have found in studies designed to address the issue directly that the inclusion of maps with a narrative is more effective than repetitions of text alone. Our findings are consistent with their conclusions, differing only in degree (significance), not in direction.

Further comparisons between the results of this study and those of other researchers are difficult. As discussed earlier, the experiments by Kulhavy and his associates (1993) measured primarily non-spatial learning and used quite different methodologies than were used here. Gilmartin's methodology was similar, but her subjects were university students and the non-illustrated text did not contain redundant information. Scevak et al. (1993) used 11th graders as subjects but gave them extensive instruction on how to use maps strategically to organize text, resulting in subjects' higher learning from text with maps. The early research by Davis and Hunkins (1968) and Davis (1971) is probably the most closely comparable to this study: the subjects were junior high school students, the experimental design was similar except for the redundancy built into the text for this study, and those researchers, too, found no significant differences in subjects' scores based on reading text with maps versus text alone.

. . . it seems certain that junior high students are capable of comprehending maps such as those used in this study.

In light of previous research related to children's map-reading abilities, it seems certain that junior high students are capable of comprehending maps such as those used in this study. Yet, as was the case with Davis' (1971) junior high students, they did not use them to their greatest advantage in studying a geographic text, at least not to levels of statistical significance. Perhaps students at this grade level need further instruction and/or prompting to take advantage of maps' capacity to communicate spatial material efficiently. And, as Kulhavy and his associates have shown, maps can enhance the learning of non-spatial information in text also.

Although the participants were told explicitly to attend to the maps, there is no way to know how many actually did. It is the opinion of the first author, who administered the experiment, that a number of students were quite disinterested in the task and were not really trying to learn the material. Perhaps this problem could be ameliorated in future research by testing students individually or in small groups or by offering an incentive for high scores. Such measures might also reduce the variation in responses and make results such as we found here statistically significant.

Geographers, psychologists, and educators all have an interest in understanding the pedagogic relationship between illustrations and text. Most prior research indicates that the presence of maps enhances learning from text, and our findings were consistent with that generalization but not at statistically significant levels. We have suggested some factors that may have affected our results, but further research will be needed to investigate those ideas. In the meantime, based on our experience and on evidence from other studies, it seems likely that one effective way to increase students' learning from maps and text is simply to teach them that maps are tools which can help them understand and recall spatial locations and relationships.

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