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Mind Fields: Negotiating Shared Meanings via Concept Maps

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Student understanding of course content is often characterized by isolated and fragmented knowledge segments. All too often, faculty are confronted by the realization that what they understand to be integrated and coherent knowledge, is memorized by their students as bits and pieces of factual knowledge with limited meaning. Why does this happen? One reason may be that as faculty develop courses, focus is placed upon transmitting disciplinary knowledge at all costs. Learners' needs to establish meaningful links and relationships among concepts (both within and between courses) is rarely considered. In fact, many instructors are themselves "novices" about what constitutes meaningful learning, consequently, university courses are designed so that concepts are disconnected rather than linked.

As overarching visual representations of the relationships between concepts as well as propositional relationships, maps provide a basis for dialogue to make explicit what is often tacit knowledge held by experts and novices. Therefore, concept maps appear well suited for use as a means to construct epistemologies and to comprehend text. They allow us to make creative interconnections at the theory building level and provide learners with a tool for negotiating meaning, discussing misconceptions, and constructing shared technical vocabularies (Beyerbach, 1988, Beyerbach & Smith, 1992; Novak, 1990). Meaningful learning is characterized by connected-ness of concepts. It occurs when learners actively interact with information sources rather than passively memorize isolated facts. This results in construction of conceptually linked knowledge structures. If students are to learn how to best represent or make explicit and observable what they know, one approach is to assist them in the use of concept maps. Concept mapping is a visual representation of knowledge structures. The emphasis is placed upon the relationships or links between concepts rather than on the explication of the concept in isolation from other knowledge. Mapping concepts permits both students and teachers to represent their conceptual frameworks externally, and provides the basis for dialogue to see if there is shared meaning, differing meanings, and possible misconceptions. It offers instructors a powerful means (1) to assist learners to develop beyond representational to conceptual understanding and (2) to assess student knowledge and comprehension/learning.

Wandersee (1990) refers to concept maps as *cartographies of cognition*. We would extend his metaphor to include not only the end map product, but also the process of construction and interpretation of concept maps as means for epistemological rehabilitation, curriculum development, and as evaluation measures. The critical attribute which renders them useful for these goals lies in their fostering of higher order ways of thinking. Construction of maps allows and indeed, often forces us to represent our thinking as elaborated, categorized, synthesized, and evaluated structures.

In the following discussion we will provide a rationale for the use of concept mapping in the construction of our epistemology, in the restructuring of our teacher preparation program, and the impetus for research efforts at West Virginia University. These applications have evolved naturally from consideration of contemporary cognitive literature.

Concept mapping is an effective cognitive tool for both examining and explicitly representing belief systems that have been in place for the past 25 years at our institution. By mapping these assumptions and by exploring alternate and synthetic ways of thinking about the way we think and learn, we hope to provide an environment for scholars and students which supports creative and meaningful learning

Epistemological Rehabilitation

We began pilot studies a year ago on the effects of teaching concept mapping to pre-service teachers. We read research by Mikulecky and Dansereau about the enhancement of expository text comprehension for university undergraduates who had been taught how to map texts by linking key concepts. At that time, we understood mapping solely as a technique to improve the study strategies of our students. Our study was empirical and quantitative and we did not yet understand the wider implications of what we had read in Novak & Gowin's (1984) Learning How to Learn. The results of the study proved promising and so we decided to continue pursuing this line of inquiry.

Study 1

Research suggests that fewer than 5% of 17 year olds are able to demonstrate adept use of advanced level study strategies with expository texts (Mikulecky, Clark, and Adams, 1989). According to cognitive researchers, successful students need to be able to identify information which is important and then they must use appropriate study strategies to learn and retain that information. As novices, most undergraduates do not have the background knowledge in a content area which would aid them in determining the main ideas in a text or lecture. Research indicates that when teachers do address study skills and strategies, they can play a powerful role in enhancing the performance of students enrolled in their classes (Schmidt, Barry, Maxworthy, and Huebsch, 1989).

Students in an undergraduate educational psychology course were assigned to one of two groups. Group composition was determined by random stratification according to scores on the Learning and Study Strategies Inventory (LASSI). All subjects were trained to identify key concepts and to graphically map the relationships among ideas. Dependent measures included a traditional test over the content, text passages for identification of key concepts, and graphical map of the relationships among key concepts. Preliminary results indicate significant differences when concept maps are used as a method of review prior to testing, and when they are constructed by collaborative working groups.

Method

Subjects. The subjects were 21 pre-service teachers enrolled in an undergraduate educational psychology course. Subjects were trained in concept mapping as part of the course requirements. There were 5 males and 16 females. The class standings were 2 freshmen, 10 sophomores, 8 juniors, and 1 senior.

