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ABSTRACT

This study compared the effects of instructor-provided vs. learner-generated analyses of semantic relationships between major concepts on structural knowledge acquisition in an introductory psychology course. One group explained the relationships on instructor-provided graphic organizers; the other group classified relationships between concepts by completing skeletal maps provided by the instructor. Increase in structural knowledge was related to practice effect for both groups; the group that generated analysis scored higher at a near-significant level. Regardless of group, there was a significant relationship between total exam score and frequency of completing the treatment exercises (an indicator of motivation). Eight graphs displaying the statistical findings are included. (Contains 19 references.) (Author)

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Learner-Generated vs. Instructor-Provided Analysis of Semantic Relationships

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Abstract

This study compared the effects of instructor-provided vs. learner-generated analyses of semantic relationships between major concepts on structural knowledge acquisition in an introductory psychology course. One group explained the relationships on instructor-provided graphic organizers; the other group classified relationships between concepts by completing skeletal maps provided by the instructor. Increase in structural knowledge was related to practice effect for both groups; the group that generated analyses scored higher at a near-significant level. Regardless of group, there was a significant relationship between total exam score and frequency of completing the treatment exercises (an indicator of motivation).

Introduction

Learning and Semantic Networks

Our semantic networks represent our knowledge structures which enable learners to combine ideas, infer, extrapolate or otherwise reason from them. Learning consists of building new structures by constructing new nodes and interrelating them with existing nodes and with each other. The more links that the learner can form between existing knowledge and new knowledge, the better the learner will comprehend the information and the easier learning will be. Learning, according to semantic network theory, is the reorganization of the learner's knowledge structure. During the process of learning, the learner's knowledge structure begins to resemble the knowledge structures of the instructor, and the degree of similarity is a good predictor of classroom examination performance (Diekhoff, 1983; Shavelson, 1974; Thro, 1978). Instruction, then, may be conceived of as the learner's mapping of subject matter knowledge (usually that possessed by the teacher or expert) onto the learner's knowledge structure.

If we accept the conception that learning involves the reorganization of the learner's cognitive structure, then instruction involves the learner's assimilation of the expert's knowledge structure. In order to help students reorganize and tune their knowledge structures, we need instructional strategies for depicting and displaying appropriate knowledge structures to students and tools for helping them organize their knowledge structures. Instructional strategies may illustrate or convey appropriate knowledge structures to students, whereas the tools or learning strategies may help learners to acquire and refine their own knowledge structures (Jonassen, Beissner, & Yacci, 1993).

Instructional Strategies vs. Learning Strategies

Instructional strategies and learning strategies lie on a continuum that describes the level of learner involvement. An instructional strategy is a method or technique for providing instruction to learners. These strategies are implemented through instructional tactics (Jonassen, Grabinger, & Harris, 1991). For instance, an instructional strategy may recommend motivating the learner prior to instruction, which may call for tactics such as arousing learner uncertainty, asking a question or presenting a picture. A strategy aimed at teaching a concrete concept may call for the use of tactics such as matched example-nonexample pairs or deriving the criterion attributes from a set of examples. Instructional strategies provide the overall plan that guides the selection of instructional tactics that facilitate learning. Essentially, instructional strategies are instructor-provided interventions that are meant to constrain learner processing of information. The instructional strategy used in this study graphically illustrated key concepts and their interrelationships between those concepts, which attempted to map the teacher's knowledge structure onto the learners' structures.

Learning strategies are mental operations that the learner may use to acquire, retain and retrieve different kinds of knowledge or performance. The fundamental difference between instructional strategies and learning strategies is that the former are largely mathemagenic and the latter are generative (Jonassen, 1985). Mathemagenic instructional strategies control the processing of learners while leading them to learning, so they result in anticipated learning outcomes. They facilitate acquisition of specific content knowledge (intentional learning) but generally do not facilitate or even impede the acquisition of any other knowledge (incidental learning).

Learning strategies, on the other hand, are generative; that is, they enable learners to take an active, constructive role in generating meaning for information by accessing and applying prior knowledge to new material. Wittrock's (1978) generative hypothesis asserts that meaning for material presented by computer or any other medium is generated by the learner's activating and altering existing knowledge structures in order to interpret what is presented. Learning strategies are intended to increase the number of links between presented information and existing knowledge. Learning strategies, unlike instructional strategies, are more learner-controlled as well as learner-generated, because they engage the learners and help them to construct meaningful representations. Their success depends upon the learner taking an active role in controlling their use. The strategy that was investigated in this study facilitated the acquisition of structural knowledge.