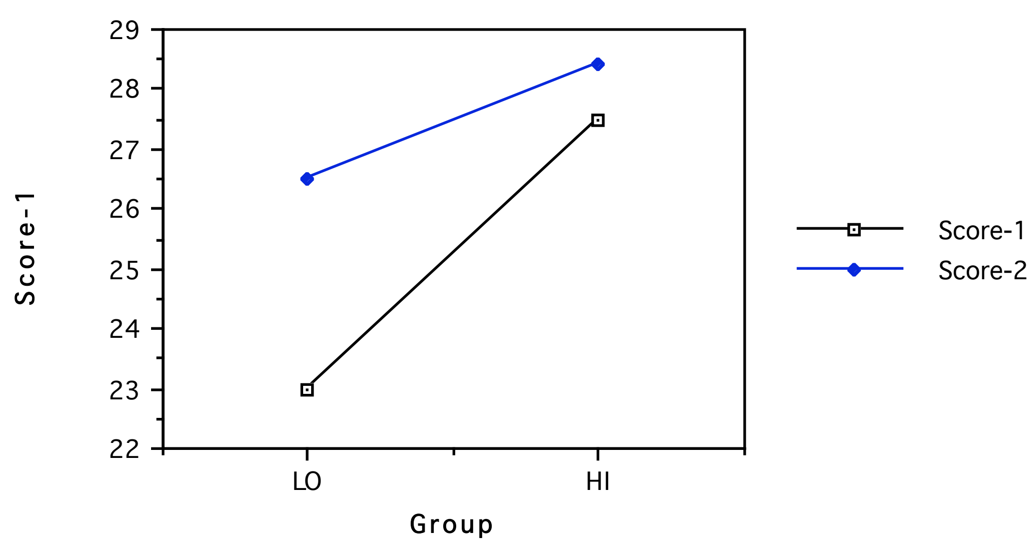
The design was a 2x2 mixed format with one between-subjects variable and one within-subjects independent variable. The between subjects variable was key-word score (low versus high in representing key words from the text on subjects' first concept map). The within-subjects variable was test occasion (beginning versus ending test). These multiple-choice tests were derived from an author-generated, text-book test bank. These tests were constructed to be parallel, and items were computer scrambled within each test. The dependent variable was test performance. The scores on both of the tests could range from 0 to 30.

Instructional Strategy and Procedure. In the first unit of the course, students copied a teacher-generated concept map for the first two chapters of that unit. This provided introductory training in terminology and procedure of concept mapping. On the second chapter of Unit 1, subjects were required to generate their own concept map prior to instruction. After these maps had been collected, additional group participation was used to enhance the map generated as the instructor lectured. During the subsequent class session, the initial test was administered.

In Unit 2, the concept map for the first two chapters was solely instructor generated. In the second of those chapters, students were required to individually generate a concept map prior to instruction. After collection of these maps, students participated in construction of a group-generated map on an overhead projector. Students then individually constructed a concept map on this same chapter as a review for an exam.

In Unit 3, the instructor generated a map for the first of two chapters. In the second chapter of this unit, students individually generated a concept map with use of the text book. Keeping these maps, they were then required to contribute to the class map for this chapter on the overhead projector. Their maps could be revised as the class progressed. Maps were collected at the end of that class session, and the final test was administered the following session.

Results. Would concept map training help improve the test performance of pre-service teachers, particularly those whose initial maps indicated conceptual deficiencies? A two-way mixed analysis of variance yielded a significant main effect for high versus low key-word score (between-subjects) on beginning and ending test performance, $F(1,19) = 7.04$ $p<.01$. The main effect (within-subjects) for test occasion, $F(1,19) = 5.14$, $p<.05$. This interaction is depicted in Figure 1 and indicates an increase for the entire sample. There was a dramatic improvement, however, for those subjects who initially had performed poorly in representing key words on their concept maps.



Analyses of variance were also computed with total concepts (item score), depth (length score), defined as the number of subsumed categories in a single item stream as portrayed by lines drawn outward from the stimulus word, and breadth (stream score), defined as each line drawn out from the central concept if it led to one or more words or phrases as independent variables and test scores as the dependent measure. These analyses also supported the propositions that (a) concept map performance is indicative of test performance and (b) test performance improves with training in generating concept maps.