Instructional and Learning Strategies for Facilitating Structural Knowledge

The learning variable that was investigated in this study was structural knowledge. Structural knowledge is the knowledge of how concepts within a domain are interrelated (Diekhoff, 1983). Structural knowledge enables learners to form the connections that they need to describe and use scripts or complex schemas. It is a form of conceptual knowledge that mediates the translation of declarative knowledge into procedural knowledge. There are a number of instructional strategies for conveying structural knowledge representations and a number of learning strategies for facilitating knowledge acquisition (Jonassen, Beissner, & Yacci, 1993). Instructional strategies that affect the way that learners encode these structures into memory include explicit graphic, mapping techniques, such as graphical organizers, spider maps, semantic maps, and causal interaction maps, for conveying knowledge structures to students. Teachers and designers may use a number of verbal instructional techniques, such as content structures and elaboration theory, to convey the underlying structures in materials to students. There are also a number of learning strategies that learners can use to build their own structural knowledge representations, including pattern noting (Buzan, 1974; Fields, 1982), networking (Dansereau, Collins, McDonald, Holley, Garland, Diekhoff, & Evans, 1979) and the node acquisition integration technique (Diekhoff, Brown, & Dansereau, 1982).

Among these strategies is a study strategy called the *Frame Game* that was developed to accompany an educational psychology textbook (Clifford, 1981). The Frame Game is a text processing strategy that identifies the most important concepts in a textbook chapter and then requires the learner to identify the relationships between the concepts by assigning them to predetermined, mapped relationships (see Fig. 1 for a completed frame and Fig. 2 for a frame to be completed by students). This analysis strategy requires that learners search, contrast, validate, elaborate, confirm, and test information from the chapter. These relationship maps may be used to engage learners in generative processing of textual information or to depict the information.

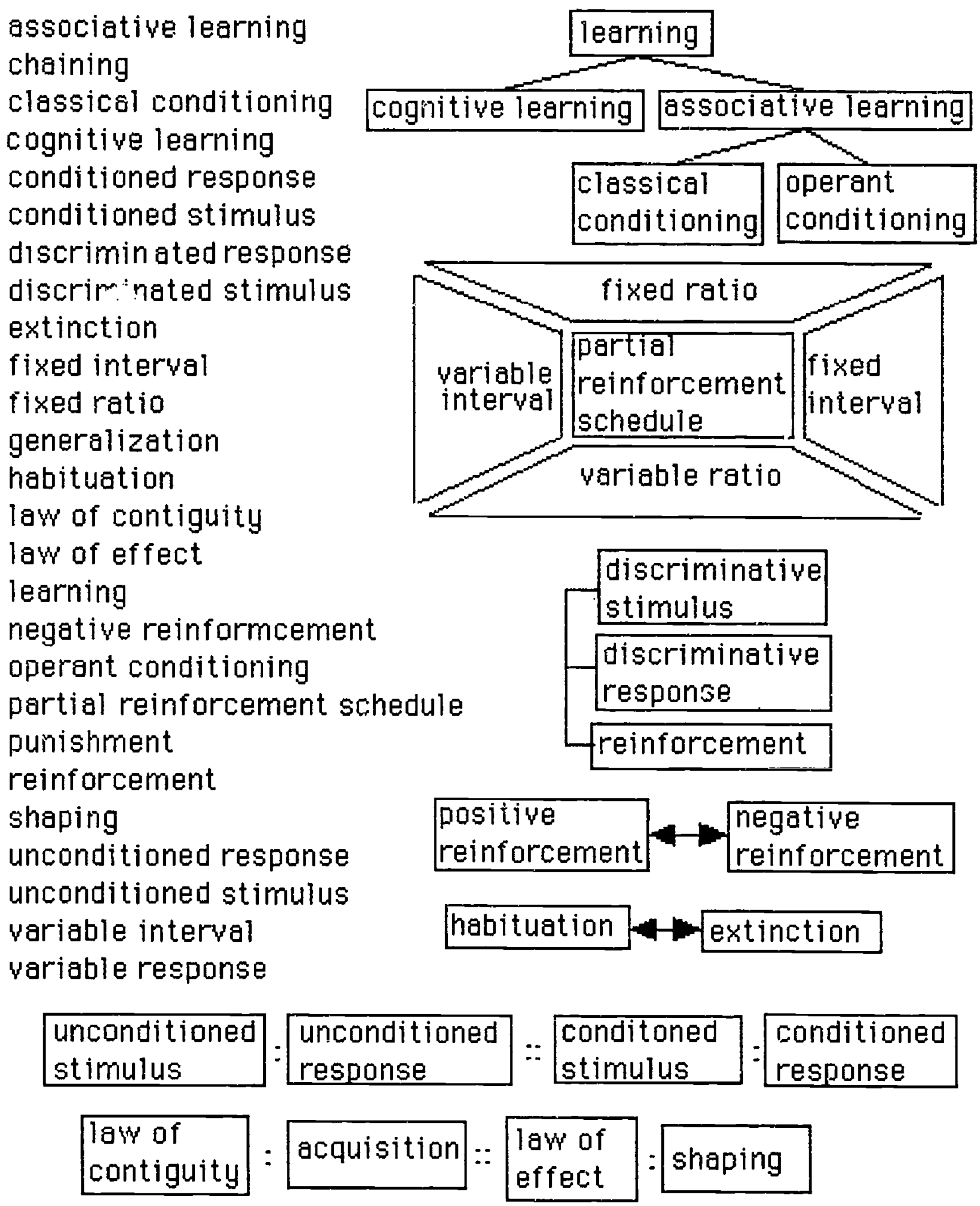

Fig. 1. Completed frame for chapter in psychology textbook.