The implications for training pre-service teachers in concept mapping as a study strategy are promising on two levels. First, mapping provides an opportunity for students to enhance their comprehension and mastery of course material. It appears to help these students shift from a shallow understanding of teaching constructs to a richer representation of deep structure and interrelationships. The interpretation is that concept map training has a powerful effect on academic performance, particularly for at-risk learners. The finding that concept-map training helps improve test performance of both high and low ability students ameliorates concern about lack of progress by more apt students. Secondly, it offers instructors formative information about how students comprehend and organize content material and, thus, empowers teachers to be more effective facilitators of learning through an interactive process. This sort of cartography assists students, instructors, and evaluators of program effectiveness to differentiate conceptual relationships that matter from those that do not.

Study 2

Our work with pre-service teachers is based on presenting instruction that moves from general to discrete concepts with a focus on how those concepts are related. In order to provide students with a structure to organize new information, we have emphasized principles before facts, and relationships before recall. Prior to class discussion of new material, students are asked to draw individual concept maps representing their understanding of the text they have read. In class, instruction is anchored in the representations of concepts drawn by the instructor or "expert" and then collaboratively generated by students in the class as the semester progresses. In this way, instructors may assess student comprehension and provide corrective feedback in order to negotiate shared meaning with learners.

Our goal is to help students develop an integrated and synthetic framework by which they may learn to link concepts and move beyond recall and memorization to higher order thinking and problem solving skills. The ultimate aim is to train them to teach their students using this method. If the facilitation of learning is best achieved by assisting students in the development of personal meaning and shared understanding, it is important to probe for student misconceptions about the knowledge base under study. What better way to accomplish this end than by modeling for students how to make explicit their own understanding and by using concept mapping to drive instruction?

Method

Subjects. The subjects were 20 pre-service teachers enrolled in an undergraduate educational psychology course. Subjects were trained in concept mapping as part of the course requirements. There were 4 males and 15 females.

Instructional Strategy and Procedure. The first unit of the course was composed of chapters 2-5 of Eggen & Kaucheck's Educational Psychology: Classroom Connections (1992). After an initial concept map training period of approximately half an hour using content unrelated to the course content, students were asked to draw concept maps after they had read the text chapter, but before they received any instruction on the content. During lecture, the instructor constructed an expert map which students could copy, if they elected to do so. This first map was considered as a baseline and was not included in subsequent analyses.

On all subsequent chapters (chapters 3, 4, 5, 7, 10, 11, & 13) where mapping was utilized, students were required to generate individual concept maps prior to instruction. Students were provided carbon for copies if they wished to retain their maps. After the maps were collected, the instructor generated an expert map as lecture progressed. In addition, students were provided a handout on concept mapping procedures and strategies.

Dependent Measures

In addition to students' performance on course tests, there are 6 other dependent variables of interest to us in this investigation. **Key word scores** are scores for each key concept given to students by instructor scored as 1 point. **Valid relationships score** denotes the links between two concepts, one of which involves a key word, scored as 1 point, if the relationship is valid. **Hierarchy level score** is any valid key word which lies along an item stream if such a key word is subsumed. If for example, a key term is at the 3rd or 4th level of subsumption on the expert map and is drawn by the novice at the first level of subsumption below the valid root node, it is scored at the first level of depth . Each level is assigned 1 point. **Item stream score** is any key word arising from a valid root node. The key term may lie anywhere along the item stream connection if it is not intersected by an invalid relationship, scored as 1 point. **Example** is any key word designated as an example on the expert map if it is drawn as part of a valid relationship, scored as 1 point. **Cross link** is any valid linked relationship between sets of concepts on map, scored as 1 point.

Preliminary Findings

We are still in the process of analyzing the students' maps. We have graphed each individual student's number of key word representations as they compare to the expert map, for each of 8 different concept mapping occasions (these occasions correspond to text chapters noted above). A few patterns have been observed which include: a steep positive slope for the graphs of 19 students on the chapter 3 maps (student development), and for 12 of the 17 students who completed the map of chapter 11 (individual differences). In 11 cases, there was depressed mapping performance on the chapter 4 maps (individual differences) as compared to their success in mapping chapter 3.

Our initial interpretation of this phenomenon is that the content covered in the text chapters 3 and 11 is quite well-structured while that of chapter 4 is ill-structured. It has been our observation that much of the research on concept mapping pertains to well-structured fields of study. This is particularly descriptive of the work done in the natural sciences (Jegede, Alaiyemola, & Okebukola, 1990; Wallace & Mintzes, 1990).

The maps we have described thus far are those completed prior to instruction. Observation of individual maps indicate that our students made very little use of cross-linkages in the pre-instruction mapping. The explanation for this may lie in the fact that the textbook used (like most texts) segments the content and provides the novice with few instances where concepts introduced in one chapter are linked to earlier concepts from preceding text chapters. It is our hypothesis that the students may be mapping the text to conform with its structure. We have also collected post-instruction maps from students that remain to be analyzed. The test for the hypothesis should lie in the comparison of the two sets of maps. If in fact instruction emphasizing integration and interconnectedness of concepts resulted in student learning of relationships, then the post instruction maps should document that.