In this study, we compare (1) the provision of structural information to learners as a review of the information with (2) the learner analysis of the relationships between the concepts in the chapter (For a more complete discussion, see Cole & Jonassen, 1993.)

The patterns of frames in Fig. 2 represent different relationships between concepts, such as hierarchical, sequential, and associates relationships. Students have to analyze the concepts and decide which combinations can fit into the structures. Such an activity requires deep-level semantic analysis of the main ideas in the textbook and lectures.

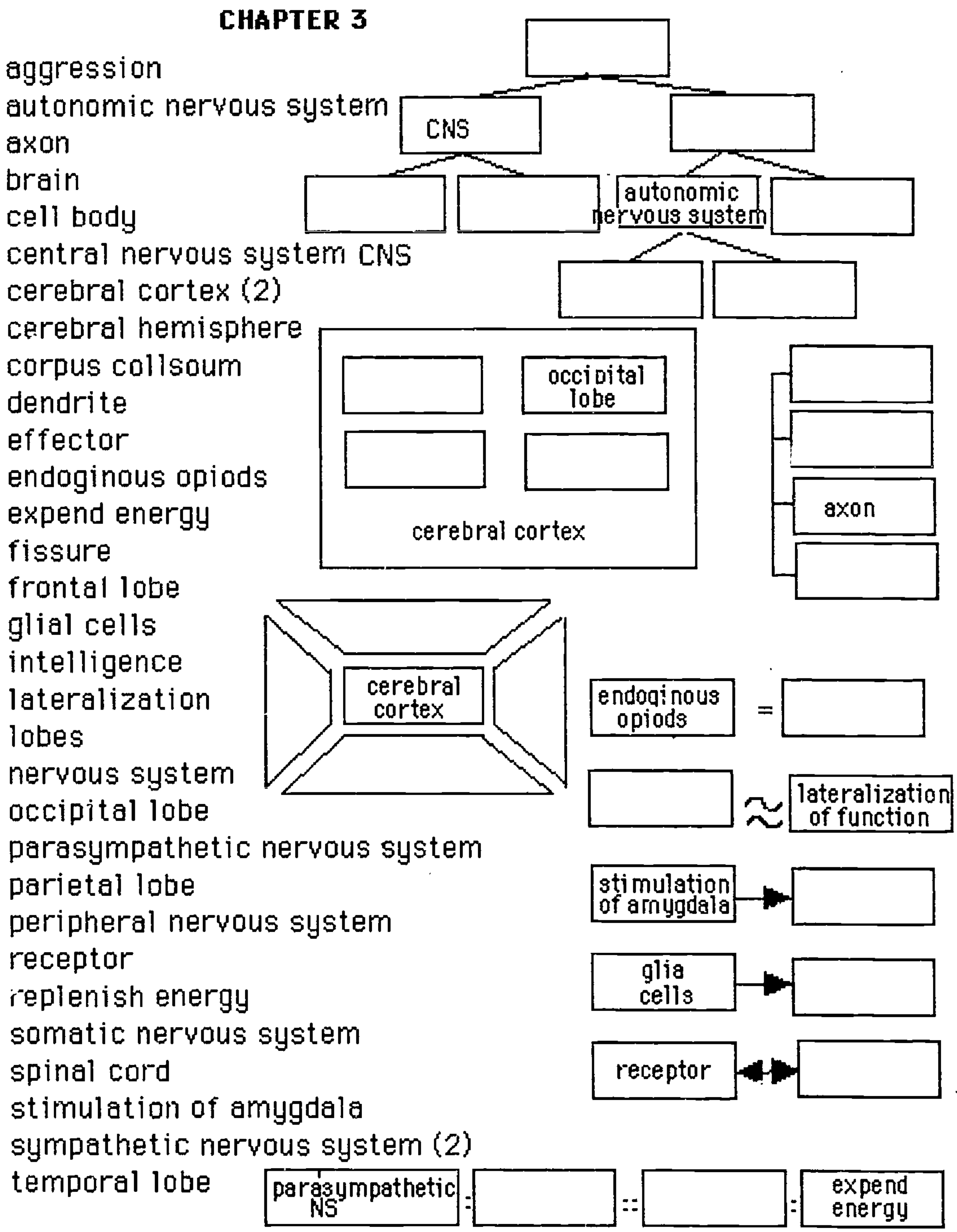

Fig. 2. Student frame from psychology textbook.

Purpose of Study

The primary purpose of this study was to clarify and extend the findings of a prior study (Jonassen, Cole, & Bamford, 1992) comparing the effects of a structural knowledge instructional strategy with the effects of a structural knowledge learning strategy on the acquisition of structural knowledge. In that study increases in structural knowledge acquisition interacted with content difficulty and the relative difficulty of the exercises. Motivation also appeared to be a factor for one Group.