Future Research

We have planned future research for the fall semester in which we intend to examine: (a) the structure of specific content segments with concept map performance; (b) the structure of the text related to concept mapping performance when students are provided expert maps emphasizing cross linkages within the chapter; and (c) the effect of having students collaboratively generate maps in class using an expert model that illustrates and emphasizes cross linkages to other concepts in other chapters. We noted only one pre-instruction map in which this type of connection was drawn. There were few maps on which cross-links were drawn illustrating the interrelationship of concepts within the text chapter.

We agree with Novak (1984) and Wittrock (1990, 1992) about the probable efficacy of maps for improved comprehension of expository text when students generate these types of linkages. Mikulecky, 1987; Anderson & Huang, 1989; Armbruster & Anderson, 1980, have assessed what effect using concept maps may have on students' comprehension of expository texts. They reported significant gains for both junior high school and university undergraduate students. It is our expectation that we will find comparable data.

Support for research in concept mapping may be found in current neuroscience publications (Archives of Clinical Neuropsychology, Annals of Neurology, International Journal of Neuroscience). The results of this line of inquiry may prove useful to learning theorists and students as they attempt to construct meaning from their experiences. Connecting concepts from neuroscience with those of education and psychology is crucial. In their article "Reconceptualizing relevance in education from a biological perspective," Iran-Nejad, Hidi, & Wittrock (1992) write, "Understanding the nature of the problem of relevance in education requires understanding the assumptions behind our educational practices as well as the dynamics of how the nervous system works to both create the mind and enable people to function in authentic contexts" (p. 412).

Certain themes reoccur in current neuroscience research literature which reflect a return to the functionalist perspective ascribed to by Dewey (1896), Angell (1907), and Bartlett (1932). The assumption adopted by these early functionalists was, "simplification by integration, as opposed to isolation, and thus put the moment-by moment mental activity, the functional brain organization, and the authentic real-world context into one holistic, coherent, and coordinated picture." (Iran-Nejad, Hidi, & Wittrock, 1992, p. 411). Some of these contemporary themes include such concepts as intentionality/generative processes (Wittrock, 1992), affect (Dunn, Dunn, Andrews, & Languis 1992; McGuinness & Pribram, 1980; Novak, 1990); interactivity and complementarity of hemispheric processes (Gazzaniga, 1977; McLendon, 1982; Sperry, 1968); meaningfulness and the drive toward meaning making (Magoon, 1977 in Jonassen, Beissner & Yacci, 1993; Novak & Gowin, 1984), learning as both a social and neural process, (Rochelle & Clancey, 1992) executive function and self-regulation, (Languis & Miller, 1992) and context.

Our current reading has led us to select Merlin Wittrock's theory of generative learning as the theoretical framework for our future research. Wittrock's model is comparable to Luria's (1973) model which proposed three functional systems of the brain: a) arousal and attention; b) reception, analysis, and information storage; c) planning, organizing and regulation of cognition and behavior. The Wittrock model differs significantly from other cognitive theories (e.g., connectionism, neural nets, symbolic interactionism) that use the computer as metaphor for the acquisition, storage, and retrieval of information from memory with the learner as the passive recipient of stimulus input.

The four major learning processes which compose the generative learning model are: (a) attention, (b) motivation, (c) knowledge and preconceptions, and (d) generation. Rather than focusing on the structural properties of knowledge, the model focuses on processes of learning such as attention and arousal; motivational processes such as attribution and interest; knowledge creation processes, such as preconceptions, concepts and beliefs; and generation processes, which include analogies, metaphors, and summaries (Wittrock, 1990; Wittrock, 1992). While Wittrock's research underscores the importance of the generation processes, we believe that our efforts involving the knowledge creation component of the model will be fruitful. More importantly, we believe that the neural research base upon which it is to be predicated will lend credence to our belief that learners are intentional and purposeful in their attempt to make meaning of their experiences. In this way, generative learning resembles the functionalist assumption of *simplification by integration*. In addition to understanding how information or knowledge is structured, "Research based on the generative model deals with the effects of generation of meaningful relations - among concepts and between knowledge and experience - on learning from teaching" (Wittrock, 1992, p. 532). As Mandler (1983) suggests, until individuals impose some sort of organization or order on materials, the materials are not meaningful. Concept mapping practice appears to be a generative process which provides the opportunity to impose order on the concepts contained within expository texts. As we continue to work with preservice teachers, we will continue to explore strategies that capitalize upon the facilitation of their learning and provide tools to enhance the learning of their future students.

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