In this study, we wanted not only to compare the effects of providing graphical organizers in the form of completed frames with requiring students to complete frames as a study strategy prior to examinations, but also to overcome several limitations of the previous study. First, we wanted to ensure at least minimally similar cognitive processing of the organizer and the frames by students in their respective groups. In the earlier study, students who received the organizer had not been required to process it in any way. Moreover, the students who received the organizer might have engaged in rote memorization or some form of verbal mediation. Second, since incentives play an important role in student performance (Hicken, Sullivan, & Klein, 1992) we wanted to provide adequate incentive for completing the exercises. Third, since it apparently takes months for a new learning strategy to displace a well-established old one (Duffy & Roehler, 1989), we wanted to have students utilize a single strategy for an entire semester; in the earlier study students used each strategy for one exam in a counter-balanced research design. Fourth, we wanted to eliminate the confounding effect of the counterbalanced design since we could not control the difficulty level of each chapter. The results of the prior study suggest that it is more difficult to assimilate structural knowledge for some chapters than for others. For example, it is easier to relate learning and memory concepts to a class of college students than it is concepts on physiology. Finally, we wanted to include enough items on each subscale of structural knowledge to be sensitive to learner performances on each exam.

Method

Subjects

Thirty-eight students from two sections of a General Psychology (Psy 101) course at a large community college in metropolitan Denver completed the study during eight-week summer term, 1992. Five other students failed to complete all of the tests so they were dropped from the analysis. There were 21 subjects in Group 1, and 17 in Group 2.

Instruments

Four subject-matter exams were designed for the experiment. Each exam consisted of 60 questions worth one point each, 34 of which were multiple-choice questions testing recall and comprehension of the text and lecture material. In order to assess structural knowledge acquisition following various treatments, we developed three subscales to measure different aspects of structural knowledge: (a) 10 relationship proximity judgments, (b) 8 semantic relationships, and (c) 8 analogies. All of the structural knowledge test questions were developed to focus on relationships between important concepts contained in the textbook chapters.

The relationship proximity judgments required that students judge the strength of the relationship between two terms and assign a number between 1 and 9 to each of several pairs of concepts to indicate how strong a relationship they thought existed between the concepts in each pair (Diekhoff, 1983; Schvaneveldt, Durso, Goldsmith, Breen, Cooke, Tucker & DeMaio, 1985; Shavelson, 1972). For example:

_____ 2. endorphins — amygdala

_____ 3. cerebral cortex — Broca's area

_____ 4. seratonin — temporal lobe

The semantic relationships subscale consisted of eight multiple-choice questions that required students to understand and recognize the nature of the relationship between two concepts. These relationships were paraphrased from the textbook or lecture. For example:

_____ 16. sensory registers .... short term memory
  a. precedes
  b. is defined by
  c. is independent of
  d. is inferred by

_____ 17. acoustic .... memory
  a. results in
  b. is independent of
  c. is opposite of
  d. is an example of

Finally, the analogies subscale required students to complete eight analogies consisting of four of the concepts from the textbook or lecture. For example:

_____ 22. decay : forgetting :: _______ : retrieval
  a. mood
  b. repression
  c. rehearsal
  d. primacy

_____ 23. acquisition : extinction :: punishment :____________
  a. negative reinforcement
  b. positive reinforcement
  c. variable reinforcement
  d. classical conditioning

These three types of questions were used to assess structural knowledge acquisition. In order to provide standards for assessment, the researchers agreed on the answers to each of these questions. Answers to the multiple-choice questions were recorded on the front of Scantron answer sheets; semantic-proximity items were written on the back. Exams covered history and methodology of psychology (chapters 1 & 2), physiology, sensation and perception (chapters 3 & 4), learning and memory (chapters 6 & 7), and motivation, emotion, and states of consciousness—primarily sleep (chapters 5, 9, & 10).

Materials

Researcher-generated study maps were generated for each chapter; mapping allowed students to visualize the relationships among terms — superordinate/subordinate/coordinate (hierarchical) and sequential organization—as well as the depiction of the terms in classes, analogies, similarities, cause and effect, and opposites (see Fig. 1). Each map alphabetically listed all the terms used in the frames. Students were also instructed to study the list of terms at the end of each chapter in the text.

Templates of maps were designed for a student-generated-mapping exercise to be assigned prior to Exam 2. These maps (see Fig. 2) were the same as the instructor-provided maps in Fig. 1 except that most of the frames in the maps were empty, requiring the student to fill in the appropriate concepts. Since a prior study (Jonassen, Cole, & Bamford, 1992) indicated that having extra terms in the list made the cognitive load too great, the lists in this study included only the terms actually used in the frames. To further optimize the cognitive demands on the students, the templates provided at least one term in each set of frames (always one in each pair of terms in an analogy).

Procedure

The study was a quasi-experimental design using intact psychology classes. The classes met 150 minutes twice a week at 9:50 a.m. (Group 1) and 6:30 p.m. (Group 2) for the duration of an 8-week summer term. One of the researchers served as instructor for both sections of the course.

A repeated-measures design was utilized to assess learning across the semester and to measure group differences.

	Group 1	Group 2
Exam 1	Maps Provided	Maps Provided
Exam 2	Maps Provided	Maps Generated by the Class as a Whole
Exam 3	Maps Provided	Maps Generated in Small Groups
Exam 4	Maps Provided	Maps Generated Individually

Prior to Exam 1, students acquired mapping concepts and procedures by completing a generic mapping exercise. This exercise introduced students to the mapping process that they would encounter throughout the semester. Students were told that they would be involved in a study about using learning strategies.

One week prior to Exam 1, a study sheet containing key terms from lecture and text was distributed. The class prior to the exam was partially devoted to explaining the key terms' relationships within the instructor-provided maps that were distributed to both groups. Exam I covered chapters 1 and 2 (history & methodology of psychology).

One week prior to Exam 2, a study sheet containing key terms from lecture and the text was distributed to both groups. A portion of the class period immediately prior to the exam was devoted to the mapping exercise. Group 1 received instructor-provided maps; students were required (as a homework assignment) to explain in writing the mapped relationships. Group 2 students received the templates designed for student-generated-mapping, and the teacher facilitated whole-class problem solving of how to complete the maps correctly. Exam 2 covered chapter 3 and 4 (physiological psychology, and sensation and perception).

One week prior to Exam 3, a study sheet containing key terms from lecture and the text was distributed to both groups. As with Exam 2, a portion of the class period prior to the exam was devoted to the mapping exercise. As before, Group 1 students were required (as a homework assignment) to provide a written explanation of each graphically mapped conceptual relationship in the instructor-provided maps. Group 2 students received the templates designed for student-generated-mapping. Students divided into groups of 3-4 students and completed the mapping exercise in class. Exam 3 covered chapters 6 and 7 (learning & memory).

One week prior to Exam 4, a study sheet containing key terms from the lectures and the text was distributed to both groups. As before, Group 1 students were required to provide a written explanation of each graphically mapped conceptual relationship in the instructor-provided maps. Group 2 students received the templates designed for student-generated-mapping. Group 2 students were required to complete this exercise individually as a homework assignment. Exam 4 covered chapters 5, 9, and 10 (motivation, emotion, and states of consciousness—primarily sleep).

Following each exam, the instructor reviewed the exam in class and provided feedback on each student's test performance. Homework assignments (written descriptions of maps for Group 1, and student- or group-generated maps for Group 2) were assessed for degree of completion; the homework assignments altogether counted 10% of the course grade.

At the end of the semester, students were administered a questionnaire designed to assess their perceptions of the mapping strategies that were presented in class.

Exam items included 34 general recall/comprehension items, and 26 structural-knowledge items—8 analogies, 8 relationships, 10 proximities—for a total of 60 questions per exam. Scores on each dependent measure of interest were converted to percentages so that they could be compared across scales and subscales. These dependent measures were all analyzed using a repeated-measures analysis of variance (ANOVA). Because we assumed that students in each treatment were learning to apply their respective mapping strategies on the exercises for Exams 1 and 2, analyses focused on Exams 3 and 4.

Results

Total Exam Scores

An ANOVA of the total exam scores for Exams 1 and 2 indicated no statistically significant differences between Groups 1 and 2. This was the period in which the learners were practicing their respective skills; so analyses focused on Exams 3 and 4. No significant differences in the total scores occurred between groups or between exams (see Fig. 3).

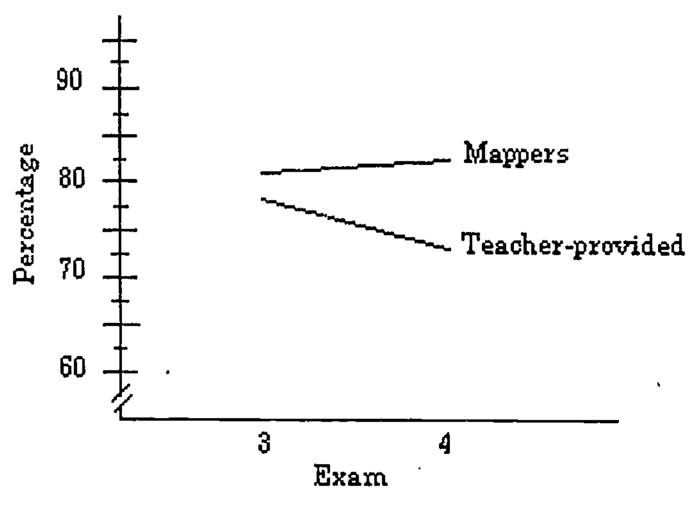

Fig 3. Total exam scores

Group 1 (teacher-provided) scores declined five percentage points on Exam 4, while the mapping group's score increased slightly. However, the interaction was not significant ($p = .10$). Next we wanted to determine if completion of the assigned exercises contributed to total exam performance. The total number of maps completed by all subjects were summed and classed into three groups: those who completed only a Few of the maps, those who completed Most of the maps, and those who completed All maps. Total scores were significantly different between these groups (*M*= 67, 78, 85 for Exam 3 and 68, 72, and 85 for Exam 4 for the Few, Most, and All groups respectively; $F = 7.4$, $p < .01$), but the treatment group by completion group was not significant. The treatments did not appear to differentially affect total exam performance. Next we analyzed the three subscales for structural knowledge (proximities, semantic relationships, and analogies).

Structural Knowledge Performance

Proximities. Student proximity scores were compared with experts' scores, yielding a correlation coefficient for the 10 proximity items on each exam. These coefficients were compared using ANOVA (see Figure 4).

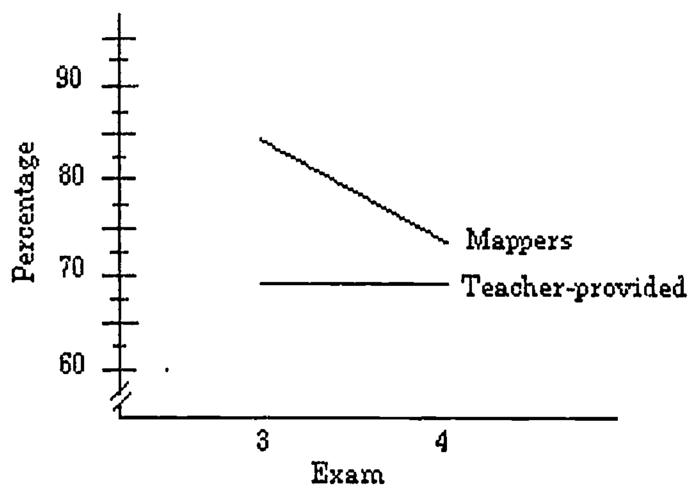

Figure 4. Total proximities score

A significant main effect occurred for treatment ($p < .05$), with the mapping-group scores ($M = 79$) exceeding the teacher-provided group scores ($M = 69$). The repeated measures by group interaction neared significance ($p = .06$), with the teacher-provided group's scores remaining stable between Exams 3 and 4 and the mapping group's scores declining significantly. This difference becomes even more dramatic in a comparison of intentional learning (mapped items) and incidental learning (unmapped items; see Fig. 5).

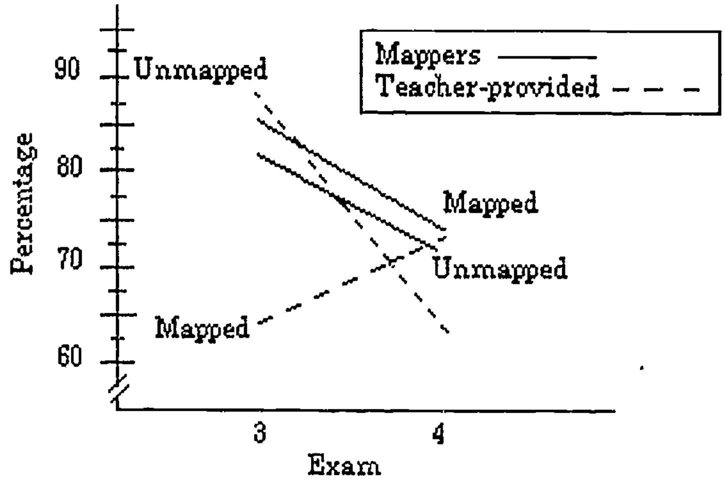

Fig. 5. Mapped and unmapped proximities

On mapped proximity items, the teacher-provided group's scores increased significantly while the mapping group's scores decreased significantly ($F = 6.3$, $p < .05$). The interaction on the unmapped proximities (incidental learning) was not significant. This indicates that the content of Exam 4 was more difficult than Exam 3 and that the mapping group was impeded by some aspect of that Exam.

Semantic relationships. On the relationship items, there was a significant repeated measures effect ($F = 10.4$, $p < .01$; see Fig. 6) and a significant difference between those who completed Few, Most, or All of the mapping exercises ($p < .01$ for both exams).

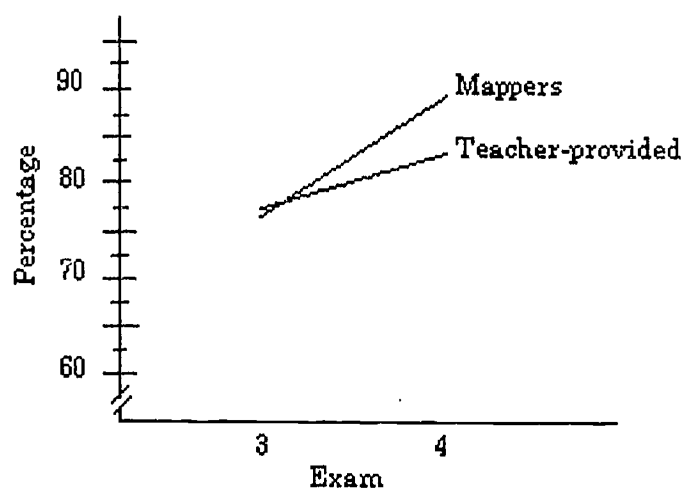

Fig. 6. Total relationship scores

The scores of both groups increased from Exam 3 to Exam 4, indicating a significant practice effect. As with the proximity items, those who completed All of the exercises outperformed those who completed Most and those who completed just a Few of the map-related exercises assigned during the term. Unlike the proximity items, there was a significant repeated measures by group interaction on intentional learning (mapped items), with the teacher-provided group maintaining a steady performance between Exams 3 and 4 and the mapping group increasing its performance (see Figure 7). There was a significant repeated measures effect for incidental learning, with both groups improving their performances between Exams 3 and 4 (see Figure 7).

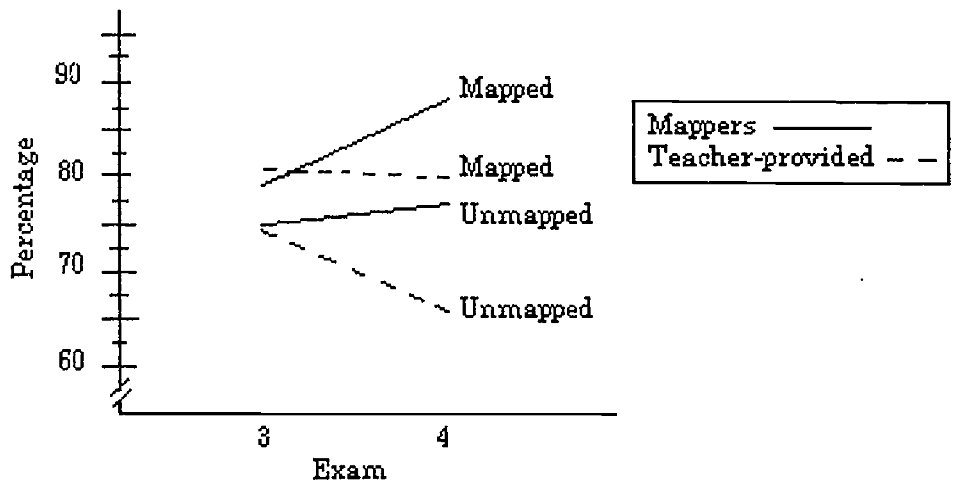

Fig. 7. Mapped and unmapped relationships

Analogies. There was a significant repeated measures by treatment interaction on the analogies ($F = 6.7, p < .05$), with the teacher-provided group declining and the mapping group improving (see Fig. 8). There were too few mapped analogies for any meaningful interpretation of intentional learning. However, there was a significant repeated measures by treatment interaction for incidental learning ($F = 6.7, p < .05$), with the teacher-provided group declining and the mapping group improving (see Fig. 8).

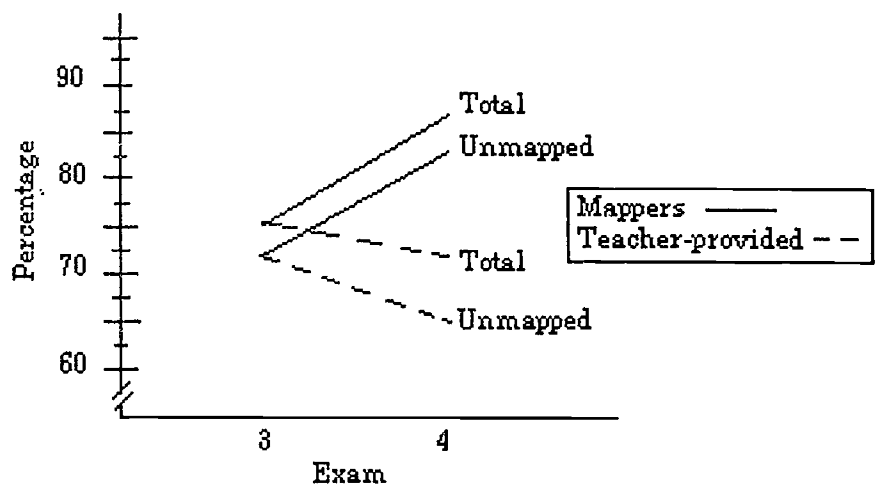

Figure 8. Analogy Scores

Non Structural Knowledge Performance

The first 34 items of the test were predominantly recall and comprehension items. There was a significant practice effect for the total score on this section of the test ($F = 8.5, p < .01$) as well as on the recall items ($F = 27.8, p = .0001$). Both groups declined on both measures between Exams 3 and 4 (see Fig. 9).

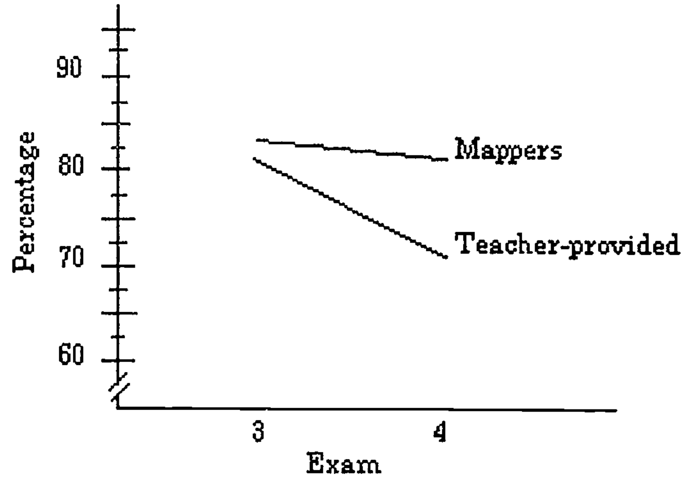

Fig. 9. Non-structural knowledge total scores

A repeated measures ANOVA revealed that both groups declined significantly in intentional learning ($F = 4.7$, $p < .05$), and incidental learning ($F = 14.6$, p .0005; see Figure 10). These findings confirm the above interpretation that the content of Exam 4 was more difficult than the content of Exam 3.

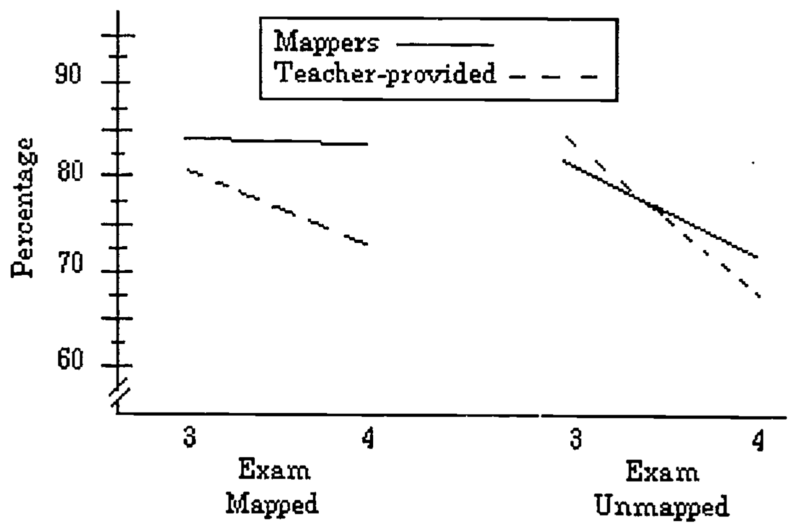

Fig. 10. Mapped and unmapped non-structural knowledge

Discussion

The most consistent result is based upon the number of mapping exercises completed by each group. Confirmatory regression analyses regressing the number of exercises completed onto each of the dependent variables resulted in significant predictive value for the number of exercises students completed ($p < .01$). Clearly, both treatments engaged the learners in some deeper level thinking.

However, the results of this experiment were not as distinct because the nature of the treatments were so similar. In this study, we over-compensated for problems experienced in the previous study. The processing that the two strategies required was fairly equivalent, though slightly more difficult for the group who completed their own maps. That is, there was not a sufficient difference between the instructional strategy and the learning strategy used in the study. The difference in performance was most obvious on the analogy questions, which students always find most difficult. In subsequent research, the activities should be more clearly distinguished.

In general, students performed better on intentional learning (items cued by the maps) than on incidental learning. The significance of this difference is more complex than it at first seems, since few of the test items were directly represented on the maps. Moreover, with the exception of the proximity items (the most nebulous of the structural knowledge items), the mapping group generally outperformed the teacher-provided group on both intentional and incidental learning. Thus the more generative strategy seems to have facilitated both intentional and incidental learning more than did the more instructor-supported strategy. However, it is again important to note that the strategies involve relatively similar degrees of instructional support. Results of a prior study by Jonassen, Cole and Bamford (1992) suggest that placing heavier cognitive demands on learners can be counter-productive.

Future Research

This study only began to address the many questions about how best to support the acquisition of structural knowledge. Future studies must address, for example, (a) the relationship between individual learning characteristics (e.g., verbal ability, and field dependence/independence), (b) how much instructional support is optimal (the results of this study, combined with those of the previous study by Jonassen, Cole, and Bamford (1992), challenge the assumption that the more the learner generates, the more he/she will learn), (c) what concepts to map, (d) how to depict concepts (e.g., Do different types of frames differentially facilitate the acquisition of specific types of structural knowledge?), (e) the role of incentive in such studies (the current study may not have provided adequate incentive; would greater incentives increase the effects?). Future research with college-level students should also include a control group who invoke their own strategies.

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